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Multimodality: Contributions to the Universal Access Research Agenda

Noëlle CARBONELL (1), Dominique Scapin (2)

(1) Université Henri Poincaré, Nancy 1, LORIA (CNRS & INRIA), Campus Scientifique, BP 239, F54506 Vandœuvre-lès-Nancy Cedex, France, E-mail: Noelle.CarboneЪ@loria.fr
(2) INRIA, Unité de Rocquencourt, Rocquencourt, BP 105, 78153 Le Chesnay Cedex, France, E-mail: Dominique.Scapin@inria.fr

ABSTRACT

Novel forms of multimodality involving new media, such as speech, gestures, pen, gaze, and their potential contributions to advancing the implementation of Universal Access are briefly reviewed. Then, applications to the Healthcare domain are considered, which focus on extending electronic patient record accessibility.

1 Universal Access: a Topical Challenge

The development of a world wide Information Society represents a major social evolution, which may increase social exclusion, unless user interface designers consider accessibility issues carefully, and have appropriate standards and guidelines at their disposal.

International initiatives focusing on the implementation of Universal Access are developing; see, for instance, Stephanidis et al. (1997) or the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (URL: http://www.w3.org/WAI/).

However, achieving Universal Access raises still numerous usability issues, as it means implementing computer accessibility for:

i. all users including disabled and elderly people,

ii. in any context of use (e.g., wearable computers, mobile computing, smart home artifacts, virtual or augmented reality interactive environments).

First, existing guidelines on Universal Access are of a high level of abstraction. They depict desirable product features (e.g., "equitable use"), but do not provide sufficient details on how to approach and structure design activities, or how to assess tentative proposals in regard to a given feature or target objective. This gap has been identified as one of the main drawbacks that prevent European industries to apply in practice the principles of Universal Access.

In addition, Universal Design (Story, 1988), that is the design of products or services that are usable and acceptable by potentially everyone, everywhere and at any time, has not yet made its way into the software industry, although the seven principles defined to guide the implementation of this approach are well established in engineering disciplines, such as architecture.

Finally, the concepts of adaptability and adaptivity have been proposed to accommodate intra- and inter-user diversity. In particular, they have been experimented in the AVANTI European Project, for providing disabled users, especially blind and motor handicapped people, with easy computer access (cf., Stephanidis et al., 1998). However, the implementation of these concepts presents limitations, at least for the time being:

- Adaptations are predefined, hence static, and their scope is limited.
- As for present implementations of adaptivity, they are still too crude and unreliable to be useful:
  - The utility and usability of self-adapting existing user interfaces are still poor, since such systems infer their evolution strategies mostly from the analysis of the current user’s actions, hence from ambiguous or imprecise cues on users’ capabilities, preferences, goals and strategies.
  - In addition, notifying users (or making them aware) of the interface evolution, and enabling them to control this evolution, is an unsolved issue which requires long-term research efforts.
- Finally, these paradigms have not yet addressed issues relating to the diversity of use contexts.

In contrast, multimodality appears as a promising approach and fruitful short-term research direction for advancing the implementation of Universal Access principles, as shown in the next section.

2 Multimodality and Universal Access

2.1 Definitions

(Coutaz & Caelen, 1991), (Maybury, 1993; 2001), (Bernsen, 1994), among others, define ‘media’ and ‘modalities’ contrastingly. They use the first term for referring to the hardware and software channels through which information is conveyed, and the second one for designating the coupling of a medium with interpretation processes capable of transforming physical representations of information into meaningful symbols or messages, and conversely.

1. cf. also the website at: http://www.design.ncsu.edu/cud/
employed to process incoming information, e.g., vision, audition, and haptics.' (Maybury, 2001:382)

To characterize the various possible combinations of modalities, a taxonomy comprising four classes has been proposed (Coutaz & Caelen, 1991). As we focus here on issues relating to usage rather than implementation, we only need to consider two classes in this taxonomy:

- "alternate multimodality" which characterizes a multimodal sequence of unimodal messages;
- and "synergic multimodality" which refers to multimodal messages or, in other words, to the simultaneous use of several modalities for formulating a single message. For instance, speech associated with pointing gestures on a touch screen, as in the following command: "Delete this." + pointing a file icon in the display is a form of synergic multimodality.

In the remainder of the paper, 'multimodal[ity]' used without qualifier refers to synergic multimodality.

2.2 Assets and potential contributions

Multimodal human-computer interaction facilities are invaluable for increasing computer accessibility, thanks to the recent development of new interaction media and modalities especially.

Such facilities are indeed necessary for enabling all citizens to access electronic information easily. Giving users the possibility to choose among equivalent input and output modalities (or forms of multimodality) according to their motor and perceptual capabilities, is necessary for accommodating the needs of users with physical disabilities.

Besides, multimodal voice-based user interfaces prove most useful in situations where keyboard and mouse are awkward or impossible to use (e.g., wearable computers, home automation, ...). In such contexts of use, speech associated with a designation modality, such as pointing gestures on a touch screen, pen or gaze, provides users with appropriate means of interaction.

A short review of the state of the art regarding the design and implementation of usable speech-based multimodal interaction is presented in the next paragraph.

2.3 State of the art

Output forms of multimodality associating speech with sound and graphics are easy to implement. However, only a few recommendations are available for the design of multimodal system messages integrating these modalities.

In particular, studies are needed on the specific contribution of speech to the usability of system outputs. Otherwise, speech will only be used as a substitute modality for graphics, in situations where graphical displays are awkward or impossible to use.

Multimedia presentations are not considered here, since, according to our definition of multimodality, they are outside the scope of multimodal interaction.

Input forms of multimodality coupling speech with designation gestures, using a pen or one's hand on a touch screen, have motivated many more studies, both from a software viewpoint and from an ergonomic angle. Robust fusion and interpretation of multimodal inputs can now be achieved (Nigay & Coutaz, 1993). As for utility and usability issues, they have been addressed by many researchers: Oviatt et al. (1997) on the use of speech and pen, Robbe et al. (1997; 2000) on the use of speech and gestures on a touch screen, (Baber, 2001) on multimodal interaction with wearable computers, and (Keates, 2001) on interfaces for motor handicapped users. From the conclusions of three related empirical studies, (Carbonell, 2001) demonstrates the advantages of controlled speech over spontaneous speech as an input modality either in unimodal or in multimodal interaction environments. The paper also includes a set of recommendations for the design of acceptable (i.e., usable and robust) oral or multimodal command languages.

However, the contribution of gaze as a useful complementary input modality (for designation mainly) remains still to be investigated thoroughly. Published research amounts to a few recent studies only (cf., for instance, Hansen et al., 1998), probably by reason of the following obstacles:

- The lack of unobtrusive devices for capturing eye movements;
- The absence of reliable algorithms for tracking and interpreting eye-fixations, in terms of gaze directions and targeted objects, with sufficient accuracy (Spindler & Chaumette, 1997).

2.4 Applications in Healthcare Telematics

Healthcare Telematics represents a critical application domain for Universal Access and Universal Design principles, as it caters for the population at large, and involves a variety of specific target user groups, in particular, doctors, nurses, patients, administrators.

In addition, access to electronic medical information is required in a great diversity of situations and contexts of use. Therefore, Healthcare Telematics will greatly benefit from the implementation of Universal Access principles, hence from the introduction of multimodal user interfaces integrating new input-output media and new interaction modalities, such as speech, pen, finger and

1. This class results from the grouping of the 'alternate' and 'exclusive' multimodality classes in (Coutaz & Caelen, 1991).
2. That is, the expressive power (semantics) of the various modalities considered should be equivalent.
3. i.e., controlled speech (involving a restricted subset of natural language) associated with pointing gestures on a touch screen (using fingers).
hand gestures, or gaze. It represents a stimulating and challenging application domain for multimodality. In particular, focusing on the accessibility of Electronic Patient Records (EPR) gives the opportunity to address both classes of issues raised by the application of Universal Access principles to software design, since EPRs have to be accessible:

- to every patient, that is, potentially, to all citizens;
- to a wide range of specific user communities with contrasted user profiles, such as doctors, nurses, administrators, …);
- in a great variety of contexts/situations: GPs’ offices, hospital wards, ambulances, cars, etc.

For instance, the introduction of wearable computers with multimodal user interfaces into Healthcare Telematics would greatly improve the working environment of various medical staff, for instance: GPs on house visits, surgeons in operation theatres, specialists in hospital wards (cf. the European Project ‘Ward in Hand’), emergency teams in ambulances or on accident sites. Wearable computers with such user interfaces would also increase significantly the comfort of self-monitoring patients at home.

As participants in the IS4ALL European thematic Network and Working Group, we are currently assessing the usability of various multimodal access facilities to EPRs in diverse contexts of use.

3 Conclusion

Novel forms of multimodality involving new media (e.g., speech, gestures, pen or gaze), and the potential contributions of multimodality to advancing the implementation of Universal Access have been briefly reviewed. Then, applications to the Healthcare domain have been proposed, which focus on extending electronic patient record accessibility.

4 References


2. IS4ALL, that is ‘Information Society for All’, is a European network and working group supported by the EC (IST Programme support measures), from October 1, 2000, to October 1, 2003.
3. IS4ALL web site address: http://is4all.ics.forth.gr
Examining the Role of Risk Perception in the Use of Obstetric Technology

Michèle JEFFCOTT (1)

(1) Department of Computing Science, University of Glasgow, 17 Lilybank Gardens, Glasgow G12 8QQ, United Kingdom, E-mail: shellyj@dcs.gla.ac.uk

ABSTRACT

Although it is well documented that the perinatal period is the most dangerous time of life, the last 50 years have seen dramatic falls in both perinatal and maternal mortality (Herczeg, 1997). The most significant factor behind this has been the steady increase in the amount and effectiveness of technological interventions in the management of labour. However recent years have also seen dramatic changes in the responsibilities within maternity care teams and the role of the woman in decision-making. This has resulted in a shift in the attitudes towards intervention due to a desire to return to more natural birth situations. (Changing Childbirth, 1993). This paper outlines the results of a psychometric risk perception tool distributed to consultants and midwives in a high technology maternity unit and a 'home-away-from-home' non-intervention unit in Scotland. The aim of this work is to examine how underlying risk perceptions and attitudes towards technology are linked to organisational culture and what benefit this knowledge has in order to better understand issues surrounding the acceptance and use of technology in obstetric health care.

1 Introduction

Throughout Europe, Obstetric accidents, or ‘adverse events’ as they are known, have led to a progressive rise in the number of litigation cases. In the UK, obstetric litigation currently costs its National Health Service (NHS) £160-200 million per year, constituting 60% of all medical litigation pay-outs (Young et al. 2001). The more obstetricians get sued, the more they intervene with birth. The result is that over the last 20 years national caesarean section (CS) rates in some countries have doubled, and in some hospitals, they have gone up four-fold. France currently has a national CS rate of 30% (Enfants, 2000), while the combined operative and instrumental delivery rate in Spain is 40% (Wagner, 2000). Surveys on maternal deaths in the UK (Hall & Bewley, 1999) show that the mortality rate for CS is six times that of vaginal birth.

Figures like these, added to a genuine desire to improve quality of care to patients, have motivated dramatic advances in safety and the re-evaluation of risk management and communication strategies throughout obstetrics. However, the success of these initiatives relies on the wide integration and support of healthcare workers at all organisational levels. This cannot be achieved without a thorough understanding of the underlying attitudes that these professionals have to the risk and hazards of their daily work (Hale & Glendon, 1987). And it is crucial that the subsequent models of risk perception and behaviour that are produced include measures of organisational culture and safety status if they are to accurately reflect the reality of the work environment (Pidgeon, 1998).

This research aims to uncover variations in how the risks of different fetal monitoring techniques are perceived, particularly in regard to obstetric care workers acceptance and use of medical technologies.

1.1 Methods of Fetal Surveillance

The use of continuous electronic fetal monitoring (C-EFM) is routine throughout Europe, with countries like Spain using it on 90% of all women in labour (Wagner, 2000). However, many empirical evaluations have shown that it is a crude way to assess fetal oxygenation and is not associated with any decrease in either fetal mortality or cerebral palsy (MacDonald, 1985). Also, C-EFM has been identified by UK obstetricians as a main factor behind the growth of CS rates, second only to fear of litigation (Francombe & Savage, 1993).

Widespread concern over the efficacy of C-EFM has prompted searches for better methods of fetal monitoring. These include a variety of invasive and non-invasive techniques, such as fetal pulse oximetry and fetal blood sampling. This work specifically examines the risk perceptions that different obstetric staff have towards existing C-EFM technology, and to newly adopted methods as well as those techniques yet to be introduced into the British NHS (such as ST-waveform analysis monitors). It also focuses on a number of existing pregnancy screening methods (such as ultrasound and amniocentesis) and other birth interventions (such as vacuum-assisted delivery) in order to evaluate perceptions of their associated risks. All forms of medical intervention during the birth process constitute risk, and therefore require comparative investigation in this study.

2 Method

2.1 Participants

In total, 18 obstetric health care providers (6 male, 12 female) completed the questionnaire. 5 of these were Consultants, with an average of 13.5 years experience. 9 were Midwives (Grades E, F & G), with an average of 9.5 years experience. Finally 4 participants were Registrars (SpR), with an average of 3 years experience. The
consultants were mainly based in the high technology obstetric ward, as high risk patients needing specialist care are routinely transferred there from the low intervention ‘home-away-from-home’ annex. The midwives and registrars work routinely in both areas, although many of the midwives stipulated on the questionnaire that they were permanently based in the annex, where low risk women are cared for with C-EFM on admission only and epidurals are provided only in cases of severe maternal exhaustion.

2.2 Questionnaire

Participants were presented with 14 adverse event scenarios, each involving a different fetal monitoring technique. Below is an example scenario focusing on fetal blood sampling, which involves measuring fetal blood pH to assess acidosis levels, a precursor of fetal hypoxia (oxygen starvation):

On finding a persistent non-reassuring fetal heart rate (FHR) the midwife called for a registrar to set up for a fetal blood sampling. As the cervix was suitably dilated the test was performed. However, there was continued fetal scalp bleeding from the puncture site, which became difficult to control and distressing to Mrs. T.

The participants were then asked to rate each of the scenarios on nine characteristics of risk similar to those found to be important in prior studies by Slovic, Fischhoff et al. (1985) and Kraus and Slovic (1988). The nine characteristics were:

1. Anticipatory knowledge by risk managers
2. Anticipatory knowledge by those involved in adverse event i.e. obstetric care workers
3. Severity of the consequences (to both woman and fetus)
4. Dread of the entire range of potential consequences
5. Confidence in future use of the technology (or in performance of the activity)
6. The overall Riskiness of the technology or activity (to both woman and fetus)
7. Ability to Control the risks involved with the technology or activity
8. Ability to Observe the risks at the near miss stage prior to development of an adverse event
9. Future Effort needed for Risk Reduction

3 Results

The mean perceived risk of the various fetal monitoring techniques varied greatly, from 1.7 to 8.0 on the 10-point likert scales. The two techniques judged to be most risky were amniocentesis and the intrauterine pressure catheter (IUPC). The two techniques judged to be least risky were intermittent auscultation, with both the pinard stethoscope and doppler ultrasound. Intermittent auscultation (IA) is a minimal intervention method involving traditional listening of the fetal heart rate (FHR). Table 1 presents the techniques whose mean ratings were extreme on each of the nine judgment scales. Participants also made Invasiveness ratings for each technique and these are presented next to the mean ratings as Invasive (In), Non-Invasive (NI) and a Mixture (M). Techniques, such as amniocentesis, fetal pulse oximetry (FPO) and the intrauterine pressure catheter (IUPC) are repeatedly the most negatively rated on all characteristics. Techniques such as intermittent auscultation and fetal blood sampling (FBS) were consistently rated toward the less serious pole of each scale.

Table 1: Extreme Scenarios for 9 characteristics

<table>
<thead>
<tr>
<th>Risk Scale</th>
<th>Highest Methods</th>
<th>Invas. Scale</th>
<th>Lowest Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Knowledge</td>
<td>IA-Pin 6.0</td>
<td>C-EFM 4.1</td>
<td>Epid 1.7</td>
</tr>
<tr>
<td></td>
<td>C-EFM 2.8</td>
<td></td>
<td>Amnio 1.8</td>
</tr>
<tr>
<td>2 Knowledge</td>
<td>IA-Pin 4.7</td>
<td>Ultra 4.3</td>
<td>Epid 1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FPO 2.3</td>
</tr>
<tr>
<td>3 Severity</td>
<td>Amnio 6.8</td>
<td>I-EFM 6.0</td>
<td>FBS 2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FSS 2.7</td>
</tr>
<tr>
<td>4 Dread</td>
<td>FPO 6.1</td>
<td>IUPC 5.9</td>
<td>FBS 3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C-EFM 3.4</td>
</tr>
<tr>
<td>5 Confidence</td>
<td>IUPC 6.9</td>
<td>FPO 6.3</td>
<td>IA-Dop 2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IA-Pin 2.9</td>
</tr>
<tr>
<td>6 Riskiness</td>
<td>Amnio 6.3</td>
<td>IUPC 6.3</td>
<td>IA-Pin 2.6</td>
</tr>
<tr>
<td></td>
<td>FPO 6.3</td>
<td></td>
<td>IA-Dop 3.2</td>
</tr>
<tr>
<td>7 Controllability</td>
<td>Amnio 7.7</td>
<td>Vac 6.0</td>
<td>IA-Pin 2.6</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>IA-Dop 2.6</td>
</tr>
<tr>
<td>8 Observability</td>
<td>I-EFM 8.0</td>
<td>Ultra 7.8</td>
<td>Epid 2.2</td>
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<td></td>
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<td></td>
<td>STAN 4.0</td>
</tr>
<tr>
<td>9 Effort</td>
<td>IUPC 6.9</td>
<td>C-EFM 4.3</td>
<td>IA-Pin 3.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FBS 4.1</td>
</tr>
</tbody>
</table>

Results of the intercorrelations among the nine judgment scales, and the subsequent principle component analysis that five of the characteristics were subjected will be presented and discussed in the presentation accompanying this work.

4 Discussion

These results showed that those techniques viewed as invasive were generally judged to be highly dreaded and risky, and displaying poor confidence, controllability and observability. Conversely, it was the non-invasive techniques that scored low on dread, severity, and riskiness and high on knowledge and confidence. However, some invasive techniques such as fetal blood sampling (FBS) and epidurals were judged as not being of particular cause for concern. This was due mainly to the fact that they are established techniques within maternity care and as a result, obstetric care workers appear to have adapted well to controlling their associated risks.

The invasive and non-invasive categorisation sits well with a technology and non-technology split. It also reflects the novelty of the risks, as new techniques such as fetal pulse oximetry (FPO) and the STAN monitor are both highly dreaded and poorly observable, compared to the commonplace fetal blood sampling (FBS) and fetal scalp stimulation (FSS).
Separate means for medical and midwifery workers perceived risk judgments were also calculated. Considerable differences were found in their ratings for intermittent auscultation (IA) and continuous electronic fetal monitoring (C-EFM). Midwives consistently rated IA more positively and C-EFM more negatively than the consultants and registrars. This reflects differences in the responsibilities of their roles and also the environments where they provide care.

5 Conclusion
This study has two main findings. The first is that variations occur in the risk perceptions of invasive (high tech, novel) compared to non-invasive (low tech, commonplace) fetal monitoring techniques. The second is that variations occur in the risk perceptions of midwives compared to medical staff.

The value of uncovering these technological and cultural variations in how the risks of fetal monitoring techniques are perceived is that it gives insight into obstetric professionals ultimate decisions surrounding their acceptance and use of technological devices. If risk information can be presented more sensitively to cultural groups who are weary of technology, then this will filter down to patients and hopefully improve their own acceptance of advantageous technologies during their labour. Many seemingly intrusive forms of technology designed for intrapartum care, actually decrease the "medicalisation" of labour through reduction in CS and other interventions, rather than increasing it, as is the common assumption about technology (Henney, 2000). This conclusion has a direct impact on the development of risk management policy, highlighting the need for more attention to be given to the presentation of risk information regarding new technologies.

6 Acknowledgements
Thanks are due to both Dr. Alan Cameron and Diane Anderson who have supervised this work at the Queen Mother’s Hospital, Glasgow. Also thanks go to all staff who completed the questionnaire and to my own academic supervisor, Professor Chris Johnson. This work is supported by the UK Engineering and Physical Sciences Research Council and is carried out as part of the University of Glasgow Accident Analysis Group.

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On the Development of a Medical Safety Reporting System

Ben-Tzion KARSH (1), Kamisha Hamilton (2) and John Beasley (3)
(1) Department of Industrial Engineering, University of Wisconsin-Madison, 1513 University Avenue, Rm. 387, Madison, WI, 53706, USA, E-mail: bkarsh@engr.wisc.edu
(2) Department of Industrial Engineering, University of Wisconsin-Madison, 1513 University Avenue, Rm. 392, Madison, WI, 53706, USA, E-mail: kjhamilton@students.wisc.edu
(3) Department of Family Medicine, University of Wisconsin-Madison, 777 South Mills, Madison, WI 53715 USA E-mail: jbeasley@dfmp1.fammed.wisc.edu

ABSTRACT

To begin the process of addressing quality of care in primary care, a taxonomy and reliable system of reporting errors is essential. It is highly likely that such a system will contain a web-based reporting component, making this a special case of working with a display unit. To this end, the objective of this research is to develop the content of a medical safety reporting system using multiple focus groups of primary care physicians (specifically family physicians) and family practice nurses and medical assistants of a Midwestern state in the US. The results of this study may be used to create a statewide medical safety reporting system for family physicians and their clinical assistants. This in turn will allow for the creation of a taxonomy of errors in family medicine, which will allow for the tracking of medical error trends and proposing of methods to reduce errors or mitigate their impact using quality engineering techniques. To date, five of the physician focus groups have been conducted, of which three have been analysed and are discussed here.

1 Introduction

Primary care has become more complex and more relevant, especially in managed care organizations. Primary care, in comparison to hospital care, requires greater variation and expected deviation from evidence-based guidelines. Therefore, information on hospital error (e.g. IOM, 1999) may not be applicable to primary care. To begin the process of addressing quality of care in primary care, a taxonomy and reliable system of reporting errors is essential (Fischer et al 1997). However, currently no reliable system of reporting errors in primary care settings exists.

Incident reporting itself has been a growing focus in hospital studies of patient safety, much of which has been done in Australia as part of the Australian Incident Monitoring Study (AIMS), which started in 1987 (Baldwin et al 1998; Runciman et al 1993). To obtain a full picture of the types of errors committed in family practices, it is necessary to have a reporting system that will be both useable for potential reporters and useful for capturing all pertinent data and disseminating the findings back to the health care community. Therefore, this study was designed as a user centered study that collects data from physicians and other clinicians in family medicine such as nurses and medical assistants in order to explore issues in the design of such a medical safety reporting system. The research question being addressed is “What are the barriers and motivators for the design of a reporting system for capturing medical errors in family practice and what design features enable and motivate potential reporters to report?”

2 Methods

2.1 Design

A repeated focus group design using two separate groups is being used to collect the data. The two focus groups have the same objective, but one is composed of family physicians and the other of family practice nurses and other clinical employees such as medical assistants (to all be referred to as clinical assistants).

Most focus group designs bring together a group of people once and are conducted with all group members and the moderator in the same location. However, in the current study, two groups of health care professionals agreed to convene for 10 focus group meetings. In addition, the focus group meetings are taking place over teleconference phone lines because of the geographic dispersion of the focus group participants. Participants outside of the local area dial in with a toll-free number. The focus groups meet 1-2 times per month for 10 total meetings. Each meeting lasts 1 hour. The conversations are audiotaped and the tapes are transcribed. The sessions are moderated by two of the authors (BK and JB).

2.2 Participants

Physicians and clinical assistants are being used because in practice either one may see an incident, so either one should be empowered to report an incident. The physician and clinical assistants were selected using a form of purposeful sampling known as stratified purposeful sampling. The stratification variable was job title – either family physician or family practice clinical assistant. Within each stratum the participants were recruited so as to have a range of experience and ethnic backgrounds, both genders, and urban and rural practice locations.
2.3 Procedures
Potential participants were identified using the membership listing of the state’s family physician Academy and a listing of clinical assistants developed previously by two of the authors (BK and JB). The Academy has 1458 members: 53% practice in rural locations and 72% are male. Ninety-three percent are office-based practices and the majority are part of a family practice or multi-specialty care group. Recruitment letters and informational forms approved by the Health Sciences Institutional Review Board at the University of Wisconsin-Madison were mailed to potential participants. This process continued until a minimum of six and a maximum of 10 individuals per group volunteered to participate. Eight physicians and six clinical assistants make up the current focus groups.

Focus group times and dates were arrived at through correspondence. During the first focus group, the purposes of the study and confidentiality safeguards were reviewed. From there, the topics for subsequent focus group meetings were explained. The topics include: (1) fears and concerns about reporting medical errors, (2) potential purposes of a medical error reporting system, (3) barriers and motivators for reporting to a system given each of the identified purposes, (4) what to report (e.g. chain of causality, mitigating factors, who, what, when, where, how, systems issues, positive factors, near misses, adverse events), (5) instructions for using the reporting system, (6) mechanisms of and medium for reporting, (7) uses of the reported data, (8) security and ethical issues and (9) end-of-study feedback meeting. The number of topics is not meant to correspond to the number of focus groups. Some topics are taking less than one hour to discuss while others are taking longer.

2.4 Analysis
The three analytical steps being used are indexing, data storage and retrieval, and interpretation. These steps are conducted on an ongoing basis as the transcripts of the audiotapes of the focus groups are completed. The qualitative analysis software QSR NVivo is being used to facilitate the analysis. Analytical induction is being used during interpretation.

3 Results and Discussion
Three physician transcripts have been analysed thus far. The topics covered in these transcripts are 1) problems and concerns physicians have regarding a reporting system, 2) purposes for an error reporting system, and 3) motivators and barriers to reporting given each of the potential purposes of the system.

Physicians have a broad range of concerns regarding the implementation of a statewide error reporting system. The discussion spanned topics ranging from system integrity and abuse to the ethics of error reporting. Confidentiality of the system was the most prevalent concern. The participants had concerns of who would be identified, if the patient needed to be included, and if it was even necessary to have identification in the system at all. Ultimately they felt strongly about not having identification in the system. All the physicians agreed that they would only report if there were no identifiers, commenting that they would feel most comfortable reporting to a “blind system.” To quote one participant, “…literally no identifiers other than maybe age and a few clinical points that would again not allow anybody to put two and two together…” A consequence of this, however, is in the possible compromise of the system’s integrity. It remains to be determined how the validity of the system could be verified if it were anonymous or confidential. Similarly, participants voiced concerns about access to the system. “Would patients have input into this where now they have access to patient complaint or patient satisfaction fliers or forms? Would patients be invited to join the database, where they observed or experienced themselves some medical misadventure?”

A key concern centred around the possibility of an error reporting system leading to punitive outcomes. One participant stated “Why should they report anything, if there is going to be any retaliation or punitive things happening, I think you’re going to have to lose that ability if you want any incentive for people to report to it.” Consequences mentioned included fines, sanctions, revoked licenses, or malpractice suits. Interestingly enough, however, physicians felt they had little control over the existence of a system. There was a sentiment that sooner or later, it would be mandated in the health care system.

Participants voiced concerns relating to system abuse. One respondent commented, “But I wonder if there would be some potential for abuse of a system where, for whatever reason, somebody might begin reporting or exaggerating perceived errors that were just differences of practice styles or turf battles type of thing.” While this issue might be alleviated with system rules regarding identification in the system, this represents a significant issue that will have to be addressed in the system design.

