

Analysis of Conditions and Organization of Work of Notebook Computer Users

Marzena Malińska
Joanna Bugajska
Joanna Kamińska
Anna Jędryka-Góral

Central Institute of Labour Protection – National Research Institute (CIOP-PIB), Poland

Aim. The aim of this study was to evaluate working conditions with a notebook computer (notebook) as a potential cause of musculoskeletal disorders. **Material and methods.** The study had 2 stages. The first one was a questionnaire survey among 300 notebook users. The next stage was an expert analysis of 53 randomly selected workstations. The questionnaire survey included questions about the participants, their working conditions, work organization and also duration of work with a notebook. **Results and conclusions.** The results of the research showed that most examined operators used a notebook as a basic working tool. The most important irregularities included an unadjustable working surface, unadjustable height of the seat pan and backrest, unadjustable height and distance between the armrests and no additional ergonomic devices (external keyboard, docking station, notebook stand or footstool).

notebook computer working conditions organization of work

1. INTRODUCTION

The use of a notebook computer (notebook) not only as an auxiliary device (while travelling or when out of the office), but as the main, and very often the only computer in the office, is becoming an increasingly frequent phenomenon [1].

By their nature, notebooks are not designed for continuous work at a stationary office workstation. Inconveniences related to working with a notebook are caused by, e.g., a fixed connection of the keyboard with the monitor, the small size of the computer and the monitor itself as well as frequent problems with operating pointing devices (e.g., the touch pad). There have been relatively few epidemiological studies on working conditions at a computer workstation. An analysis of studies on working with a desktop computer suggests that there is

a casual relationship between long working hours with a computer and health disorders, mainly with respect to the musculoskeletal and visual systems. This was the reason for preparing recommendations and guidelines on shaping proper working conditions with a notebook according to the principles of ergonomics. Conditions in which a notebook is used do not always make it possible to apply the principles of ergonomics as they often force an incorrect posture, which results in musculoskeletal load.

Therefore, it may be assumed that working long hours with a notebook in non-ergonomic conditions (random location of a workstation, no additional devices such as an external keyboard, document stand, footstool) and, on the other hand, failure to have regular breaks result in musculoskeletal pain [2, 3, 4, 5, 6].

This paper was based on the results of a research task carried out within the scope of the first stage of the National Programme “Improvement of safety and working conditions” partly supported in 2008–2010—within the scope of state services—by the Ministry of Labour and Social Policy. The Central Institute for Labour Protection – National Research Institute was the Programme’s main co-ordinator.

Correspondence and requests for offprints should be sent to Marzena Malińska, CIOP-PIB, ul. Czerniakowska 16, 00-701 Warszawa, Poland. E-mail: mimar@ciop.pl.

Legal documents such as Directive 90/270/EEC and implemented national documents do not consider cases of using a notebook at work [7, 8]. Therefore, it is necessary to carry out studies on working conditions with a notebook. The objective of this study was to evaluate working conditions (work organization, duration of work, workstation equipment) with a notebook as a potential cause of musculoskeletal disorders.

2. METHODS

2.1. Study Group

The study involved 300 workers using a notebook to perform their occupational daily duties. Over 64% of the participants were office workers, 16% were managers, 10% worked in the field and 10% did other kinds of work, e.g., laboratory work.

Participation in the study was voluntary; it required written consent from the participants. The Committee for Ethics of the Central Institute for Labour Protection – National Research Institute (CIOP-PIB) approved the study.

The study had two stages. In the first one, a questionnaire survey was carried out among 300 users of notebooks, then 53 randomly selected workstations of those users were analysed.

2.2. Questionnaire Surveys

The questionnaire survey consisted of information on participants and questions on work organization and duration of work with a notebook. The general part of the survey included questions on gender, age, education, type of work (office, in the field, managers, etc.) and anthropometric data (height, weight). The second part included questions on total work experience and work experience with a notebook (in years), the average daily time of using a notebook at work and at home (in hours), the frequency of using a notebook (every day, several times a week, occasionally), types of tasks for which a notebook is used and the frequency of breaks during work and the way of spending them.

2.3. Expert Analysis

Experts used a checklist to analyse notebook workstations. The following factors were evaluated: (a) location of the notebook (on a computer desk, on an ordinary desk, on an ordinary table, other solutions); (b) adjustable height working surface (e.g., tabletop); (c) adjustable chair (height, seat pan and backrest angle); (d) adjustable armrests (height, distance between them, no adjustment possible); (e) chair with or without five wheels; (f) presence of additional external devices (a keyboard or a docking station).

2.4. Statistical Analysis

The statistical analysis was carried out with Statistica 9.0. For descriptive analysis, mean values and standard deviations (quantitative variables) and frequencies (qualitative variables) were calculated.

