The computer workers’ working conditions influencing the health in modern buildings

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Abstract

The paper is aimed at improving the workplace ergonomics. The psychosocial character of computer workers’ health risks in modern buildings is investigated. The influence of indoor climate conditions on development of health damages at workplace are also taken into consideration. The computer workers (accountants, secretaries, etc.) often work in static posture. 295 workers from different enterprises and firms were questioned about the health risks in the work environment and health disturbances connected with their work. For the investigation Kiva questionnaire and Workability Index were used. The results 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 in the same level using the steadily enhancing rehabilitation means. The most injured regions of the body were the right wrist and the neck. The rehabilitation means have to be developed and the possibility for rehabilitation must be made available to the greatest possible number of workers. The novelty of the study is that the work conditions (indoor climate, lighting) are closely connected with the development of musculoskeletal disorders (MSDs) in glazed buildings. Low temperatures (<20°C in office) in winter and high temperatures and draught in summer; deficiency of day-lighting etc. are supplementary factors for developing the MSDs.

KEY WORDS: indoor climate, modern buildings, health disturbance, musculoskeletal disorders

1. Introduction

The modern glazed buildings (including atrium-type) are very common for office-rooms in cold and hot climates [1]. The new type of construction is used for high-school buildings and in commercial centres. The biggest successes of atrium-type buildings are their appearance and heat savings in the rooms closed to the atrium. Some problems with work conditions also occur: ventilation of the rooms [2,3], the deficiency of natural lighting (in the rooms closed to the atrium) [4,5]; in towns the houses are built too close to each other and the modern wall materials can disturb the office-workers in the building of the opposite side. The spotted wall material (Fig. 2) of the opposite side house (Fig.1) reflects in sunny days the sunlight directly to the computer screen of the office-workers in atrium A.

There are other types of glazed buildings (high, 10 story houses) that give good natural lighting in winter where there is usually deficiency of it; but it might be too cold on the 8th or higher floor in -30°C of outdoor temperatures. That kind of buildings are too hot in summer and the temperature of the indoor air might raise over 30°C. The surveillance of the ventilations systems is expensive. The non-regulated ventilation (draught, the cold air blowing onto the employee in winter from the ventilation system); sick building syndrome [6, 7] in the rooms where the windows cannot be opened etc. can cause health problems of physiological and psychological character to the office-workers [8].

The work with computers causes musculo-skeletal disorders (MSDs) to the people if they work continuously and without pauses. The hands, neck, shoulders and back fatigue occurs caused by the static posture for accountants, secretaries etc. [9]. There are connections between the work conditions and health disturbances [10]. MSDs of the
in the workplace also take part in the ergonomics-related training, workplace reorganization, new tools (such as the obtain of a chair, safety device, keyboard, forearm) and keeping rest intervals. One as well as a combination of different methods are used. Articles overviews show that the intervention has not caused the negative or harmful influence on the ergonomics and health of the workers [13]. The effectiveness of the intervention is assessed in the review articles as unclear because the different studies give or does not give the same effect of the intervention. Coming from that, Kennedy [14] had made recommendations for carrying out the intervention studies. It is always recommended to choose also the control-group; to carry out the intervention with sufficiently large number of respondents. If the number of investigated persons is small, then it is better to test the intervention group and control group; not to use the variety of intervention methods on a number of different small-group of persons, to choose the duration the intervention method from 4 to 12 months; to choose the intervention with combined of different methods, as it is likely to effect. In spite of the increase of the MSDs as occupational and work-related diseases in Estonia, there are not sufficient adequately performed investigations on the health of office workers. To prevention of the musculoskeletal pain it is important to raise the staff awareness and direct their attention to the problems associated with computer work.

The measured work environment conditions were: the air temperature, humidity, air velocity in the workplace [5]; the workplace lighting, as well as the carbon dioxide concentration in the work room [6]. The studied rooms were taken from different houses of the university having no windows, rooms with un-openable windows, openable windows, but closed to the atrium [1]. The atrium A has a transparent of light roof and the slope between the roof and the wall. This type of design gives to the workers better working conditions [2, 3]. The paper in the field of indoor environment focuses on two issues: the cleanliness of the air in the office space with modern design and the absence or shortage of natural light [7].