Another set of inter-related concerns were system ownership, data analysis and system integrity. Probably the most frequent question in the discussion was “who is collecting the information and what are they going to do with it?” The discussion revealed that physicians felt most comfortable keeping the data within the profession, but felt this might be in conflict with public/patient awareness. Said one participant, “…keeping it within the profession and within research I think makes a lot of sense. But then, to the public, does that look like we are holding our cards close to our chest because we have something to fear…” Physicians were also concerned about who would perform analysis of the data. They wanted to ensure that the data would be evaluated objectively by a professional who understood the weaknesses in the medical system coupled with the performance demands of physicians.
The last major topic to be discussed in the first focus group was the ethics of error reporting. Would junior physicians report on senior physicians? Would physicians feel protective of one another? These realistic issues would affect the integrity of the system and affect working relationships. Regarding this issue, a participant stated: “So it’s a tough one whether that’s part of the guild where we cover our … protect our own, or whether it’s the open disclosure because patient protection is the primary goal.”

The purpose of an error reporting system was the subject of the second focus group discussion. The issues here, thus far, have been accountability, performance standards/grading systems, system improvement, and the payer’s perspective.

While physicians feel that accountability could lead to a punitive system, they do feel that accountability is a viable purpose for an error reporting system. Accountability can serve as a means of identifying clinics that have serious problems and aid in correcting them before too many outcomes become lethal. One respondent commented that failure to improve error rates should result in some sort of punitive sanction. For example, “I think… I’m maybe overly optimistic, but I’m hoping there would be someplace between accountable and punitive where there might be some acknowledgment or recognition and some responsibility without automatically being punitive…”

One of the primary purposes of an error reporting system would be simple method of system improvement. Along these lines, they discussed the value in sharing practice information. This enables them to learn how other institutions have dealt with certain system problems, or why an institution may not have any instances of a certain problem. One of the respondents even shared an innovative idea of reporting solutions.

The payer’s perspective, however, may be in conflict with those purposes identified by physicians based upon system improvement and physician learning. Physicians generally feel that payers would want to use the system to manipulate the clinic’s practice. For example, payers may use it as a tool to not pay for services or deviate payment.

The third transcript is currently under review; it addresses the motivators and barriers to the use of an error reporting system. Some motivators listed are physician learning, the medium for reporting, and system feedback. Some barriers discussed concern punitive systems, underreporting due to a cumbersome system, as well as the fear that nothing useful will come out of the system.

As stated earlier, the transcripts are undergoing content analysis using inductive analysis. Once these transcripts are coded, it is anticipated that topics will be able to elicit insight to the following questions: What aspects of physician culture lend themselves to reporting errors? What are physician attitudes to reporting errors? What system characteristics would make physicians prone to reporting errors? How would an error reporting system aid and enhance physician practice? What are the vulnerabilities of an error reporting system? How can a computerized reporting system be designed such that it will be useable and useful?

4 Acknowledgements

This study was funded by a grant from University-Industry Relations at the University of Wisconsin-Madison. The authors would like to thank Jennifer Schwarz, Brett Marquard, Rich Holden, Alice Chen and Nick McDonough for their work on summarizing relevant literature, reviewing focus group transcripts, and editing. The authors are also grateful to the physicians and clinical assistants who have participated in the focus groups.

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Concurrent Use of Input Devices – Relief or Overload?

Ahmet E. ÇAKIR
ERGONOMIC Institute for Social and Occupational Sciences, Research Company Ltd, Soldauer Platz 3, D-14055 Berlin, Germany, E-mail: ahmet.cakir@ergonomic.de

ABSTRACT

RSI and CTD are not “achievements” of the era of the computerized workplace. They are closely related to other long-documented symptoms of muscle strain; doctors have been diagnosing writer’s cramp since the early 19th century. From about 1950 to the advent of the mouse-based graphical user interface for computers, researchers considered the keyboard the culprit in most repetitive-strain injuries; studies focused on the role of the keyboard during the first RSI “epidemic” in Australia. In general, fatigue and other ailments due to overuse may be overcome in part by varying the workload, such as by alternating the parts of the body that are active over a certain period. Concurrent use of a keyboard and another input device, such as a mouse, can in theory provide relief because the muscles involved are partly different. As this paper shows, however, under current circumstances the opposite is usually true because keyboard use can aggravate problems caused by another input device like a mouse or a tablet.

1 Introduction

Long before the terms RSI or CTD became popular, the mechanical typewriter was responsible for most musculoskeletal problems of typists, as it required rapid movements of the fingers and a high level of force on the keys. Until the 1950’s, German secretaries who claimed to suffer injuries from keyboard use were unable to receive compensation, as there was no consensus that this type of workload caused “tenosynovitis.” However, a 1952 court decision meant it was possible, at least in theory, to acknowledge certain types of “overuse damage” as an occupational disease in Germany. By 1961, the insurance of employers had begun to cover treatment for diseases such as tendovaginitis (Peters, 1976).

Yet twenty years later, after the use of electric typewriters and computers had become widespread, more people than ever were experiencing musculoskeletal disorders. In surveys, about 5% to 20% of our subjects (Çakir et al, 1978) claimed to suffer from muscle strain to a degree that they needed to visit a physician, in most cases an orthopedist.

Computer GUIs ought to be more beneficial to their users. When they switch between keyboard and mouse, users exert different sets of muscles, which should allow some to recover while others are in action. This concurrent use of keyboards and alternative input devices should balance the overall workload and could therefore be a promising intervention (Cooper and Straker, 1996).

2 Musculoskeletal problems of users of input devices

2.1 Prevalence of musculoskeletal disorders

Analyses of work-related ailments among German workers based on early retirements and stationary treatments (Blohmke and Reimer, 1980) produced a very interesting result: The only group among white-collar workers that had a higher prevalence of musculoskeletal disorders (ICD 720-729) was female office workers (O/E ratio = 110%). In contrast to this, the O/E ratio for male office workers was the lowest among white-collar workers, as was expected.

In general, these disorders were more prevalent among women and blue-collar workers. While this outcome could plausibly be explained by analyzing gender-related differences and differences of workload, there is no simple explanation for female office workers having more than twice as many problems than male office workers – more than male metal-workers! (Fig. 1)

Figure 1: Prevalence of musculoskeletal disorders (office and metalworkers) (Source: Morbidity statistics for German workers 1975-1979)

The authors found that women tended to work in more constrained postures, in louder environments, and at machines with keyboards (mostly typewriters).

2.2 Somatic problems and their causes

A better explanation was found by analyzing data on complaints of subjects with different tasks, all working with VDTs. If the keyboard were the major cause there would be no difference between groups of subjects whose time spent at the workstation was equally long. If, on the other hand, gender differences were more
powerful determinants, women would encounter more problems than men.

After analyzing data from 1021 VDT workers and more than 300 typists (Çakir, 1981; Çakir et al, 1983) we found out that the self-reported vision problems were highly correlated with the frequency of complaints about somatic problems (correlation 0.59). Visual complaints were always significantly correlated with headaches, and headaches with postural problems.

Through intervention studies it was possible to demonstrate that causal relationships were behind the correlations. This was demonstrated, e.g., by analyzing postures of users while using keyboards with and without gloss or by comparing somatic complaints of subjects with and without appropriate viewing distances. For example, 49% of VDT users wearing “reading glasses” (focal distance 330 mm) needed medical treatment for backaches compared to 32% of a comparable population without eyewear (Çakir et al, 1978). Users working with black glossy keyboards tried to change their posture to reduce visual problems resulting in increased levels of backaches. The increase against users of matt grey keyboards was about 40%. Similar effects can be demonstrated for other workers with constrained postures.

2.3 Impact of self-control

The most powerful determinant for the perceived workload as well as for somatic problems was, however, the degree of self-control on the workflow and on posture. For instance, programmers and clerical workers, working about 4 hours a day at their VDTs, reported significantly different levels of stress and musculoskeletal problems.

Subjects who worked in restricted postures with the lowest level of control over their environment experienced the most problems (Fig. 2). Under these circumstances, ergonomic interventions at the workplace could lead to only minor improvements. Thus, we recommended eliminating such jobs in the long run.

Medical research demonstrated in a long-term study that psychological factors such as time pressure and alienation contribute to manifested musculoskeletal disorders and injuries, as do physical factors such as unsuitable chairs or workstations (Karmaus et al, 1990). This is not surprising, since experimental psychology of the 1930’s had already demonstrated that greater task difficulty increases muscular tension (Davis, 1938).

The workers worst hit by unfavorable working conditions in offices were stenographers, who had to cope with high levels of ambient noise while trying to hear the dictated text, which itself was louder than the noise in factories with heavy machinery.

As a result of the analyses performed at the beginning of the 1980’s, we predicted that the problems of male office workers would keep increasing until they would equal those of the female workers because two main determinants (lack of control and constrained postures) would change in the negative direction. They did.

3 A workplace in 2002

3.1 Where did the keyboard go?

With the advent of the era of graphical user interfaces (pioneered by the Xerox Star, and brought to the mass market by the Apple Lisa and Macintosh), many expected that the keyboard would lose its dominant role as an input device. In fact, in some work areas (e.g., graphic design) other devices such as mice and tablets play the main role. What has happened to the keyboard? It is still there and is being used alongside the other input devices, and not necessarily less intensively than in the past. While generations of engineers and ergonomists have tried to achieve an even load for both hands by redesigning keyboards, today the biggest load is (for right-handers) on the right hand and the right arm, which mostly acts outside its “neutral” position when operating an additional input device.

Unfortunately, the dreams of a “keyboardless” future blurred the vision of both manufacturers and ergonomists with the result that the standard keyboard is a bulky box the width of which exceeds the shoulder breadth of almost all potential users. (Fig. 3)
The original typewriter keyboard with character keys and a few function keys was extended by navigational keys of the editing sector and a numeric sector. Both were placed to the right of the original setting. While few users are able to adopt a neutral position in the horizontal plane, there are even fewer, if any, who can hold their wrist in a neutral position in the vertical plane for both keyboard and mouse. (Fig. 4)

If the use of each input device took a longer time some users might try to change their posture accordingly, but not while alternating within minutes or seconds. The overall outcome is that users are likely to spend longer periods of their working day in a constrained posture that can increase the risk of overuse syndromes, if not injury.

Figure 4: Arm posture and position of the wrist after adjusting the chair for a comfortable position for typing.

Another very useful achievement of our days, “over-size” monitors, force the user into an upright body position. Currently, the biggest screens are about 22” in diameter, but this is not the last word in monitor size. Not many people can maintain a relaxed head posture while working with them.

The introduction of GUIs has forced users to employ bigger screens for the same task because of the space requirements of the interface. Standard programs such as word processors generally require a 17” monitor under Windows compared to 13” under MS-DOS. At the same time new tasks have emerged that need even more space for various tasks (e.g., “imaging” to view scanned documents in full size or image processing for displaying large numbers of palettes). But the design of furniture has not changed very much. Thus, the ability of users to maintain an “optimal” posture has vanished.

3.2 Who is in control?

Computer users have no real alternative, other than perhaps to substitute a tablet, trackpad, or trackball for a mouse. Even so, most people seem to accept the mouse as the sole means for pointing tasks. Few workplaces offer their employees tablets of sufficient size. A tablet suitable for working on a 21” display is at least A4 size, or about 50 cm wide. Its bulk means users have even less control over posture.

Using a mouse together with a standard keyboard means that the closest point a typical right-handed user can place the mouse is about 330 mm from the middle of the body, on average about 500 mm, in excessive positions of the hand about 600 mm. If this is compared to the average elbow-to-elbow breadth of Central Europeans (5th percentile, female 185 mm (= 370 mm ÷ 2), 95th percentile, male 256 mm (= 512 mm ÷ 2)) it becomes obvious that no user will be able to adopt a neutral posture as required by the ISO 9241-5 standard. According to this standard, a workstation is adequately designed if the user is able to adopt a posture with no muscle intentionally contracted (see also ISO 9241-9, definition of “neutral posture”).

The degree to which deviations from the neutral posture cause problems, pain, and even injury depends on usage. Here, software plays an important part, as it determines the overall use of the mouse and the intended way of alternating between it and the keyboard. Yet most programmers are not aware of this even if they themselves belong to the sufferers.

Between 1980 and today, many computer users have lost control over the pace of work, tasks performed, and time. While 20 years ago computers were only able to offer partial support for office work, and mostly for text-based tasks, today’s computers offer more services than one really needs. This is an excellent development from the point of view of functionality. However, for most tasks computers have become indispensable. Thus, in most cases rest breaks are the only alternative, but not necessarily the best.

In some work areas, such as telephone call centers, users have almost no control over time and workflow. Even opportunities to take “micro-pauses,” i.e., very short rest breaks, which are highly effective for recovering from input tasks, are rare.

4 Outlook

The situation between the years 1980 and 2002 has changed significantly in at least two ways. Today people enjoy working with new and powerful equipment, and have shed the “computer anxiety” of a few years ago. Unfortunately, enjoying things may only partly help to overcome problems created by losing control over important factors such as workflow and posture. In future, users are likely to have more than simple headaches.

While in former times office workers would find some relief during their free time, in 2002 many are likely to continue working with the same type of equipment at home or elsewhere. This only aggravates their problems. For other people not working in offices, the use of input devices in one part of life may increase the likelihood of experiencing problems in another. Thus, standard protective measures at the workplace may not suffice. For many people it will be too late, if they begin their careers after having worked for years with computer equipment that was not designed for children or young people.

The “Tokyo Declaration” concerning design requirements for younger users including children, announced at the end of WWDU 97, gained worldwide attention –
without practical consequences, though. The notion that most future office workers will work with computers outside professional working domains gives some good food for thought.

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Workstation and Self-Report Predictors of Musculoskeletal Symptoms Among Keyboard Users

Naomi SWANSON (1), Robin Dunkin (1), Margit Alderson (2)
(1) National Institute for Occupational Safety and Health, Taft Laboratories, 4676 Columbia Parkway, Cincinnati, Ohio 45226 USA, E-mail: nws3@cdc.gov
(2) Metamora, Illinois 61548 USA

ABSTRACT

The present study was done to determine the role of workstation, work environment and individual factors as predictors of musculoskeletal symptoms in a population of computer users. The subjects were 414 employees of a large insurance company who completed musculoskeletal symptom and work environment surveys. Workstation measurements were taken for each subject. The results indicated that chair variables (seat pan size, backrest size, chair adjustability) were the primary workstation measurement predictors of musculoskeletal symptoms. Job characteristics, such as time spent at the computer, task concentration requirements, and work backlogs were also significant predictors of symptoms.

1 Introduction

Studies since the 1970's have shown a link between workstation and furniture design and musculoskeletal symptoms among computer users (e.g., Cakir, Hart and Stewart, 1978; Hunting, Laubli, and Grandjean, 1981; Sauter, Schleifer, and Knutson, 1991). Although there has been a significant improvement in office furniture and equipment as a result, musculoskeletal symptomatology still remains a significant problem among computer users, indicating that other job variables may play a role in symptomatology. The present study was done to determine the role of workstation, work environment and individual factors as predictors of musculoskeletal symptoms among a population of computer users. Data are utilized from a longitudinal intervention study in which the effectiveness of alternative keyboards in preventing or alleviating musculoskeletal discomfort is being evaluated. The current analyses used baseline data collected before subjects were assigned to alternative keyboard conditions (i.e., all subjects were still using conventional keyboards).

2 Method

2.1 Subjects

Subjects were 414 employees (63 M, 349 F) in a variety of jobs (e.g., word processing, claims processing, etc.) at a nationally-based insurance company who performed intensive typing activities for three hours or more per day.

2.2 Procedure

At the beginning of the study, each subject completed a musculoskeletal symptom survey, and a work environment survey. The musculoskeletal survey asked about the frequency, duration and intensity of symptoms in the back, neck, shoulders, arms and hands. The work environment survey included questions about job demands, job stress and satisfaction, and subject demographics. At this time, measurements were also taken of each subject’s workstation (e.g., work surface height, depth, width), chair (e.g., height, adjustments), and equipment (e.g., screen and keyboard angles).

2.3 Analyses

Two groups of items were selected from the work environment survey for inclusion in the analyses. One group consisted of control items (e.g., age, sex, general health, tenure), and the second group consisted of work environment and individual factors judged to potentially influence musculoskeletal symptomatology (e.g., intensity of work, backlogs, rest breaks, job satisfaction). A third group of variables was constructed from the workstation measurement data. Initial correlation and regression analyses were conducted separately with each group of variables to eliminate nonsignificant variables. The variables remaining after these analyses served as predictor variables in a final regression analysis. Outcome variables consisted of the duration, frequency and intensity of symptoms in the back, neck, shoulders, arms and hands.

3 Results

Subjects were most likely to report discomfort in the neck (50%), back (44%), right hand (38%) and right shoulder (25%) regions. They were least likely to report discomfort in their left upper extremity, or in the right arm region. On average, their discomfort lasted approximately 1 hour - 1 day, occurred approximately once a week, and was of moderate severity.

For the most part, individual/control variables were not significant predictors of discomfort among these subjects. The exception was a variable measuring general health (i.e., poor to excellent), which was a significant predictor of neck, shoulder, hand, and back symptoms. Chair variables were the primary workstation measurement predictors of musculoskeletal symptoms. Smaller seat pan size was a significant predictor of neck, right and left shoulder, and right arm symptoms. Taller backrests were associated with increased right and left shoulder, right arm, left hand and back symptoms. Chair
adjustability was associated with right shoulder, arm, and hand symptoms. Lower work surface heights were associated with more neck and right arm discomfort.

The amount of time spent at the computer (self-report), the amount of concentration required by the job, and work backlogs were the primary work environment predictors of symptoms. Individuals who spent more time at the computer reported more neck, and right shoulder and arm symptoms. Those whose jobs required more concentration reported more right shoulder and right hand symptoms. Subjects who reported work backlogs also reported more neck, and right and left shoulder symptoms. Individuals who reported high levels of job stress reported more right arm symptoms, and individuals who were less satisfied with their jobs reported more back symptoms.

4 Conclusions

The results indicate that a combination of workstation and job characteristics best predicted musculoskeletal symptoms in this population. Chair variables, particularly seat pan size, backrest size and chair adjustability, combined with time spent at the computer, greater task concentration requirements, and work backlogs were the primary predictors of musculoskeletal symptoms. The results point out that comfort is affected by aspects of the job as well as by workstation and office furniture/equipment design, and that the two should not be assessed independently of one another.

5 References


The Prevalence of Neuromusculoskeletal Disorders in a Population of Insurance Company Workers Based on Clinical Interviews

J. Steven Moore (1), Naomi SWANSON (2)
(1) Dept. of Environmental and Occupational Health, School of Rural Public Health, Texas A&M University Health Science Center, 3000 Briarcrest, Suite 300, 1266 TAMU, Bryan, TX; E-mail: jsmoore@srph.tamu.edu
(2) National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH, 45226; E-mail: nws3@cdc.gov

ABSTRACT

The present paper contains the results of baseline medical interviews/examinations of 418 subjects participating in a longitudinal study of alternative keyboard effectiveness. Sixty-eight percent of the subjects were prevalent neuromusculoskeletal cases, with the most common site for symptoms being the neck, followed by the wrists.

1 Introduction & Methods

In February 2000, the National Institute for Occupational Safety and Health (NIOSH) initiated a two-year longitudinal study to evaluate the effectiveness of alternative keyboards in preventing or relieving neuromusculoskeletal discomfort of the neck and upper extremities. The study is being conducted at an insurance company with multiple locations in the United States. Subjects have been randomly allocated to one of three treatment groups – a fixed-angle split keyboard, an adjustable split keyboard, and a traditional keyboard (control).

Health outcomes are being assessed by two methods. The first method relies on self-reported symptom surveys. Subjects completed a body part symptom survey at baseline and every three months thereafter. The baseline survey responses identified ‘self-reported’ prevalent cases at the beginning of the study. Individuals reporting the onset of symptoms for new body parts during the observation period are identified as potential incident cases. The second method is based on interview and physical examination of all subjects by one occupational medicine physician at baseline in order to identify ‘clinical’ prevalent cases. In addition, this physician contacts those individuals identified as potential incident cases during the study by telephone to obtain a history of their new symptoms and to clarify the affected body part and the nature of the symptoms. This physician is blinded to the keyboard treatment status of the subjects. This paper summarizes the results of the baseline interviews by the physician.

Each clinical evaluation included an interview to ascertain past and current medical history with emphasis on conditions potentially related to the neck, shoulders, upper arms, elbows, forearms, wrists, and hands. Individuals reporting symptoms currently affecting these body regions to the physician were considered prevalent symptomatic cases regardless of severity or the presence or absence of concordant physical examination findings. Individuals with multifocal symptoms (e.g., neck and shoulder) were designated as one case for each relevant body part (e.g., neck and wrist).

Evidence of association between case status (by body part) and gender, 10-year age categories (< 30; 30–39; 40–49; ≥ 50), and dropout status were evaluated using chi square tests with a criterion value of p < 0.05.

2 Results

A total of 418 subjects were interviewed and examined at baseline. There were 359 females in the study population (86%). The age distribution varied from 19.4% to 32.9% across the four 10-year age categories.

Of these 418 subjects, 285 (68%) reported having symptoms in one or more body parts. The remaining 133 subjects (32%) were completely asymptomatic at baseline. The number of cases and the point prevalence for each body part are summarized in Table 1. None of the conditions were associated with dropout status.

Neck case status was associated with male gender (OR = 3.14; p < 0.01) but not age. Even though some of these individuals had symptoms in multiple muscles, the trapezius, paracervical, and periscapular muscles were involved in isolation in 82 (45%), 57 (31%), and 13 (7%) cases, respectively. Trapezius case status was associated with male gender (OR = 4.46; p < 0.01). Paracervical case status exhibited a positive trend with age. Periscapular case status exhibited a negative trend with age.

Table 1: Number and prevalence of cases

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Cases (#)</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td>184</td>
<td>44</td>
</tr>
<tr>
<td>Shoulders</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>Upper Arms</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Elbows</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Forearms</td>
<td>33</td>
<td>8</td>
</tr>
<tr>
<td>Wrist</td>
<td>79</td>
<td>19</td>
</tr>
<tr>
<td>Hands</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Back</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>
Shoulder case status had a significant positive trend with age, but no association with gender. There were too few upper arm cases to warrant statistical analysis. Elbow case status was not associated with gender or age. There were 14 lateral elbow pain cases (47%) – 7 were only on the right side (50%), 2 were only on the left side (14%), and 5 were bilateral (36%). These lateral elbow cases had a significant positive trend with age. There were only 2 medial elbow pain cases (7%). There were 9 elbow cases suggestive of ulnar nerve entrapment at the elbow (30%) – four cases affected the right side (44%), 2 the left side (22%), and 3 were bilateral (33%).

The 33 symptomatic forearm cases were not associated with gender or age. Of these cases, 16 affected only the right side (48%), 3 affected only the left side (9%), and 13 affected both sides (39%). Also, 20 cases occurred only on the extensor side (61%), 8 only on the flexor side (24%), and 5 on both sides (15%).

As a group, the 79 symptomatic wrist cases were not associated with gender or age. Of these cases, 33 affected only the right wrist (42%), 16 only the left wrist (21%), and 31 both wrists (39%). Also, 35 cases were localized to the extensor side (44%), 21 to the flexor side (27%), 8 to the ulnar side (10%), and 1 to the radial side (1%). The affected side could not be localized for 15 cases (19%).

Among these 79 wrist cases, there were 8 suspected cases of tendon entrapment at the first dorsal wrist compartment, e.g. de Quervain’s tenosynovitis (10%). All 8 cases were female and 6 cases were greater than 50 years of age. There was no statistical evidence of association with gender, but a significant trend with increasing age. Five of these 8 cases were on the right side (63%), 1 was on the left side (13%), and 2 were bilateral (25%).

There were 17 suspected cases of carpal tunnel syndrome (22%). Sixteen cases were females (94%). Eight cases (47%) occurred in subjects greater than 50 years of age, and there was a significant trend with increasing age. Ten cases affected only the right side (59%), 7 both sides (41%), but none only the left side.

There were 7 wrist ganglion cases (9%). Five were on the right side (71%), 1 on the left side (14%), and 1 on both sides (14%). All cases were females and all age categories were represented.

There were 21 cases that affected only the hands or fingers. Of these, 20 cases were affected only on the right hand and 1 was affected on both hands. Hand case status had no association with age or gender.

There were 8 cases that affected the back. All cases were females. Four cases were in the 30 – 39 year age category.

3 Discussion
The results reported in this paper describe the baseline symptoms reported to the physician examiner. Subsequently the presence of baseline symptoms will be combined with concordant physical examination findings and, using a priori case definitions, cases of specific disorders will be identified. These baseline physician interview-based cases as well as the baseline examination-based diagnosis cases can be compared to the ascertainment of cases by the self-reported symptom survey. These baseline cases represent a cohort of subjects whereby the efficacy of alternative keyboards in relieving musculoskeletal symptoms (secondary or tertiary prevention) may be evaluated.

The 133 subjects who were asymptomatic for all body parts represent one set of subjects whereby the efficacy of alternative keyboards in preventing the development of musculoskeletal symptoms and disorders may be evaluated. Another set is individuals who were symptomatic in one body part at baseline (e.g. the neck) but were asymptomatic in other anatomically distinct body parts (e.g. elbows, forearms, wrists, and hands). A third set is comprised of individuals with a past history of musculoskeletal symptoms or disorders of one or more body parts who were asymptomatic at baseline whereby the efficacy of alternative keyboards in preventing recurrence of these symptoms or disorders can be evaluated. A variety of statistical techniques, such as logistic regression, will be used to test hypotheses about treatment effects and identify predictor variables that best predict case status or a change in case status.

4 Conclusion
In this study, 68% of the subjects were prevalent neuromusculoskeletal cases based on interview by a physician. The most common symptoms involved the neck (44%), followed by the wrists (19%), and then the shoulders, elbows, and forearms (7-8%). The trapezius muscle was the most common site for neck symptoms, followed by the paracervical muscles. In the distal portion of the upper limb (elbow to hand), approximately 50% of the reported symptoms affected only the right side, 35% both sides, and 15% only the left side. In the forearm and wrist, approximately 60% of the reported symptoms affected only the extensor side, 30% only the flexor side, and 10% both sides.
Finger Flexor/Extensor and Trapezius Loading During Keyboard Use

Brian LOWE (1) and Naomi Swanson (2)

(1) National Institute for Occupational Safety and Health, Cincinnati, Ohio, 45226, USA, E-mail: blowe@cdc.gov
(2) National Institute for Occupational Safety and Health, Cincinnati, Ohio, 45226, USA

ABSTRACT

This paper presents preliminary results of a study of muscle activity associated with keyboard use within a large insurance company. Surface electromyograms (SEMG) were recorded from 52 employees from a variety of departments at this insurance company. The median relative activity of the SEMG observed during keyboarding from the flexor digitorum superficialis (FDS), extensor digitorum communis (EDC), and trapezius muscles averaged 2.4, 5.5, and 3.7 percent of voluntary maximum activity, respectively. The 52 employees were categorized based on their job as either word processors, for whom total keystrokes per day were known to be high, or other job categories, for whom total keystrokes per day were lower. Comparisons of muscle activity between word processors and those in non-word processing departments indicated that the word processors exhibited significantly (p < 0.05) higher relative activity in EDC and significantly lower relative activity in trapezius. The latter of these findings was unexpected and appears to relate to differences in static working posture of the shoulders.

