Computer users' health risks caused by the simultaneous influence of inadequate indoor climate and monotonous work

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Abstract. This paper is aimed at improving the workplace ergonomics of computer workers (working as information-technologists or in offices and at the till of trade companies). The paper includes the assessment of the risk of monotonous work, but also the influence of indoor climate conditions on development of health damages at workplace (developing carpal channel syndrome). A questioning of workers was carried out (Kiva questionnaire) to clarify the opinion of workers about the work atmosphere at the workplace. The novelty of the study is that the work conditions (indoor climate, lighting, noise) are closely connected with the monotonousness of the work. Cold temperatures (<20°C in office), bad lighting (<300 lx at the till or <400 lx in the office) are supplementary factors for developing the musculoskeletal disorders. The results of analysis of repetitive work (ART tool) show that the intensity of work for workers totally engaged in info-technology is high, but in some way monotonous, therefore health problems like musculoskeletal disorders are very common. The rehabilitation possibilities are proposed. The questioning of the workers showed that the workers working with computers are focused on their own work tasks and do not require very much the relations with the co-workers.

Key words: computer workers, musculoskeletal disorders, indoor climate conditions.

Introduction

The human body responds to the work environment hazards through four systems – central nervous, automatic nervous, endocrine and immune – which are constantly interacting as a complex network (Raja et al., 1996). A safe workplace design commonly presumes the decrease of physical overload factors like heavy weights; working in a compulsory position or monotonously, but often the other work environment hazards, like low temperatures, high noise levels etc. have to be carefully considered. These hazards in the work environment which affect office workers are considered to be stress factors that alter the functioning of the organism and damage the peripheral and central nervous system (Galinski et al., 2007; Tkatsova & Tint, 2010; Kaidis et al., 2011).

Working with computers presents ergonomic risks due to fixed and often awkward postures that are maintained for a too long time, repetitive and sometimes forceful (Chang et al., 2007; Nag et al., 2009; Zakerian, 2009; Malinska et al., 2010; Mueller & Hassenzahl, 2010). Repetition strain injury (or overuse syndrome) caused by physical overload include such common lesion as the channel bursitis, etc. (Orsila et al., 2011). This group of diseases includes mono-and polyneuropathies, compression. In the case of repetitive strain injuries affecting the upper extremity, the prime cause of injury is continuous repetitive and/or static overuse of muscles in one-way movement patterns, which are used to perform most work activities (typing, writing, using a computer mouse).

Material and methods

The work conditions of the Estonian workers (n = 106) using the computer in their everyday work were investigated. The number of info-technology workers was 73. As a control-group the consumer workers (using computers, n = 33) working at different trade companies (at the till; in offices) were examined. Different methods were used: the ART tool for assessment of repetitive work (Health and Safety Executive, UK and the measurements in the work environment; Kiva questionnaire (Näsman, 2012; Tuomivaara et al., 2012) which all are directed to determination of hazards in the work environment. The preventive (rehabilitation) measures were also recommended.

The method used for monotonous work assessment (The ART Tool)

In January 2007, the Health and Safety Executive (HSE) presented the Health and Safety Laboratory (HSL) with a prototype of a tool for the risk assessment of repetitive tasks of the upper limbs. The tool was named ART tool (Assessment of Repetitive Tasks). The technical content of ART draws upon earlier work to develop the Occupational Repetitive Actions methods (Colombini et al., 2002) and the Quick Exposure Check (David et al., 2008). As a result, ART examines twelve risk factors that have been grouped into four stages: 1) Frequency and repetition of movements; 2) Force; 3) Awkward postures (of the neck, back, shoulder/arm, wrist and hand); and 4) Additional factors (which include aspects of task duration, recovery, perceived work pace and other object and work environment factors).

The assessment is split into four stages: Stage A: Frequency and repetition of movements; Stage B: Force; Stage C: Awkward postures; Stage D: Additional factors. The result is the sum of these four stages.

Task score = A1 + A2 + B + C1 + C2 + C3 + C4 + C5 + D1 + D2 + D3

If you assess both arms, the scores for the left arm and right arm should be kept separate and not combined.

The calculation of the exposure score (risk level) is got when the task score is multiplied with the duration multiplier.

Task score [ ] X Duration multiplier [ ] = Exposure score [ ]

The task scores and exposure scores help prioritise those tasks that need most urgent attention and help check the effectiveness of any improvements.

