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Ergonomic burdens and harms at the workplace of accountants

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ABSTRACT

Workers spend a lot of time at work, and therefore, it is important to ensure healthy workplaces. The aim of this study was to evaluate the ergonomic strains of accountants and suggest measures to overcome the work-related overload and improve the working conditions. We monitored the work of three accountants through the Ovako Working posture Assessment System (OWAS) methodology and measured the microclimate and lighting conditions. The results of microclimate conditions show that the room temperature was 26 °C, the humidity was 47 %, and the airflow 0.11 ms^{-1}. The results of the OWAS methodology gave us insights into the overload of the spine and the upper and lower limbs. In most cases, corrective measures are needed. Immediate measures need to be implemented for the upper limb load for all the observed subjects, while arm load needs to be further researched. Our findings could reduce the work-related discomforts if workers and employers followed our recommendations.

Key words: ergonomics, accountant, burden, OWAS, sitting at work, display screen equipment

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INTRODUCTION

For a healthy and pleasant work, a workplace needs to be properly regulated and organized. The tendency to adapt the workplace to psychophysical abilities of the individual is very old, but now more relevant than ever [1]. The awareness of importance of ensuring health and safety in the workplace occurred many years ago, as legislation in this area has existed since 1974.The legislation is called The Health and Safety at Work Act [2]. An integrated approach to workplace health-promotion programs should include attention to the work environment, especially occupational safety, health, and ergonomics. Ergonomics is the scientific study of people at work. Occupational ergonomics attempts to improve the connection between the workforce and the work environment through the optimized design of jobs and work systems [3, 4]. The most common goal is avoidance of work-related musculoskeletal disorders such as low back pain and tendonitis, which represent a major cause of morbidity and absenteeism around the world [5, 6]. The ergonomics can design good workplaces that cannot only reduce injury risks but also enhance health and capacity of workers [7].

Workplace health-promotion programs should include attention to the work environment, especially occupational safety, health, and ergonomics.

Many jobs require people to sit whilst working. Unsuitable sitting can lead to discomfort, back pain, and upper limb disorders. This may lead to staff absences from work and worse performance. Employers are required to provide seating for employees that is suitable and safe. Employers must assess risks in the workplace, including seating. A risk assessment involves identifying hazards and deciding whether enough has been done to prevent harm to people [8, 9].

Unsuitable sitting can lead to discomfort, back pain, and upper limb disorders.

The risk assessment must be comprehensive. There are five steps that may assist in assessing:

Step 1: Look for the hazards.

Step 2: Decide who might be harmed.

Step 3: Evaluate the risks.

Step 4: Record the findings.

Step 5: Review the assessment regularly [9].

Employers must assess risks in the workplace, including seating.

When choosing seating, employers need to consider the needs of the individual, the type of work being carried out and the dimensions of the workstation. It is important that a chair is comfortable for the worker, that the lower back is adequately supported, that the edges are appropriately shaped to prevent uncomfortable pressure on the thighs, that the height is adjustable, and that the backrest is properly adjusted in height and depth. However, we must not forget the armrests and in some cases the footrests as well. The aim should be to avoid employee's discomfort and to promote well-being. When people are working with computers, an employer must ensure that the seating is adjustable to allow the hands to work at the elbow height. There should be place for the legs to fit comfortably under the boards. Armrests should not prevent the user from getting close to the workstation. When using a keyboard or mouse, it should be possible to place the feet flat and comfortably on the floor [9, 10].

Display Screen Equipment (DSE) is the equipment that has a display screen, regardless of the display process involved. It includes conventional display screens, laptops, touch-screens, and other similar devices [10]. If the workplace with DSE is not adapted to the workers, various problems may occur. Some workers may experience fatigue, eyestrain, upper limb problems, and backache from overuse or improper use of DSE. These problems can also be experienced from poorly designed workstations or work environments. The causes may not always be obvious and can be due to a combination of factors. Nina et al. discovered the importance of the correct posture while using a computer when they observed 67 workers working with their own computers. They found that mouse-elbow height match was a significant predictor for discomfort of the lower back. Inappropriate keyboard height could cause discomfort of the shoulders and upper back. Also, Demure et al. [12] warn that musculoskeletal pain requires rapid intervention for improving their work posture. Therefore, DSE workplace needs to ensure the proper relation between chairs, desks, and keyboards; the height of the screen is also very important (Figure 1).