The present work also contains a survey of office workers, the extent of which they are satisfied with working conditions in the glazed buildings. Furthermore, the employees' perceptions were also examined, such as the lack of natural light disturbs them or not.

Novelty of the study consists in the individual approach to the workers and their opinions. One worker may not feel the shortage of the natural light, but she feels air temperature discomfort. Different people have different health disturbances (except of flu that may catch a great number of people simultaneously). The indoor climate quality in buildings is related to the workers wellbeing including job satisfaction, motivation and productivity. The European Standard EN 15251:2007 sets the new demands for previously socialist-countries for indoor climate (IC) quality: for air temperature, humidity, velocity (ventilation), carbon dioxide concentration, noise and lighting in office and research-rooms. The investigation and modelling of the air quality in the office rooms has become a very important issue in many countries of different climate (in cold and warm area). The prevention of rising the concentration of carbon dioxide (CO₂) over the norms (800 ppm over the out-door CO₂ concentration) and ventilation of the rooms have new approaches to improve the situation.

Objectives of the study were: to investigate the working conditions through the measurements in the work environment and the health risk analysis by the specialists and using the questionnaires for office-workers.

2. Methodology/Material/Approach

In the study the indoor air quality assessment in 7 different glazed buildings office-rooms was carried out (Table 1). The measurements of working conditions (microclimate, lighting, concentration of carbon dioxide) were carried out. Measurements in the work environment are based on ISO, EN DIN, EVS standards: 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 894:2008+A1:2010 “Daylight in dwellings and offices”.

The measuring equipment used for microclimate: TESTO 435. TESTO 435 enables also the measurements of CO₂ concentration) and ventilation of the rooms have new approaches to improve the situation.

The work conditions of the Estonian workers (n=350) using the computer in their everyday work were investigated. The workers' opinion on the existing work conditions was assessed (295 answers). Nordic questionnaire, Kiva questionnaire and Work Ability Index (WAI) [15, 16] were the basis for compile the questionnaire. The questionnaire consisted of 67 questions (an example in Table 2) which all were directed to determination mostly psychological and physiological hazards in the work environment. The preventive (rehabilitation) measures were also recommended.
The Kiva questionnaire consists of the following questions:

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

3. Results

The results are given in three parts: the natural lighting conditions in atrium-type buildings; the results of measurements of indoor air indicators in the investigated offices and the investigation of the opinion of workers on physiological and psychological risk factors in the work environment.

3.1. The natural lighting in the atrium-type buildings’ offices

Recent biomedical studies have shown that besides visual function, light plays also an important role in human wellbeing. Due to the recent discovery of a novel photoreceptor in the eye the necessity for dynamic lighting has become clearer. Light is signalling the time of the day by the means of the newly discovered photoreceptor cells and a separate nerve system to our biological clock, which in turn regulates the circadian (daily) and circannual (seasonal) rhythms of a large variety of bodily processes [17]. In the building B the natural lighting conditions worsened a lot in 2012 when 3 additional floors were built after. The area on atrium is only 4x4 metres.

3.2. The results of the measurements in the investigated offices

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 are given in Table 1.