1 Introduction

Keyboard use has been linked with musculoskeletal disorders of the upper limbs, as it accounted for 15% of all lost workday cases in 1998 classified by the U.S. Bureau of Labor Statistics as repetitive motion injuries. Several studies have explored keyboarding finger forces, but most have been in laboratory settings and have included fewer than 10 participants. This study examined surface electromyography (SEMG) recorded from the digit flexor and extensor muscle groups, in addition to the trapezius from 52 employees of an insurance company in an attempt to describe loading of the upper limbs during keyboard use. These data are part of a prospective study designed to evaluate the effects of keyboard design on musculoskeletal health.

2 Method

2.1 Subjects

In this investigation SEMG was recorded from 52 (6 male and 46 female) employees selected from a broad range of job titles within a large insurance company. Of the 52 participants, 18 were word processors and 34 represented a variety of other job titles. Participants used one of three keyboards: Lifetime Classic II, Lifetime Designer, or HP Vectra Multimedia (VL8).

2.2 SEMG Recording

SEMG was recorded bilaterally from trapezius, flexor digitorum superficialis (FDS), and extensor digitorum communis (EDC). Bipolar surface electrodes were attached to these muscle groups based on published recommendations (Zipp, 1983; Perotto, 1994). EMG amplitudes were normalized relative to maximum EMG activity obtained by averaging over three MVC exertions that statically replicated the function of these muscles in keyboarding. This was accomplished by mounting a subminiature load cell under the “f” key of a traditional keyboard. Subjects applied a maximum isometric key-press force with the 3rd digit (middle finger) on this key to obtain maximum FDS EMG (EMG_{max}). EMG_{max} for EDC was elicited during a maximal static extension of the 3rd digit (“keypull”) against a digit cuff located just proximally to the distal interphalangeal joint (DIP) and attached to the load cell. Trapezius MVC was elicited by a maximal shoulder shrug against a fixed load cell. Approximately 24 minutes of EMG were sampled during each subject’s normal work routine. Only EMG data corresponding to “keyboarding” activity was further analyzed. Raw EMG was filtered with a 20 Hz analog high pass filter prior to sampling. The RMS (40 ms TC) of the high-pass filtered signal was calculated and expressed as the muscle’s relative activity (RA) by normalizing to the maximum (RMS_{max}) and resting (RMS_{rest}) electrical activity of the muscle according to equation 1.

\[
RA = \frac{[\text{RMS}_{\text{task}} - \text{RMS}_{\text{rest}}]}{[\text{RMS}_{\max} - \text{RMS}_{\text{rest}}]} 
\]  

F

Following normalization the relative activity (RA) data were characterized by their amplitude probability distribution function (APDF). The APDF characterizes the RA amplitude statistically by plotting cumulative probability against relative activity level. The median (50th %tile) and 95th %tile RA served as dependent measures.

3 Results

Figure 1 shows the APDF for each of the three muscle groups averaged for the 52 employees. The mean 50th and 95th percentiles of the relative activity are shown in Table 1. Mean 50th percentile RA was 3.7%, 2.4%, and 5.5% MVC for the trapezius, FDS, and EDC, respectively. The mean 95th percentile RA was 10.3%, 15.4%, and 18.4% MVC for the trapezius, FDS, and EDC, respectively. Comparisons between word-processors (WP) and employees in other job categories (non-WP) are shown in Figure 2. Word processors exhibited sig-
significantly greater relative activity in EDC (p < 0.05) and significantly lower relative activity in trapezius (p < 0.05). The increased relative activity in FDS among the WPs was not statistically significant.

Table 1: Mean 50th and 95th percentile relative activity and mean RA of other published studies

<table>
<thead>
<tr>
<th></th>
<th>Trapezius (%MVC)</th>
<th>FDS (%MVC)</th>
<th>EDC (%MVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160th %tile RA (mean ± s.d.)</td>
<td>3.7 ± 3.2</td>
<td>2.4 ± 1.6</td>
<td>5.5 ± 2.5</td>
</tr>
<tr>
<td>195th %tile RA (mean ± s.d.)</td>
<td>10.3 ± 7.3</td>
<td>15.4 ± 8.9</td>
<td>18.4 ± 7.1</td>
</tr>
<tr>
<td>(a) Fernström et al. (1994)²</td>
<td>3.7</td>
<td>1.6</td>
<td>7.1</td>
</tr>
<tr>
<td>(b) Gerard et al. (1994)³</td>
<td>-</td>
<td>5.0</td>
<td>7.5</td>
</tr>
<tr>
<td>(c) Gerard et al. (1996)²</td>
<td>-</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>mean of similar studies⁴</td>
<td>3.7</td>
<td>2.9</td>
<td>5.6</td>
</tr>
</tbody>
</table>

¹present study, ²median RA, ³mean RA, ⁴average of medians and means from studies a-c

4 Discussion

The median relative activity levels observed in this study agree closely with those that have been reported in small-sample studies using similar methods (see Table 1). For EDC and trapezius the differences between the median RA of the present study and the mean and median RA of other similar studies is within 0.1 of 1% MVC. The 17% lower median FDS RA observed in this study could be due to a lower make force of the keyboards used, as the make force of the keyboard is most influential on flexor activity.

A variable critical to digit flexor and extensor loading is that of typing rate. Faster typing (defined by more keystrokes per unit time) requires higher velocity and acceleration of the digits striking the keys through higher activation of the digit flexor and extensor muscle groups. Thus, the measures of FDS and EDC loading were expected to be higher for the word processors than for subjects in job categories involving lower keystroke volume. This was the case for EDC, but the expected higher FDS loading among WPs was not statistically significant.

The unexpected finding of a lower relative loading of trapezius among WPs is not likely related to keystroke volume. Static working posture of the shoulders appears to be the more relevant determinant of trapezius muscle activity. Working posture will be explored more fully through the remainder of the data analysis portion of this study.

5 References


The Seating Clinic for Office Workers

Goroh FUJIMAKI (1), Hideki Oyama (2), Taku Teraoka (3) and Kageyu Noro (4)
(1) Graduate School of Human Sciences, Waseda University, 2-579-15 Mikajima, Tokorozawa, Saitama 359-1192 Japan, E-mail: fujimaki@human.waseda.ac.jp
(2) Advanced Research Institute for Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjunku, Tokyo 169-8555 Japan
(3) Advanced Research Institute for Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjunku, Tokyo 169-8555 Japan
(4) School of Human Sciences, Waseda University, 2-579-15 Mikajima, Tokorozawa, Saitama 359-1192 Japan

ABSTRACT

There is a significant information gap between users and seating developers. To bridge the gap, “The Seating Clinic & Design Studio” was established in 1999 at Waseda University. The purpose of the studio is to select or design a well-fitting chair for each individual. Solutions for seating problems are also discussed in the studio. This paper reports about the survey of the visitors who came to the seating clinic.

1 Introduction

There is a significant information gap between users and seating developers. For example, information about the adjustments of a chair is not always communicated well between seating developer and the seat’s user. To have a well-fitting chair, the user must choose a chair that fits, or adjust a chair to fit the body properly. Although there are numerous ergonomic chairs on the market, users generally do not know the right way to adjust them. The “participatory approach” has already been proposed to bridge the gap between users and seating developers (Noro 1994, Noro 1998). “The Seating Clinic & Design Studio” was established in 1999 at Waseda University (Noro et al, 2000) to implement that approach. The purpose of the studio is to select or design a well-fitting chair for each individual. Solution of seating problems such as backache, are also discussed in the studio.

2 The overview of the seating clinic & design studio

This studio is divided into two sections: The first section is concerned with the measurement, evaluation, and development of seating. For example, a study on the evaluation method of seating comfort by body pressure distribution and development of measurement system for pelvic angle are carried out in this section. And by using these techniques, the studio is concerned with the development of a chair by cooperation of a maker. The second section is a showroom of recommended office chairs. This showroom, which is called the seating clinic, is open to the public and in it users can learn how to adjust a chair or the preferred way to sit. The flow of the clinic is shown on Table 1.

3 Survey of the visitors

Since “The Seating Clinic & Design Studio” was established in 1999, the total of the visitors to date is 192 persons (124 male, 68 female). The majority of the visitors’ age brackets were twenties and thirties (Figure 1). Brief survey of the visitors was conducted.

Table 1: The flow of the clinic

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acceptance</td>
</tr>
<tr>
<td>2</td>
<td>Interview</td>
</tr>
<tr>
<td>3</td>
<td>Examination</td>
</tr>
<tr>
<td>4</td>
<td>Clinical chart</td>
</tr>
<tr>
<td>5</td>
<td>Advice</td>
</tr>
</tbody>
</table>

Figure 1: The total number of visitors

3.1 The type of a chair in daily use

The type of a chair which visitors use daily was surveyed (Figure 2). 55 percent of the visitors use an office chair. 31 percent use a dining chair. Figure 3 shows the result on each age bracket. A younger age brackets use an office chair more than an elderly age brackets, and an
elderly age brackets use an elderly chair more than a younger age brackets.

Figure 2: The type of a chair in daily use

Figure 3: The type of a chair in daily use on each age brackets

3.2 Visit purposes

Figure 4 shows the visitors’ visit purposes. 63 percent of the visitors had physical pain and came to the seating clinic. Detail of the physical pain is shown in Figure 5. 58 percent of the physical pain was back pain.

Figure 4: Visit purposes

Figure 5: Detail of the physical pain

4 Conclusion

From the result of our survey, 63 percent of the visitors had a physical pain, and most of them had a trouble with their chairs during a computer work. Although there are numbers of ergonomic office chairs on the market, it is considered that general users do not know the right way to use them. It is clear that users need more information about their chairs.

5 References


Relationship Between Visual Discomfort and Musculoskeletal Illness for VDU (Visual Display Unit) Operators?

Arne AARÅS (1), Gunnar Horgen (2), Hans-Henrik Bjørset (3) and Ola Ro (4)

(1) Alcatel STK A/S, P.O. Box 60 Økern, 0508 Oslo, Norway, E-mail: arne.aaraas@alcatel.no
(2) Buskerud College of Engineering, Dept. of Optometry, P.O. Box 235 Kongsberg, Norway
(3) K. O. Thomæsvei 11, 7033 Trondheim, Norway
(4) Premed. P. O. Box 275, Økern, 0511 Oslo

ABSTRACT

The study is a parallel group design with two intervention groups (T and S) and one control group (C) of VDU workers. Three serial interventions were carried out in the T and S groups, first a new lighting system, then new workplaces and last an optometric examination and corrections if needed. The new lighting increased illuminance levels (300 lux to 600 lux), increased luminances of the room surfaces (30 cd/m² to 80 cd/m²). The two intervention groups reported significant improvement of the lighting conditions, visual conditions and reduced discomfort and glare. Further, a clear tendency to reduction of visual discomfort was reported after the optometric corrections in both intervention groups. No significant changes were observed in the C group. This group reported significantly more visual discomfort compared to the two intervention groups after 2 years. After 3.5 years, the C group got the same interventions. This group reported significant reduction of visual discomfort after interventions while the two groups (T and S) continued to report significant reduction of visual discomfort after 6 years.

1 Introduction

Total renovation of two buildings at Alcatel Telecom Norway, Oslo, was carried out in 1991-92. By this process a very poor lighting was established. Simple luminaires were applied with ineffective louvres and downward light distribution only. After a rather short period of time the VDU operators reported visual problems, eye fatigue, blurred vision, glare and headache. These problems resulted in establishment of a multidisciplinary team to carry out a longitudinal epidemiological study, where the effect of introducing ergonomical workplaces and new luminaires was evaluated. In addition, optometric corrections were given, if needed. The three interventions were implemented in a serial way, Aarås et al (1998).

2 Aims of the study

Is there a relationship between visual discomfort and pain in the upper part of the body?

3 Study design

The study is a prospective parallel group design with three groups of male VDU workers, performing software engineering. About 50 subjects participated at commencement in each group. Two groups (T and S) got first the new lighting system, then the new workplaces and last optometric corrections if needed. The third group (C) acting as a control group, got no intervention, until after about 3.5 years when also this group got the new lighting, new workplaces and optometric corrections. Subjective symptoms were assessed by using Visual Analog Scale (VAS).

4 Interventions

4.1 Lighting

The new system, with localized lighting, applies suspended luminaires with a light distribution about 25 % diffused upwards and 75 % downwards, through an effective reflector-louvre system. Bjørset (1987) studied the optimal positioning of the luminaries relative to the screen. Figure 1.

Figure 1: The workplace with the new table/chair and the new luminaires.
4.2 Optometry
Criteria for prescribing an optometric correction were based on clinical experience and earlier studies. The corrections were modified to fit the physical dimensions of the actual workplace. The spectacle lenses recommended were white, organic lenses with antireflection coating.

4.3 Workplace
The workplace intervention consisted of installing new tables and chairs. The table allows the operators to support the forearms and hands.

5 Results
After increasing the average illuminance of the relevant work areas from below 300 lux to above 600 lux and the luminance levels of ceiling and walls from below 30 cd/m² to above 80 cd/m², the operators reported a highly significant improvements of the lighting and visual conditions and a significant reduction in the glare problems (p=0.0001) while no significant changes was reported in the C group. In fact, regarding lighting and visual conditions, the control group assessed a small, but significant worsened visual condition (p=0.008) (Aarås et al 1998).

The visual discomfort during the last month was reported significant reduced in the intervention groups (p=0.03), while no significant change was observed in the control group (p=0.28). Figure 2.

Further, a clear tendency to reduction of visual discomfort was reported after the optometric interventions in both intervention groups (p=0.07), while no significant change was observed in the control group. After two years, the T and S groups reported significantly less visual discomfort after optometric intervention compared with the C group.

After 3.5 years, the C group got the same interventions as the T and S groups. The operators in the C group reported significant improvements in visual conditions and glare problems. No significant changes were reported for these parameters from two to six years in the T and S groups (Aarås et al 2001). Further, visual discomfort was significantly reduced after lighting and optometric interventions in the C group (p=0.03).

After six years of the study, a cross-sectional investigation of the relationship between visual discomfort and distance from the window was performed. When using a sightline to the screen parallel to the window, there is a significant reduction in visual discomfort for those sitting more than 1.5 m from the window compared with those sitting closer to the window than 1.5 m (p=0.03).

A correlation was found between visual discomfort and the average pain intensity in the neck and the shoulder, the correlation coefficient was between 0.30<r<0.40. Further details: Neck pain was related to visual problems (p=0.008) and burning and itching of the eye (p=0.004). Shoulder pain as well as forearm and hand pain were related to induced phoria (p=0.04). Back pain was related to burning and itching of the eye (p=0.03). Headache was related to visual discomfort (p=0.01).

6 Discussion and Conclusion
The study has shown that both lighting and optometry are important for reduction of visual discomfort for VDU workers. Further, the study documented that visual discomfort correlate to neck, shoulder and back pain. Therefore, lighting and optometry must be considered in addition to workplace design in order to reduce the musculoskeletal pain in the neck and shoulder.

7 Acknowledgements
This study was supported by grants from The Norwegian Research Council and The Norwegian Employer Federation, Division TBL.

8 References.
Visual Load Evaluation in Bank Clerks: an Objective Methodology

Roberto ASSINI, Daniele Grosso, Pierluigi Zambelli, Ilaria Antonelli, Bruno Piccoli
Department of Occupational Health, University of Milan-ICP Hospital Milan, Italy, E-mail: workvis@mailserver.unimi.it

ABSTRACT

The recent Italian law n°422 of December 2000 has changed the definition of VDU operator to "worker using a VDU for at least 20 hours per week". According to this new definition the number of VDU operators in Italy could be almost 20 million. So it would seem opportune to set out objective and reliable guidelines in order to efficiently apply the law. As scientific literature has reported, there is a relationship between visual load intensity and appearance of symptoms (occupational asthenopia). In this study we objectively measured the average observation time of professional targets and the average observation distance while working. The investigation was carried out in 4 bank agencies in Milan and measurements were repeated for two days consecutively. Three subjects were studied twice for a total amount of 24 days of investigation. Results show that time spent at VDU workstations is usually between three and six hours, which is less than total hours worked, and work organisation often requires several tasks to be carried out away from the workstation. The declared time spent at VDU by the operators, during the ergophthalmic interview does not seem to correspond to the time spent at the VDU workstation.

Considering the average observation distance it is possible to calculate the subtended angles by occupational targets and the required accommodation and convergence, that are respectively between 20% and 70% of the available accommodation and between 25% and 78% of the available convergence.

1 Introduction

Following the EEC directive 90/270 of 1990, consequent to the relevance assumed by "work and vision" in international literature, particular attention was given to primary and secondary prevention. Following the emanation of Decrees 626/94 and 242/96 by the Italian government, the EEC directive 270/90 was accepted, except for the definition of a VDU operator. According to the EEC directive a VDU operator is a worker using a VDU for a relevant amount of work time while for Italian laws Decrees 626/94 and 242/96 a VDU operator uses a VDU for at least 4 hours/day 5 days/week. As this particular situation is rare in Italy, the exposure to VDU work has been always assessed with anamnestic questionnaires.

The recent law n° 422 of december 2000 has changed the definition of VDU operator to “worker using a VDU at least 20 hours per week”. According to this new definition the number of VDU operators in Italy could be almost 20 million. An objective and reliable guide line to evaluate exposure and efficiently apply the law requirements is therefore necessary.

The visual work load of a VDU operator is essentially:

- **near**, the objects are generally 50-80 cm from the operator;
- **prolonged**, observation must be maintained for many hours;
- **fixed**, often size and layout of workplaces inhibits physiological activation and relaxation of accommodation and convergence.

Scientific literature (Bergqvist, 1989, Piccoli et al. 1996, Scullica et al. 1989) shows a relationship between intensity of visual load and appearance of symptoms (occupational asthenopia). According to our research, a reliable evaluation of visual work load should consider two parameters:

- average observation time of objects (“professional targets”) located at less than 1 meter;
- average observation distance while working.

In VDU operators, professional targets are usually represented by screen, keyboard, mouse and documents. Frequently there are other professional targets such as calculators, telephones, etc.

While working, VDU workers maintain accommodation and convergence activated for many hours, which could cause visual fatigue and occupational asthenopia.

2 Materials and methods

The research was carried out in four bank agencies in Milan, studying in each one:

- 1 cashier;
- 1 back office operator;
- 1 commercial operator.

Measurements were repeated for two days consecutively. 12 subjects were studied twice, for a total of 24 days. The workers involved were aged 36 +/- 7.6 years and 66% were men.

Each subject underwent to a specific ergophthalmic interview in order to exclude workers affected by ocular pathologies or symptoms that could interfere with the results of the experiment.

Observation distance and VDU work duration were monitored with electronic equipment recently designed in our Department. This instrument is composed of a computer to calculate the measurements and store data, a control unit that enables communication between the computer and the peripheral devices, peripheral devices that emit and receive ultrasounds. The transmit-
ting source is located on the occupational targets, the receiver is on the operators forehead (nasion) attached to a goggles without lenses (Piccolo et al. 2001). The distance of the two sensors represents the observation distance. It is calculated measuring the time between the transmission of the signal and its reception (considering that the propagation speed of ultrasounds in the air is about 340m/sec.). The accuracy is +/- 0.5 cm and frequency of registration is 5/sec. The instrument registers an interruption (int) signal when the subject has to move away from the workstation and an outfield (out) signal when the operator observes targets outside the occupational visual field.

Interpupillary distance was measured to quantify exactly, in prismatic dioptres, the average convergence.

3 Results and conclusions

The study has been divided in three stages:

1. evaluation of work tasks
2. ophthalmic anamnesis;
3. analysis of objective measurements.

3.1 Evaluation of work tasks

3.1.1 Cashier

These workers are frequently in contact with the clients and perform the greater part of operations using VDUs. In some cases the VDU is located behind the work desk, which imposes a longer observation distance and obliges the operator to stretch (over extend) the upper body (cervical and dorsal spine). The work required is for deposits and withdrawals, handling of miscellaneous paper work and delivering of debit and credit cards. During these tasks the work with VDT is interrupted by personal interaction with clients, signatures, stamping of receipts, counting of money, etc. Furthermore the operator can move away from the workstation to send faxes, prepare cheques and contact colleagues. Additional operations are opening and closing of security box (twice in an hour) and refilling of Automatic Teller Machine (ATM). After closing time work tasks consist mainly in controlling documents and counting money. The main occupational targets are:

- VDU (display, keyboard);
- paper documents;
- clients’ face.

During this phase, vision at far is limited by office furniture and equipment.

3.1.2 Back office operator

Back office work tasks depend on the importance of the agency. Usually these operators are involved in video data controlling (in particular cash operations), checking documents, treasury, controlling cheques. The screen is located laterally. Work with VDU is more intense and continuous during data controlling that requires network links.

3.1.3 Commercial operator

These operators are usually in contact with clients to open accounts, make investments, approve loans, provide information, etc. VDU is used to inquire/check data for clients. The equipment is lateral, to allow an adequate space to communication with the clients. Sometimes the operators move to send faxes, use photocopy machine, or consult colleagues. Other activities, at particular times of the year (e.g. christmas, end of financial year) are characterised by an intensive use of VDU.

3.2 Ophthalmic anamnesis

It is opportune to consider that during time (int) there can be a certain visual load at near (reading of documents, display observation in other workstations, etc.) that is 20% of the total. During time (out) a relevant amount of time (50%) is occupied in observation of occupational targets out of the field of reception character-
ised by visual load at near. On the other hand we must consider that in some cases visual axes of the operators, in particular head positions registered within the field of reception, are directed further than the occupational targets with a visual load at far. The relevant amount of (int) and (out) times implies that VDU time is only a small portion of worked time, oscillating between two and three hours.

Considering the limited number of subjects in this study, it is not epidemiologically relevant, but it is possible to observe that the objectively measured (tVDU) is much shorter than the declared tVDU, in particular for commercial operators. If we add to (tVDU) also the amount of (int) and (out) characterised by visual load at near, we find that, with the exception of the cashier, it is longer than the declared tVDU. On the other hand (tws) is very similar to declared tVDU.

Observation distance is also worth of note. In fact, 66% of operators had an average observation distance of 80 cm, even though literature reports an average observation distance of 60-70 cm.

By the average observation distance it is possible to calculate the subtended angles of the occupational targets, and the theoretical required accommodation and convergence. The analysis of this data shows that the required visual acuities are not very high (2-3 decimals). On the contrary, accommodation and convergence seems to be relevant, especially if maintained for many hours consecutively and for many days per week (values between 16% and 68 % of accommodation theoretically available and between 20% and 72% of convergence theoretically available). In these conditions it is possible to hypothesise that, particularly in case of operator’s hypersusceptability (found in some cases), an overload of the visual apparatus could cause asthenopia.

4 References

ASSINFORM (2001): Relationship between compute sciences and telecommunications.


The Vision Charge at Work with Video Display Terminal

Hilda HERMAN, Despina Marinescu, Mircea Cristescu and Andriana Contulescu
Institute of Public Health, Dr. Leonte Street No 1 – 3, 76256, Bucharest Romania

ABSTRACT

The vision charge at work with video display terminal has been studied in calculus technics – data entry, program projection and technical editing to make evident the visual strain causes and to decrease it. Research methods included: equipment and work analysis, environment characterization especially the lighting conditions, dynamic assessment (before and during work) of some visual indicators and subjective symptomatology investigation in 200 female operators. Results showed that many visual functions participate in work: visual acuity, ocular accommodation and convergence, eye movements, contrast and chromatic sensibility, perception speed, visual field. The performance decrease of the visual indicators during work in most or all subjects and the high frequency of the ocular and visual complaints show the visual fatigue, which was higher at calculus technics – data entry, followed by editing and then by program projection. Technical, organization, medical and social interventions are necessary to prevent the vision superstrain.

1 Introduction

Especially in the last twenty years the industry and the administration have introduced new technologies with an information character which employ the cathodic screen to present the information. So the work at video display terminal (VDT) has been increasingly extended in the offices and also in other domains including a great number of operators, to deposit and process the information. The reception of the information displayed on the cathodic screen imposes the permanent participation of the vision in the work. Of course the conditions of this reception depend on many factors of the “man-machine” system which may be favourable or unfavourable for the operators producing in the last case strain and fatigue. Hence we have studied the vision participation in this work at calculus technics – data entry, program projection and technical editing to make evident the visual strain causes and to decrease it.

2 Materials and Methods

The basic conception of the study was that the organism strain at VDT is determined by all factors of the work tasks and working conditions (Herman et al, 1987, 1991). An important objective was making evident the organism reactions during work, by means of physiologic, psychological and hormonal tests applied dynamically before and during work and at the work end in the morning (7-15 hours) and afternoon (15-22 hours) workshifts. Following neuropsychic indicators, most with sensorial (visual) and central significance, were assessed before the work start and at the work end in 200 subjects:

- Eye accommodation and convergence distances, by the Douane figure. Three measurements were made for each position and the final results were their mean values.
- Palpebral blink frequency, by direct watching and counting the blink during the three minutes of Weston test performing. The number of blinks/min was established.
- Visual acuity to near with performance elements – time and mistakes at optotype reading, an original “Optotype” test (Herman, 1995). The optotype with six groups of numbers was illuminated at 40 lx and the reading time (aloud and as quickly as possible) was established by timing. The test was applied also after 4 work hours.
- Critical fusion frequency (CFF) at green light, with three measurements for each investigation and with the final mean value result. CFF was assessed after 4 work hours too. The test was circular with the diameter of 0.7 cm and the light frequency ranged from 20 to 60 Hz/s.
- Visual perception speed by the tachistoscope, at letter and number tests with 10 variations. The exactitude coefficient was calculated.
- Watching the frequency of the eye direction between the work surfaces, with timing.
- Exactitude at Weston performance test (with interrupted Landolt rings), which was completed in a period of 3 minutes.

Indicators of the general organism strain were assessed in 60 subjects before and during the whole workday: the heart rate as global indicators of the biological organ-
is cost and the urinary excretion of catecholamines (adrenaline, noradrenaline).

The subjective symptomatology was investigated by a questionnaire, completed by 100 subjects, including many questions about the subjects’ data, the symptoms and their causes, the proposals.

The tested subjects were healthful female operators, with normal vision: age of 20 – 35 years (mean of 28 years ± 3 years), seniority at VDT of 2 – 10 years (mean of 7 years ± 2 years).

The data were analysed and calculated by the computer which a special program: arithmetical mean, standard deviation, mean of differences between the work end and the start values, paired “t” (Student test), significance of “p”, change frequency of the values at the work end towards the initial values.

3 Results and Discussion

The studied activities at VDT carried out in halls with windows and conditioned air. The operators worked always sitting at tables with the VDT equipment and materials, placed in parallel rows with the windows. There are three work surfaces – cathodic screen, keyboard, document or manuscript, which have different characteristics of the lighting, chromatics and distances towards the operators’ eyes. The height of the table surface from the floor was 70 – 75 cm. The distances between the eyes and the three work surfaces were: at calculus technics, 40 – 57 cm for eye-screen, 36 – 71 cm for eye-keyboard, 33 – 58 cm for eye-document; at editing, 60 – 83 cm for eye-screen, 33 – 42 cm for eye-keyboard, 39 – 57 cm for eye-manuscript. These distances are dependent on the emplacement of the work surfaces on the table and the operator’s work manner. The position of the work surfaces on the table towards the operator may be: the screen left or right, the document and manuscript right or left, the keyboard right or in front.