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In providing an adequate job with DSE, we can help with the following recommendations:

- Forearms should be in a horizontal position.
- The user's eyes should be at the same height as the top of the screen.
- Make sure there is enough workspace to accommodate all documents or other equipment.
- Arrange the desk and screen to avoid glare or bright reflections. This is often easiest if the screen is not directly facing windows or bright lights.
- Make sure there is space under the desk to move legs.

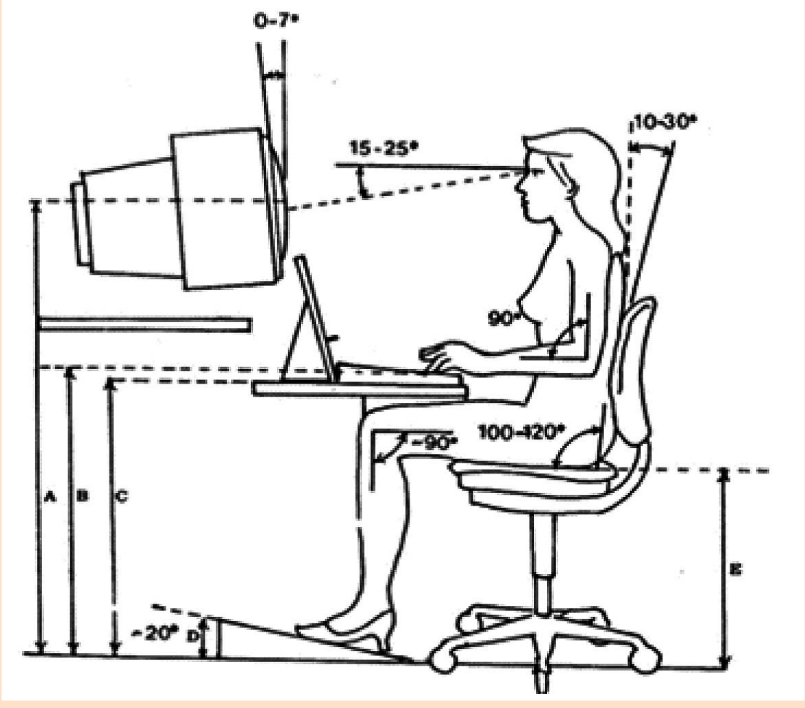


Figure 1:
The correct posture while using the computer [1]

– Avoid excess pressure from the edge of seats on the backs of legs and knees. A footrest may be helpful, particularly for smaller users.
– Adjust the brightness and contrast controls on the screen to suit the lighting conditions in the room.
– Make sure the screen surface is clean.
– Select colours that are easy on the eye [9].

While at work using a computer, fatigue, eyestrain, upper limb problems and backache may occur. This can be prevented if users make stretch and change the position, look into the distance from time to time, blink often, change the activity, and short, frequent breaks are better than longer ones. Interventions aimed at reducing the musculoskeletal disorders due to computer work should be directed at both physical/ergonomic factors and work organizational and psychosocial factors [9].

In addition, microclimatic conditions are important factors in the working environment, which can affect workers in a positive or negative way. In case of extreme conditions, they can be perceived as harmful effects on human health. Microclimatic parameters are determined by temperature, relative humidity, and airflow. These physical quantities define subjective well-being (comfort) or ill-being (discomfort). The temperature of the working environment depends on the body heat production affected by the intensity of employee's activity: sitting at work, standing at work, mechanics work, intensive, and very intensive work [13]. Humidity in the working environment is a specific factor. The scope of permissible values of relative humidity depends on the temperature of the environment. Human feelings can be negatively affected by a low value of humidity (< 20 %) and humidity in excess of 60 % [14]. People with sedentary work in confined spaces are more responsive to airflow than to the movement in the nature [15]. In addition, the airflow in workplaces is prescribed to be at the maximum levels, which are also dependent on the air temperature. The lower the temperature, the lower the permissible airflow. An air temperature of 20 °C prescribes ≤ 0.18 ms^{-1}, at 22 °C ≤ 0.22 ms^{-1}, at 24 °C ≤ 0.26 ms^{-1}, and at air temperature of 26 °C, the permitted value of airflow is ≤ 0.30 ms^{-1}[16].

Large variations of brightness in direct line of sight between the eyes and the surroundings are stressful for the body.

