Prevention of physiological and psychological stress at computer-equipped workplaces

Piia Tint, Kalju Meigas, Viiu Tuulik, Viive Pille, Kristel Oha, Karin Reinhold, Deniss Karai, Varje-Riin Tuulik, Mariliis Lauri
Tallinn University of Technology
Estonia

Abstract

This investigation was carried out in the frames of Interreg 4A project "Workability and social inclusion" headed by the Arcada University of Applied Life. Tallinn University of Technology and Riga Stradins University were involved. A questionnaire based on the Nordic, WAI (Workability index), and Kiva questionnaires was compiled to study psychosocial and physical working conditions at computer-equipped workplaces for 295 workers. Occupational hazards were measured. To investigate the level of stress of workers the cortisol level in saliva was measured. After the first questioning of workers on the psychosocial factors at workplace, the Metal Age programme was implemented and after the intervention, the Kiva questionnaire and the cortisol level in saliva were measured again. The results showed that if the preventive measures for solving the problems at workplace are implemented, and employers and employees are trained and consulted using the appropriate programmes, the stress situations could be avoided. The workers were divided into two groups (under 40 years- A and over 40 years- B). These groups were found to differ in the perception of psychosocial risk factors at the workplace. Group B assessments for the psychosocial working conditions were better than those of group A. In group B employees appeared to be more afraid of losing their jobs. Therefore, the employees in group B were not so interested in the work atmosphere as in group A. It is not easy to find a new position after losing one at the age over 40 years.

Introduction

The work was carried out in the frames of Interreg 4A project" Workability and social inclusion" headed by the Arcada University of Applied Life of Finland. The number of occupational diseases is the specific indicator that influences hazards on the worker in the work environment. Occupational diseases in Estonia are usually diagnosed in the late stage when the worker is already disabled. In this late stage it is difficult to find proper rehabilitation methods for a total health recovery. The majority of occupational diseases in Estonia are connected with musculoskeletal disorders (MSDs). Intensive use of computers causes major health problems like tissue damages, imbalance in blood flow, formation of the carpal tunnel syndrome (Oha et al., 2010). Computer-workers are under pressure as increasing amounts of

In D. de Waard, K. Brookhuis, R. Wiczorek, F. di Nocera, R. Brouwer, P. Barham, C. Weikert, A. Kluge, W. Gerbino, & A. Toffetti (Eds.) (2014). Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2013 Annual Conference. ISSN 2333-4959 (online). Available from http://hfes-europe.org

work have to be done within limited time. Stress is not only a feeling. It changes functions in the body: release of a variety of hormones, increased breathing, quickened pulse, and the production of more stomach acid. Computer work causes social problems: it distracts an individual from normal social or family relations and this in turn may lead to depression (Eltayeb et al., 2007). The interaction between the body and the work environment is complicated and four important systems (central nervous, automatic nervous, endocrine and immune) are involved in this network (Raja et al., 1996).

There are numerous hazards in the work environment (low temperatures, draught, noise etc.) that affect office workers and can damage the peripheral and central nervous system (Tint et al., 2012a). The physical complaints are very closely connected with psychological disturbances of computer workers (Zakerian & Subramaniam, 2009). The first symptoms of stress to appear can be physical (lack of appetite, sleeplessness, headache, pain in chest) and psychological (difficulties to concentrate, imbalance, anxiety, irritability, difficulties to make a decision, burnout). Illnesses and social problems develop under permanent stress. In stressful situations, the emotions created increase adrenocorticotropic hormone activating adrenal cortex, which extract cortisol. Changes in the cortisol level is an indicator of stress level (Melamed et al., 1999; Hofman, 2001). It is necessary to develop solutions for decreasing unreasonable stress and anxiety in workers suffering from stress situations at work.

Stressors like time limits, bad relationships between co-workers or with the employer, too much work wanted by the employer are considered to be the factors that can cause fatigue in the upper extremities (Feuerstein et al., 2004; Kulin & Reaston, 2011; Panari et al., 2012).

Lahtinen et al. (2002) focus on the psychological and social dimensions of managing and solving indoor air problems in their interviews and questionnaires. Their interviews were very critical of the process of solving the indoor air problem. The study supported the hypothesis that psychosocial factors play a significant role in indoor air problems.