The lighting was natural, artificial or mixed, according to the season, hour, sky state (serene, clouded), workplace emplacement. The microclimate and the noise were normal. The lighting presented some deficiencies: lower illumination for the document or manuscript (especially at clouded sky or artificial light), differences of illumination and luminance between the work surfaces, brightness because of the lamp reflection on the screen. At the daylight the operators preferred to cover the windows by curtains when the sky was serene and the sunbeam entered the chamber directly, to watch better the screen. At the work surbrage the operators preferred to work after 2 and 4 work hours. The work analysis showed postural strain by operators’ permanent sitting position with the trunk and the head right or bend (with 18 – 31 degrees) to the work surfaces, assuring the distances between the eyes and the visual information and the frequent movements of the fingers to act the keyboard (2.7 – 5.8 actings/s at numeric signs, 0.8 – 1.8 actings/s at alphabetic signs). At data entry the work is very sustained, the operator introduces all the time the data and watches their correctness on the screen. The editing includes the text entry and the correction of the text displayed on the screen. The motor activity on the keyboard at program projection is less sustained because the analysis of the data on the screen or document is more important for the work content.

The neuropsychic charge is sensorial and mental. At program projection and editing the mental charge is higher because the thinking participation is more important (creative thinking). The visual strain predominates: visual acuity, eye accommodation and convergence, retina adaptation, ocular movements, contrast sensibility, visual perception speed, visual field. The neuropsychic indicators have changed (decrease, increase) during work, predominating the decrease of their performance after 4 work hours and at the work end, in most or all subjects, making evident the fatigue appearance related to the organism strain. At accommodation and convergence the increase of the distances predominated showing a decompensated muscular fatigue (“hypermetropization”) (Saito et al, 1979) with asthenopia. At data entry the operator watches predominantly the document, the screen is watched 5 – 10 times/min at the numeric signs and 10 – 30 times/min at the alphabetic signs. At editing - text entry the manuscript and the keyboard are watched predominantly and the look direction changes between these surfaces about 5 – 8 times/min. At text correction the look direction changes between the screen and the keyboard until 48 times/min. The CFF test decreased very significantly (p < 0.01, 0.005, 0.001) in all subjects at data entry and editing. The perception speed decreased in 10 – 75% of subjects and increased in 20 – 40% of subjects, but the most changes were not significant; these changes were significant only at editing. The blink frequency decreased in 10 – 37% of subjects and increased in 45 – 90% of subjects, especially at alphabetic data entry (75 – 90% of subjects, p < 0.05 and 0.001). The time reading at “Optotype” test increased in all subjects at all VDT activities, the highest increase was at editing (p < 0.05, 0.02, 0.001). The subjects’ number with mistakes increased also often. The performance of the “Optotype” test and CFF decreased also after 4 hour (p < 0.05 and 0.02), hence an orientation for the break organization in the workday at VDT. In the afternoon workshift the performance decrease of the indicators was higher, because of the lighting but also of the circadian rhythm. At alphabetic data entry the performance decrease was higher than at the numeric data because the possibility to mistake is greater. These results and the high subjects’ percentage with ocular and visual complaints (59 – 83%) show the visual and general fatigue. The plaits were: photophobia, eye smarting and ache, remanent images, conjuctiva congestion, flying spot in the visual field, shedding tears, foggy vision, foreign body feeling in the eye. The fatigue was higher at calculus technics - data entry, followed by editing and then by
program projection. Decrease of the heart rate and urinary excretion of catecholamines during work makes evident a disactivating state of the organism, which is characteristic for the sedentary work without motor discharge, as the work at VDT, reflecting the fatigue. This result is related to the changes of the neuropsychic indicators.

4 Conclusions

The visual strain level and fatigue at work with VDT depends on many factors, especially the lighting characteristics, work surface emplacement, work furniture, document writing, work organization (especially work agglomeration), operators’ vision state and professional training and experience. Deficiencies of these factors increase the visual charge and fatigue. Technical, organization, medical and social interventions related to the mentioned factors are necessary to prevent the vision superstrain.

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A Trial for Preventing Asthenopia among VDT Workers

Masako OMORI (1), Tomoyuki Watanabe (1), Jo Takai (1), Hiroki Takada (2), Masaru Miyao (2)

(1) Graduate school of Medicine, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan, E-mail: masako@med.nagoya-u.ac.jp
(2) Graduate School of Mathematics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan

ABSTRACT

We report the results of three surveys to determine whether a minibreak during which VDT workers view an imaginary distant view leads to fewer subjective complaints of asthenopia. The 3D image used was a repeating parallel pattern showing planets which uses the “Single Image Stereogram” method named “Stretch Eye”. This is a shift method in which the planets diverge just at the point that makes a single shift between the right and left eyes, so that they appear to be more distant than the monitor screen. We evaluated the effects of Stretch Eye on asthenopia. An accommodative relaxation of about 1 D was observed in subjects after gazing at the image. We investigated whether or not this program could influence eyesight. The subjects were employees of two IT companies. They were evaluated according to a visual analogue scale (VAS) for subjective symptoms of asthenopia and eyesight. As results, Stretch Eye was effective in easing visual fatigue due to VDT work and improved the eyesight under working conditions.

1 Introduction

Although there have been numerous relaxation methods for musculoskeletal and mental stresses caused by VDT work, effective and authorized coping for visual fatigue have seldom been proposed. “Stretch Eye”™ is a computer program which was developed to prevent computer operators from suffering asthenopia. Computer operators can show the Stretch Eye easily on their monitors to see a virtually far stereoscopic view without wearing special glasses. It is aimed to diminish visual disorders viewing targets moving progressively further away on the monitor for a few minutes. Infinite remote targets virtually appear based on the principle of single image stereograms (Figure 1). This study was aimed to reveal the effect and mechanisms of Stretch Eye from the subjective symptoms, visual physiology and follow-up study of eyesight.

2 Subjects and Methods

2.1 Experiment 1: Subjective Symptoms under Hard Training of Computer Usage

Twenty subjects were selected up from among new employees of an IT company and divided into two groups to match the status of gender and refractive conditions. Group A was asked to view the Stretch Eye image for a few minutes every hour for a week. Group B was asked to take rests only for a few minutes every hour for a week. The visual fatigue of the two groups was investigated using the visual analogue scale (VAS).

2.2 Experiment 2: Measurement of Accommodation

Using a specially made accommodate-optometer, we measured and recorded accommodative fluctuation of a 24-year-old female subject with normal sight while she was viewing Stretch Eye for 60-second periods. Visual function was tested using a custom-made apparatus. This combined an automated infrared accommodo-refractometer (Nidek AR-1100) and an original binocular half-mirror system (Miyao et al., 1992; Miyao et al., 1996. The display images were placed in front of the small mirror for the tests. Subjects gazed at each type of image through a half (dichroic) mirror and an ordinary small mirror. The instrument measured visual accommodative changes of the right eye at a 12.5 Hz sampling rate objectively in both binocular and natural viewing condition (Otaka et al, 1993) (Figure 2).

Figure 1: Example of Stretch Eye image
The distance between the neighbor balloons is increased from 40 mm to 50 mm.
Subjects could see the target on the LCD display binocularly through an upper mirror, liquid crystal shutters (LCS), and a dichroic mirror. LCS were opened and closed (open-closed=1) at a rate of 27 times per second alternatively for both eyes. The target for each eye was displayed synchronously at the same rate of 27 times per second.

The distance between the subjects’ eye and the target on the screen was 50cm (2D) (Note: diopter (D)= 1/distance (m); MA (meter angle)= 1/distance (m)). Using this synchronous viewing system with a crossed view caused the subjects to see a presumed (virtual) near target, and with an uncrossed view to see a presumed far target. In this experiment, infinitely remote targets virtually appear based on the principle of single image stereogram (Figure3).

2.3 Experiment 3. Follow-up Study of Eyesight for 8 Weeks

Thirty VDT workers were followed up their eyesight. They used Stretch Eye for 4 weeks and did not use it for 4 weeks. The order of the two periods was balanced. Their eyesight was measured in the evenings of the first Monday, and the fourth Friday.

3 Results

3.1 Eye fatigue under Hard Training

The VAS scores were scaled from 0 (no visual fatigue) to 100 (severe fatigue). The mean value (± SD) was 59.4 ± 7.7 among the group who took breaks only and did not view Stretch Eye, against 37.5 ± 8.3 among the group who did view Stretch Eye. Thus, Stretch Eye significantly eased their eye fatigue (p<0.001, t-test).

Figure 2: A schematic view of the device developed for the present experiment.

Figure 3: The principle of single image stereogram.

Virtual target was calculated as the theoretical virtual distance based on pupil distance.

\[ x = \frac{PD \times d}{PD - e} \] (mm)

Where:
- \( x \): Virtual distance
- \( PD \): Pupil distance
- \( X_\perp \): Virtual distance
- \( d_\perp \): Screen distance
- \( e \): Figure interval

Figure 2: A schematic view of the device developed for the present experiment.

Figure 3: The principle of single image stereogram.
3.2 Measurement of Accommodation
The display was set at a distance 50 cm from the subjects’ eyes. However, the accommodative distance ranged from 50 cm to 3 m (Figure 2, Figure 4). The accommodative power differed by about 1 D from the near to far point.

Figure 4: Accommodative fluctuation of the left eye
X-axis shows time: 0-50 sec,
Y-axis shows diopter: 0-1.5 diopter

3.3 Follow-up Study of Eyesight for 8 Weeks
The eyesight of 30 VDT workers was measured on the evenings before and after the 4-week sessions. There were two sessions, one with and one without Stretch Eye. Eyesight was measured at 5 p.m., on the first Monday evening and the fourth Friday evening, but data of the period with and without Stretch Eye could be obtained for only 28 and 17 subjects, respectively, due to business demands of the others.

Figure 5 shows eyesight following periods with and without Stretch Eye. After the period with Stretch Eye, eyesight under working conditions (with glasses if they were used during work) was significantly improved compared to the values on the first Monday evening (p<0.05, Wilcoxon’s matched pairs sign rank test), whereas no significant change was observed following the period without Stretch Eye.

Figure 5: Eyesight under working conditions was improved after using Stretch Eye for 4 weeks (Comparison of mean values)

4 Conclusion
Stretch Eye was tested with regard to three aspects: subjective eye fatigue, vision in a stereoscopic view, and changes in visual acuity following 4 weeks each with and without Stretch Eye. Among VDT workers, Stretch Eye significantly eased eye fatigue and improved eyesight under working conditions.

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VDU Work-Related Visual Fatigue - Assessment of Accumulation

Verislav STANCHEV
National Center of Hygiene, blvd D.Nestorov 15, Sofia 1431, Bulgaria, E-mail: vstanchev@sf.icn.bg

ABSTRACT

On the basis of observations the work of most operators of VDU may be characterized as short distance work, continuous and static. In comparing the process of development fatigue in the group of VDU operators statistically significant changes were observed in the measured visual functions after 2 hours work. Concerning the group working another visual activity — assembly in a printing house — most of the indicators had a significant change at the end of the working day. To confirm daily accumulation of visual fatigue induced with visual display units, the following visual functions were investigated: the nearest point of clear vision, tonic accommodation, tonic convergence, threshold of contrast sensitivity, questionnaire for subjective assessment of visual fatigue. For the aim of this research persons of both groups were examined — 5 persons working with VDU and 5 persons doing assembly. All of them had values of tonic accommodation which corresponded to the working distance longer than the usual one. The values of tonic convergence in these persons corresponded to a longer distance than the working distance. This was done in order to observe persons for whom it was known that they work with increased effort of visual system. Tendencies for change of the values of tonic accommodation and tonic convergence in persons working with VDU were observed, while this tendency was lightly observed in persons doing assembly. An increased variety of the measurements was observed at the end of the work. The results of the questionnaire showed an almost equal increase of complaints. Interesting changes were observed in the threshold of contrast sensitivity. On the first place, the increased variety of measurements observed at the end of the working day impressed. In case that the threshold didn’t change essentially in the group working with VDU. These results might be due to the accumulated fatigue of accommodation, i.e. most of all due to optic factors. The work with VDU is a serious loading of vision system - basically because of the fact of static position of accommodation and convergence for long periods of time. The lack of possibility to look out whole working is characteristic for the operators activity. In assembly, there are procedures such as supplying materials, which are micro pauses for the visual system. Possibly these are the main reasons for some differences in the effect of cumulation of vision fatigue in both kinds of activity.

1 Introduction

Computer technology has become an integral part of most working places in all spheres of life and human labour. Those using the computer technologies in their daily work are often forced to look at a screen of letters and symbols, whose “readability” largely depends on the hardware’s and software’s characteristics. Most jobs require an over 5-hour work on a VDU. Hence the importance attached to the problem of the accumulation of visual fatigue within a one-week working period.

From the perspective of ergophthamology, three are the most typical features of the operator’s work, i.e. it can be characterized as ‘short distance’, ‘continuous’ and ‘static’. The nature of the operator’s work thus determined the selection of the appropriate methods of analysis.

The following visual functions were studied in view of providing the most objective picture of the accumulation of visual fatigue during the work on a VDU:

1. The nearest point of clear vision
2. Tonic accommodation
3. Tonic convergence
4. Threshold of contrast sensitivity
5. Questionnaire on the subjective assessment of visual fatigue

For the purpose of the study representatives of both groups were examined, five people working with VDU and five assembling. Within the working day both groups perform visual activity for over six hours and a half, according to the respective supervisors’ data.

2 Results and discussion

The persons studied showed a visual acuity of 1.0 by Snellen, without any correction. Their tonic accommodation values were typical of a working distance, far greater than normal. Their tonic convergence values were also typical of a working distance, by far exceeding the normal. The trends of the indicators’ fluctuations at the beginning of their work shift were studied. A questionnaire (Hauer et al., 1989) was employed to assess subjective complaints; this questionnaire was adapted in view of being appropriate for VDU job; it consisted of 6 questions, with a 10-point scale.

Of the group of video terminal operators, statistically feasible changes to the measured visual functions could be observed within the very first working hour. The data of tonic accommodation were as follows:

- at the beginning of work: \( X=1,16; S_X=0,30 \)
- after an hour’s works: \( X=1,31; S_X=0,30 \)
- after two hours’ work: \( X=1,48; S_X=0,28 \)
The changes are statistically significant.

As to the assembling workers’ group, it was at the end of the working day that most indicators showed a marked change in values.

The tonic accommodation and tonic convergence values showed a clear tendency of change with the group of VDU operators, whereas such a tendency could hardly be observed with the assembling workers. With both groups the changes were not relevant and material. The values themselves were quite variable and fluctuating towards the end of the working week.

On the basis of analysing the questionnaire’s results, the following conclusions are arrived at: there is an equal increase in complaints with both groups; however, these complaints start growing at an earlier point with the VDU operators.

Interesting changes were to be noted to the threshold of contrast sensitivity. What draws the attention in the first place is the growing variability of the changes, registered at the end of the working week.

In case the threshold does not undergo considerable changes, these results may be attributed to the accumulated fatigue of accommodation in the VDU group, and above all those working on optical factors.

![Figure 1: The chart shows the tonic accommodation values in the VDU group (measured at the beginning of the working day)](image)

### 3 Discussion

Mutti and Zadnik (1996) elaborate upon the changes to accommodation and convergence, and whether these changes are persistent up to the end of the working week.

The length of the working period on a VDU is considerable and significant factor for the appearance of asthenopia both throughout the working day (Sanchez-Roman, 1996), and the working week (Rechichi et al., 1996). This factor is brought to the fore compared to other factors studied, such as the factor of the working environment and the working process. Pech et al., 1994 found certain statistically relevant changes in the visually evoked potential, and in the contrast sensitivity and refraction after a four-hour period of VDU work. Changes in the refraction were ± 0.25 D after four hours work, and ± 0.6D after six hours work. Miwa and Tokoro (1994) described the relation between tonic accommodation and asthenopia. There are other authors who establish a relation between the two indicators, and the importance attached to this relation differs.

The sensitivity of the pupils is considered yet another likely reason to cause a change in the contrast sensitivity, apart from the transient myopathy. Not only does the pupil regulate the amount of light the eye will perceive, but it also has an impact on its chromatic and optical aberrations. It is also regarded as a proved fact, that too narrow a pupil, that is an eye, perceiving an amount of light different from the optimal, will result in a decrease in the contrast sensitivity (for the visual acuity, measured by tests based on spatial and frequency sinusoidal stimuli, Arden (1978) and Vistech tables. Nakamura (1996) makes use of an infrared optical measuring device with a pupil metre to estimate the impact visual burdening has on the reactions of the pupils. The authors arrived at the conclusion that the people doing visual work have narrower pupils compared to the results of the controlling tests (29mm² compared to 38mm², p<0.01); he also concluded that these people manifest a higher degree of variability of the pupil’s area (9,2% compared to 3,4%, p<0,01). Since changes in the tonic accommodation were also found, the author described changes in the activity upon the parasympathetic innervation of the iris and/or m. ciliaris, which is most likely to affect the subjective assessment of visual fatigue.

VDU work heavily burdens the visual system, mainly due to the fact that the static state of accommodation and convergence has to be maintained for a longer period of time. Operators normally have no time to look at a distance while they work. The characteristics of the workplace are not up to the standards recommended as well (Sotoyama et al., 1995; Jaschinski-Kruza et al., 1999). Assembling is accompanied by procedures of providing materials; the latter are micro pauses for the visual system, and the nature of the work presupposes a dynamic posture rather than a fixed and static one. These are the most likely factors determining the different effects of the accumulation of fatigue with the two types of jobs.

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New Ergophthalmological Tool for Combined Measurements of Asthenopia and Current Subjective Workload at VDU Workplaces

Thomas STÜDELI (1), Marino Menozzi (1, 2)

(1) Institute of Hygiene and Applied Physiology, Swiss Federal Institute of Technology Zurich, ETH-Zentrum, Clausiusstr. 25, CH-8092 Zurich, Switzerland, E-mail: stuedeli@iha.bepr.ethz.ch, http://www.iha.bepr.ethz.ch/pages/leute/stuedeli/stuedeli.htm
(2) Space Medicine Research Center, Research Institute for Environmental Medicine, Nagoya University, Japan

1 Introduction
Eye discomfort and musculoskeletal discomfort are the main problems reported by VDU operators. We estimate that about 30% of VDU users frequently report asthenopic complaints. Asthenopic complaints of VDU users have been investigated since the very beginning of ergonomic research on VDU workplaces (Läubli et al. 1981), (Cole, 1996).

Asthenopia per se has been investigated in the past twenty years. Among factors causing asthenopia, psychological workload (Mocci, 2001), (Smith, 1997), lightning condition, technical and other ergonomic factors (Läubli et al. 1981), (Aaras, 1998), (Wolska & Switula 1999) have been identified.

1.1 Aims
With the current research doctrine influence from psychological strain on asthenopia can be granted. To what extent psychological strain influences visual strain is more difficult to show. It is a challenge to quantify and examine asthenopic complaints and psychological strain related to practice, i.e. to investigate 1) both factors at the same time and 2) during work time. We present an ergophthalmological tool, which has been developed considering the two factors mentioned above.

The fact that ergonomical factors and psychological strain affect asthenopia, leads to the question how much the type of work, work intensity and the management of work hours (e.g. breaks) may affect visual complaints.

2 Questionnaires
Two questionnaires, which are short and easy to fill out have were chosen for our propose, which is to report the actual asthenopic complaints and the actual psychological strain at the same time.

2.1 Actual asthenopic complaints
The assessment of asthenopic complaints is rather complex because of the variety of the different influencing factors. Complaints can be recorded on a long term, retrospective basis (Mocci, 2001) or by registering the actual asthenopic complaints in a short and rather general way (Tab. 1). To all of the three questions listed in Tab. 1, the subjects can add a value between 1 “nothing” and 10 “strong” (Stüdeli et al. 2001).

2.2 Actual psychological strain
To measure the actual psychological strain of the subjects, the standardized questionnaire KAB (German: Kurzfragebogen zur aktuellen Beanspruchung) has been used. This questionnaire is filled out within half a minute and correlates with the self assessment of both, experienced and expected actual strain (Müller & Basler, 1993).

In the KAB questionnaire, the subjects have to rate their psychological state in five dimensions on opposite pairs of adjectives. Subjects value their current strain using a scale ranging from 1 to 6. The question to be answered is: Now I feel like....The average rating gives the actual psychological strain index (see Tab. 2).

3 Field studies
To investigate the coherence of asthenopia and psychological strain, we conducted a study under lab-conditions (chapter 3.1) and in the field, at different VDU work places like stock broker, call-centre (chapter 3.2). These studies helped us to improve and grow from a questionnaire on paper over an electronic questionnaire (Stüdeli et al. 2001) to a web-based electronic questionnaire (broker, chapter 3.2).
3.1 Search Task (laboratory)

Combined psychical and asthenopic self-assessments were examined using 12 subjects in a display related search task in the laboratory. The total required to complete the task varied from 30 to 65 minutes. The subjects scanned 240 matrices of 40x40 capital letters “E” presented on a display. In 50% of the presented matrices one letter “E”, at any location, was replaced by a capital letter “F”. The Subjects were asked to report, as soon and as good as possible, whether one of the letters in the matrix has been replaced or not, answer and reaction time were recorded. An extensive description of the search task can be found in Menozzi (1999 & 2001). Before and after completing the task, the subjects had to fill out the two questionnaires. Every 40 matrices (5-10 minutes), the subjects could take a very short break (5-30 seconds).

3.2 Daily work on VDU (field)

9 brokers working in a common bank office filled out our questionnaires three times during work hours: in the morning, before they started to work (about 7 to 8 am), just before the lunch break (about 11.30 am) and in the evening at the end of the work (5 to 7 pm). The questionnaires were also applied in a second field study, in which the suitability of two display technology for office work, was rated. VDU users of our institute have been investigated for this purpose during a period of at leased two weeks. The subjects worked half of their days on a CRT display and half on a LCD. The subjects completed their usual work without restrictions.

4 Results

4.1 Search Task

Results of all of the three questions on actual asthenopic complaints correlate with the psychological index (Pearson: complaints $p=0.51$, headache $p=0.65$ and strain $p=0.54$). There is a tendency of lower psychological strain but higher visual complaints for subjects that solved the visual task in a short time. The self assessed psychological strain raised from 37% before, to 47% after the task. At the same time the visual complaints raised from 17% to 36% (Fig. 1). To compare the two different indexes, results of both indexes are presented here as a fraction of the maximal value. Ratings of the psychological strain are, in our experience, higher as the reported asthenopic complaints (see Fig. 1 & 2).

4.2 Daily VDU users

In average the brokers have been working 7.2 hours/day on TFT displays. During the work hours the subjects rested 52 minutes/day. The average effective work time was 8.2 hours/day. In Fig. 2 visual complaints and psychological strain computed using 36 questionnaires (evening) are shown.

There is a tendency of lower complaints ($p=-0.28$) and strain ($p=-0.3$) after work days with longer breaks (Fig. 2). Only the days were taken into account, in which sub-

j ect s reported a time of brake between 5 and 9.5 minutes per hour of work time.

![Figure 1: Increase of visual complaints and psychological strain through intensive VDU work of 30-65 minutes.](image1)

![Figure 2: Influences of breaks during work hours on visual complaints and on psychological strain of brokers.](image2)
Work on VDU is a demanding visual work and provokes asthenopic complaints. Asthenopic complaints raise during work whereas psychological strain does not show this tendency. In our laboratory conditions, effects from psychological strain from “outside the experience” can be taken as minimal. The measured strain is provoked by a demanding monotonous search task. Fast fulfillment of the task lowered psychological strain of the subjects (motivation) but raised visual complaints.

It seems that short work breaks have an influence on asthenopia as well as work intensity. Note the difference in visual complaints between Fig.2 (broker) and Fig. 3 (Ph.D. students). These differences of visual comfort can not be explained by different psychological strain or display technologies.

To know more about these open questions we need to add objective measurements of work intensity, such as typing speed or mouse movements to the subjective assessments. The development of our tool will lead us to a computer program that help to achieve almost continuous measurements of asthenopic complaints, psychological strain and objective work load. A future application in practice could be to support specialists in stress- and relaxation management of VDU work.

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7 References


Health Survey Among Japanese VDT Workers

Masaru MIYAO (1), Sohei Yamamoto (2), Susumu Saito (3), Tetsuo Misawa (4), Takanori Ochiai (5)

(1) Graduate School of Mathematics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan, E-mail: mmiyao@med.nagoya-u.ac.jp
(2) Japan Industrial Safety and Health Association, 5-35-1 Shiba, Minato-ku, Tokyo 108-0014, Japan
(3) National Institute of Industrial Health, 6-21-1 Nagao, Tama-ku, Kawasaki 214-8585, Japan, saitos@niih.go.jp
(4) Chiba Institute of Technology, 2-17-1 Tsudanumna, Narashino 275-0016, Japan, E-mail: XLG01612@nifty.ne.jp
(5) Fujitsu Health Care Center, 4-1-1 Kamikodanaka, Nokahara-ku, Kawasaki 211-8588, Japan, ochiai@jp.fujitsu.com

ABSTRACT

This survey was held in 1997. One thousand sixty sites where asked to fill out a questionnaire. For each site, ten VDT workers where expected to respond to this survey. Responses were received from 414 sites (39 % response rate). Altogether we received 4425 questionnaires, a 42 % response rate. As results, in the young male group of workers, aged 20 to 39, long time workers in both periods (peak and standard) rated the highest amongst workers having a weak eye site (no glasses), less than 0.3 of visual acuity on both eyes. The complaint rate of eye fatigue rose according to the working hours. The complaint of neck and shoulder stiffness in male workers rose according to the peak season working hours. Mental stress symptoms such as insomnia, exhaustion or depressive mood rose according to the peak season working hours for male workers and according to standard working hours in the input type of female workers. From this survey we can conclude that in the importance of the peak season working hours should be stressed for health status of the workers.

1 Introduction

Japan’s Ministry of Labour issued a guideline for VDT workers in 1985. Recently the working conditions as well as computers for VDT workers have been changed dramatically. This survey was held in 1997 in order to renew the guideline that should fit the new conditions, such as LCD displays, note type computers and big CAD.

2 Subjects and Methods

One thousand sixty sites where asked to fill out a questionnaire. One thousand sites were member-enterprises of Japan Industrial Safety and Health Association (JISHA) and 60 sites were collected from data processing industries. For each site, ten VDT workers where expected to respond to this survey. Responses were received from 414 sites (39 % response rate). Altogether we received 4425 questionnaires, a 42 % response rate. We then only selected 3852 written questionnaires, where major questions were filled out. The questionnaire also included basic questions such as age, gender, working hours, type of work and health status. The respondents to the questionnaire were 2365 male respondents and 1487 female respondents. All workers were classified into two age groups; one, the young group which age was rated from 20 to 39 years old and secondly the middle-aged group rated from 40 to 59 years of age. VDT working hours have been classified as follows: The standard season was classified from 0 hour up to 1.9 hours, from 2 hours up to 3.9 hours and from 4 hours or more. The high peak season ranged from 0 hour up to 3.9 hours, 4 hours up to 7.9 hours, 8 hours and more (Tables 1 & 2).

3 Results

The major kind of computers where PC’s (80%), the major input devices were keyboards (97%) and mouse (65%).

In the young male group of workers, aged 20 to 39, long time workers in both periods (peak and standard) rated the highest amongst workers having a weak eye site (no glasses), less than 0.3 of visual acuity on both eyes (Figures 1 & 2).

The complaint rate of having a pain in eyes rose according to the working hours (Figure 3).