The eye is a sensory organ that detects the brightness of objects and surroundings and must constantly adapt to its environment. Large variations of brightness in direct line of sight between the eyes and the surroundings are stressful for the body. The consequences of these differences may be manifested as pain in the eyes and head, general discomfort and rapid and unnecessary fatigue [17]. Good lighting of workplaces has long been considered as one of the most important tasks that are associated with productivity and work efficiency. Numerous researches have indicated that good lighting will positively contribute to work performance. Optimal level of lighting is important for the comfort during continuous work of long duration [18, 19,20, 21]. Workplace in office must be designed so that light sources do not cause glare or disturbing reflections on the screen. In the office, the most suitable is natural lightning or artificial lighting, which is the closest to the natural one. Windows must have adequate shading to prevent the incidence of

sunlight on the job. Distracting reflections on the screen reduce the visibility of characters. Workers unconsciously respond by holding the head in the unnatural position and this causes neck pain [1]. The minimum required illumination at fixed positions is 200 lux. Workplaces where workers perform work with greater visual requirements (DSE definitely is) must be equipped with the additional local lighting [22].

This study explored three workplaces of accounting companies. We determined the ergonomic position of workers who work mainly sedentary work with Display Screen Equipment. The welfare of employees is also influenced by microclimatic conditions and lighting of the workplace, therefore, we also measured these parameters.

METHODS

The study was performed among a group of workers, working in a small accounting company, who had been using DSE daily. Data were obtained on the basis of a five-day observation of three accountants at work. Workers were monitored daily for eight hours. We used the OWAS method (Ovako Working posture Assessment System). The OWAS method was used to determine an improper posture during work. In the second part of the research, we measured the microclimatic conditions (temperature, humidity, airflow) in the office and lighting in all three workplaces.

The welfare of employees is also influenced by microclimatic conditions and lighting of the workplace.

In the office, the most suitable is natural lightning or artificial lighting, which is the closest to the natural one.

The OWAS method was used to determine an improper posture during work.

OWAS method

OWAS identifies the most common work postures for the back (4 postures), arms (3 postures) and legs (7 postures), and the weight of the load handled (3 categories). These postures have been classified into four categories indicating needs for ergonomic changes. The observations are made as "snapshots" with constant time intervals. The observed posture combinations are classified into four ordinal scale action categories, which are based on expert's estimates of the health hazards of each work posture or posture combination [23]. This method is suitable for different jobs, which also include sedentary job [24]. Using this method is time-consuming, as the employees must be monitored all their working day for several days. The OWAS method has its limitations, since it does not separate the right and left upper extremities: also, the assessments of the neck, elbows, and wrists are missing [25].

Temperature, humidity, airflow, and lighting measurements

Measurements of microclimatic conditions were performed using a measuring device Testo 445. The temperature, humidity, and airflow were measured 10 cm and 110 cm above the ground. The first measurements were performed at 4 pm, when the air conditioner was switched on. The outside air temperature was 26 °C, the weather was cloudy. The second measurements were performed in the evening, at 10 pm, when the outside temperature was 19 °C.

The lighting was measured with a luxmeter Testo 545. Measurements of lighting were performed at three workplaces. The measurement of the daylighting was influenced by the two windows of size 1.14 m^2

and a transparent surface 0.82 m^2. Measurement of artificial lighting was performed in the evening at 10 pm. When taking measurements of the artificial and combined lighting, four ceiling lights were turned on and additionally two table lamps at the desk.

Environmental conditions on the workplace in the office are provided by the ISO Standard 9241 [26]. ISO 9241 is a standard from the international organization for standardization covering ergonomics of human-computer interaction. According to the regulations, they must provide the following values:

- Temperature 19–23 °C
- Humidity 40–60 %
- Airflow < 0.25 ms^{-1}
- Lighting 300–500 lux [26].

RESULTS AND DISCUSSION

Results of ergonomic burdens (OWAS)

By using the OWAS methods, we were estimating ergonomic burdens of three accountants at their workplace. The results of the OWAS method showed an excessive burden for certain positions and they are shown in Figures 2–6. In determining prohibited positions, we used symbols, which are shown in Table 1. The symbols of different measures are used in Figures 2–6. Measures depend on the positions of different parts of the human body at the workplace. For each position are prescribed the maximal permitted limit values [27].

Observing the thoracolumbar spine in all three workers, we found that they were in the so-called prohibited position 1.4 (Figure 2).

In the situation 1.4, a stooped posture is noticed, since the deflection is greater than 15°, combined with a torsion or lateral flexion greater than 30°. This situation was mostly recorded when employees were sitting at the table, leaning to the side, and opening or closing drawers of the desk. The measures are necessary in the foreseeable future.

When observing the arm, we noticed that the most problematic position 2.2 occurs when one or both arms are away from the midline of the body (abducting). This position was present in all workers during all observation days, and it exceeded the physiological recommendations. Corrective measures are needed immediately (Figure 3). This situation occurs when people working with computers have a lot of documents in front of them. In this case, the keyboard is too far from

Table 1: The legend of measures and symbols used in the Figure 2–6.