Brauer and Mikkelsen (2010) studied the psychosocial work environment - at the individual and workplace level. The moderate differences between the workplaces in the perception of the indoor environment, as well as large differences between the individuals in the same building indicate that some occupants do perceive problems in the indoor environment even in the absence of a general indoor problem in the workplace. The authors also mention that the complaints are usually “over-reported” or over-estimated.

Stuffy air, noise, temperature, lighting deficiency might be the supplementary risk factors for developing MSDs and psychosocial stress at workplaces (Tint et al., 2012a). The main physiological and psychological stress factor is a poorly designed workplace (Tint &Traumann, 2012b).

Social relationships are important for the physical health of workers (Eisenberg & Cole, 2012). Socially connected people live longer than socially isolated people and

the first have increased resistance to a variety of somatic diseases ranging from heart disease to cancer (Miller et al., 2009).

Studies that consider the working conditions, physical overload and psychosocial risk factors are complex and have not been conducted in Estonia until now. Therefore, the results of the project "Work ability and social inclusion" are very important, offering ideas for further research to improve of the psychosocial work environment. The results could also be implemented in other post-socialist countries as the early stage in the work environment was almost the same for all of these states.

The research question: is it possible to reduce the physical and psychosocial risk at workplaces by speaking with people, training them and solving the problems regarding the issues of their complaints? Different hazardous factors (indoor climate, psychosocial factors, static posture etc.) are influencing the computer-worker (figure1). If the improvement methods in the working environment are implemented, the level of stress of workers has to be decreased.

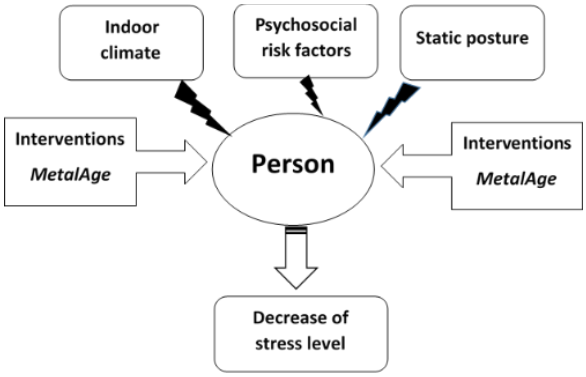

Figure 1. The structure of the study

Material and methods

The aim of the investigation was to increase the work ability, stress management, good leadership behaviour and thereby social inclusion of the workforce. Therefore, the Metal Age programme (Näsmän, 2011) is perfectly relevant for this purpose. A questionnaire based on the Nordic, Workability index and Kiva questions was compiled and forwarded to the workers by the Internet or as copy before the intervention of the Metal Age programme. 295 workers from different office-rooms from different institutions (including high school) were interviewed about the health risks and health disturbances connected with their work. The health disturbances were specified.

The Kiva questionnaire after the Metal Age programme implementation was conducted with 136 persons selected from four institutions (from those most interested in co-operation and improvements in the working environment, figures 2-5) and the cortisol level of computer-workers was measured before and after the Metal Age implementation for the same persons in 29 cases.

Figure 2. Office in institution 1

Figure 3. Office in enterprise 2

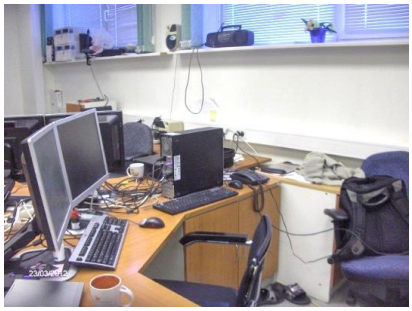

Figure 4. Office in enterprise 3

Figure 5. Office in high-school

Questionnaires

The Nordic (Lindström et al., 2000), WAI (Tuomi et al., 1998) and Kiva (Näsman, 2011) questionnaires were used to investigate the stress factors arising from the relationship between the employees and employers at the workplace.

Work Ability Index (WAI) is determined on the basis of the answers to a series of questions that take into consideration the demands before the interview with an occupational health professional who rates the responses according to the instructions.