The system for interpreting the exposure score is proposed in the table below:

Exposure score	Proposed risk level	Actions needed
0–11	low	consider individual circumstances
12–21	medium	further investigation required
22 or more	high	further investigation required urgently

Measurements in the work environment

Measurements in the work environment are based on ISO, EN DIN, EVS standards: ISO 7726:1998 'Thermal environments – Instruments and methods for measuring physical quantities'; EN 15251:2007 'Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics', EN 12464-1:2002 'Light and lighting- Lighting of work places- Part 1: Indoor work places', EVS 891:2008 'Measurement and evaluation of electrical lighting in working places', ISO 9612:2007: 'Acoustics – Guidelines for the measurement and assessment of exposure to noise in a working environment'. The measuring equipment used for microclimate: TESTO 435. TESTO 435 enables also the measurements of CO_2. Measurements of lighting the workplaces and screen were performed using the light-metre TES 1332 (ranges from 1–1,500 lx). The lighting was measured on the worktable, on the screen and on the keyboard. Lighting was measured at the local workplaces (normally at a height of 0.80 m above floor level), where a suitable measuring grid was applied. Noise, was measured using a hand-held Type II Sound Level Meter (TES 1358).

Results

The health complaints at work are often caused by badly designed workplace, but these shortages are closely connected with indoor climate conditions (bad microclimate, excessive noise, insufficient lighting). Sometimes the psychosocial factors also take place as not good relations between the employers and employees, stress coming from home or street with the workers to the workplace etc.). Therefore these three components were investigated thoroughly. The results of indoor climate investigations (considering the exposure limits) are given in Table 1 and 2. The air temperature in the stores' offices is sometimes under the norms (<20°C). The lighting at the till was insufficient in some of the investigated firms.

Table 1. The assessment of indoor climate at workplaces

Company	Risk level	Air temperature, °C, U*=0.6°C	Air velocity, $m\ s^{-1}$ U*=0.01 $m\ s^{-1}$	Air humidity, % U*=2.0%
The limit	< 4	20–22 ^{0}C	<0.3 $m\ s^{-1}$	30–60%
Public administration institution, computer workers (53)	1–2	22–22.4	0.1	34–41.5
Medium-sized industrial com-pany1,computer workers (20)	2–3	22.0–22.8	0	22.4–25.7
Big trade company 1, workers at the till (10)	2	19	0.03	50
Big trade company 1, office workers (10)	3	18–19	0.1–0.3	48.4
Big trade company 2, workers at the till (10)	3	19	0.01–0.03	50.5
Medium-sized trade company 3, workers at the till (3)	3	19	0.01–0.03	48.4

(Abbreviation: *U – uncertainty of measurements, k = 2)

Table 2. The assessment of lighting, noise and the content of CO_2 at workplaces

Company	Lighting, lx U*=10.4%	Noise, dB(A) U*=2.0 dB	CO_2, ppm U*=10 ppm
The limit	300–500 lx	55–60 dB	<800 ppm
Public administration institution, computer workers (53)	306–704	45–50	650–731
Medium-sized industrial company 1, computer workers (20)	284–643	45–50	700–1091
Big trade company 1, workers at the till (10)	250–300	60	660
Big trade company 1, office workers (10)	300–350	55–60	850
Big trade company 2, workers at the till (10)	400	60–65	750
Medium-sized trade company 3, workers at the till (3)	400	65	760

(Abbreviation: *U – uncertainty of measurements, k = 2)

The results of repetitive work are given in Table 3. The results of KIVA questionnaire are given at the end of the chapter (Results).

Table 3. The assessment of monotonous work by photo method

Workplace		A1/A2	B	C1/C2	C3/C4	C5/D1	D2/D3	D4	RL
Fig. 1	R	3/3	4	0/1	2/2	½	½	1	21 – medium
	L	3/2	2	0/0	0/1	0/2	1/1	1	13 – medium
Fig. 2	R	6/0	2	2/0	4/0	0 /6	1/1	1	22 – **high**
	L	3/0	1	2/0	2/1	1/6	1/1	1	18 – medium
Fig. 3*	R	3/3	4	0/1	2/2	½	1/1	1	20 – medium
	L	3/0	2	0/0	0/1	0/2	1/1	1	11 – low
Fig. 4*	R	3/3	4	2/2	4/1	2/2	1/1	1	25 – **high**
	L	3/0	2	2/2	4/0	½	1/1	1	18 – medium
Fig. 5*	R	3/3	2	2/2	2/0	2/0	0/0	1	16 – medium
	L	0/0	0	2/0	2/0	2/0	0/0	1	6 – low
Fig. 6*	R	3/3	2	2/2	0/0	2/0	0/0	1	14 – medium
	L	3/2	0	2/0	0/1	0/0	0/0	1	8 – low