Symbols	Legend
□	Measures are not required
○	Measures are needed in the short term
△	Measures are needed immediately
☆	Further research is needed

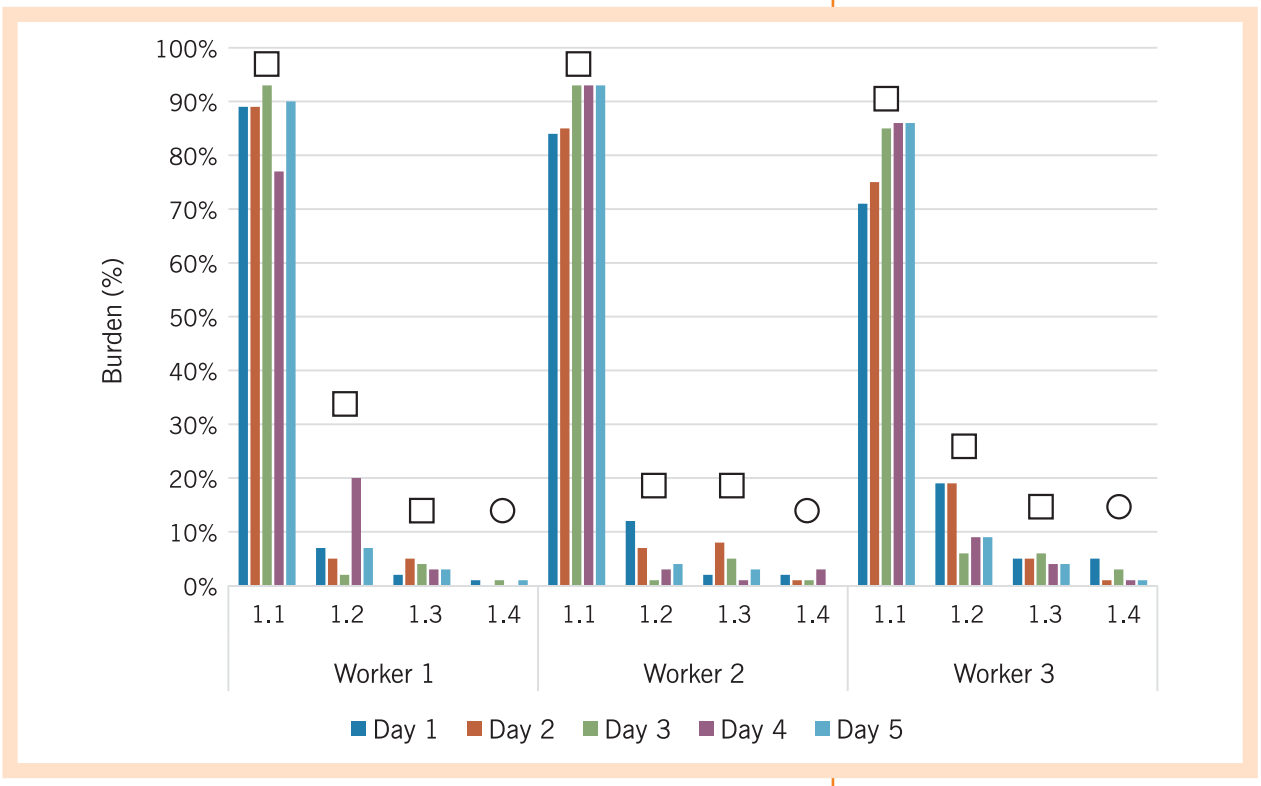
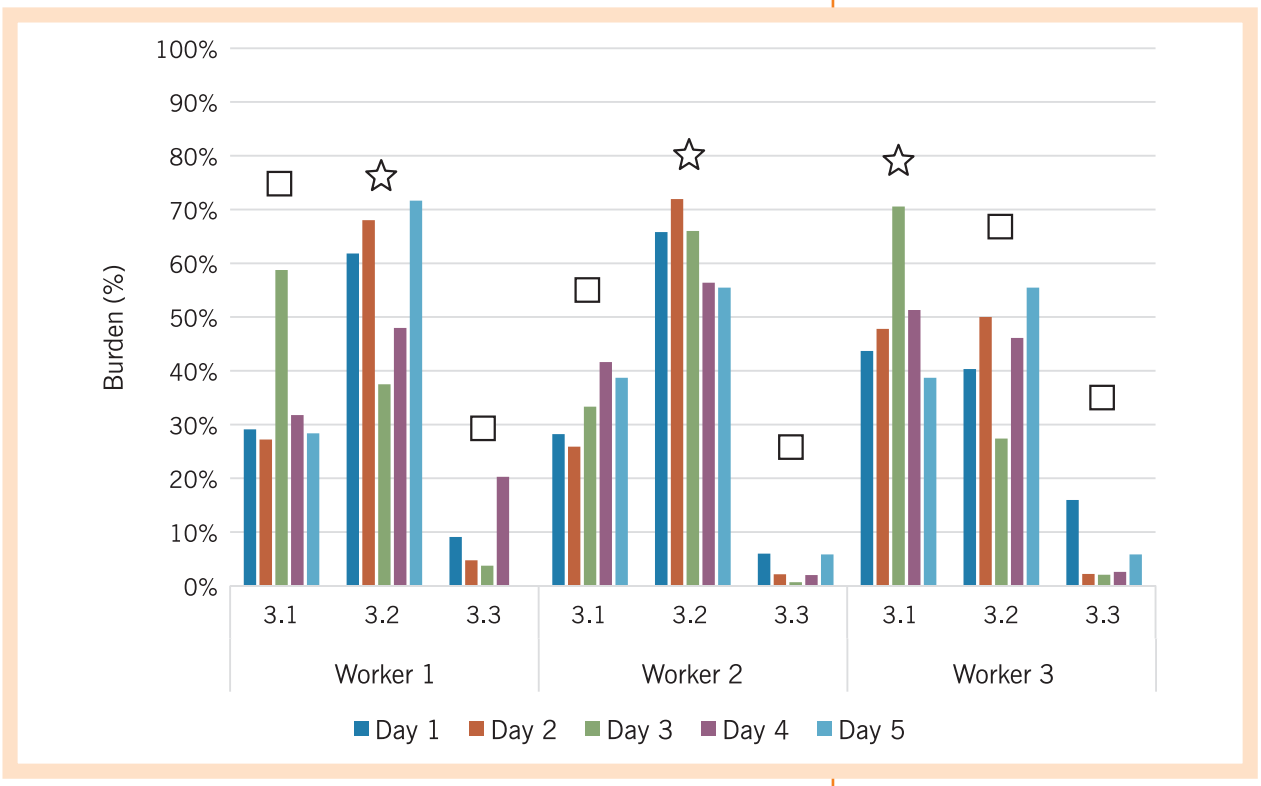