Kiva questionnaire characterizes the wellbeing of workers at work. The ratings were given in an 8-point scale (1- not at all, 8- very much so, certain or well). The Kiva questionnaire was composed of seven questions:

1. Have you enjoyed coming to work in the last weeks?
2. I regard my job meaningful
3. I feel in control of my work
4. I get on with my fellow-workers
5. My immediate superior performs as superior
6. How certain are you that you will keep the job with this employer?
7. How much can you influence factors concerning your job?

Measurements of working conditions

The indoor air conditions were measured using the following standards and measuring equipment: EVS-EN-ISO 7726:2003 "Thermal environments- Instruments and methods for measuring physical quantities"; EVS-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", EVS-EN 12464-1:2011 "Light and lighting- Lighting of workplaces- part 1: Indoor work places", EVS 891:2008 "Measurement and evaluation of electrical lighting in working places". The measurement equipment used for microclimate: TESTO 435. TESTO 435 enables also the measurements of CO_2. Workplaces lighting and and screens were measured using the light-metre TES 1332 (ranges from 1-1500 lx). The lighting was measured on the worktable, on the screen and on the keyboard. Dust was measured with HazDust EPAM-5000.

Determination of fatigue in muscles

Myometer "MYOTON-3" was used to diagnose the functional state of the skeletal muscles of office workers. Myometer is a hand held state device developed at University of Tartu, Estonia (Vain & Kums, 2002). Myoton exerts a local impact on the biological tissue by means of a brief mechanical impulse. The impact force is small enough so that it causes no changes in the neurological reaction of the biological tissue. The tissue responds to the mechanical impact with damping or oscillation which is registered by an acceleration sensor located on the measuring tip of the device (figure 6 and 7).

Figure 6, 7. Myometer for muscles stiffness measurements

Determination of cortisol level

The high-performance liquid chromatography method (HPLC Water Alliance with UV detection) was used to determine cortisol in saliva (Kawasaki et al., 1979; Kalman et al., 2004). Saliva samples were collected three times during the day: in the mornning (8-9), at noon (12-13) and in the afternoon (16-17). Each participant was asked to hold special sampling tubes "Salivette" in their mouth for three minutes. The samples were analysed by the Laboratory of Hygiene and Occupational Diseases in Riga Stradins

University.

Results

For statistical data processing (except working environment hazards measurements), the computing programme SPSS.13 (Windows) was used. The arithmetic mean and standard deviation (SD) were calculated. To ascertain connections between the characteristics, the Spearman rank correlation (r- correlation coefficient) was applied, differences between the groups were tested with a Student's t-test. The difference $p<0.05$ was considered statistically significant.

Measurements in the work environment

Table 1 shows the results of measurements in the work environment. In winter the humidity of the air is too low. By the norms (EVS-EN 15251:2007), relative humidity of 40-60% is required for the worker to feel comfort. The level of carbon dioxide ~1000 ppm is felt by the workers as poor microclimate. The lighting of workplaces equipped with computers is usually good, in the frames of norms (300-500 lx), but sometimes infotechnologists prefer working in dark (without electrical lighting). However, this situation must be avoided.

Table 1. Results of measurements indoors in offices (2012-2013)

Room type	*T, ^0C Cold/warm season U=0.6^0C*	*R, % Cold/warm season U=2.0%*	*L, lx U=10.4%*	*CO_2, ppm U=10%*	*Dust, mg/m^3 U=10%*
Office 1, Figure 1	20-22/ 28-30	22-23/ 35-65	495-890	537-998	0.030
Office 2, Figure 2	20-22/ 24-28	15-25/ 35-75	200-250	500-750	0.020
Office 3, Figure 3	18-22/ 20-24	20-30/ 40-74	350-600	350-1200	0.015
Office 4, Figure 4	17-20/ 22-28	15-30/ 40-70	690-1209	478-1152	0.011

U- the uncertainty of measurements; T- temperature of the air; R-relative humidity; L-lighting; CO_2- concentration of carbon dioxide in the air; Dust- dust concentration in the air