The complaint rate of dry eyes as well as eye aches in the young group rose due to the peak seasons working time (Figures 4 & 5).

The complaint of red eyes in the young group rose according to the working hours in standard season and peak season. For any visual complaint, contact lenses wearers had significantly higher rates compared to those without contact lenses.
Table 1: The number of analyzed respondents by gender, age group, job-type and working hours a day in the standard season

<table>
<thead>
<tr>
<th>Working hours in the standard season</th>
<th>-2h</th>
<th>2-4h</th>
<th>4h-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male VDT workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young repetitive</td>
<td>410</td>
<td>301</td>
<td>210</td>
<td>921</td>
</tr>
<tr>
<td>Middle-aged repetitive</td>
<td>351</td>
<td>168</td>
<td>86</td>
<td>605</td>
</tr>
<tr>
<td>Repetitive</td>
<td>761</td>
<td>469</td>
<td>296</td>
<td>1526</td>
</tr>
<tr>
<td>Young dialogue</td>
<td>99</td>
<td>162</td>
<td>378</td>
<td>639</td>
</tr>
<tr>
<td>Middle-aged dialogue</td>
<td>70</td>
<td>49</td>
<td>81</td>
<td>200</td>
</tr>
<tr>
<td>Dialogue</td>
<td>169</td>
<td>211</td>
<td>458</td>
<td>839</td>
</tr>
<tr>
<td>Male total</td>
<td>930</td>
<td>680</td>
<td>755</td>
<td>2365</td>
</tr>
<tr>
<td>Female VDT workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young repetitive</td>
<td>530</td>
<td>321</td>
<td>205</td>
<td>1056</td>
</tr>
<tr>
<td>Middle-aged repetitive</td>
<td>95</td>
<td>64</td>
<td>31</td>
<td>190</td>
</tr>
<tr>
<td>Repetitive</td>
<td>625</td>
<td>385</td>
<td>236</td>
<td>1246</td>
</tr>
<tr>
<td>Young dialogue</td>
<td>29</td>
<td>44</td>
<td>153</td>
<td>226</td>
</tr>
<tr>
<td>Middle-aged dialogue</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Dialogue</td>
<td>32</td>
<td>48</td>
<td>161</td>
<td>241</td>
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<tr>
<td>Female total</td>
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<td>433</td>
<td>397</td>
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</tr>
<tr>
<td>All total</td>
<td>1587</td>
<td>1113</td>
<td>1152</td>
<td>3852</td>
</tr>
</tbody>
</table>

Table 2: The number of analyzed respondents by gender, age group, job-type and working hours a day in the high peak season

<table>
<thead>
<tr>
<th>Working hours in the standard season</th>
<th>-4h</th>
<th>4-8h</th>
<th>8h-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male VDT workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young repetitive</td>
<td>207</td>
<td>566</td>
<td>153</td>
<td>926</td>
</tr>
<tr>
<td>Middle-aged repetitive</td>
<td>221</td>
<td>337</td>
<td>38</td>
<td>596</td>
</tr>
<tr>
<td>Repetitive</td>
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<td>903</td>
<td>191</td>
<td>1522</td>
</tr>
<tr>
<td>Young dialogue</td>
<td>42</td>
<td>308</td>
<td>287</td>
<td>637</td>
</tr>
<tr>
<td>Middle-aged dialogue</td>
<td>43</td>
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<td>48</td>
<td>198</td>
</tr>
<tr>
<td>Dialogue</td>
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<td>335</td>
<td>835</td>
</tr>
<tr>
<td>Male total</td>
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<td>1318</td>
<td>526</td>
<td>2357</td>
</tr>
<tr>
<td>Female VDT workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young repetitive</td>
<td>348</td>
<td>623</td>
<td>64</td>
<td>1035</td>
</tr>
<tr>
<td>Middle-aged repetitive</td>
<td>63</td>
<td>114</td>
<td>11</td>
<td>188</td>
</tr>
<tr>
<td>Repetitive</td>
<td>411</td>
<td>737</td>
<td>75</td>
<td>1223</td>
</tr>
<tr>
<td>Young dialogue</td>
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<td>135</td>
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<td>228</td>
</tr>
<tr>
<td>Middle-aged dialogue</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Dialogue</td>
<td>19</td>
<td>146</td>
<td>78</td>
<td>243</td>
</tr>
<tr>
<td>Female total</td>
<td>430</td>
<td>883</td>
<td>153</td>
<td>1466</td>
</tr>
<tr>
<td>All total</td>
<td>943</td>
<td>2201</td>
<td>679</td>
<td>3823</td>
</tr>
</tbody>
</table>

Figure 1: Visual acuity without correction and the high peak working time period

Figure 2: Visual acuity without correction and the high peak working hours

Figure 3: The complaint rate of eye fatigue and the high peak working hours

Figure 4: The complaint rate of eye aches and the high peak working time period
4. Conclusion

We can conclude that in the importance of the peak season working hours should be stressed for health status of the workers. Repetitive work like input raises the complaint rate of the eyes, musculo-skeletal troubles and mental stress symptoms. Based on this survey, Japan’s new guideline for VDT workers is being issued by the end of March 2002.

5. References


Ergonomic Designs and Multimedia Effects on the Activities of Malaysian Companies: A Cost and Benefit Approach

Kok Thim CHAN (1) and Rabindra Nath Sen (2) 
(1) Faculty of Management, Multimedia University, Jalan Multimedia, 63100 Cyberjaya, Selangor, Malaysia, ktkchan@mmu.edu.my 
(2) Ergonomics Centre, Faculty of Management, Multimedia University, Jalan Multimedia, 63100 Cyberjaya, Selangor, Malaysia. rnsen@mmu.edu.my

ABSTRACT

The present paper attempts to evaluate the effectiveness of ergonomic designs using cost and benefit analyses. It is envisaged that organisational sickness may be attributed to the improper or unergonomic designs of work, work methods, work station, machines, tools, working conditions, work organisation, etc. Most Malaysian firms are not aware that ergonomic designs could improve efficiency, productivity, occupational health and safety of the people at work, whereas actually the use of ergonomic designs can enhance workers’ performance, workflow, organisational health and save both direct and indirect costs in the long run. The present paper provides also an identification of factors involved, e.g., the direct and indirect costs due to loss of working hours, rising costs of medical bills due to sickness and absenteeism, etc., should be accounted and compared with the benefits like cost reduction in paying compensation and for losses. Organisation should recognise the positive effects of cost and benefits analyses in applying ergonomic designs to achieve a judicious and optimal allocation of resources in a practical sense.

1 Introduction

Organisational sickness may be attributed to the improper ergonomic design of the working environment. The concept of organisational sickness merely refers to the similarity of illness of an individual either physical or mental or both aspects whereas there may be "behavioural sickness" for an organisation (Randall, 1998). People can become ill through the experiences or traumatic stress due to work with the onset of physiological and psychophysiological strains. Organisation becomes sick when the internal system malfunctions, and when it faces tremendous strain through competition, legislation, economic downturn and external pressures. To restore efficiency and to enhance the value of its people, one of the solutions will rest on the ingenious ergonomic designs of work, work station, work process, work methods, machines, tools and equipment, work environment, working conditions, occupational safety, health, etc. Most firms are not aware that such ergonomic designs could help to improve workers’ performance and efficiency, workflow, make the organisation healthier and save the direct and indirect costs in the long run. According to Hendrik (1996), "organisational decision-makers expect to proactively support ergonomics simply because it is the right thing to do", but in reality this is not what happens. The truth is that most firms would have to justify their investment in tangible outcomes that can be measured.

Usual cost and benefit analyses (Mishan, 1998 ; Zerbe, 1994) do provide some measures of ergonomic designs for companies that wish to put benchmark for comparison and adherence to quality and standards. There is little information on the application of ergonomic designs being practised by Malaysian multimedia companies. Lot of experimental designs has been introduced to study the cost.

There is practically no study undertaken to record the effectiveness of ergonomics applied in Malaysian multimedia companies. With the help of ergonomic designs, the benefits could be better reaped in the investment of proper equipment and machines used by the employees in their working environment.

1.1 Objective

The present paper attempts to evaluate the effectiveness of ergonomic designs using the cost and benefit analysis in the work and working conditions of Malaysian Multimedia Super Corridor (MSC) companies. It also extends the use of ergonomic solutions to promote a healthier organisation and improve the quality of life for its workers and the firm itself.

1.2 Method

It seems to be easier to calculate the costs of the ergonomic designs than actually the gains from the designs. The benefits are quite vague in the monetary terms and can be subjectively interpreted. Therefore, our model is based on the approach to project the results of the benefits rather than costing them. One must look into some intangible components of benefits and assess its usefulness.

Therefore, applying the financial concepts to time the value of money and the probability of outcome provided by some close proxies to measure in absolute terms, the benefits, which can be estimated based on the expected return over a time factor; for example, Benefits = Expected returns (value or percentage). This can be explained in terms of the expected value gained if the benefits (in value) can be predicted by the
expected inflows of gains objectively. The present value concept from the financial literature may be used. The present value of each expected gain over a time period can be quantified using an appropriate discounted rate. This resulted in assessing the possible benefits arising from an investment which have certain costs built in the process which can be represented by:

Possible Benefits = Present Value of Possible Gains Predicted

Incidentally, Birdman (1996) has provided similar model that is proposed here. Most analysts used the net present value (NPV) criterion to evaluate projects. The net present value of a project equals the present value of the benefits (PVB) minus the present value of costs (PVC), i.e.,

\[
NPV = PVB - PVC
\]

Finally, if all the costs of a project occur immediately where \( t=0 \) and all the benefits will be known over the remaining number of years which is denoted by \( t \), then the equation can be simplified as following:

\[
NPV = -C_0 + B_1(1 + i) + B_2(1 + i)^2 + B_3(1 + i)^3 + \ldots + B_t(1 + i)^t
\]

where,

\[
C_0 = \text{Initial Cost}; B_1 = 1^{st} \text{ year Benefits}; B_2 = 2^{nd} \text{ year Benefits}; i = \text{Appropriate discount rate}; t = \text{Time}
\]

Managers and decision-makers can use this formula to estimate the relevancy of ergonomic designs in a more precise approach to justify the costs of interventions or evaluating ergonomic designs before implementation. The present approach is one of the better alternatives and is recommend to all companies in Malaysia as well as in other countries.

2 Results

In our survey, 150 firms were identified in the Multimedia Super Corridor and questionnaires regarding ergonomic designs, cost, benefits and its usage were sent. As mentioned in a paper (Hignet, 1999), qualitative methodology implies an interactive approach to both data collection and analysis.

In the present pilot study, the responses received from only 22 firms were very discouraging. These 22 firms have spent around RM10,000 to RM850,000 in their R&D and employed a minimal of 5 to a maximum of 8000 personnel. The staff involved in the design process ranges from 2 to 20. Majority of them is also exporting and at least 13 firms employed skilled foreign workers. Sixteen multimedia firms are in the servicing industries.

Eighteen firms confirmed that it is easy to use cost and benefit analysis and 90% of them agreed that the usefulness of designs should be evaluated. Seventeen firms believe that it is easy to assess costs and benefits and majority of the respondents strongly agreed that cost savings are much more important. It is interesting to note that all the firms believe that design with cost and benefit assessment is important and cost efficient. All the respondents also state that better ergonomic designs can avoid accidents and design defects. More than 95% of the firms agreed that ergonomic design is pertinent to their organisations. All of the firms agreed that good designs can benefit their employees and better designs can help to save money for their companies.

3 Discussion

Probably, many ergonomic designs will fail in the first phase in Malaysia due to costs and inappropriate designs. In attempting to bring success in ergonomic design, the factors in determining the costs and benefits must be carefully identified. Cost factors like loss of working hours, loss of revenue due to rejects and rework of products, medical bills due to sickness, stress, and absenteeism, etc., are to be analysed and compared against the benefits obtained, like the saving of compensation and rewards (intrinsic and extrinsic value) to the workers. Limitations to the development of ergonomic designs should also be taken into consideration.

Ergonomic designs evaluation and intervention have contributed substantial improvements to health, safety and productivity of individuals in the working environment in developed and in other industrially advanced countries (Levin, and Bennedyk, 1999). The cost and benefit approach may seem to be the only method to balance the amount of investment versus the expected return over a certain period. In fact, cost-benefit analysis will enhance the understanding of the ergonomic application where cost justification is vital to the acceptance of ergonomic design evaluations and interventions in the eyes of the business communities and often in a more economic sense.

From our survey, most firms believe that it is quite easy to ascertain the costs and benefits. In reality, both cost and benefit factors are difficult to be accepted. This limitation will not provide benefits nor it can be measured to ascertain the value in dollars. There are several companies in Malaysia who have used ergonomic designs in low-cost housing, highways, intelligent buildings, shopping malls, light rail transit, working environments, etc. The fact is, it is still not possible to justify the (social) benefits substantially. It is hoped that the costs and benefits approaches can convince them to refine their evaluation process when pursuing the more scientific approach to ergonomic designs for the products manufactured by the organisation for the users.

4 Conclusions

Finally, the valuation process as presented in the present paper is quite practical and accepted if the basic distinction between the cost and benefit factors are vividly identified. It is obvious that the economic dimension plays a very important role to achieve the required change needed by an organisation or a firm to cure its illness entrapped within its environmental setting. Organisations should recognise the positive effects of costs and benefits analyses when evaluating ergonom-
ic designs as to effectively achieve an optimal allocation of resources in a practical sense.

5 Acknowledgement

We express our sincere gratitude to the management of the Multimedia University for funding the present study.

6 References


Towards Better Understanding of Risks Arising from Work with VDU Through Risk Assessment

Hilja TAAL

Institute of Business Administration, Tallinn Technical University, 101 Kopli Street, 11712 Tallinn, Estonia, E-mail: hiljat@tv.ttu.ee; hiljat@staff.ttu.ee

ABSTRACT

This In the future possibilities for work with visual display units (VDU) are expected to widen both at work independent of work area and in leisure time. This study deals results of risk assessment by students of the Faculty of Economics of Tallinn Technical University. Part of them work regularly as employees in offices and some of them use VDU regularly at home. The study tried to specify the meaning of the phrase “a significant part of the working day” used in the 90/270/EEC directive as well as in the first Estonian ordinance concerning work with VDU and to find out how the length of the working time with VDU influences the users’ health. Some additional aspects connected to work-related health hazards from the point of national legislation were involved.

1 Background

Increasing use of computers is a worldwide trend nowadays. We use VDU in any situation and everywhere—in internet searching, in enterprise internal network, e-mail, and in banks, control desks etc.

1.1 Health problems

The hazard of having musculoskeletal pain in the wrists, the neck, shoulders, muscular pain in and arms due to the use of a keyboard and a mouse is widely known. In addition, time pressure increases influence of monotonous work. Also many people suffer from the so-called computer vision syndrome (CVS). A survey conducted by COMDEX 98 at Las Vegas, which was sponsored by Bausch & Lomb, proved that 86% of the respondents suffer from CVS, and 98% of those persons were working on a computer for 2 hours a day.

American Optometric Association reports that 10 million cases related to CVS come for professional help yearly. So 25% of all computer users in the USA seek medical intervention because of CVS. A human-machine interface takes place during work at a workstation with a visual display units (VDU) involving electromagnetic fields emitted by VDU that are usually considered to have a rather low level. At a workstation with VDU different kinds of electromagnetic fields, such as non-ionizing ELF and VLF but also ionizing air in rooms, occur.

1.2 The costs of injuries

In today’s working environment the number of people working with VDU is increasing rapidly. Also in Estonia the use of VDU is expanding in at a high rate in working, teaching, learning processes as well as in everyday life. A recent survey found that there are 5.5 million display screen equipment operators in the UK—one quarter of the work force (2000).

In the USA $20 billion was paid in compensation claims for RSI in 1993. Indirect costs were estimated at up to $100 billion by the US Occupational Health and Safety Administration. The Department of Labour Administration reports that out of 40 million PC users in the USA, 32 million suffer from CVS, which means that 80% of the users suffer from CVS (2000).

Out of all known and researched computer related occupational health hazards RSI, also called the Cumulative Trauma Disorder (CTD), and CVS are the most common.

These facts indicate that also in Estonia continuous explanatory work is required to improve the working habits of all population groups in order to avoid health risks due to work with VDU and the related medical costs.

Work with VDU means that working environments are more demanding, requiring cognitive and reasoning abilities and when something goes wrong, problems may be increased as systems are controlled by automation.

2 Methods

We are updating our methods of teaching ergonomics and give knowledge through lectures and practical training. One component of practical training is homework (Taal, 2000). The purpose of homework is to fix ergonomics knowledge and make students aware of the actual risks in work situations through risk assessment.

A checklist was compiled for systematic analysis of workplaces with display from the point of view of postural and visual ergonomics, it also includes requirements for technical characteristics of display and microclimate and noise, and possible health impairment due to incorrect workplaces. Some questions were added concerning the respondent’s problems with health connected with working with display, the number of hours worked daily with display, the age of respondents, and suggestions for healthier work environment. Also, each student had to do self-determination of his (her) posture at workstation using RULA (McAtamney, 1993) assessment to make clear work posture the risks of cumulative trauma disorder through posture, force, and muscle-use analysis.
3 Discussion

Figure 1 compares eye and musculoskeletal discomforts by respondents who work one or two hours daily in office or at home.

Figure 1: Distribution of complaints by respondents at home and in office working two hours daily

Respondents who work with VDU at home one hour daily have significantly fewer visual and postural complaints than those who work in offices (10% compared to 60% visual and 19% postural). Respondents who work with VDU two hours daily have similar values within both groups. The level is very high: more than 60% of respondents in the respective group had visual discomfort. Complaints concerning postural discomfort are on the same level for both respondents working at home and respondents working in offices. Also a research in Sweden suggests that over 98% of people working at least 2 hours daily with VDU have eye problems risks (How many, 2000).

To investigate the influence of the duration of working time with display on health, all respondents were divided into groups with respect to the number of complaints and working hours (Figure 2). Only students in the office groups had three complaints.

In the group working one hour in office 25% of the respondents had two complaints about health and had 31.5% one complaint. In the group working two hours both one and two complaints occurred in the case of 28.6% of the respondents.

4 Health and environmental policy

Ergonomics and health problems are interconnected involving also other scientific disciplines. In making any decision on risk reduction in the working environment the limited amount of resources available should also be taken into account.

The results of our studies carried out were taken into consideration in ordinance concerning work with VDU. We analysed the Estonian ordinance from the year 1996 and decided that all workstations for work with VDU have to be in accordance with standard EN 29241 and electromagnetic radiation has to satisfy the TCO and MPR norms.

The new Estonian ordinance concerning work with VDU points out that workstations must meet ergonomics requirements independent of hours worked with VDU. Breaks for rest depending on the working time with VDU are necessary. An obligatory requirement in the new ordinance is that people working at least half of their daily work time with VDU, have to have both eye sightseeing and musculoskeletal medical examinations.

Although health hazards are known today, taking measures to prevent them is not yet a public trend in Estonia. That is why our ordinance based on Directive 90/270/EEC concerning work with VDU was revised although it already included:

• examination of eye and eyesight
• periodic breaks for workers using VDU constituting at least 10 per cent of the working time in a working day
• and for solving visual ageing problems, on a doctor’s recommendation, provision of workers with appliances for work with VDU.

Among prevention principles medical examination for musculoskeletal problems to avoid musculoskeletal diseases was added.

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The Influence of Job Stressors on the Taking of Rest Breaks Among Call Center Operators

Naomi SWANSON (1), Paula Grubb (1), Christina Beam (1), Robin Dunkin (1), Lawrence Schleifer (2), Steven Sauter (1)

(1) National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, Ohio 45226, USA, E-mail: nw3@cdc.gov
(2) University of Maryland, College Park, Maryland, USA

ABSTRACT

Nearly 5000 customer service operators in a large government agency were surveyed about working conditions at their agency. The survey included questions about rest break behaviors and job stressors. The results indicated that job demands were predictive of rest break behaviors. Employees who reported low levels of job control, supervisory support, and decision making ability, along with greater time pressures, work backlogs, and contact with upset customers also reported taking fewer rest breaks during the workday.

1 Introduction

Recent studies by NIOSH and others have established the efficacy of frequent rest breaks in relieving musculoskeletal discomfort, stress and self-reported fatigue among workers performing repetitive work (e.g., Dababneh et al., 2001; Galinsky et al., 2000). The ability to take breaks in many jobs may be influenced by a number of factors, from administrative policies to managerial supportiveness to workplace factors such as time pressures and heavy workloads. The present study was undertaken to determine the impact of job demands on the (self-reported) break-taking behavior of customer service representatives in a government agency. Data are utilized from a longitudinal intervention study in which the effectiveness of a supervisory best practices intervention in improving worker satisfaction, health and well-being is being evaluated. The current analyses used baseline data collected before the supervisory intervention was implemented at the call centers.

2 Methods

2.1 Subjects

The subjects were 3223 women and 1452 men (mean age of 35-44) employed as customer service operators in 15 call centers of a government agency. The agency employed a conventional rest break schedule mandated by a labor-management agreement. Employees were allowed a 15-minute break during the first half of their shift, and a second 15-minute break during the second half of their shift. In addition, they were allowed a 30-minute meal break at the mid-point of their shift. Calls were automatically routed to the operators, and consisted of inquiries from the public about the completion of government forms.

2.2 Procedure

At the beginning of the study, each subject completed a survey on working conditions at the agency. The survey included questions about job demands, supervisory behaviors, work climate, rest break behaviors, job stress, job satisfaction, motivation, health, and subject demographics.

2.3 Analyses

Two groups of items were selected from the survey for inclusion in the analyses. One group consisted of control items (i.e., age, sex, ethnicity, part time/full time status, job title), and the second group consisted of job stressors that might influence the taking of rest breaks (e.g., workload, time pressure, job control, supervisory support, backlogs, etc.). Stepwise regressions were done in which the control variables were forced in first, after which the job stressors were entered. Outcome variables consisted of a) number of brief, unscheduled breaks taken per day, and b) number of times per day that the worker got up and left their workstation (this could include scheduled rest breaks). These rest break variables were then correlated with job satisfaction, job stress, general health and job commitment to determine the relationship between the taking of breaks and well-being in this population.

2.4 Results

The subjects reported taking an average of three brief, unscheduled rest breaks per day, and reported getting up and leaving their workstation an average of 4 times per day.

A. Brief, unscheduled rest breaks: Job control was the strongest predictor of the number of brief, unscheduled rest breaks that workers took, with more breaks taken by those reporting a higher level of job control. Time pressure, supervisory support, work backlogs and contact with upset people were also associated with the number of brief, unscheduled rest breaks taken during the day. Workers who reported less time pressure, more supervisory support, less work backlogs and less contact with upset people took more breaks during the workday.

B. Breaks involving leaving the workstation: Job control was also the strongest predictor of the number of times that workers got up and left their workstations, with those reporting a higher level of job control leaving their
workstations more times per workday. Additionally, greater supervisory support, higher levels of decision-making, higher levels of skill-use, less time pressure, and lower work backlogs were also associated with workers being able to leave their workstations more frequently.

C. Rest breaks and well-being: Individuals who took two or more brief, unscheduled rest breaks per day reported higher levels of job satisfaction, better general health, and lower levels of job stress than individuals who took one or no unscheduled break. Those who left their workstations two or more times during the workday reported higher levels of job satisfaction and lower levels of job stress.

3 Conclusions

The results indicated that job demands are predictive of the ability of workers to take rest breaks during the day. More specifically, workers who reported that they have lower levels of job control, less supervisory support, less decision-making ability, greater time pressures, greater work backlogs, and more contact with upset people, were significantly less likely to take brief, unscheduled rest breaks, or to get up and leave their workstations during the workday. Although analyses of the relationship between the number of rest breaks taken per day and worker well-being indicated that workers who take more breaks were more satisfied and less stressed, these results should not be interpreted in a causal fashion at this time. Structural analyses are currently underway to determine the causal pathways between job stressors, rest breaks, and health and well-being in this population of workers.

4 References


Symptoms and Clinical Findings from the Musculoskeletal System among Operators at a Call Center in Sweden – a 10 Month Follow-Up Study

Allan TOOMINGAS (1), Tohr Nilsson (2), Mats Hagberg (3), Kerstin Norman (1), Ewa Wigaeus Tornqvist
(1) Ergonomics, National Institute for Working Life, SE 112 79 Stockholm, Sweden, E-mail: allan.toomingas@niwl.se
(2) Department of Occupational Medicine, Sundsvalls hospital, SE-851 86 Sundsvall, Sweden
(3) Occupational and Environmental Medicine, Sahlgrenska University Hospital, SE-412 66 Gothenburg, Sweden

ABSTRACT

The musculoskeletal health status among 57 operators at one call center in the northern Sweden were followed during 10 months, parallel to a reference group of 1226 professional computer users in other occupations. The call center operators were much younger than the reference group. Symptom cases were found at baseline among 86% of female and 68% of the male call center operators compared to 72% and 50%, respectively, in the reference group. The neck and shoulder regions were most frequently affected. During the 10 monthly follow-ups about 35% of the call center operators reported symptoms during all follow up months, compared to 23% in the reference group. Muscle and nerve affections were the most common specific findings at medical examination of incident symptom cases at the call center and among the other professional computer workers. More studies should be done on the working conditions and health status among call center workers.

1 Introduction

Call centers are relatively new organizational units that use telephones and computers to manage communication with e.g., customers, the public, or government agencies. Independent call centers are proliferating rapidly as many companies are outsourcing their telephone services to specific companies to more efficiently manage uneven demands for services.

Since the early 1990s, call centers in Europe have been concentrated to the Netherlands and the British Isles. There have been call centers in Sweden since the mid-1990s (Figure 1).

The expansion of call centers can have a positive impact on many rural communities by creating new jobs. However, problems have been noted, e.g., with low wages, lack of control, the feedback systems, working hours, stress, the emotional burden of dealing with demanding or unpleasant customers, inadequate opportunities for

Figure 1: Typical Swedish Call center

Call centers is one of the most rapidly growing labor market sectors today. There are an estimated 5 million people employed in call centers in the United States, and approximately 1,5 million in Europe. According to the state-run Invest in Sweden Agency, approximately 35,000 people were employed in Swedish call centers in 1999, while industry growth forecasts some 130,000 employees by 2005, corresponding to an annual growth of 25%. Call centers are expanding primarily in rural areas, where there is a good supply of available labor.

In a study of call centers in Great Britain, it was found that operators and managerial staff were relatively young, usually under 35, and they had worked at the call center for only a short time (two years or less among 50% the managerial staff and 75% of the operators) (Austin Knight & Calcom Group, 1997). Operators and managerial staff were predominantly women (70 and 60% respectively) (Figure 2).

Figure 2: Young women at a Swedish call center
professional development, and insufficient physical and mental variation.

There are few studies reporting on working conditions and employee health status at call centers. Strained working conditions have been reported both concerning organizational and psychosocial aspects, like time pressure, emotional load, electronic monitoring and voice tapping of calls, but also concerning bad physical conditions, and ergonomics (Hoekstra et al., 1995, Ferreira et al., 1997, Most, 1999, Norman et al, 2001). Musculoskeletal disorders, feelings of stress and physical/mental exhaustion among the operators have been reported.

2 Aim

The aim was to study symptoms and findings from the musculoskeletal system at clinical examination among operators at one call center in Sweden.

3 Methods

The design was a closed prospective cohort study with 10 monthly follow-ups. Participants were operators at one call center in the northern Sweden. Thirty-five female and 35 male operators, who were supposed to remain during the study period, were selected among all 380 operators employed at the call center. A reference group of 896 female and 636 male professional computer users in other occupations was followed in parallel.