Figure 2:
The position and shape of the thoracolumbar spine of the three workers

Figure 3:
The position and shape of the arms of the three workers



the body and arm abduction occurs. We suggest the workers having only the documents they need in front of them.

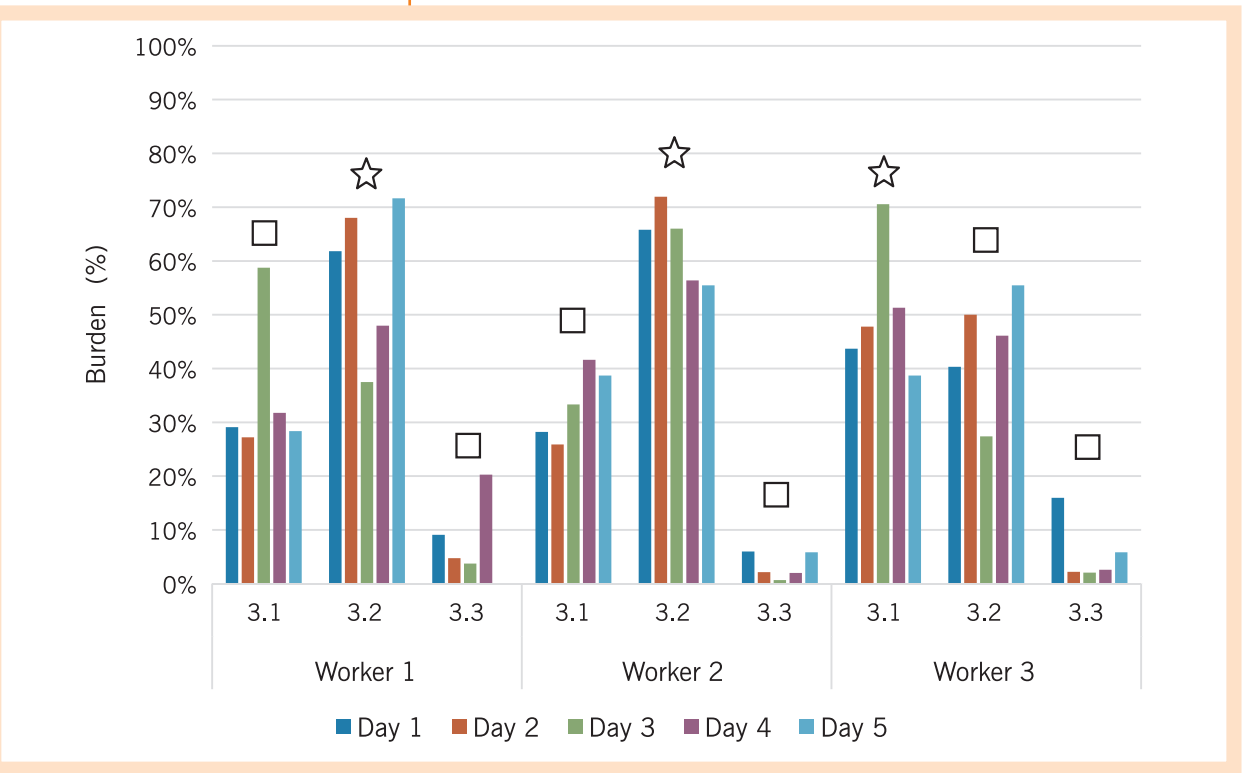
Concerning hands positioning, load was detected in the position 3.2., which was the result of typing. Because of the nature of work, the workers cannot avoid these situations; therefore, it is difficult to provide adequate measures (Figure 4). It would be necessary to do additional research. One of the options is that the employer would adapt computer programs in the way workers could be able to do more work with a computer mouse.