Responses to the questionnaires

Table 2 presents the results of the survey involving 295 office workers working with computers (94 men and 197 women) about their health disturbances. The respondents were divided into two groups: A, age <40 (40 not included) - 137 persons and B, age >39(40 included) - 152 persons. The average age of group A was 30.97 years and group B - 54.5 years (*SD* 10.0). People who responded, had been working in the same occupation for 4.81 years (group A) and 17.38 years (group B, *SD* 9.0), respectively. Over 90% of the respondents were engaged in mental work in both groups (A and B). In group A, MSDs were observed by 53.6% of the respondents; the cardiovascular disturbances were observed by 20% of the respondents (A); visual disturbances occurred in 16% of persons (A). The problem of overweight in group A occurred in 20% of the respondents. Diabetes occurred in

two people. In group B MSDs were observed by 50% of the respondents; cardiovascular disorders by 45% of the respondents; visual disturbances occurred in 23% of the respondents. The results from the questionnaire show that the computer workers assess their health status considerably high. They are optimistic in solving the problem that the monotonous work with computers will continue and believe that their health status in the future will stay on the same level using the steadily enhancing rehabilitation means.

Table 2. Health complaints according to the questionnaire (Nordic, WAI)

Group/ Disturbances	*A (persons <40- included; years of age), % of all investigated*	*B (persons >40 years of age), % of all investigated*
MSDs	53.6	50.1
Cardiovascular disturbances	20.0	45.0
Visual disturbances	16.1	23.2
The problem of overweight	20.2	25.4
The health status good	55.2	43.4

Considering the fact that people begin to work with computers at ever younger age, according to the current investigation, more MDSs are observed by young people (<40 years of age) than by older workers (>40 years of age). The positive result is that 43.4% of the older workers consider their health status good. Visual disturbances were diagnosed for group A and B almost at the same rate. It shows that eyes get tired and sight is worsening already at a young age.

Determination of fatigue in muscles

MSDs were examined in depth for 66 display unit workers. Nordic questionnaire was used beforehand to find out the persons who might have MSDs with the aim to diagnose the disease in the early stage. Myoton allows pollide abductors muscle tone and muscle stiffness to be measured. Pain intensity was evaluated on a 10-point scale. The body mass index was assessed, average being 25.0 (*SD* 5.0).

The study group consisted of 37 women and 29 men, at the mean age of 41.7 years and the average length of service of 9 years. Employees declared the average working time with displays at 7.14 hours each day.

Muscle and joint complaints were reported only for 13 workers (19.7%). The majority of the respondents declared the existence of two or more local pain points. Neck pain complaints occurred in 37 respondents (56%), and the severity of pain was assessed at an average of 4.18. Right shoulder pain occurred in 22 patients (33.3%) and left shoulder pain in 18 (27.3%) of the respondents. Pain in shoulders was assessed with 3.80 (right) and 2.80 (left) balls. Wrist pain in the right arm was declared in 13 cases (19.7% of all) and the left wrist pain only in three cases (4.5%); the severity of 4.57 (right) and 4.01 (left). Back pain was complained by 25 (37.8%) persons with severity

of 4.28 balls (table 3).The presence of pain was generally of short-term duration, mostly for 1-7 days.

Table 3. The results of measurements of fatigue in muscles with Myoton

Pain region	*Number of workers (% of all investigated)*	*Severity of pain (0-10)*
Neck	37 (56%)	4.18
Shoulder, right	18 (27.3%)	3.80
Shoulder, left	17 (25.7%)	2.80
Elbow, right	4 (6%)	4.71
Elbow, left	4 (6%)	2.12
Wrist, right	13 (19.7%)	4.57
Wrist, left	3 (4.5%)	4.01
Back	25 (37.8%)	4.28

Myometric study revealed differences in the pain severity of complaints from employees with muscle pain and trapeze muscle pain in tonus and muscle stiffness.
As muscle strain is coming from the static posture, it can be influenced by the work psycho-emotional stress.

Thus, it might be concluded that static muscle tension causes increased muscle tone. Loaded in front of the screen is mostly the guiding hand. It is important to find the organizational measures that would ensure regular breaks and exercises, possibly combining them.