Among measurements at baseline was a questionnaire about symptoms during the last month (ache or pain in the neck, back or upper extremities). Subjects reporting symptoms 3 days or more were regarded as symptom cases. Working conditions were also registered, but are not reported here. Measurements at follow-up were made by 10 monthly questionnaires about symptoms. Subjects identified as incident symptom cases were called for a medical examination performed by a physician. An incident symptom case was defined as a subject reporting symptoms from any of the body regions above (as in baseline), and who was symptom-free during the preceding month.

4 Results

Twenty-nine women and 28 men at the call center replied to the base-line questionnaire (mean age 28 and 29 years, respectively), and 756 women and 470 men in the reference group (mean age 45 and 43 years, respectively). The call center operators had on the average been working with computers during 4-5 years and the referents during 12 years. The operators had on the average been working in their present profession since 14 months (males) or 26 months (females). The corresponding figures among the referents were 10 years (males) or 14 years (females).

Symptom cases were found at baseline among 86% of the female call center operators compared to 72% among women in the reference group. The corresponding figures among men were 68% and 50%. The odds ratio for being classified as a symptom case among call center operators versus the referents was 2.2 (95% ci 1.2-4.3) (adjusted for gender and age). The neck and shoulder regions were most frequently affected in both groups.

Out of maximum 570 possible follow-ups, about 71% were returned by the operators at the call center. During follow-up 18 operators at the call center (32%) were identified as incident symptom cases, compared to 514 in the reference group (42%). The cumulative incidence of incident symptoms was about 0.5/year among the call center operators and about 1/year in the reference group. (The number of incident cases in the call center group was judged to be too low for analysis of incidence ratios.)

About 12% of the call center operators and 21% of the referents remained symptom-free both at baseline and the whole follow-up period (Table 1). On the other hand, about 35% of the call center operators and 23% of the referents were never symptom-free, neither at the baseline, nor at any follow-up. Women at the call center reported symptoms at about 60% of the follow-up months and men at about 40% (totally about 50% out of all 405 follow-up months).

Table 1: Number (No.) and % of subjects at the call center and in the reference group who reported symptoms in one or more of the upper body regions at baseline and during 10 months follow-up.

<table>
<thead>
<tr>
<th></th>
<th>Call Center No. (%)</th>
<th>Reference group No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never symptoms</td>
<td>7 (12%)</td>
<td>260 (21%)</td>
</tr>
<tr>
<td>Symptoms only at baseline</td>
<td>12 (21%)</td>
<td>176 (14%)</td>
</tr>
<tr>
<td>Always symptoms</td>
<td>20 (35%)</td>
<td>276 (23%)</td>
</tr>
<tr>
<td>Incident symptoms</td>
<td>18 (32%)</td>
<td>514 (42%)</td>
</tr>
<tr>
<td>Total</td>
<td>57 (100%)</td>
<td>1226 (100%)</td>
</tr>
</tbody>
</table>

Fourteen out of the 18 incident cases at the call center were medically examined (5 women and 9 men) and 389 out of 514 incident cases in the reference group. Pathological findings were made in the neck-shoulder region in 5 operators, shoulder joint 1 operator, wrists and hands in 4, and in the back in 3 operators. Affected structures were considered to be muscles in 4 operators, nerves in 4, joint in 1, and miscellaneous in 5 operators. Three operators were classified as cases of neck/shoulder pain syndromes and another three as cases of nerve compression. The results from the reference group were similar but with a somewhat lower frequency of nerve related findings and a higher frequency of tendon related findings and diagnoses.

5 Discussion

This study demonstrated a very high prevalence of symptoms from the upper body regions among call center operators. In fact, the call center operators was the...
occupational group that reported the highest prevalence of symptoms among all professional computer users out of more than 30 different occupations and companies in the study. On the average, the call center operators experienced symptoms every other month. More than a third of the operators experienced symptoms every month. The call center operators were mostly under 30 years of age compared to the middle aged reference group. They had been working at call centers for only 1-2 years, which was about 1/10 of the corresponding seniority among those in the reference group. There are several plausible explanations why these young and novice professional computer workers would be in such a bad health condition. The working conditions, both the psychosocial and the work-station design, were worse at the call center than among the reference group (Norman et al, 2001). This was most prominent concerning the work-station design and the level of influence at work. The work tasks at the call center were less varied than among the referents and the call center operators also worked longer at the computer work-station without taking rests. These are well known risk-factors for e.g. neck-shoulder disorders among computer users (Punnet & Bergqvist, 1997).

As found in many other studies, the women both at the call center and in the reference group reported more symptoms than the men. Findings in medical examination of incident symptom cases were similar among men and women. They were also similar to findings in the reference group and what has been reported from examinations of other professional computer users (Punnet & Bergqvist, 1997).

This study has reported results from one Swedish call center. There are reasons to believe that conditions differ between call centers. As these results, like in other studies, indicate unfavourable health conditions, further studies should be done on working conditions and health at call centers.

6 Conclusions

Operators at this call center were more symptom-loaded than other professional computer users. Symptoms were long lasting or recurrent. Clinical findings indicated lesions mainly affecting muscles or peripheral nerves. More studies should be done on the working conditions and health status among call center workers.

7 Acknowledgements

The Swedish Work and Environment Found is gratefully acknowledged for founding of this study. We would like to thank all contributing staff at the call center and the reference companies and also all ergonomists and assistants for practical help during data collection.

8 References


Implementing ISO 9241 Parts 3 and 5 in North America - The BIFMA Ergonomics Guideline for VDT Furniture

Dennis R. ANKRUM
Human Factors Research, Nova Solutions, Inc. 421 W. Industrial Ave., Effingham, IL 62401 Email: Ankrum@aol.com

ABSTRACT

ISO 9241 part 5 requires that a fit be achieved between computer users and their workstations. Because of the wide anthropometric variation among populations, ISO does not specify dimensions for workstations. The Business and Institutional Furniture Manufacturers Association (BIFMA) has developed an ergonomic guideline for furniture intended for computer use in North America. Rather than attempt to create a standard of its own, BIFMA has applied the measurable furniture-related principles and design requirements of ISO 9241 parts 3 (Visual display requirements) and 5 (Ergonomic requirements for office work with visual display units) to the North American population. While conforming to the accepted practice of providing dimensions for the 5th – 95th dimensions of the population, the guideline includes an “Ultimate Test for Fit” for each parameter to help ensure that each worker can be provided with an ergonomic work environment.

1 Introduction

Selecting VDT furniture for a large number of users, different tasks and posture preferences can be a nightmare. After the qualitative features have been determined, the necessary adjustment ranges and dimensional requirements becomes the issue. Ideally, even large companies would have a stable workforce and detailed records of each worker’s relevant body dimensions. In reality, furniture specifiers have relied on a hodgepodge of specifications – many of which have little to do with the actual physical characteristics of the workforce. To provide guidance both for its members and for computer workstation users, the Business and Institutional Furniture Manufacturers Association (BIFMA) has developed the Ergonomics Guideline for VDT (Visual Display Terminal) Furniture Used in Office Work Spaces, for furniture intended for computer use North America.

The provisional draft was released in January 2001 and the public comment period lasted until June 30, 2001. The final version was approved on March 1, 2002.

2 ISO

ISO 9241 is the internationally recognized standard for computer workstations. It presents accepted principles for office ergonomics. Part 5 provides guidance for determining the dimensional requirements for computer workstation furniture that will accommodate the body sizes of specific working populations. To accommodate the North American population, BIFMA has applied the measurable, furniture-related principles and design requirements of ISO 9241 parts 3 and 5 (ISO 1992, 1998). Because of the wide variety in body sizes in different countries, ISO 9241 does not provide specific dimensions for workstation components such as chairs and worksurfaces. For the North American population, BIFMA used the most widely accepted anthropometric survey available, the 1988 Anthropometric Survey of U.S. Army Personal (ANSUR) (Gordon et al., 1988).

While the population measured by ANSUR does not precisely reflect the office working population of the US and Canada, it is the most encompassing set of measurements available at this time. The measurement method used in the ANSUR survey is consistent with the anthropometric measurements described in ISO 7250: Basic Human Body Measurements for Technological Design.

3 Fit

The application of the concept of “fit,” as defined in ISO 9241-5, 4.3, is the primary consideration of the guideline:

Selection and design of furniture and equipment requires a fit to be achieved between a range of task requirements and the needs of users. The concept of fit concerns the extent to which furniture and equipment (work chairs, work surfaces, visual display units, input devices, etc.) can accommodate individual users’ needs. (ISO 1998)

Since, except under special circumstances, workstations cannot be custom-made for individual users, some alternative forms of ensuring a good fit are required. The extent to which the workstation provides a good fit between the requirements of users and their work should be of primary consideration. (ISO 1988)

Current design practice for industrial products takes the relevant anthropometric dimensions of the 5th percentile of female to 95th percentile male working population into account. (ISO 1998)

The BIFMA guideline follows the 5th,95th-percentile convention, but recognizes its limitations. While many people assume there exists a “5th percentile female” and a correspondingly large male, such a person is impossible. The percentiles refer to individual body segments, not standing height. People with long shins tend to have shorter thighs, and vice versa. Therefore, some users will be too “long” or “short” for a “typical” seat depth, but fine for everything else. A user who falls
within the 5th-95th percentile range for one body dimension may be outside that range for another. Specifying for only the 5th-95th percentile means that much more than 5% of the population will remain accommodated. To ensure that all workers are accommodated, it is necessary to have some workstations that are smaller, and some that can be larger, than the fabled 5th-95th percentile. Recognizing that, the BIFMA guideline provides an Ultimate Test for Fit. Passing the Ultimate Test for Fit ensures that the furniture fits the individual, even if it does not conform to the recommended dimensions.

4 Scope
The purpose of the guideline is to provide guidance in applying the relevant measurable ergonomics principles and design requirements found in ISO 9241-3 and 9241-5 to the dimensions and adjustment ranges of chairs and worksurfaces used in the design of workspaces utilized specifically for intensive VDT work. It is intended for use by professionals involved in the design, manufacturing, specifying, qualifying and purchasing of office furniture for VDT workspaces. The more intensive the VDT usage, the more important adherence to the ISO principles becomes.

5 Conformance
Designing products to fit the 5th percentile female to 95th percentile male body dimensions will accommodate a large number of users. It is important, however, to realize that purchasing/designing furniture for the above range will not accommodate at least 5 percent of the users for any particular dimension. In order to accommodate users outside the 5th to 95th percentile ranges, it will most likely be necessary to purchase components that are not within that range. The practice of ergonomics requires fitting the work environment to the user. A furniture component that fits a particular user conforms to ISO and the recommendations in the Guideline, even if it does not conform to certain numerical ranges.

6 Limitations
The workspace dimensions recommended in the guideline are based on meeting the requirements of the 5th percentile female through 95th percentile male body dimensions in an upright posture, relying on a single database, ANSUR. Alternate postures may result in different dimensional requirements. If the anthropometric dimensions of a particular user population can be estimated, it is preferable to utilize those dimensions. While the ANSUR body dimensions are generally taken from upright postures, there is no uniquely correct working posture that would fit any user for an extended period and/or accommodate every personal working habit. The dimensions given in the guideline consider these generally upright postures only. Other dimensions may be acceptable if other postures are assumed. The application of ISO principles to specific user/workspace combinations may result in dimensional conflicts. The final criterion for determining whether an individual has been accommodated is the Ultimate Test for Fit. The application of ergonomic principles is broader than anthropometry. Workstation design should consider other aspects such as lighting, acoustics, heating and ventilation, and psychosocial aspects.

7 Guideline format
The guideline addresses work chairs and worksurfaces. Each specification is subdivided into the following parts:

7.1 ISO Related Quote and Reference.
Quotes from ISO provide the guiding principles upon which the recommended specification is based.

7.2 Relevant Body Dimension
Photographs and drawings from ANSUR (Gordon et al., 1988) illustrate the critical body dimension and show how it was measured. Data is provided for the appropriate 5th percentile female and 95th percentile male body dimensions. In some cases, such as seated eye height from the floor, which is critical for determining screen height, the dimension is calculated within subjects using the raw data from the ANSUR database.

7.3 Why is the parameter important?
Many persons responsible for specifying computer support furniture are unfamiliar with ergonomic principles. They sometimes take what they consider the safest avenue by specifying only those components with dimensions that accommodate the fabled 5th – 95th percentile. That has resulted in refusing to accommodate individuals who require furniture that falls outside the recommended dimensions. The explanation of the importance of the parameter provides the basis for the recommendation and will hopefully allow specifiers to determine when specialized components would not only be allowed, but necessary.

7.4 Discussion
This section explains how the relevant body dimensions were used to determine the recommended dimensions/ranges, including where allowances have been made for clothing, shoes, or postural variation.

7.5 Recommended Dimensions/Ranges
Recommended adjustment ranges or minimum-maximum settings are provided based on the 5th-95th percentile body sizes. The chair dimensions provided in the guideline are obtained using the Universal Measurement Procedure® for the Use of BIFMA Chair Measuring Device (CMD)® BIFMA/CMD-1. In some cases, because of variables beyond the control of the manufacturer, no specific numbers are provided.
7.6 Ultimate Test for Fit for the Individual User

Most ergonomic guidelines provide either specifications or a performance requirement. Conform to a specification-based guideline is achieved by providing furniture that meets a list of dimensional requirements, i.e., the seat adjusts from x to y. Performance based guidelines focus on how well the furniture actually fits the user. An example would be, “Can the person sit in the chair with their feet flat on the floor?” The BIFMA guideline combines both. It provides dimensions to fit workers from the 5th percentile female to 95th percentile male body dimensions, but it also provides an Ultimate Test for Fit.

Passing the Ultimate Test for Fit ensures that the furniture fits the individual even if it does not conform to the specified dimension. Furthermore, because the dimensional ranges cover only from the 5th percentile female to the 95th percentile male body dimensions, the guideline explicitly states that it is impossible to “fit” all users by purchasing only those components that fall within the recommended ranges.

8 Conclusion

The BIFMA ergonomic guideline applies the principles of ISO 9241 parts 3 and 5 to furniture intended for computer user in the U.S. and Canada. It provides dimensions and adjustment ranges to accommodate from the 5th percentile female through the 95th percentile male body dimensions.

Recognizing that this will not accommodate all users, it provides an Ultimate Test for Fit to ensure that all users can achieve the ISO goal of “fit.”

BIFMA G1-2002 may be ordered at www.bifma.org or BIFMA, 2680 Horizon Drive SE, Suite A-1, Grand Rapids, MI 49545-7500 USA, (1-616-285-3963).

9 References


Comparison of Stationary LCD and CRT Screens - Some Visual and Musculo- Skeletal Aspects

Per NYLÉN
National Institute for Working Life, S-11279, Stockholm, Sweden. E-mail: per.nylen@niwl.se

ABSTRACT

Most individuals spend an increasing amount of time in front of their computer screens, both at work and at home. The actual work at the screen has often also been intensified including more frequent and longer interactive phases, often together with increased manuscript reading straight from the screen instead of using a paper printout. This development motivates improved visual and postural ergonomics at all computer work. LCD screens might contribute to such improvements, as compared to the traditional and today cheaper CRT screens. In general, LCD screens generate considerably less flicker and reflexes; the latter factor thus permits a lowered screen position. Some advanced graphic presentations are still only possible using CRTs. Due to the reduced depth, the LCD screen is often easier to place correctly on the table in relation to light sources and incoming day light. The considerably lower weight of the LCD screens makes it easier to move and twist in different directions during work, actions rarely done with the CRT. Such screen movements allow more varied work postures and are thus favourable.

1 Introduction

In the end of year 2002, the proportion of LCD screens sold will probably pass 50% in Sweden and be around 30% in Europe. Along with the increasing proportion there is a considerable decrease in price compared to CRT screens. Difficulties in choosing between LCD and the cheaper CRTs are common and comparing analyses of the different aspects are often welcomed.

The total time spent in front of computer screens is still increasing; both for private and professional activities due to increase in e.g. activities on the web, communication by e-mail, and interactive education. Leisure time playing on the computer has increased also among many parents and young adults. Different professional work tasks performed at home, instead of at the office and often by using a computer, are also increasing. This increase in total time spent in front of computer screens motivates further improvements in visual and postural ergonomics.

In the following, aspects of only stationary computer screens are discussed, notebooks are not included.

2 Visual ergonomics

2.1 Flicker

Exposure to both visual and non-visually observed amplitude modulated light is unavoidable when viewing a CRT-screen, even at static presentations such as a text page. Visually observed modulations, i.e. flicker, are both annoying and reduce readability and productivity. Non visual modulations from normal fluorescent lighting using AC 50-60 Hz have been shown to cause discomfort in general but also severe annoyance in a strictly controlled study in persons claiming them selves to be hyper sensitive to electromagnetic fields. When exposed to high frequency fluorescent lighting (several thousand Hz) in the same study, a considerable part of the reported symptoms disappeared. Claimed hyper-sensitivity to electricity might therefore partly be a hyper sensitivity to amplitude modulated light. It has been proposed that similar effects might be induced by non-visually observed amplitude modulated light from CRT screens too. The LCD-technique generates much less, if any, amplitude modulated light in the frequencies found in CRTs, i.e. between 50 and 100 Hz.

2.2 Peripheral sharpness

When using the CRT technique, the exact positioning of electron beam is more difficult at the peripheral parts of the screen. This results in a decreased sharpness in these parts. A LCD screen has the same sharpness all over the screen.

2.3 Advanced graphic applications

The resolution of CRT-screens can still be increased beyond the limits of the LCD. High-speed graphic presentation and needs for high resolutions like at the physicians detailed examination of computer generated x-ray images still requires CRT-technology.

2.4 Reflexes

The glass surface of CRT-screens often gives rise to reflection of light sources and bright areas in the surroundings. The manufacturers are reducing reflexes generation by applying different optically active layers on the screen surface. Lately, CRT screens with completely flat glass surface instead of traditionally slightly curved surface have been introduced. The flat surface decreases the risk of reflexes from e.g. light sources in ceiling projected in the upper part of the CRT screen.

The screen surface of LCD screens is normally made of a plastic glossy material with low reflectance factor, thus considerably reducing the risk of disturbing reflections. The reflex risk reduction permits the LCD screen to be placed lower and more twisted upward relative to the user, a location often recommended to reduce musculoskeletal strain.


2.5 Viewing Distance

The weight and size of the CRT-screen results in the fact that they are rarely, if ever, moved or adjusted on the desk surface. In contrast, the lower weight and reduced depth of the LCD screens permits frequent movements and adjustments on the desk. Adjustment of viewing distance and body posture is thus easier. An increased need to adjust the viewing distance is seen at work at height adjustable desks when alternating between standing and sitting positions (Fig 1). At standing position, the body is often slightly bent forward, and the face consequently horizontally closer to the desk. This position requires movement of the screen towards the distant desk edge to achieve the optimal viewing distance. The need for distance adjustment is most pronounced in elderly users due to their reduced ability to accommodate at close distances (presbyopia).

Figure 1: Schematic illustration of the difference in viewing distance at sitting and standing work at a fixed screen position.

Sometimes the performance of graphic work is facilitated by temporarily pulling the screen really close for magnification, another advantage of easily movable screens.

2.6 Secondary effect on visual ergonomics

Due to the simplified movements and reduced depth of LCD-screens, the desk surface can be more optimally used for e.g. manuscript holders. The location of the screen on the desk is also critical. The 19” CRTs are so huge that they are often placed in the corner of the desk to get enough space for keyboard and support for wrist and lower arm. Much too often the only corner available is a corner close to a window, which means considerable problems with contrast glare due to unbalanced light intensities from the window and the screen. LCD screens can, due to the reduced depth be placed perpendicular to the window, a location which almost eliminates the risk of contrast glare and reflections in the screen surface from window.

3 Musculoskeletal ergonomics

3.1 Body posture variation

The possibilities to adjust the LCD screen desk position mentioned above are also an advantage for the achievement of good musculoskeletal conditions. The static body posture i.e. fixed neck, shoulder, and back positions most often found at work with CRT screens are a well known risk factor. The fixed positions are mainly due to the fact that the heavy CRT screens, even for strong and tall male users, are difficult to reach and thus relatively even heavier to move as they are located at the far part of the desk. By using a screen that can be easily moved on the desk surface the body posture can be considerably more varied, thus reducing the risk of musculo-skeletal problems. The fact that a LCD screen can be moved must, however, be pointed out to many former CRT users since they are so used to computer screen that cannot be moved on the desk. It is thus an important educational task for all professional categories working with computer ergonomics to teach LCD users that these screens have the obvious advantage that their position should be adjusted to the body posture, instead of vice versa.

3.2 Secondary effect on musculoskeletal ergonomics

The LCD-screen can also be pushed away completely from the central part of the desk surface. Hereby, the desk is more easily converted for task which does not require the computer, an advantage especially in small office rooms with only one desk. These tasks can then be performed on a larger space without spatial disturbance from the screen, which ought to be an advantage for varied body postures and reduced musculoskeletal strain.

4 Other aspects

4.1 Energy consumption

LCD- screens consume considerably less than 50% of the energy needed for CRT-screens of comparable size. A lot of the energy consumed by CRTs are converted to heat which imposes a ventilation problem and often requires further energy consumption due to the need for air cooling acheived by air condition.

4.2 Need for printouts

Improved visual ergonomics would permits an increased proportion of comfortable text reading straight

Figure 2: Common desk location of large CRT screen seen from above.
from the screen instead of reading from a printout. This fact means increased productivity, a reduced number of printouts; in a longer time perspective resulting in decreased need and thus costs for printers, printer maintenance and separate printing rooms.

4.3 Exposure to electromagnetic fields
Although the health risks of EMF exposure in grown-ups is questioned, a lot of employees are concerned about such fields and want to avoid unnecessary exposure. LCD screens produce only a minor fraction of the EMF produced by CRTs and are thus, in this respect, preferred by many users. For users claiming hypersensitivity to electricity, LCD-screens might be the only way to use computers and reach the possibilities like the web and e-mail, social activities they would otherwise be isolated from.

5 Conclusions
Visual and musculoskeletal ergonomics deserve detailed attention when choosing between LCD and CRT screens, including factors like flicker, reflexes, screen mobility and the connected possibilities to vary viewing distance and body posture.
Development of Floor-Cushion with Pelvic Support (Ergo-Zabuton)

Hideki OYAMA (1), Taku Teraoka (2) and Kageyu Noro (3)
(1) Advanced Research Institute for Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan, E-mail: oyamaro@nifty.com
(2) Advanced Research Institute for Science and Engineering
(3) School of Human Sciences, Waseda University, 2-579-15 Mikajima, Tokorozawa-shi, Saitama 359-1192, Japan

ABSTRACT

This paper presents a new ergonomic cushion with the pelvic support. It was developed in order to prevent the musculoskeletal problems of floor seating. Its effectiveness was examined through measuring of the pelvic motion. The result showed that the cushion reduced the rear rotation of pelvis and the flexion of back.

1 Characteristics of the Japanese seated posture

The typical Japanese posture is floor-seated posture. Dainoff (2000) reports that the standing posture for VDT work are increasing in work places in Western countries. The floor-seated posture for VDT work is rare, however, a height-adjustable table to fit the posture from floor-seated to standing has been developed (Herman Miller Inc, USA). In the future, there is possibility that the floor-seated posture will introduce into VDT work. The reason is that changes in work posture (or free posturing) are recommended to reduce fatigue (Kroemer, 1999). The Japanese floor-seated posture for VDT in the office is unknown. However the posture tends to increase at home, especially in the wintertime. Figure 1 shows the floor-seated posture for VDT work.

Figure 1: Floor-seated posture for VDT work

The floor-seated posture is used not only Japan, but is a life posture also distributed widely throughout the world. Figure 2 shows the typical floor-seated postures. To the present time, the musculoskeletal problems of floor-seated posture have been pointed out. One of the main problems in the floor-seated posture is the flattening of lumbar curve. Particularly in VDT work, the flattening of lumbar curve increases, because the trunk tends to lean forward. This is the cause of discomfort and pain. In order to reduce the problem, we developed a new ergonomic cushion "zabuton" to improve floor-seated posture (Figure 3). "Zabuton" is a Japanese sounding name of a floor-cushion.

Figure 2: Examples of floor-seated postures

The floor-seated posture is used not only Japan, but is a life posture also distributed widely throughout the world. Figure 2 shows the typical floor-seated postures.

2 Development of a new ergonomic floor-cushion (Ergo-zabuton)

The feature of the seating tool is following. There are differences between male and female in the Japanese floor-seated postures, therefore two models were developed. In order to reduce the rear rotation of the pelvis, the pelvic support was put into use. The material is hard chipped cork. Cushion material is the polyurethane.

Figure 3: Floor-cushion with pelvic support
Development of Floor-Cushion with Pelvic Support (Ergo-Zabuton)

Hideki OYAMA (1), Taku Teraoka (2) and Kageyu Noro (3)

wrapped with soft polyester. These are being applied for a patent.

3 Experiment: Effect of pelvic support

3.1 Method

The purpose of experiment was to examine the effect of pelvic support. Measuring of the pelvic motion was taken in floor-seated posture. The method referred to Wu’s (1998) one. The measuring system consists of gyroscopic and acceleration sensors. The measuring equipment was fixed to the right iliac crest with the aid of a contact belt. The zero value of the pelvic inclinometer was calibrated corresponding to the erect standing posture of the subject. Back and forward movement of the body (pitch angle) was recorded at a sampling interval of 1 second. In order to analyze the relation between the variation in the inclination angle and the variation in body posture, video recording was made of the subjects from sagittal plane. The subjects were 2 university students (1 male and 1 female).

3.2 Result

Figure 4 shows the time series of the pitch angle while the subject changes the posture from standing to floor-seated. The floor-seated posture was compared under condition with standard cushion (without pelvic support) and new cushion (with pelvic support). By the comparison of the pelvic angle with and without pelvic support, the pelvic angle tends to rotate backwards about 10 degree more in the condition without support. Analysis of VTR observation leads to the conclusion that the subject’s back extends in the condition with pelvic support, and bends in the condition without it.

4 Conclusion

In order to prevent the forward bending posture in the Japanese floor seating, we developed new floor cushion with the pelvic support. As an experimental result on the effect of pelvic support, the cushion reduced the rear rotation of pelvis and the flexion of back. The cushion with pelvic support is proposed, as one of useful tool for the free posturing (from floor-seated to standing posture) in VDT work.

5 References


Figure 4: Variation in the pitch angle of pelvis and the posture, under the conditions with and without pelvic support
Possibility of the Deep Vein Thrombosis Sideration on the Visual Display Terminal Work

Reiko MITSUYA (1), Yuichi Ebine (2), Nozom Sato (3) and Kageyu Noro (4)

(1) Ergonomics of Human Sciences, Waseda University, Mikajima 2-579-15, Tokorozawa-city, Saitama, Japan359-1192 , E-mail: smitstuya@sa2.so-net.ne.jp
(2)+ (3) Industrial Engineering of Science and Engineering, Kinki University, 3-41 Kowakae, Higashi-Osaka City, Japan 577-8502
(4) Ergonomics of Human Sciences, Waseda University, Mikajima 2-579-15, Tokorozawa-city, Saitama, Japan359-1192

ABSTRACT

Recently with the growth of the telecommunication technologies and the office organizations the office worker’s work environment has changed dramatically. Meanwhile the foot swelling is reported on a long-term Visual Display Terminal (DVT) work as a working load to the body. Also the Deep Vein Thrombosis that is called ‘Economy Class Syndrome’ stems from the static posture on the airplane. The foot swelling often occurs when man keeps the static posture. This study focuses on examining the occurrence of the foot swelling on VDT work and researching the relief method of symptoms. The foot swelling was measured by two kinds of methods. One is wet system by water and the other is dry system by measure tape. The experiments were conducted under three different conditions. As a result it was found that keeping the consolidated seating posture for a long time would trigger off DVT and the stretching of the leg and foot should be effective.