<table>
<thead>
<tr>
<th>Room type</th>
<th>Indoor air temperature, °C, U = 0.6 °C</th>
<th>Indoor air humidity, %, U = 2.0%</th>
<th>Natural lighting, lx (Sept.-March), U = 10.4%</th>
<th>Concentration of carbon dioxide, measured</th>
<th>Concentration of dust in the air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold season</td>
<td>Warm season</td>
<td>Cold season</td>
<td>Warm season</td>
<td>CO₂, ppm</td>
<td>U=10%</td>
</tr>
<tr>
<td>Building A, rooms closed to the atrium</td>
<td>20-22</td>
<td>24-28</td>
<td>15-25</td>
<td>35-75</td>
<td>5-250</td>
</tr>
<tr>
<td>Building A, rooms closed to outdoors</td>
<td>18-22</td>
<td>22-28</td>
<td>20-30</td>
<td>40-75</td>
<td>350-600</td>
</tr>
<tr>
<td>Building B, rooms closed to the atrium</td>
<td>18-20</td>
<td>20-24</td>
<td>10-21</td>
<td>35-65</td>
<td>25-350</td>
</tr>
<tr>
<td>Building B, rooms closed to outdoors</td>
<td>17-20</td>
<td>22-28</td>
<td>15-30</td>
<td>40-70</td>
<td>350-600</td>
</tr>
<tr>
<td>1. Glazed office-rooms (on 8th floor)- built in 2008</td>
<td>22-24</td>
<td>25-29</td>
<td>34-41.5</td>
<td>35-65</td>
<td>344-914</td>
</tr>
<tr>
<td>2. Glazed office-rooms (ground floor), built in 1980s</td>
<td>20-22</td>
<td>28-30</td>
<td>22-23</td>
<td>35-65</td>
<td>495-890</td>
</tr>
</tbody>
</table>

U - the uncertainty of measurements; the dust concentration in the smoking room (building B) was 0.099 mg/m³

The main results of the investigation: the indoor air is too dry in winter season (relative humidity 10-20%); the air temperature in the workrooms depends on the rooms' location in the building and the relaxation time of the temperature is too high (the rooms are not heated or cooled with enough speed according to the sudden changes of the outdoor air temperature); if the room area is smaller than 10 m² per worker, then the concentration of CO₂ is over the limits (>800 ppm); noise is a problem when the ventilation is working in a very high capacity. The concentration of dust is low and the moisture in the rooms (causing bad smell) is observed only in the first floor closed to the atrium. The artificial lighting was mainly sufficient in the investigated firms.

3.3. The investigation of the opinion of workers

The workers were questioned on satisfaction with the indoor air temperature, humidity of the air, the ventilation and the deficiency of natural lighting in the rooms closed to the atrium. If the windows were to the direction of the opposite side (to outdoors), then there were no complaints about lighting. Sometimes the workers complained about the fluorescent lamps that these were too strong and there was a pain in the eyes at the end of the work-day.

The questionnaire (based on Nordic, WAI, Kiva questionnaires) was presented to the computer-workers by internet to conclude the relationship between the workers and the employer, the development of diseases (particularly the MSDs) etc. A total of 295 (291 correct answers) people from different institutions (computer-workers from the university, hospitals and enterprises) answered the questionnaire. Among them there were 94 men and 197 women. 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 the group A was 30.97 years and the group B - 54.5 years. People who answered, had been working in the same occupation accordingly 4.81 years (group A) and 17.38 years (group B). On the average the respondents were university educated and married. Over 90% of the respondents were engaged in mental work in both groups (A and B). The example of the questions and answers (from the Nordic questionnaire) is given in Table 2. The most annoys the mentally working people the lack of the opportunity to influence on their own job content and the reduction of the work motivation or desire to work therefore. To the question “Does your immediate superior encourage you to speak up, when you have different opinion?” The answer was: sometimes.

Work Ability Index questionnaire revealed the workers current performance with the best level of life. Both groups evaluated it with 8 in the scale of 1-10. In the group A some musculoskeletal orders occurred in 86 (62.7% of
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all) people, among them 22 (16%) cases were by the physician-diagnosed; cardiovascular diseases were mentioned by 22 people (17%), 10 (8%) of them were the physician-diagnosed; visual disturbances occurred in 20 persons (16%) (15 physician-diagnosed). The problem of overweight in this group occurred in 25 (20%) persons, 22 were diagnosed by a doctor. The diabetes occurred in two people. In the group B 114 people (74.0% of all) had the musculoskeletal disturbances (to 67 or 43.5% of the persons the disease was diagnosed by the physician); about cardiovascular diseases complained 9 persons (6%), 10 of these diseases were diagnosed by the physician); visual disturbances occurred in 13 persons (23%); 7 cases of which were diagnosed by the doctor. Overweight in this group occurred in 14 (25%) people - all these cases had been diagnosed by the doctor and diabetes didn’t occur. The question: At what age are you planning to retire? was presented to the both groups. The answer was 67.0 years for the group A and 67.1 years for the group B.