L – left hand, R – right hand
* not shown in the paper

Fig. 1. Work at the till.

Fig. 2. Receivers of goods.

Fig. 1. The worker is sitting appropriately with the scales within reach of her right hand. No excessive movements are necessary. The work is monotonous.
Right hand: RL= (6+0+2+2+0+4+0+0+6+1+1)x1=22; risk level: medium
Left hand: RL=(3+2+2+0+0+0+1+0+2+1+1)x1=13; risk level: medium.

Fig. 2. Receivers of goods: their work is before computers 90% of the workday. The work is monotonous.
Right hand: RL=(6+0+2+2+0+4+0+0+6+1+1)x1=2; risk level: high
Left hand: RL:(3+0+1+2+0+2+1+1+6+1+1)x1=18; risk level: medium.

The analysed photos (Figs 3*–6*, Table 3) were taken in different big trade companies' offices and salesrooms at the till. Fig. 3* is analogue to the Fig. 1 in a different trade company. The scales position in Fig. 1 and Fig. 3* is ergonomical, there is no need to twist the body. Fig. 4* is analogue to Fig. 1, but the scales are not ahead of the worker, but can be in the right or left position. Fig. 5* is taken in an office-room of accountants. The lighting is too low which is the supplementary risk factor for developing physiological complaints. The workers are working with computers 50% of the workday. Fig. 6* is taken in the office room for scientific workers. To improve the work conditions, the workplaces are separated with supplementary walls between the work-tables. The worker is working with the computer 30% of the workday.

There are different possibilities to make the work-place more comfortable. Some possibilities for the ergonomic design of workplace for computer workers are given in Figs 3–5.

Fig. 3. A sitting rest.

Fig. 4. The worker is sitting on the ball.

Fig. 5. The height of the working table could be regulated.

The results of Kiva personnel questionnaire (info-technology workers) gave the result that the job is very meaningful for the workers. The workers assessed the factor in 10 point scale (1-bad; 10-very good). The questions and answers (ANS) were: Have you enjoyed coming to work in the last weeks? ANS: 6.05; How meaningful do you regard your job? ANS: 8.17; How well do you feel in control of your job? ANS:4.20; How well do you get on with your fellow-workers? ANS:2.44; How well does your immediate superior perform as superior? ANS:3.40; How certain you are that you will keep job with this employer? ANS:5.01; How much can you influence factors concerning your job? ANS:3.30. The lowest mark is given to the relationship with the co-workers, but the work with computers usually does not need very much to be related with the other workers, it is more related to the computers. The work is very meaningful for the workers. The dispersion of the study was 95% and the level of significance 0.05.

Discussion

The work is repetitive both for workers (at the till and info-technology), but the movements, made by the right hand, are different. The probability of developing the carpal-syndrome disease is higher for info-technology workers who use the mouse. As the number of musculo-skeletal disorders has risen caused by the work with computers so the rehabilitation methods are very important. The authors of the present study suggest the following: the complex treatments of these syndromes include active and passive methods of physiotherapy. The active part is organized by the physiotherapist. Systematic application of physical education, exercise therapy improves the functional capacity of the organism to physical stress. The role of the physical therapist in the occupational health team is to ensure that an optimum work environment exists for the prevention of injury and for the rehabilitation of work-related impairment, activity limitation, and participation restrictions. There are also physical therapies which influence the tissues metabolic activity and have positive influence on the repairing process. These are massage, physical agents therapies and water immersion therapy. The most important is the workplace ergonomic design (Figure 3–5) to prevent the health damages.