Responses to the Kiva questionnaire

The Kiva questionnaire was conducted twice: before the intervention of the Metal Age programme and after it (table 4). The number of used questionnaires was 136. According to the Kiva questionnaire, the investigated workers had high satisfaction coefficients with work. In addition, the stress indicators did not evaluate the stress-levels high. Kiva methodology for deploying a team is intended to find solutions to the specific results of the work of the team. It is connected with the character of work to find suitable working arrangements to be developed and therefore it is suitable for work-related psychosocial and MSDs prevention.

Table 4. Responses to the Kiva questionnaire

The question	*Office 1 B/A**	*Office 2 B/A*	*Office 3 B/A*	*Office 4 B/A*
1	5.0/7.1	6.2/7.3	7.3/7.8	7.1/8.1
2	5.3/8.0	8.4/7.8	8.3/8.7	8.3/8.2
3	8.0/7.7	7.7/7.6	8.3/8.4	8.2/7.9
4	7.8/8.0	8.4/8.9	9.0/9.1	8.5/8.9
5	3.5/7.7	7.3/7.8	8.3/8.5	7.4/8.3
6	5.5/8.0	7.2/8.1	8.8/7.3	8.1/8.2
7	5.8/4.9	7.0/7.6	7.5/7.4	6.7/7.4

B/A* - the mean values before the Metal Age intervention/ after the Metal Age intervention

The changes in the Kiva questionnaire are shown in Figure 8. The relations between the employer and the employees were usually improved (questions 1-2, 5-7). A slight decrease appeared in questions 3, 4: Does your immediate superior help you develop your skills? Does your immediate superior tackle problems as soon as they surface?

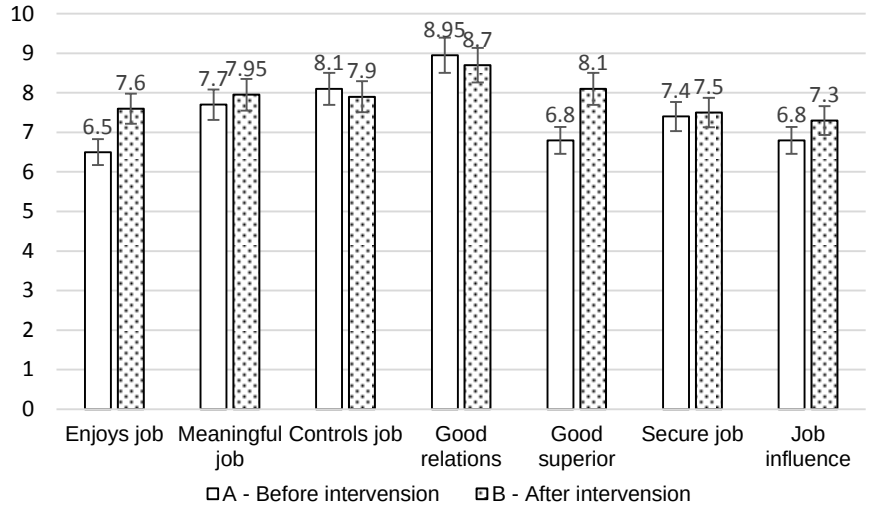

Figure 8. The responses to the Kiva questionnaire before and after the intervention (10-point scale)

The measurements of the cortisol level in saliva (table 5)

Table 5. The cortisol levels of office workers

Cortisol levels, nmol/l	*Office 1 M/L/E**	*Office 2 M/L/E*	*Office 3 M/L/E*
Before intervention	10.3/4.6/4.1	8.9/6.1/4.8	10.5/6.5/5.5
After intervention	10.2/7.6/7.0	9.5/7.0/6.0	10.2/6.5/5.5

M/L/E*- measurements of cortisol in M-morning/ L-lunch-time/E-evening

The changes in the cortisol levels in the three investigated offices are given in Figure 9.

The usefulness of the Metal Age programme is obvious, particularly in the office situated in a small town where the knowledge of ergonomics is poorer than in the capital (two other investigated offices).