Kiva questionnaire (scale 1-10) revealed that the group A enjoyed coming to work by 6.5 points, by 8.0 points the workers considered their work important; the possibility to influence on their own work content was evaluated by 6.7, the relationships with co-workers with 8.4 points and with the boss it was assessed with 7.5 points. To the confidentiality that the worker will continue with the same employer was given 7.5 points (of 10). Group B enjoyed coming to work by 7.3 points, the importance of the work was assessed by 8.5 points. 8.5 were given to the relationships with co-workers and with the boss 7.1 points. An average of 6.8 points was confident that they will continue with the same employer in the future, and 6.8 points were given to the possibility to have impact of their work process.

Table 2.
Do the following issues harm/hinder how you cope at work or how you manage to do your work?

<table>
<thead>
<tr>
<th>The question</th>
<th>(Value: 0)</th>
<th>(Value: 1)</th>
<th>(Value: 2)</th>
<th>(Value: 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) things related to health or functional ability (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>b) things related to education or know-how (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>c) issues relates to the work environment or the physical load of the job (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>d) issues related to the work community or the mental burden of the job (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>e) reduction of work motivation or desire to work (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>f) difficulties outside work (in the family, the economic situation etc.) (group A)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Total A</td>
<td>45 %</td>
<td>38 %</td>
<td>15 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Total B</td>
<td>57 %</td>
<td>32 %</td>
<td>6 %</td>
<td>6 %</td>
</tr>
</tbody>
</table>
Rehabilitation

The work is repetitive for info-technology workers, the movements, made by the right and left 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 (Fig. 7) to prevent the health damages.

Discussion

The ergonomics of workplaces has to be considered in the design of workplaces. If the house in already built it is possible to improve the work conditions, but it takes time and money. The standard EVS-EN 15251 has to be presented during the design of workplaces. The glazed buildings are very modern, but also include problems (like insufficient lighting or ventilation, too many workers in one room, the windows cannot be opened etc.). 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 is monotonous. 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 their own workplace and work-tools. 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 (engaged in info-technology or original office-work: accountants, secretaries etc.). Despite the stress sometimes felt by the workers, time pressure, work interruption and intense periods in the work, the respondents were satisfied with their jobs. This was demonstrated both by Kiva and WAI questionnaires. The respondents had sufficient latitude to work, relationships with colleagues were good and the workplace atmosphere was good also; despite of some shortcomings in the organizational factors the employees were satisfied with the management. Work stress was felt by the 2/3 of the respondents „only a little „or „to some extent“. In small doses, stress is good - such as when it helps to conquer the fear or gives extra endurance and motivation to get something done.

Based on the investigation by the age groups (A under 40 years and B over), it might be concluded that the number of visual disturbances in the group A has increased as the people begin to use the computers in the younger age. The analogous disturbing phenomenon was observed in the assessment of the health status of the workers: the A group of the respondents (workers under 40 years) assessed their health status worse. The health status assessed “good”: accordingly by 55% of people in the B group and 43% in the A group. The work in the offices is monotonous and the workload might be high. The risk scores for right and left hand are different. 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 young and ageing workers. 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.

Implementations

The results could be used in the improvement of workers’ working conditions particularly in the cold or hot season or areas; for regulation the ventilation in the rooms; for improvement the ergonomics of workplaces, improvement of lighting.

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Fig. 7. Ergonomic solutions of the workplace: 

a) ergonomic keyboard  

b) ball as a chair  

c) ergonomic chair

References