Figure 5 shows the position of the legs. It can be seen that it often comes to a position 4.1, which represents physiological or non-physiological seating. Taking measures is necessary shortly. By doing so, the workers could change positions of the lower limbs. Part of the work could be done in the sitting position (work on the computer) and a part in the standing position (while organizing documents). On the fourth day, the worker 1 was repeatedly observed in the situation 4.4. This position means standing on one or both legs, which are highly curved in the hips, knees, and ankles.

On the fourth day, the worker 1 greatly exceeded the physiological recommendations for this position, because she was cleaning up the warehouse, which is not part of the everyday tasks. This situation occurred during the cleaning of the lower shelves and that caused curves in the hips, knees, and ankles.

Figure 6 shows the positions of the cervical spine. In all subjects, there was a load in the position 5.2. In this situation, the head is bent forward for more than 30°. The excessive burden of cervical spine in this position

Figure 4:
The position and shape of the hands of the three workers



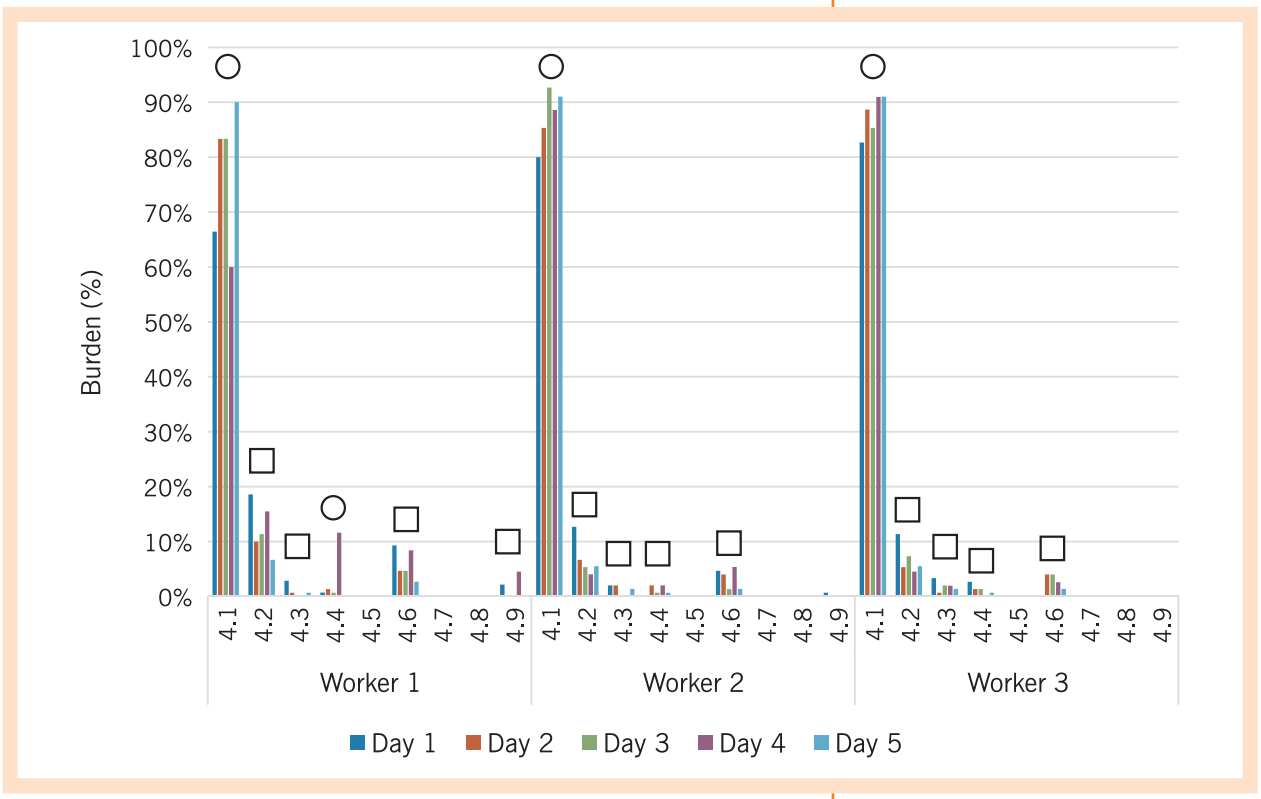
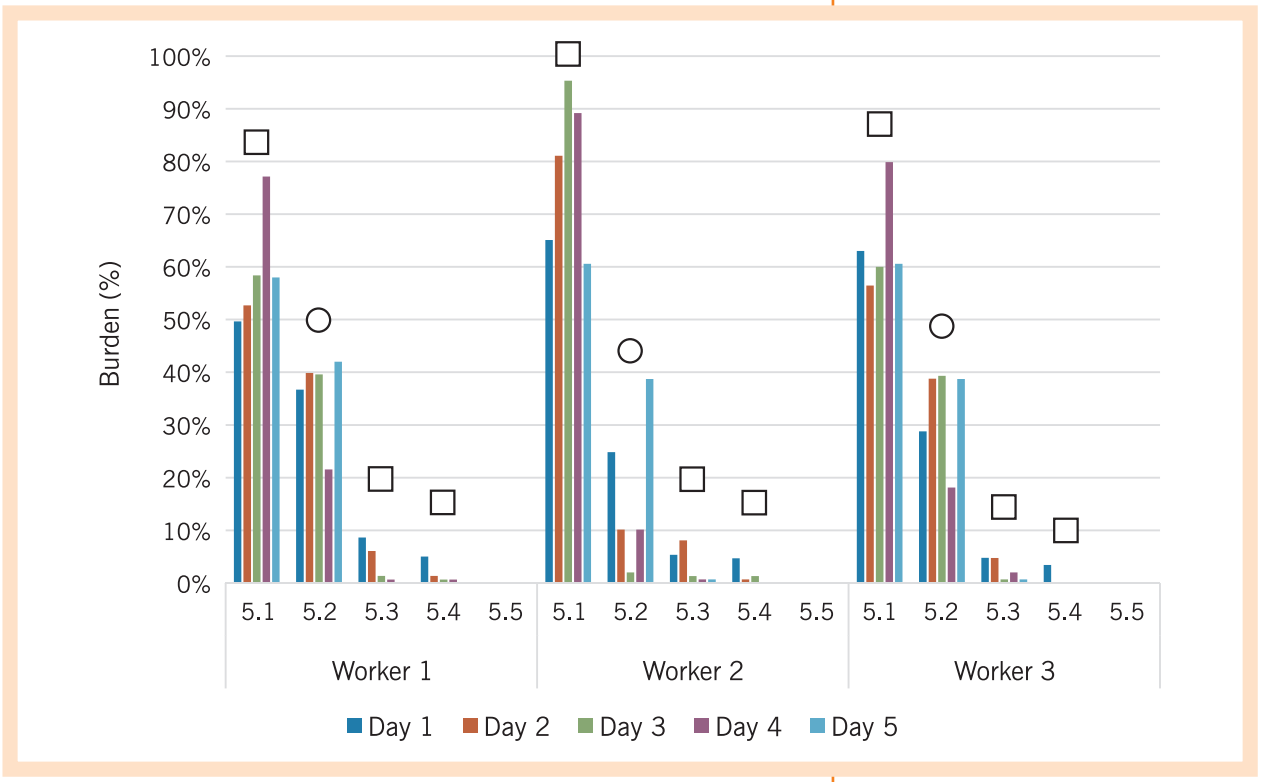


Figure 5:
The position and shape of the legs of the three workers

Figure 6:
The position and shape of the cervical spine of the three workers



is due to viewing of documents that are placed too close to the body of the worker, which is on the edge of the table. Thus, the workers' heads were heavily bent forward. The burden in the position 5.2 is also due to inadequate height of a screen. Annex to the Rules on safety and health requirements for work with visual display units [28] states the necessity of guaranteed possibility of adjusting the height of the screen in the way that the upper row on the screen is approximately 5cm below the eye level of a worker. Screens at workstations in the accounting firm have no possibility of adjusting the height, they are positioned too low and this does not meet the policy requirements. We recommend the employees to raise the screen or the monitor by putting it on a shelf.