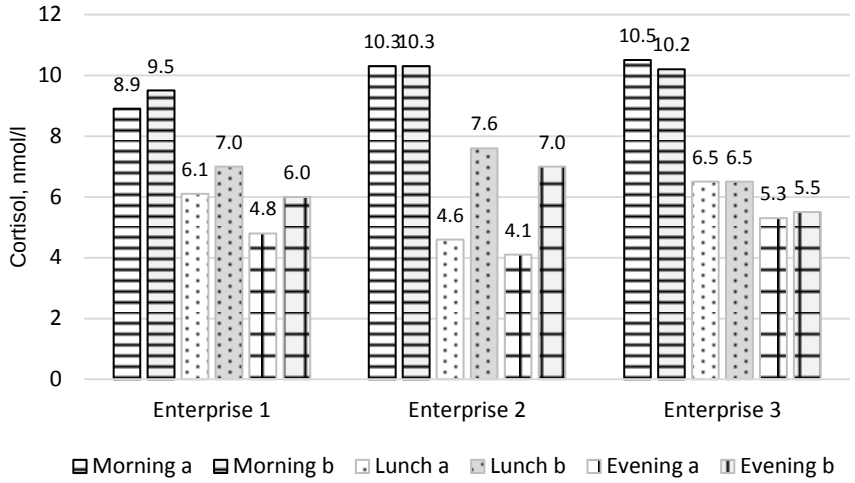

Figure 9. The change of the cortisol level in saliva before (a) and after (b) the intervention

Prevention and rehabilitation

The proposals were given for ergonomic improvements at workplaces (new ergonomic chairs, the possibility to change the height of the worktable; the change of the situation of a monitor etc.). The complaints in the air of the work environment and lighting deficiency complaints were reported to the employer. The rehabilitation of MSDs are possible using balneological methods of treatment and methods of physiotherapy (Tuulik et al., 2013; Visnola et al., 2010; Wargenaar et al., 2012).

Conclusions

The myometer allows the basic indicators of the skeletal muscle condition (stiffness and elasticity) to be determined. The data are valuable for the early diagnosis of possible health disturbances caused by work and for planning the rehabilitation treatment in an early stage of overload caused MSDs. MSD questionnaires, objective methods and environmental measurements are useful to plan prevention and early rehabilitation before the disability appears.

The indoor air and other problems in the same workroom could be defined individually in quite different ways. Therefore, an individual approach for every workplace has to be implemented considering the anthropological and other features of the worker who will work in the certain workplace. The info-technology workers often work in under-lighted working conditions although there is a possibility to raise the (artificial) lighting to the normal limits (400-500 lx).

The main conclusion from the investigation is that stress situations at workplace could be prevented by use of proper intervention programmes. It is most interesting (based on the study results for under 40 - year and over 40 – year workers) that there are different conditions for younger workers and for older workers or the same

conditions are felt by the two groups of workers in different ways. In addition, the age and the sex of the employer and the employees have their influence on the questionnaire results.

References

Brauer, C. & Mikkelsen, S. (2010). The influence of individual and contextual psychosocial work factors on the perception of the indoor environment at work: a multilevel analysis. *International Archives of Occupational and Environmental Health, 83,* 639-651.

Eisenberg, N.I., Cole, S.W. (2012). Social neuroscience and health. Neuropsychological mechanisms linking social tied with physical health. *Nature Neuroscience*, *15*, 669-674.

Eltayeb, S., Staal, J.B., Kennes, J., Lamberts, H.G.P., & de.Bie, R. (2007). Prevalence of complaints of arm, neck and shoulder among computer office workers and psychometric evaluation of a risk factor questionnaire. *BMC Musculoskeletal Disorders*, *8*(68), 1-11.

Feuerstein, M., Nicholas, R.A., Huang, G.D., Dimberg, L., Ali, D., & Rogers, H. (2004). Job stress management and ergonomic intervention for work-related upper extremity symptoms. *Journal of Applied Ergonomics*, *35*, 565-574.

Hofman, L.F. (2001). Human saliva as a diagnostic specimen. *Journal of Nutrition*, *131*, 1621-1625.

Kalman, B.A. & Grahn, R.E. (2004). Measuring salivary cortisol in the behavioural neuroscience laboratory. *Journal of undergraduate neuroscience education*, *2*, A41-A49.