Conclusions

The indoor climate in big stores conduce to musculoskeletal disorders and carpal syndrome in the hands (particularly for the workers in stores, but also in the counter). The air temperature in the stores' offices is sometimes under the norms (<20°C). The lighting at the till was insufficient (<300 lx) in some of the investigated firms. The info-technology workers often work with under-lighted working conditions although there is a possibility to raise the lighting to the normal limits (400–500 lx). The work in the office and at the till on both monotonous, but differently. The risk scores for right and left hand are different. The questioning of the workers showed that the workers working with computers are focused on there own workplace and work-tools and are not very much related to the co-workers. The interior architect has to follow the ergonomic principles of workplaces from the beginning of the building use. The expectation of having to remain in a sitting position when working with computers should be diminished. The rehabilitation is necessary for both type of the workers (in info-technology and trade companies).

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References

Chang, C-h., Amick, B.C., Menendez, C.C., Katz, J.N., Johnson, P.W., Robertson, M., Dennerlein, J.T. 2007. Daily computer usage correlated with undergraduate students' musculoskeletal symptoms. *American Journal of Industrial Medicine* **50**(6), 481–488.

Colombini, D., Occhipinti, E., Grieco, A. 2002. Risk assessment and management of repetitive movements and exertions of upper limbs: job analysis, In: OCRA risk indices, prevention strategies and design principles. Elsevier Science Ltd, London.

David, G., Woods, V., Li, G., Buckle, P. 2008. The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. *Applied Ergonomics* **39,** 57–69.

Galinsky, T., Swanson, N., Sauter, S., Dunkin, R., Hurrell, J., Schleifer, L. 2007. Supplementary breaks and stretching exercises for data entry operators: A follow-up field study. *American Journal of Industrial Medicine* **50**(7), 519**–**527.

Kaidis, V., Tint, P., Tuulik, V. 2011. Prevention of physiological and psychological stress in a food retail chain in Estonia. In: Work, Stress, and Health 2011. Work and Well-being in an Economis Context. American Psychological Association (APA). Conference abstracts. Orlando, May 2011, 1p.

Malinska, M., Bugajska, J. 2010. The Influence of Occupational and Non-occupational Factors on the Prevalence of Musculoskeletal Complaints in Users of Portable Computers. *Journal of Occupational Safety and Ergonomics* **16(**3), 337–343.

Mueller, G.F., Hassenzahl, M. 2010. Sitting Comfort of Ergonomic Office Chairs-Developed Versus Intuitive Evaluation. *International Journal of Occupational Safety and Ergonomics (JOSE)* **16**(3), 369–374.

Nag, P.K., Pal, S., Nag, A., Vyas, H. 2009. Influence of arm and wrist support on forearm and back muscle activity in computer keyboard operation. *Applied Ergonomics* **40**(2), 286–291.

Näsman, O. Metal Age and Kiva-questionnaire. Assist in navigation towards well-being at work. Mediona OyAb. The Archipelago Academy for Well-being at Work http://www.mediona.fi/pdf/KANSI%20Metal%20Age%20ja%20Kiva-kysely%

Orsila, R., Luukkaala, T., Manka, M.-L., Nygard, C.-H. 2011. A new approach to measuring work-related well-being. *International Journal of occupational Safety and Ergonomics (JOSE)* **17** (4), 341–359.

Raja, A., Tuulik, V., Lossmann, E., Meister, A. 1996. Neural network approach to classify the functional state of CNS in case of neurotoxic diseases. *Medical & Biological Engineering & Computing* **34**(suppl.1), 241–242.

Tkatsova, L., Tint, P. 2010. The ergodesign of Estonian workplaces. In: Reliability, Risk and Safety – Back to the Future. Proceedings of the European Safety and Reliability Conference (ESREL 2010).

Ben J.M. Ale, Ioannis A. Papazoglou, Enrico Zio- editors. Rhodes, Greece, 5–9 September 2010. Taylor & Francis Ltd, London, 1979–1984.

Tuomivaara, S., Ketola, R., Huuhtanen, P., Toivonen, R. 2008. Perceived competence in computer use as a moderator of musculoskeletal strain in VDU work: An ergonomics intervention case. *Ergonomics* **51**(2), 125**–**139.

Zakerian, S.A., Subramaniam, I.D. 2009. The Relationship Between Psychological Work Factors, Work Stress and Computer-related Musculoskeletal Discomforts Among Computer Users in Malasia. *International Journal of Occupational Safety and Ergonomics (JOSE)* **15(**4), 425–434.