Results of microclimatic conditions and lighting at workplaces

Table 2 shows the results of measurement of microclimate conditions in the office in the three workplaces. Microclimate conditions in the work area were measured when employees were there (4 pm), and in the evening, when the office was empty (10 pm). The average air temperature at 4 pm was 26.2 °C, and at 10 pm 27.1 °C. When the employees were present at the workplace, the air conditioning was turned on. Rules on requirements for ensuring the safety and health of workers at the workplace [22] say that the air temperature should not exceed 28 °C. The measured values were not exceeded.

According to the standard ISO 9241 [26], which sets more stringent range of permissible levels of air temperature in the office premises, the values of air temperatures were exceeded. The standard requires a temperature range of 19–23 °C. In the office with air-conditioning, we could meet the criteria of this standard by increasing the cooling activity of air conditioners. Considering the fact that employees do not feel the discomfort because of the temperature, these measured values will not be highlighted as problematic.

When workers were present, the average measured humidity in the work area was 47 % and 50 % when the office was empty and the air conditioner was turned off. According to the Regulation on requirements to ensure the safety and health of workers at the workplace [22], the value of humidity was not exceeded. We also measured the airflow during working hours, which was 0.11 ms^{-1}, which means it does not pose a risk to workers' health. Based on the measured parameters and an interview conducted with the employees, the accountants feel good in their workplaces.

Table 2: The results of microclimate conditions in the office at three workplaces

Microclimatic conditions		Humidity [%]		Air temperature [°C]		Airflow [ms^{-1}]	
		10 cm	110 cm	10 cm	110 cm	10 cm	110 cm
Workplace 1	at 4 pm	46.10	47.10	26.1	26.2	0.2	0.03
	at 10 pm	49.20	49.20	27.1	27.1	0.01	0.04
Workplace 2	at 4 pm	46.30	46.60	26.3	26.4	0.03	0.02
	at 10 pm	49.30	49.50	27.1	27.1	0.02	0.01
Workplace 3	at 4 pm	47.00	46.90	26	26	0.26	0.1
	at 10 pm	49.60	50.20	27.1	27.1	0.09	0.03

Table 3: The results of lighting in the office at three workplaces

	Daylighting [lx]	Artificial lighting [lx]	Combined lighting [lx]
Workplace 1	1925	349	2180
Workplace 2	326	245 (822)*	562 (1025)*
Workplace 3	1055	545	1426

*Value in the bracket is lighting with extra table lamp

Table 3 shows the results of measurements of daylighting, artificial lighting, and the combined lighting at three workplaces. In the Annex of the Rules on safety and health requirements for work with visual display units [28], it is indicated that the overall lighting of the workplace should be 400 lx ± 100 lx, which would ensure satisfactory lighting conditions. We found out that daylighting at the workplace 2 does not meet the conditions laid down in the Rules on safety and health at work on a display unit [28], but the employer had an additional lamp, which reached the prescribed value of the combined lighting.

CONCLUSION

The ergonomic arrangement of the working environment is a concern of an employer. The accounting firm is aware of the problem of overload in the workplace and is taking care of the realignment, improvements, and appropriate measures. We spend a great part of our life at the workplace, therefore, it is important that the work conditions are good and the work itself does not pose a risk to health. The study of ergonomic strains in the workplace of three accountants showed that the workers are in some inadequate positions. Due to improper seating, abduction of arms, and long-term and excessively bent position of the head, employees feel discomfort in the shoulders, back of the neck, upper back, lower back, and on the buttocks. Because of using the computer and incorrect position of the forearm, they have pain in the wrists. The measurement of microclimate conditions showed a deviation of an air temperature in the office, which was too high according to the standard ISO 9241. However, the workers feel good at the workplace; therefore, this failure has no particular meaning. Furthermore, they have an option for cooling the office using air conditioners.

We spend a great part of our life at the workplace, therefore, it is important that the work conditions are good and the work itself does not pose a risk to health.

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