1 Introduction

Recently, there have been innovations in the telecommunication technologies and the office organizations through remarkable growth in the use of information technology (IT). This trend has dramatically changed office workers’ work environments. The working stresses become more complicated and diverse, which sometimes result in mental fatigue. Meanwhile the foot swelling is reported on a long-term Visual Display Terminal (VDT) work as its influence to the body.

The VDT works become popular not only in the office, but also at home because personal computers have become into wide use and the Internet users rapidly increased. In addition to the above, the foot swelling often occurs when man keeps the static posture on the airplane, train and bus during the long-distance trip’s. Also, the Deep Vein Thrombosis (DVT) that is well known to us as it is, the accumulated water leaches through the vein and lymph vessel, which twines around the fat tissues causing the hypertrophy.

This study aims to examine the occurrence of the foot swelling and how to alleviate the condition in daily life, by checking the influence of the committed posture on VDT work to the lower legs.

2 Measurement Methods

The foot swelling was measured by two kinds of methods. One was measuring the foot volume (Paul, 1995) by the variations of water using the original water tank (figure 1). The other was measuring the circumference of lower thigh, instep and forefoot with a tape. At the same time the subjective evaluation was conducted by the questionnaire that is related to the discomfort.

3 Subjects and Conditions

Subjects were healthy 5 males and 5 females. They were university students.

The experiments were conducted under the three different conditions. Firstly the subject was operating only VDT work. Secondly the subject was doing the same work with drinking a cup of water twice at 25 minutes intervals. Finally the subject was going on VDT work while doing four kinds of stretching exercises for two times at 20 minutes intervals.

Figure 1: Experimental apparatus (Mitsui et al. 2001)

4 Results

4.1 Foot swelling rate

Figure 2 and Table 1 show the results of the foot-swelling rate each foot parts. The swelling rate was apparently the highest under the condition 1 (only VDT work). By two-way ANOVA the significant difference was showed between the only VDT work and VDT work with stretch-
ing in the maximum circumference of the lower leg. (p < 0.05) The lower swelling rate was the lower leg and forefoot.

And about the result of foot discomfort was showed in figure 3. (The highest score was ten) By one-way ANOVA the discomfort score was higher in VDT work with stretching < VDT work with drinking water < only VDT work apparently.

5 Discussion and Conclusion

For sixty minutes VDT work with stretching was effective for workers to reduce foot-swelling rate, which was concluded in this experiment. By approaching from subjective evaluation, we obtained knowledge that the static posture for long time as a only VDT work affected the physical discomfort, especially the lower leg, foot, buttock that were causes of foot swelling. In this experiment we predicted the risk factor of DVT sid-eration on VDT work was static posture for long term as well as the factor of Economy Class Syndrome.

The results indicated that DVT is likely to occur in daily life especially associated with the VDT work in the modern office where IT is broadly used. Excessive air conditioning and keeping the consolidated seating pos-ure for a long time would trigger off DVT. It was found that stretching is effective (Tetsuka et al. 1996) for elim-inating the foot selling on the VDT operation. Further re-search would be continued.

6 References


Ergonomic Examination of Alternative Sitting and Standing Concepts at the VDU Workplace

Armin WINDEL
Federal Institute for Occupational Safety and Health, Group Ergonomics, Friedrich-Henkel-Weg 1-25, D 44149 Dortmund, Germany, E-mail: windel.armin@baua.bund.de

1 Introduction

Despite the light physical work and the supposed lack of ‘classic’ risk factors for muscular and skeletal diseases, German employees in the office domain in particular are very often affected by muscular-skeletal disorders (see Zoike, 1999). The predominant neck pains and headaches, neck-shoulder-arm syndromes or lumbar and back aches tend to be reversible muscular disorders and cause absence from work more rarely than in occupational groups performing heavy muscular labour. Even so the health of employees working in offices has long been acknowledged as an economic factor. This is highlighted by the numerous movement and back exercise programmes implemented by health insurance organisations and companies since the end of the 80s.

It has not been established beyond all doubt in what proportion the different facets of office work contribute to muscular-skeletal complaints on account of the multiplicity of causes. There is no doubt, however, that so-called circumstantial prevention, where the optimum, i.e. humane design of working conditions is the prime consideration, is of crucial importance in preventing muscular and skeletal disorders.

To summarise, the aim of ergonomic work design is to achieve a balanced load by adapting the task, workplace, working environment and work organisation to human abilities, skills and needs (Fig. 1). Below is an overview of the contribution of alternative office workplace concepts to the prevention of muscular and skeletal disorders. Measures of so-called behavioural prevention, where the study and teaching of healthy modes of behaviour for the person working in an office are the central concern, will not be dealt with at this point.

2 Ergonomic design of the office workplace

To determine the prevention potential of alternative office design, it is necessary to characterise the muscular-skeletal stress and strain situation of office employees: it is mainly characterised by the following disorder patterns affecting the neck, shoulders and back, the head area and the extremities:

- painful limitations of free movement
- painful groups of muscles
- painful tendon insertion points and
- changes in the pattern of movement which can increase the complaints arising (see Schwaninger et al, 1991)

The working conditions connected with these complaints have been studied closely over the past few decades. To summarise, the following strains were identified as risk factors for muscular-skeletal disorders:

- inadequate work equipment and furniture (especially desk and chair)
- unfavourable positioning of the main items of equipment of keyboard and VDU
- lack of system ergonomics (harmonisation of work equipment and furniture and adaptation to the working environment)
- unfavourable task with repetitive sequences of motions
- excessively long daily working hours at the VDU with too few breaks and few changes in posture

Figure 1: Influencing factors affecting the muscular-skeletal stress and strain situation at the office workplace (starting points and examples for circumstantial prevention)
The view – unfortunately widespread – that compliance with the directives or standards leads to effective prevention of muscular-skeletal disorders in office work does not go far enough. Consideration of the criteria required by directives and standards is regarded as a necessary condition, but not a sufficient one. A well-designed workplace, i.e. one installed in every respect to the state of the art, creates, in other words, the conditions for trouble-free work, but this is not sufficient to prevent complaints or promote health.

3 Promotion of movements as a preventive measure in office work

The reasons for this can be sought mainly in unfavourable, static postures, which lead to a lack of movement at the office workplace. In the age of the modern information and communication society, nearly all activities are performed sitting in the office and administrative domain. There are good reasons for this. Standing requires much greater energy than sitting, mainly due to the involvement of larger groups of muscles in the thighs and buttocks. Because fatigue sets in more quickly, standing is not so good for work which involves greater concentration. Extended standing places a greater strain on the hip joint. Because the leg-vein-muscle pump is inactive, blood clots may arise in the leg vessels, which in turn encourages vein disorders such as varicose veins and thrombosis. In addition there is an impaired stability of the trunk, which means that standing as a posture is less suitable in particular for activities with sometimes fine motor requirements (operation of a mouse at the computer) at least over longer periods.

Consequently sitting is regarded nowadays as a generally accepted posture in offices. Because of the anatomy and physiology of the human body, sitting over long periods also causes problems, however. Even at an office workplace designed in all respects in accordance with the state of the art, constant sitting with no change of posture will lead sooner or later to impairments and complaints, depending of the constitution of the individual concerned. In addition to creating optimum working conditions, there is a further, essential goal of ergonomic work design in the avoidance of static postures and the promotion of movement at the workplace. Supplementing the measures already mentioned with respect to individual behavioural prevention, recently alternative workplace concepts have been under discussion (see Berquet, 1991).

Within the framework of a recently concluded research project of the Fraunhofer Institute Industrial Engineering, which was instigated and funded by the German Federal Institute for Occupational Safety and Health, the preventive potential of alternative seating possibilities (high chairs, various forms of swinging axle seats, sitting balls, kneeling chairs) with conventional rotating office chairs according to DIN 4551 and of sitting-standing concepts (various forms for high desks, standing-sitting desks with extreme height adjustment range) was examined as compared to a conventional sitting desk to DIN 4549 (Wittig, 2000). Figures 2 and 3 arrange the various concepts and provide an overview.

The study design not only took account of the comparison of the alternative furniture with the respective conventional sitting and standing-sitting concepts, but also combined alternative sitting with standing-sitting concepts. Various analytical methods were used, which ranged from the measurement of spinal column strain (e.g. based on spinal column flexion), measurement of muscular activities in the lower back and the shoulder-neck muscles, multimoment studies to record the postures, to subjective estimates of the perceived stress-strain situations on the basis of questionnaires. The investigations consisted of a number of combined field and laboratory research series. The field tests involved employees from four enterprises in the banking, insurance and service sectors. In all the random sample consisted of 42 subjects.

The results show that alternative sitting facilities do not generally have a beneficial effect on the muscular-skeletal stress-strain situation as compared to a revolving office chair according to DIN 4551. Kneeling chairs, swinging chairs and in particular also the sitting ball were not accepted by most users after a short time and consequently the users stopped using them. Only the high chair was rated positively compared with the other alternative seating facilities. But it can only be used to a limited extent in the office at conventional desks. Taking account of the body dimensions of the individual concerned, the adjustment range of desks according to DIN 4549 is far too small for nearly 50 % of all office workers. Desks whose height cannot be adjusted and which have heights of 720 or 750 mm are invariably of no use for those using high chairs. The use of a high chair therefore requires desks with an adjustment range substantially greater than that specified in DIN 4549.

Most standing-sitting concepts also exhibit no directly evident benefits as against the conventional desk with office chair: statistically there was no evidence overall of favourable effects on the muscular-skeletal stress-strain situation. Of all alternative standing-sitting concepts, however, the desk with extreme height adjustment (so-called alternating standing-sitting work), where work can be performed both in a standing and in a sitting position, exhibited the greatest potential for supporting movement. While the other standing-sitting concepts were used only between 3 and 5 times a day and the use duration for high desks was on average only 5 minutes and a maximum of 15 minutes, the figures for the extremely height-adjustable standing-sitting desk was greater by a factor of 6 (average use duration) and 4 (maximum use duration). Only with this piece of furniture did most of those asked express the desire to use it again.

To summarise, it was found that high desks degenerate in many cases to an additional place just to put things on. Given the results of the study, it cannot be assumed for the average user that a standing and sitting dynamism is furthered which would counteract the lack of
movement and constrained postures as risk factors for muscular and skeletal disorders. The movement needed to prevent muscular and skeletal disorders in the form of alternating work in a standing and sitting position is possible, however, with the use of an extremely and easily height-adjustable desk at which the individual can work in both a standing and a sitting position. On a critical note, however, it should be said that a meaningful distribution of tasks which combines sitting activities, standing activities and movement (VDU work broken up by phoning while standing, walking to the photocopier and copying while standing ...), would appear to have at least just as high a prevention potential. Corresponding measures have been known for more than 10 years and have been described under the term "mixed work" in many studies. Even so the results of studies to date also show that high desks or alternative sitting furniture can be used meaningfully if the user is appropriately sensitised (e.g. by suffering back complaints). This makes clear that in addition to circumstantial prevention (provision of the high desk), a specific behavioural prevention is needed (encouragement to use what is provided) so that standing-sitting dynamism is actually promoted.

4 References
Quieter Computer Workplaces by Using Noise Emission Data

Peter BECKER
Federal Institute for Occupational Safety and Health, Friedrich-Henkel-Weg 1-25, D-44149 Dortmund, Germany, E-mail: becker.peter@bauge.bund.de

ABSTRACT
Office workplaces are usually equipped with a computer and visual display unit. In this working environment the work tasks have changed to more complexity and to a higher level of mental concentration. An important factor to meet these requirements is a low-noise working environment as it is stated in many directives such as the EC-Directive on Work with Display Screen Equipment.

1 Introduction
Many people working in offices with a computer on or beneath their desk feel annoyed by the noise emitted from their equipment. Typical noise sources are computer components like fans, hard disks and CD-drives or printers and copiers. Although the annoyance is not always recognized directly mental concentration usually becomes lower when the noise level increases.

2 A strategy for a quiet workplace
When planning new offices or buying new computer equipment the easiest way of noise control is to make use of noise emission data given by the manufacturer of the equipment. If the noise emission values are measured and declared correctly, i.e. according to ISO 7779 and ISO 9296, a comparison among the devices of one’s choice can save up to 10 dB(A) of noise level. Moreover this is the cheapest way of noise reduction.

3 Recommended noise levels
The EC-Directive on work with display screen equipment states in its annex 2d) that “Noise emitted by equipment belonging to workstation(s) shall be taken into account when a workstation is being equipped, in particular so as not to distract attention or to disturb speech.”

Keeping noise as low as possible is always a goal in workplace related regulations, target values have been stated in international standards. For diverse types of working rooms ISO 11690 part 1 recommends the maximum background noise levels given in table 1. Here the background noise is noise arising from all indoor technical equipment or noise coming from the outside through windows or from adjacent rooms.

Table 1: Recommended noise levels

<table>
<thead>
<tr>
<th>Room type</th>
<th>Background noise level L_{PAeq} in dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual office</td>
<td>30 - 40</td>
</tr>
<tr>
<td>Multi-person office</td>
<td>35 - 45</td>
</tr>
<tr>
<td>Conference room</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Industrial lab</td>
<td>35 - 50</td>
</tr>
<tr>
<td>Industrial control room</td>
<td>35 - 55</td>
</tr>
</tbody>
</table>

A noise related qualification of office workplaces with display units can be derived from the target values together with some additional criteria
- The noise level from a single identifiable source shall not exceed the overall noise level from the other sources by more than 4 dB(A).
- Speech from other workplaces or from outside shall not be understandable. This means that the disturbing speech level is about 3 – 5 dB(A) lower than the overall background noise level.
- The noise level at workplace caused by all of the sources shall be as low as possible.

The latter leads to the following qualification of a workplace with respect to noise

Table 2: Qualification of workplace

<table>
<thead>
<tr>
<th>Rating level L_{r} in dB(A) at workplace</th>
<th>Noise related qualification of workplace</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 30</td>
<td>optimal</td>
</tr>
<tr>
<td>30 - 40</td>
<td>very good</td>
</tr>
<tr>
<td>40 - 45</td>
<td>good</td>
</tr>
<tr>
<td>45 – 50</td>
<td>acceptable in an industrial neighborhood</td>
</tr>
<tr>
<td>50 – 55</td>
<td>inconveniently but permissible</td>
</tr>
<tr>
<td>above 55</td>
<td>not acceptable</td>
</tr>
</tbody>
</table>

4 Noise emission quantities
There are at least two emission quantities that describe the noise emission from a source, i.e. the declared sound power level L_{WAd} and the emission sound pressure level L_{PA}. Both quantities are determined in accordance to ISO 7779, which defines the whole test procedure with standardized operation conditions.

The sound power level L_{WA} describes the acoustical power radiated from a single source while the emission sound pressure level L_{PA} gives information about the noise from this source at a defined operator’s or bystander’s position.

Because these emission values do not consider background noise from other sources or reflected noise from the ceiling or from walls they are well suited to be
compared among different machines to get information about the state of the art of noise control within a machine group as well as to find the quietest machine on the market. For this purpose ISO 9296 defines the way of declaration of these terms.

A correct declaration of the noise emission therefore must always refer to both ISO 7779 and ISO 9296.

5 Estimation of the noise at workplace

Because of the freefield conditions under which the sound power level $L_{WA}$ and the emission sound pressure level $L_{PA}$ are determined the sound pressure level at a real workplace caused by a particular device will be slightly different (i.e. higher) due to the specific room-acoustical conditions.

For an acoustical qualification of the noise emission of a single device the sound pressure level at the workplace $L_{AP}$ in an office with about 10 m$^2$ of equivalent absorption area can be calculated from

$$L_{AP} = L_{PA} + 10 \cdot \log \left[ 1 + 0.4 \cdot 10^{0.1(L_{WA}-L_{PA})} \right] \quad (1)$$

Note: In accordance with ISO 9296 the declared sound power level $L_{WAd}$ has to be given in Bels (B). So if one does the above calculation with a declared sound power level the $L_{WA}$ firstly has to be multiplied by 10 for transforming into decibels (dB(A)). Secondly the uncertainty of 2.5 dB which the $L_{WAd}$ involves has to be subtracted to get the expected value for $L_{WA}$ to be used in this formula.

The so calculated level $L_{AP}$ then can be taken for an assessment of a workplace qualification with respect to table 2.

In the stage of planning new offices or when going to provide an office with new equipment the noise from each single sound source must be known. Typical sound power levels of different sound sources in an office are given in table 3.

Table 3: Sound power levels $L_{WA}$ of different sources in an office

<table>
<thead>
<tr>
<th>Source</th>
<th>$L_{WA}$ in dB(A) typical</th>
<th>$L_{WA}$ in dB(A) for planning purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person talking on the phone</td>
<td>55 - 70</td>
<td>65</td>
</tr>
<tr>
<td>Personal Computer, idling</td>
<td>30 - 50</td>
<td>45</td>
</tr>
<tr>
<td>Personal Computer, hard disk access</td>
<td>35 - 55</td>
<td>50</td>
</tr>
<tr>
<td>Personal Computer, keyboard writing</td>
<td>55 - 65</td>
<td>60</td>
</tr>
<tr>
<td>Laser printer, idling</td>
<td>&lt;30 - 46</td>
<td>42</td>
</tr>
<tr>
<td>Laser printer, printing</td>
<td>55 - 60</td>
<td>58</td>
</tr>
<tr>
<td>Copier, idling</td>
<td>50 - 60</td>
<td>55</td>
</tr>
</tbody>
</table>

The contribution of a single sound source $(i)$ to the overall sound level in an office room can be calculated from

$$L_i = L_{WA,i} + K_2 \quad (2)$$

where $K_R$ is a correction term which describes the room acoustical conditions, i.e. the absorption of the walls, the ceiling and the floor.

Table 3: Sound power levels $L_{WA}$ of different sources in an office

<table>
<thead>
<tr>
<th>Source</th>
<th>$L_{WA}$ in dB(A) typical</th>
<th>$L_{WA}$ in dB(A) for planning purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copier, busy</td>
<td>60 - 70</td>
<td>67</td>
</tr>
<tr>
<td>Telephone ringing</td>
<td>60 - 80</td>
<td>70</td>
</tr>
</tbody>
</table>

The contribution of a single sound source $(i)$ to the overall sound level in an office room can be calculated from

$$L_i = L_{WA,i} + K_2 \quad (2)$$

where $K_R$ is a correction term which describes the room acoustical conditions, i.e. the absorption of the walls, the ceiling and the floor.

With respect to the three categories

- **reflecting**: only few textile or absorbing covering; no fitted carpet; floor, ceiling and walls made of concrete, roughcast, glass or varnished wood
- **normal**: usual design, possibly fitted carpet, walls and ceiling like above
- **absorbing**: additionally sound absorbing ceiling

the term $K_R$ can be taken from figure 1 for a given floor area.

After the levels $L_i$ of the essential sound sources in the office room have been determined by using table 3 together with figure 1 the resulting sound pressure level $L$ can be calculated by applying the formula for energetical addition.

$$L = 10 \cdot \log \left( \sum_{i=1}^{n} 10^{0.1 \cdot L_i} \right) \quad (3)$$

It should be noted that for a single-person office the sound power levels given for idling operation mode should be used in the calculation preferably. An operation mode “busy” in this case is always caused by the user himself and will probably not contribute to the background noise level that affects the mental concentration on his work task. On the other hand when doing this calculation for a multi-person office the sound power levels given for operation mode “busy” shall always be used.
When planning to provide an office with new computer equipment the above calculation should be done using the declared noise emission values given by the manufacturer or the vendor.

Even if all the computer equipment in an office is turned off there will be a remaining background noise level caused by noise from outside, from adjacent rooms or from house-technical installations. The handling of these topics as well as useful hints for diverse noise control measures and some calculated examples are given by Probst (to be published in 2002).

### 6 A short example

A 4x5 m² room in a quiet neighborhood shall be used as an office and shall be provided with two new personal computers and a laserprinter for shared use. The background noise level in the room due to the noise from outside is 30 dB(A).

Calculations: For a floor area of 20 m² and reflecting conditions figure 1 will give $K_R = -4$ dB. Using the sound power levels of table 3 for planning purpose equation 2 leads to contributions to the background noise level of

$$L_{1,2} = (50-4)\,\text{dB}(A) = 46\,\text{dB}(A)$$

for each of the computers and

$$L_3 = (58-4)\,\text{dB}(A) = 54\,\text{dB}(A)$$

for the printer. Equation 3 then gives 55 dB(A) for the overall background noise level, which is far too much with respect to table 1.

A new calculation with equipment that represents the state of the art of noise control, i.e. the lower values in the second row of table 3, will give

$$L_{1,2} = (35-4)\,\text{dB}(A) = 31\,\text{dB}(A)$$

and

$$L_3 = (55-4)\,\text{dB}(A) = 51\,\text{dB}(A).$$

The two computers will now contribute with 34 dB(A), while the printer is still too noisy in this environment.

Providing the room with a sound absorbing ceiling, which is always recommended for an office room, the factor $K_R$ will change to about $-10$ dB. This leads to

$$L_{1,2} = 25\,\text{dB}(A)\quad\text{and}\quad L_3 = 45\,\text{dB}(A),$$

which is sufficient for the computers but the printer’s noise is still a problem. Depending on the amount of paper to be printed the printer should either be located in a room with lower requirements regarding noise or must be insulated by an appropriate absorbing screen or a capsule.

### 7 References

Risk of Exposure to Extremely Low Frequency (ELF) Electromagnetic Fields in VDU Work Stations

Antonio CASTAGNOLI, Giuseppe Vendramin, Giulia Castellani and Giovanni Fabri
Institute of Occupational Health, Catholic University, Largo A. Gemelli 8, I-00168 Roma, Italy,
E-mail: acastagnoli@rm.unicatt.it

ABSTRACT

The authors present the results of a survey conducted on different types of VDUs to measure and evaluate the occupational exposure to electromagnetic fields (EMF) with frequencies ranging from 5 to 2000 Hz. Further investigations in the frequency range of 2-400 kHz were added. A comparison of the values obtained and indications included in the latest regulations or international guidelines shows that, in the light of present knowledge, these emissions do not pose a safety hazard for workers.

1 Introduction

As a result of the widespread increase in the use of electricity and electrical and electronic appliances since the early 1950s, background levels of electromagnetic radiation have risen considerably.

Since a number of surveys conducted to ascertain health effects related to EMF exposure have failed to provide concordant results, uncertainty has arisen over the establishment of reference levels. As recently as March 2000, an official WHO report entitled “Electromagnetic fields and protective policies” claimed that many epidemiological studies contained weak points such as inadequate evaluation of exposure. This implies that a policy of caution cannot lead to the adoption of arbitrary measures and that the practice of “prudent avoidance” does not make it necessary to establish very low limits in an arbitrary fashion, to be followed at all costs.

On the basis of preliminary findings on EMF exposure in offices, we were able to ascertain that there are three main sources of EMF pollution: VDUs (whose prevailing frequencies range from 50 to 80 Hz, while secondary frequencies may extend from 15 to 100 kHz), radio-bridge with radio beacon pylons, and proximity systems for the controlled access of personnel.

The aim of this study was to determine the intensity of EMFs emitted by VDUs in the offices of a multinational company whose employees spent an average of 6 hours a day in front of videoterminals. It was also to compare findings with the principal regulations current in weaker fields of up to 30 kHz. The frequency range of <1-300 Hz is referred as ELF (extremely low frequency) EMF.

The intensity of the deflection fields depends mainly on the size of VDU: the larger the monitor, the more intense the magnetic fields required. Depending on the model, the highest field values are to be found in front of, behind or beside the screen. The diffusion of alternate electromagnetic fields from the inside to the outside of monitors depends largely on the screening methods used. Modern low-radiation models are well screened, allowing only 20% electromagnetic radiation to filter through.

1.2 Legislation, good practice rules and evaluation criteria for time-varying EMFs

In Italy at the present time, there is no standard set of laws to regulate EMF risk prevention in life and occupational environments, although there are some specific rules concerning telecommunications systems.

At international level, the European Prestandard ENV 50166-1 (experimental regulation adopted in Italy by the Italian Electrotechnical Committee – CEI) establishes electric and magnetic field intensity limits (expressed as effective values – rms values, except for frequencies ranging from 0 to 0.1 Hz, where peak values are used) in relation to frequency both for workers and for the general population; there is also a limit to the number of hours a worker can spend in an electric field at a higher level. These limits are reported in Table 1.

Again at international level, European countries have accepted “ICNIRP Guidelines (1998), issued by the International Commission on Non-Ionizing Radiation Protection, as being the most authoritative. We decided to take them as a reference for our own evaluation. This decision was based on two considerations: firstly, even if the EU has not yet officially passed any directive on this matter, on 12th July 1999 it issued a Council Recommendation (Italy was the only country to oppose the motion) concerning the “limiting of general population exposure to EMFs ranging from 0 Hz to 300 GHz“ (1999/515/EC in EC 30/7/99 Journal) in which it adopted ICNIRP guidelines; secondly, radioprotection even in the field of ionizing radiation, greatly more dangerous
than non-ionizing ones, is largely based on the principle known as ALARA (As Low As Reasonably Achievable).

Table 1: Reference levels for occupational and general public exposure to electric and magnetic fields established by the European Prestandard ENV 50166-1, expressed as effective values - rms values; peak values in the frequency range of 0-0.1 Hz only (modified)

<table>
<thead>
<tr>
<th>Frequency range (Hz)</th>
<th>Electric field (kV/m)</th>
<th>Magnetic field (mT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workers</td>
<td>Public</td>
</tr>
<tr>
<td>0-0.1</td>
<td>42</td>
<td>14</td>
</tr>
<tr>
<td>0.1-0.23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.1-1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.1-50</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>0.1-60</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>0.23-1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1-4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.15-1500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-1500</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50-150</td>
<td>150/f</td>
<td>-</td>
</tr>
<tr>
<td>60-1500</td>
<td>600/f</td>
<td>-</td>
</tr>
<tr>
<td>150-1500</td>
<td>1500/f</td>
<td>-</td>
</tr>
<tr>
<td>1500-10000</td>
<td>1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 3 shows a simplified version of ICNIRP and EC threshold values, adopted for various frequency ranges, so that they can be compared to the strength of electric and magnetic field emitted by VDUs.

In the case of VDUs only, we also refer to Swedish regulations (especially the TCO norm, 1991), recently recommended by the Swedish Board for Technical Accreditation. These are very strict since the Swedes intend to reduce the intensity of EMFs to the lowest levels that can technically be achieved by instruments currently on the market. Swedish limits are shown in Table 2.

Not many years ago there were only a few low-radiation emission screens that complied with the MPR recommendation. Nowadays even the largest monitors can be screened at relatively low cost, so as to meet the standards established by the MPR II recommendation. TCO guidelines are slightly stricter than the MPR II but many experts wonder whether this is a sensible measure, especially as far as the limits imposed for electric field intensity are concerned.

Table 2: Threshold limits for exposure to electric and magnetic fields adopted by Swedish Guidelines (MPR II and TCO); these limits are valid for a distance from the source of 50 and 30 cm, respectively.