Kawasaki, T., Maeda, M., Tsuji, A. (1979). Determination of plasma and urinary cortisol by high-performance liquid chromatography using fluorescence derivatization with dansyl hydrazine. *Journal of Chromatography. Biomedical Applications, 163*, 143-150.

Kulin, J., & Reaston, MR. (2011). Musculoskeletal disorders early diagnosis: A retrospective study in the occupational medicine setting. *Journal of Occupational Medicine and Toxicology*, *6*, 1-6.

Lahtinen, M., Huuhtanen, P., Kähkonen, E., & Reijula, K. (2002). Psychosocial dimensions of solving an indoor air. *Indoor Air, 12,* 33-46.

Lindström, K., Elo, A.-L., Skogstad, A., Dallner, M., Gamberale, F., Hottinen, V., Knardahl, S., & Orhede, E. (2000). General Nordic Questionnaire for psychological and social factors at work. Copenhagen, Denmark: Nordic Council of Ministers.

Melamed, S., Ugarten, U., Shiron, A., Kabena, L., Lerman, Y., & Froom, P. (1999). Chronic burnout, somatic aerosol cortisol levels. *Journal of Psychosomatic Research*, *46*, 591-598.

Miller, G., Chen, E., & Cole, S.W. (2009). Health psychology: developing biologically plausible models linking the social world and physical health. *Annual Review of Psychology, 60,* 501-524.

Näsman, O. (2011). Metal Age and Kiva-questionnaire. Assist in navigation towards well-being at work. Mediona OyAb. The Archipelago Academy for Well-being at work. Retrieved September, 14, 2013, from

http://www.mediona.fi/pdf/KANSI%20Metal%20Age%20ja%20Kiva-kysely%20ENG.pdf

Oha, K., Viljasoo, V., & Merisalu, E. (2010). Prevalence of musculoskeletal disorders, assessment of parameters of muscle tone and health status among office workers. *Agronomy Research, 8*, 192-200.

Panari, C., Gugliemi, D., Ricci, A., Tabanelli, M.C., & Violante, F.S. (2012). Assessing and improving health in the workplace: an integration of subjective and objective measures with the Stress Assessment and Research Toolkit (St.A.R.T.) method. *Journal of Occupational Medicine and Toxicology, 7*, 1-10.

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

Tint, P., Traumann, A., Pille, V., Tuulik-Leisi, V.-R., & Tuulik, V. (2012a). Computer users' health risks caused by the simultaneous influence of inadequate indoor climate and monotonous work. *Agronomy Research*, 10, 261-268.

Tint, P., Traumann, A. (2012b). Health risk assessment in atrium-type buildings. *International Journal of Energy and Environment, 6*, 389-396.

Tuomi, K., Ilmarinen, J., Jahkola, A., Katajarinne, L., & Tulkki, A. (1998). Work Ability Index. Helsinki: Finnish Institute of Occupational Health.

Tuulik, V.-R., Tuulik, V., Pille, V., Tamm, M., Saarik, S., Vare, T., & Tint, P. (2013). Laser-doppler perfusion monitoring, myotonometry, and workplace risk evalution as assessment methods of musculoskeletal overuse syndromes in industry workers. *Journal of Rehabilitation Medicine*, *45*, 976-977.

Vain, A. & Kums, T. (2002). Criteria for preventing overtraining of the musculoskeletal system of gymnasts. *Biology of Sport, 19*, 329-345.

Visnola, D., Sprudza, D., Bake, M.A., & Pike, A. (2010). Effects of art therapy on stress and anxiety of employees. *Proceedings of the Latvian Academy of Sciences, Section B, 64*, 85-91.

Wangenaar, A.F., Kompier, A.J., Houtman, I.L.D., van den Bossche, & S.N.J., Taris, T.W. (2012). Employment contracts and health selection. Unhealthy Employees out and healthy employees in? *Journal of Occupational and Environmental Medicine, 54*, 1192-1200.

Zakerian, S.A. & Subramaniam, I.D. (2009). The relationship between psychological work factors, work stress and computer-related musculoskeletal discomforts among computer users in Malaisia. *International Journal of Occupational Safety and Ergonomics* (JOSE), *15*, 425-434.