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Electric field (V/m)</th>
<th>Magnetic field (µT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPR II</td>
<td>TCO</td>
<td>MPR II</td>
</tr>
<tr>
<td>5-2000 Hz</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>2-400 kHz</td>
<td>2.5</td>
<td>1</td>
</tr>
</tbody>
</table>

2 Materials and methods

Instruments used to evaluate time-varying EM fields. In order to evaluate exposure to extremely low-frequency electric and magnetic fields emitted by VDUs, we used a Wandel & Goltermann EFA-3 field analyser equipped with two isotropic probes to measure the intensity of the electric (E) and magnetic (B) fields, respectively. Measurements performed in frequencies ranging from 5 to 2000 Hz, are expressed in V/m (E) and in µT (B), as unperturbed rms values. Moreover, thanks to the analytical capacity of this instrument, we were able to detect the frequency where field values were higher (prevailing frequency) Measurements were made each time at a distance of 30 and 50 cm (sometimes also at 60 cm distance) from the screen of 23 different types of VDU (5 different makes), some of which were described as being in the “low-radiation emission” category.

On the other hand, exposure to very low frequency (VLF) electromagnetic fields (2-400 kHz) was evaluated using a Combinova FD2 analyzer, fitted with a number of wide-band isotropic probes, both for electric (V/m) and magnetic (µT) fields. Measurements were made each time at a distance of 30 and 50 cm from the screen of 150 different VDUs.

Table 3: Reference levels for occupational and general public exposure to time varying electric and magnetic fields (unperturbed rms values) established by the ICNIRP and adopted by the EC for general public in 1999 (modified, ELF and VLF range).

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Electric field strength (V/m)</th>
<th>Magnetic field strength (A/m)</th>
<th>Magnetic induction (µT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workers</td>
<td>Public</td>
<td>Workers</td>
</tr>
<tr>
<td>up to 1 Hz</td>
<td>-</td>
<td>-</td>
<td>1.63 x 10⁶</td>
</tr>
<tr>
<td>1-8 Hz</td>
<td>20,000</td>
<td>10,000</td>
<td>1.63 x 10⁶</td>
</tr>
<tr>
<td>8-25 Hz</td>
<td>20,000</td>
<td>10,000</td>
<td>2 x 10⁵</td>
</tr>
<tr>
<td>0.8-650 kHz</td>
<td>610</td>
<td>-</td>
<td>24.4</td>
</tr>
<tr>
<td>0.8-3 kHz</td>
<td>-</td>
<td>250/f</td>
<td>-</td>
</tr>
<tr>
<td>3-150 kHz</td>
<td>-</td>
<td>87</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3: Reference levels for occupational and general public exposure to time varying electric and magnetic fields (unperturbed rms values) established by the ICNIRP and adopted by the EC for general public in 1999 (modified, ELF and VLF range).

f as indicated in the frequency range column
3 Results

Table 4 illustrates electric field strength levels in V/m and magnetic field values in µT expressed as effective value (rms value), in the frequency range of 5 to 2000 Hz. The prevailing frequency that mainly corresponded to the maximum intensity of the electric or magnetic field was 50 Hz, with a range extending from 50 to 90 Hz. Table 5 illustrates electric field strength levels in V/m and magnetic field values in µT expressed as effective value (rms value), in the frequency range of 2 to 400 kHz.

Table 4: Mean and range values of electric field strength and magnetic flux density observed at varying distances from VDU:s and expressed as effective value (root-mean-square or rms) in the frequency range of 5-2000 Hz

<table>
<thead>
<tr>
<th>N. of measurements</th>
<th>Distance (cm)</th>
<th>Electric field strength (V/m)</th>
<th>Magnetic flux density (µT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>30</td>
<td>10.45 (0.95-39.0)</td>
<td>0.164 (0.055-0.460)</td>
</tr>
<tr>
<td>23</td>
<td>50</td>
<td>5.81 (0.84-15.1)</td>
<td>0.092 (0.045-0.230)</td>
</tr>
<tr>
<td>23</td>
<td>60</td>
<td>4.62 (0.80-14.7)</td>
<td>0.077 (0.031-0.220)</td>
</tr>
</tbody>
</table>

Table 5: Mean (± sd) values of electric field strength and magnetic flux density observed at varying distances from VDU:s and expressed as effective value (root-mean-square or rms) in the frequency range of 2-400 kHz

<table>
<thead>
<tr>
<th>N. of measurements</th>
<th>Distance (cm)</th>
<th>Electric field strength (V/m)</th>
<th>Magnetic flux density (µT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>30</td>
<td>1.41 (± 1.13)</td>
<td>0.05 (± 0.04)</td>
</tr>
<tr>
<td>150</td>
<td>50</td>
<td>0.83 (± 0.43)</td>
<td>0.02 (± 0.01)</td>
</tr>
</tbody>
</table>

4 Discussion

The values observed for electric and magnetic field strength clearly indicate that levels are lower than the threshold limits established for the general population by ICNIRP and EC guidelines and by the experimental ENV50166-1 regulation. We can therefore exclude the possibility of occupational risk for VDU operators.

Moreover, at a distance of 50 cm from the screen, all the VDU:s examined were within the limits proposed by the Swedish MPR II recommendation for electric and magnetic field intensity emitted during normal occupational activity, in the ELF range (in the VLF range the only magnetic field limits were exceeded in 17 VDU:s out of 150).

However, at a distance of 30 cm from the screen, three “low-radiation emission” VDU:s and three other terminals that were not in this category, exceeded the TCO limits proposed by the Swedish Board to regulate magnetic field exposure. Furthermore, electric field intensity in four “low-radiation emission” VDU:s and in four more VDU:s that were not in this category was found to be above the TCO recommendation level. In the VLF range TCO limits were widely exceeded: in 55 VDU:s out of 150, referring to electric field, and in 139 out of 150, referring to magnetic fields.

We should nevertheless remember that the TCO recommendation is very strict and that the worker station is usually placed at 50-60 cm from the screen. Current knowledge therefore leads us to claim categorically that VDU operators run no risk due to exposure to VDU electromagnetic fields.

5 References

International Commission on Non-Ionizing Radiation Protection (1998), Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), Health Physics, 74 (4), 494-516.

Assessment of Luminous Conditions for VDT Stations Based on Ergonomical and Ergophtalmological Criteria

Jean-Jacques MEYER (1), David Francoli (1), Laurent Michel (2) and Hendrik Kerkhoven (1)

(1) Institute of occupational health, Ergonomics department, 19, rue du Bugnon, CH-1005 Lausanne
E-mail: Jean-Jaques.Meyer@inst.hospvd.ch
(2) Solar Energy and Building Physics Laboratory – Swiss Federal Institute of Technologie (EPFL); LSEO-PB / EPFL-CH-1015 Lausanne – SWITZERLAND, E-mail: Laurent.michel@epfl.ch

ABSTRACT

Whereas, signs of visual strain can be directly attributed to the workload, age and the use of correcting glasses, the relation with poor luminous conditions is less obvious. Based on a series of laboratory and field experiences, with the new discomfort index "J" of the LEV, the authors accepted the hypothesis that one should dissociate the feeling of discomfort to light from the physiological discomfort, depending fundamentally on the papillary illumination and the contrasts between the task and its surroundings as well as the homogeneity of the visual field.

1 Introduction

Fundamentally, the sense of ergonomics consists of making a linkage between the "undesirable effects" on the organism and the behavior of the main "determinants" inherent in part to the subject and partly linked to the job. For vision ergonomics the interest centers particularly around the determinants and effects of processing information. The effects are both objective and subjective. Visual strain symptoms like visual fatigue, red eyes (grouping characteristic signs) reflect the effects of a strong demand of the exploration mechanisms and adjustments. Glare is more directly linked to the perception of over intensive light sources. Lighting engineers distinguish discomfort glare and disability glare. We consider mainly three causes of discomfort, viz.:
1) a lack or an excess of contrast in relation to the size of the objects;
2) the presence of strong contrasts or disturbing light sources in the visual field;
3) insufficient illumination or excessive illumination of the retina ("pupillary illumination"), unfavourable for exploration and focusing mechanisms.

With regard to visual performance, lighting engineers use essentially horizontal illuminations. Whereas this is valid for reading written text on a horizontal document, it ignores illuminations on vertical surfaces (e.g. documents or a screen) and contrasts in the visual field. In the case of working on the screen, these two aspects can hardly be separated, particularly for the part of the visual field known as the ergorama (90° visual field). A direct relation exists between luminosities perceived around the fixed spot and the papillary illumination.

Moreover, one does not consider variations occurring in a general population. For dealing with these factors, the LEV developed the new visual discomfort index "J". This was based on the variations of the acuity as a function of the luminous conditions and the individual performances according to the LEV C45 acuity-luminance test.

2 Method

An evaluation procedure was developed, specially designed with a view to learning the visual aspects of the workload at VDT stations. Inspired by a new model for visual comfort, the procedure contains both, subjective and objective indicators, stemming from three sources:
- a questionnaire relating to the task, the presence of visual symptoms or signs of discomfort and to the perception of the working conditions;
- ergophtalmological tests for evaluating visual performances;
- a series of metric and photometric measurements for evaluating existing luminous conditions in terms of indexes related to efficiency and visual comfort, in particular, the new visual discomfort index "J" of the LEV.

3 Results

The results obtained are based on several hundreds of evaluations carried out within a number of companies examined between 1984 and 2000 and, in addition, on a vast laboratory research program, illustrated with some characteristic examples.

3.1 Field data

They permit a global interpretation of the relations between causes and effects for a number of subjective and objective indicators, classified within groups according to the relevant scales and treated in terms of a multifactorial analysis and cross-tables.

More recent evaluations in the field confirmed a noticeable persistence, if not an increase, in signs of visual and postural strain. Comparable signs of strain could be observed amongst aspect or quality control operators. The causes of visual symptoms did not vary: whereas the duration and the nature of the task represent the first cause, persons at risk are being characterised by
their age, the need for dioptic corrections and by low performance ratings for light-sensibility and contrast tests.

With regard to sensorial discomfort, spontaneous complaints mainly concern thermal and sonic conditions and, to a lesser degree, the luminous conditions. It should be noted that workers often prefer less light, rather than using fluorescent tubes. When subjected to direct questions, however, it appears that, not seldom, complaints for discomfort glare and a feeling of a lack or of an excess of light are being disclosed. Concerning the luminous conditions, a clear interference exists between the psychological and physiological factors: several observations involving a strong visual strain, showed the presence of some concealed feelings of dissatisfaction related to the luminous environment.

Table 1: Examples of photometric data and the corresponding computed indexes (visual field in fig.5)

<table>
<thead>
<tr>
<th>Field data: Bank</th>
<th>Experimental Lab. data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room 4 station 16 sunny</td>
<td>Room 5 station 22 grey</td>
</tr>
<tr>
<td>Sunny grey</td>
<td>Sunny night</td>
</tr>
<tr>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>1= Horizontal illuminance (lx)</td>
<td>109</td>
</tr>
<tr>
<td>2= Vertical illuminance (lx)</td>
<td>152</td>
</tr>
<tr>
<td>3= Computed equivalent surrounding luminance (lx)</td>
<td>321</td>
</tr>
<tr>
<td>4= Recommended screen luminance (cd/m²)</td>
<td>100</td>
</tr>
<tr>
<td>5= Contrast surrounding/screen</td>
<td>3.21</td>
</tr>
<tr>
<td>6= Visibility “J” index as a percentage of dissatisfied</td>
<td>69</td>
</tr>
</tbody>
</table>

1= Horizontal illuminance (lx)  
2= Vertical illuminance (lx)  
3= Computed equivalent surrounding luminance (lx)  
4= Recommended screen luminance (cd/m²)  
5= Contrast surrounding/screen  
6= Visibility “J” index as a percentage of dissatisfied.

Figure 1: Evolution of complaints at different workplaces from 1984 through 1999.

Figure 2: Relationship between symptoms and causes in publisher1 staff.

Figure 3: Sensorial discomfort in the different groups.

Figure 4: Assessment of lighting in the different rooms of the bank group.

Figure 5: Examples of typical illumination conditions.
Assessment of Luminous Conditions for VDT Stations Based on Ergonomical and Ergophtalmological Criteria


Jean-Jacques MEYER (1), David Francoli (1), Laurent Michel (2) and Hendrik Kerkhoven (1)

According to the meteorological conditions and the moment of the day, as well as the structural and architectural characteristics of the different rooms in the same company.

The new evaluation criteria illustrate better than the solely horizontal illuminations, the large variability of lighting condition. Thus, a same index value may relate to different illumination levels and that, on the contrary, equal illumination levels may correspond to completely different indexes.

3.2 Laboratory experimentation

Following the ergophtalmological test, the subject was then invited to execute a series of on-screen acuity tests. After these he had to complete a questionnaire, equally on-screen, in order to give an appreciation of the quantity of available light, taking into account the illumination of a document on his left hand side, the discomfort glare and the colour temperature as well. The test took only some 5 to 7 minutes, but it had to be repeated four times for different illumination conditions. A fish-eye picture of the visual field was taken each time and also a number of luminance and illuminance measurements. Part of the main results are exposed in figure 7.

The tested illumination conditions, characterized with relatively homogeneous visual field, confirm the individual variability of the reactions to light. As demonstrated by the "J" index, these are being influenced by the contrasts within the visual field and the papillary illumination.

4 Conclusion

First of all, the persistence of the signs of strain, or even their increase, may appear surprising in the light of a general improvement of materials and a large distribution of recommendations. Nevertheless, according to the laboratory experiences, one should give increased priority to improving the visual conditions taking rather more into account the variability of the reactions to light. Whenever possible however, when setting up workstations, one should from the very beginning plan an individual light-management system, both for natural and artificial light sources, and their influence on the visual field.

5 Acknowledgement

The Swiss National Science Foundation supported this research - No 3220-057039.99/1

6 References


Figure 6: Experimental set up and example of corresponding fish-eye visual field.

Figure 7: Relation between the feeling of a lack/excess of light on the task and the "J" index, taking into account the physical and physiological parameters.

\[ J = 1 - A_1(C) A_2(L_1, L_e) A_3(E_p, L_m) \]

C = Contrast on screen; L_1 = Screen luminance ; L_e = equivalent surrounding luminance ; E_p = pupillary illuminance ; L_m = Maximum individual accepted luminance in C45 reference test.

A_1, A_2, A_3 = relative acuity factors for individual C45 test maximum acuity. J_1 are J value optimised for screen luminance (\(= 100 \text{ cd/m}^2\)).
Intelligent Light for the Computer Workplace

Jörg PFEFFERLE
Waldmann Lichttechnik, Peter-Henlein-Straße 5, 78056 Villingen-Schwenningen, Germany, e-mail: j.pfefferle@waldmann.com

1 Introduction

Light is one of the biologically effective factors that determine the psychophysical balance of the human body. Ergonomics at the computer workplace requires a holistic approach that goes far beyond relaxed seating position and the correct viewing distance from the monitor. The characteristics of ambient light strongly influence the mood of the work environment. Natural sunlight makes people feel livelier and creates a positive, active mood. Contemporary architecture acknowledges this need by increasing window size, even in areas such as conference rooms.

2 Requirements of today

This presents a new set of challenges for modern lighting systems that go far beyond the basic need to provide light:
- Interaction between natural and artificial light
- User-oriented lighting climate
- Individual control
- Low maintenance
- Energy efficiency

Besides these requirements, lighting must comply with the latest national and international legislation. To satisfy these highly demanding requirements, modern lighting systems offer far more than an on-off switch, and include options such as dimming, automatic control, remote switching, and interaction with sunlight. The term light management is used to describe systems offering these features.

3 Light Management

Light-management systems are often an integrated part of building management systems, or bus technology. Alongside heating, air conditioning, window shades, security systems, etc., lighting is controlled centrally. This allows, for example, lights to be switched off at predefined times such as when the building is empty. Besides helping to save energy, it is also very convenient.

An alternative to bus-controlled lighting systems and special bus light-management systems are light-management systems built into luminaires. These systems can be individually controlled, and offer significant technical advantages. They also eliminate the expense of bus installation throughout a building.

When choosing a luminaire-integrated light-management system it is essential to look closely at performance of a system. Simply adding off-the-shelf light and motion sensors to standard office luminaires is unlikely to produce satisfactory results. Good lighting must satisfy users’ ergonomic requirements. However, conventional systems are not up to the task, as their basic components cannot cover the necessary performance spectrum.

4 Our solution

Light management at the computer workplace means intelligent light, tailored to users’ individual needs. Here system luminaires, such as the Waldmann Legato P, create an ideal lighting climate in the room or the individual work space. The Legato P’s precision light sensors are “linked to the sun” and adjust light output depending on how intensive sunlight is within the room. A further innovation is the integrated HFMD presence module. The light switches off automatically after a few minutes if no-one is in the room. Combined with the light-level control, this can mean energy savings of up to 70 percent. If the employee returns to the room, the light not only switches back on, it also adjusts itself to the individually set level.

Despite all the advanced technology, luminaire-integrated light management is successful only if it meets users’ physical and psychological needs. Numerous studies show that a light-management system that does not allow individual adjustments can lead users to reject or even sabotage it (Velds and Knoop; Knoop and Velds, 2000; Knoop et al. 1997). A high priority for such intelligent systems is therefore simple and intuitive operation. Employees at their workplaces should be able to adjust lighting to their needs without expert help. Only then can this innovative technology effectively improve the lighting conditions at the computer workplace and promote better workplace performance.

5 Product features

The following need to be taken into account when choosing luminaire-integrated light-management systems:
- Light sensors for interactive, automatic light adjustment (depending on the amount of daylight in the room) should be very precise and work according to a proportional dimming strategy. In other words, sunlight and artificial light should be evaluated differently to achieve most harmonious lighting effect
- Adjustment and dimming should be pleasant and unobtrusive, as a result of measured impulse delay and asymmetrical dimming characteristic
- Frequently chosen light levels should be easy to store and recall
- The integrated presence sensor should be adjustable to match the area covered, and should detect the slightest movements within 5 - 6 m without
error. High-frequency detectors (radar) currently offer the best results

• It should be easy to add sensors to larger presence areas

• The system should offer numerous additional settings, set with dip switches, to offer maximum customizability for any environment, e.g. centralized control, stationary operation

• Operation should be simple and intuitive. Easy-to-read LEDs should provide useful feedback about the lighting status of the device

6 References


Visual Fatigue and Preferences of VDT Users under Different Lighting Systems

Agnieszka WOLSKA
Central Institute for Labour Protection, Czerniakowska 16, 00-701 Warszawa, Poland, E-mail: agwol@ciop.pl

ABSTRACT

There are different types of lighting systems suitable for VDT work, which at the same time create different interior appearances with respect to the main lighting parameters at the recommended levels. The aim of the study was to model different lighting systems for VDT work and determine their influence on the users’ preferences and visual fatigue. The results of the study showed that visual fatigue (the smallest changes in visual functions like accommodation and convergence) is the lowest for indirect and compound lighting systems. On the other hand generally the most preferred lighting system is direct lighting realized by “dark-light” luminaires but some interesting preference differences according to age, gender and VDT work experience were found. On the basis of obtained results some guidance for lighting designers could be provided.

1 Introduction

Prolonged use of VDTs has been established as a reason for visual problems, which are often called asthenopic symptoms. Among the symptoms of asthenopia are: sore, tired, tender, itchy, dry, burning or aching eyes, blurred or double vision, redness, lacrimation and headache. VDT operators very often report them. The ergonomic evaluation of the work of VDT operators in Poland confirmed that the highest percentage (above 90%) of complaints from persons working with computers concerns discomfort associated with eyesight (Kamienska-Zyla, 1993). One of the main environmental factors which influences users’ visual fatigue is lighting (Anshel, 1998; Bergqvist, 1984; Çakir, 1991; Wolska & witua, 1999). According to lighting requirements, illumination of VDT stands can be realized in different ways using different luminaires. All these lighting realizations fulfill the requirements of standards, but this is not enough to obtain users’ acceptance of lighting. The luminous environment in a given room differs significantly depending on the lighting system and type of luminaires which are used. The variety of lighting realizations for a given room, which ensure compliance with lighting requirements for VDT work give lighting designers an opportunity to create a wide range of luminous environments. Lighting should ensure that visual work conditions do not themselves result in fatigue. This means that people feel comfortable and do not complain about a lot of visual fatigue symptoms. A user-friendly luminous environment mostly depends on the users’ preferences. If something is not accepted and is not perceived as comfortable it becomes the cause of fatigue.

Even though it seems obvious that lighting correlates with users’ visual fatigue and well-being there are no reports about experimental laboratory studies concerning the influence of the type of lighting system on visual problems during VDT work and on users’ preferences.

The purpose of the study was to model different lighting systems for VDT work and to improve knowledge in the field of choosing best lighting systems for VDT stands with LCD screens, taking into consideration visual fatigue and users’ preferences.

2 Method

2.1 Participants

Participants were selected according to the criteria of age (under 40 years old), eye state and VDT work experience (novices and professionals). VDT work experience was evaluated during a pre-study group selection on the basis of an interview. The group consisted of 44 participants (15 women and 29 men) aged 17–37 with a mean age of 22.25 years. At the same time the group was composed of 22 novices and 22 professionals. All participants volunteered to take part in the study and underwent training in VDT work before the experiments. They had to become familiar with the visual task simulated by a computer program.

2.2 Lighting conditions

Experiments were carried out in laboratory conditions for the following lighting systems suitable for VDT work:

- direct-indirect (DI-L) realized by “soft-light” fluorescent luminaires ABML 2x58W,
- direct (D-L) realized by “dark-light” fluorescent luminaires XRD 2x36 W,
- indirect (I-L) realized by “uplight” fluorescent luminaires TCS 663 2x58 W,
- compound - general and task lighting (C-L) realized by an indirect lighting system as general lighting and low-luminance desk luminaire Wacolux 801 (special VDT workplace luminaire).

All lighting systems were connected with a luminous flux control system, which allows easy adjustment of lighting parameters and no flicker effect was observed. Windows in the laboratory had blinds and curtains to avoid the influence of natural lighting (daylight). The main assumption of modelling lighting conditions for each lighting system was to obtain the same illumination level of about 500 lx on the work surface – a desk and to avoid direct and reflection glare.
2.3 Experimental design

Participants performed a specially prepared visual task (Landolt’s rings) for 1.5-2 hrs. During the study, each participant took part in 4 experimental sessions (1 session for one lighting system). A computer program simulated the task and measured time needed to perform the task and the number of mistakes. Before and after the experimental session the near point of convergence and accommodation were measured. The near point of accommodation (NPA) and the near point of convergence (NPC) were measured by RAF (Clement Clarke, UK), the near point rule according to the measurement method described by London (1991a, 1991b). After each experimental session participants had to fill in a questionnaire, which concerned both visual complaints and lighting assessment.

3 Results

3.1 Visual fatigue

The mean values of complaints intensity indicated that all asthenopic symptoms were assessed as small or medium regardless of the lighting system. The biggest intensities of discomfort were found for tired eyes, redness, blurring, sensitivity to light, burning, heaviness of eyelids, lacrimation and itching. It was established (Wilcoxon signed ranks test) that sensitivity to light was significantly bigger for C-L than for D-L (p=.02), tiredness of eyes was significantly bigger for DI-L than for either I-L (p=.05) or C-L (p=.04), heaviness of eyelids was significantly bigger for C-L than for either D-L (p=.05) or DI-L (p=.003) and redness after the experiment was significantly bigger for both C-L (p=.003) and I-L (p=.01) than for the DI-L lighting system. The most frequently reported complaints were tired eyes, blurring, redness, burning, lacrimation and sensitivity to light. Changes of NPA and NPC were obtained by subtracting “before” values whereas changes of the accommodation amplitude (AA) by subtracting “after-before” values whereas changes of the accommodation amplitude (AA) by subtracting “before-after” values for each participant. Those changes were statistically analysed. After the experimental session period NPA and NPC moved away from the eyes, which corresponded with the reduction of accommodation and convergence abilities of the eyes. The mean changes of accommodation and convergence after VDT work under different lighting systems are presented in table 1. Although the biggest reduction of accommodation was found for DI-L and the smallest for the C-L lighting system; these changes did not differ significantly. According to ANOVA analysis, convergence changes did significantly in relation to the lighting system (F(3)=3.16, p=.03). The biggest convergence reduction was found for the DI-L lighting system, which was significantly bigger than convergence changes for the I-L (p=.02) and C-L (p=.005) lighting systems.

However the assessments of the considered lighting systems did not differ significantly. The room illuminated by the DI-L system was the one most frequently assessed as too bright, which was perceived as strenuous (and could be the cause of discomfort glare) for 37% of the participants.

Table 1: Changes of accommodation and convergence under different lighting systems

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lighting system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DI-L</td>
</tr>
<tr>
<td>NPA, cm</td>
<td>0.99</td>
</tr>
<tr>
<td>SD</td>
<td>1.46</td>
</tr>
<tr>
<td>Variance</td>
<td>3.13</td>
</tr>
<tr>
<td>AA, Dptr</td>
<td>0.79</td>
</tr>
<tr>
<td>SD</td>
<td>1.34</td>
</tr>
<tr>
<td>Variance</td>
<td>1.81</td>
</tr>
<tr>
<td>NPC, cm</td>
<td>1.38</td>
</tr>
<tr>
<td>SD</td>
<td>1.69</td>
</tr>
<tr>
<td>Variance</td>
<td>2.84</td>
</tr>
</tbody>
</table>

3.2 Lighting assessment

Most participants assessed the D-L system as comfortable for visual task and would have liked to work under this lighting system (see figure 1).

Figure 1: Quality assessment of lighting systems

Spearman correlation analysis between subjective assessment of lighting features and age, gender and experience in VDT work revealed that:

- females more often than males found excessively bright surfaces in the room under the I-L system (r=.54, p<.001), which could be the reason of their more rarely assessed that system as comfortable for visual work;
- females more rarely than males chose the D-L (r=-.33, p=.03) and I-L (r=-.47, p=.001) systems for regular work;
- professionals more often than novices chose the I-L (r=.37, p=.013) system for regular work;
- older participants more rarely than younger ones chose the D-L (r=-.47, p=.001), D-L (r=-.4, p=.007) and I-L (r=-.39, p=.009) systems for regular work;
- females more often than males found the room too bright under the C-L system (r=.26, p=.001),
- generally there is a tendency that females more often than males found surfaces in the room to be...
Visual Fatigue and Preferences of VDT Users under Different Lighting Systems

4 Conclusions

The luminous environment in a given room differs significantly depending on the lighting system and type of luminaires which are used.

From the point of view of visual fatigue the best lighting systems are indirect and compound lighting systems. However, a compound lighting system should be used with special care for realization of task lighting.

The obtained results show that about 1.5 hours of VDT work (with visual attention mainly on the screen) could cause small or medium asthenopic symptoms, regardless of the lighting system. However it seems that direct-indirect and compound lighting systems are the most problematic. They should be used with special attention to their appropriate anti-glare realization.

From the point of view of the users’ general preferences the direct lighting system with “dark-light” luminaires is the most preferred. But lighting system preferences with regard to users’ features differ and some guidance for lighting designers could be provided.

When most users in a given room are male indirect or direct (with “dark-light” luminaires) systems are preferred. Females and novices in VDT work are more sensitive to very bright surfaces in a room than males and professionals and they feel more comfortable when the luminances (mean values) of walls and the work surface do not exceed 60 cd/m². Additionally novices, contrary to professionals, do not prefer an indirect system. The compound system is recommended mainly for older users, who mostly prefer that system.

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6 References