3. RESULTS

3.1. Participants

The data for this study came from 131 women (43.7%) and 169 men (56.3%), aged 19–66 years. The average age of the participants was 31.3 (*SD* 9.2). Over half of the participants (65%) had university-level education, 34% had secondary education and 1% had vocational education. The total work experience was 4.2 years (*SD* 1.8). The average work experience with a notebook was 3.4 years (*SD* 1.3). Twenty-two and 18% of the participants had 2–5 and 5–10 years of occupational work, respectively. The average body weight was 71.2 kg (*SD* 13.8) and the average height was 174 cm (*SD* 9.4).

3.2. Workload and Work Organization

Over 70% of the participants considered a notebook their basic working tool. Most participants used a notebook at a stationary office workstation. About 33% of the participants also used notebooks at home and 5% during business trips. Over 67% of the participants worked with a notebook every day, 50% of them used it for work for at least 5 h daily.

The participants used a notebook to input data (17%), to edit texts (16%), to communicate and to visit websites (14.8%). Table 1 presents the data.

TABLE 1. Workload and Work Organization With a Notebook

Variable	Notebook N (%)
Tasks for which notebook is used	
data input	221 (16.62)
text editing	214 (16.09)
communicating (e-mail, communicators)	211 (15.90)
visiting websites	197 (14.80)
computing	165 (12.40)
presentations	130 (9.80)
artwork	98 (7.40)
other	94 (7.10)
Taking regular breaks after each hour of work with a notebook	
no	173 (57.67)
yes	124 (41.33)
other	3 (1.00)
Activities during breaks	
eating, drinking coffee/tea	127 (29.26)
talking on the telephone	67 (15.44)
talking with colleagues while still sitting at the desk	57 (13.13)
talking with colleagues while standing or strolling	48 (11.06)
entertainment (computer games, websites)	48 (11.06)
standing at the window, looking at the landscape	30 (6.91)
doing minor stretching exercises	28 (6.45)
other	29 (6.68)

The average number of overtime hours of notebook users on working days was 1.1 (*SD* 1.6). The average number of hours at a random workstation was 0.3 (*SD* 0.9).

Over 58% of the participants had regular 5-min breaks included in their working time. The most frequent activities during breaks were eating (29%), talking on the telephone (15%) and talking with colleagues while still sitting at the desk (13%). Only 6% of the participants did minor physical exercises during breaks. Table 2 presents the results of an expert analysis of the working conditions and the equipment at notebook workstations.

TABLE 2. Expert Analysis of Working Conditions and Notebook Equipment

Variable	Notebook N (%)
Edge of a computer desk	
rounded	142 (46.00)
unrounded	160 (54.00)
Space under a tabletop	
space for legs	268 (89.33)
no space for legs	32 (10.66)
Wrist support (at least 10 cm from the edge of a table)	
yes	99 (33.00)
no	120 (40.00)
other	81 (27.00)
Proper size and shape of a seat pan	
yes	234 (78.00)
no	66 (22.00)
Adjustable chair	
height of seat pan	202 (40.64)
angle of seat pan	101 (20.32)
height of backrest	84 (16.90)
angle of backrest	110 (22.13)
Chair with five wheels	
yes	210 (73.00)
no	81 (27.00)
Distance between a monitor and eyes	
≤45 cm	247 (79.00)
>45 cm	53 (16.67)
Position of a screen	
below eye level	137 (45.66)
at eye level	105 (35.00)
Position of a monitor	
at an angle to the window (at least 1 m away)	194 (64.66)
facing the window	65 (21.66)
against the window	41 (13.66)
Proper light at a workstation	
yes	234 (78.00)
no	66 (22.00)
Elements of equipment	
external mouse	231 (75.00)
external keyboard	66 (22.00)
pointing device (touch pad, touch screen, etc.)	50 (16.23)
footstool	3 (1.00)
computer stand	1 (0.33)
other	19 (6.30)

3.3. Workstation

3.3.1. Table

The survey showed that 63% of the participants placed a notebook on an ordinary desk. Only 6% of the participants used a computer desk with a keyboard drawer. Over half of the participants did not have adjustable working surface, with rounded edges.

On 40% of the workstations, users did not use a wrist support at least 10 cm from the edge of the table. Most participants (89%) stated they had sufficient space for their legs.

3.3.2. Chair

Only 41% of the participants could adjust the height of the seat pan, 20% could adjust the seat pan, 22% could adjust the backrest of the chair and 17% of the participants could adjust the height of the backrest.

Over 70% of the participants had a chair with five wheels, 62% of the participants had a chair with armrests. Only 19% of the chairs with the armrests had adjustable height and distance between armrests.

Approximately 78% of the notebook operators were satisfied with the size and profile of the seat pan and the backrest of their computer chairs. For the other participants (22%), the shape of the chair did not ensure a comfortable sitting posture. Most participants (69%) used the back of the chair while working on a notebook.

3.3.3. Monitor

At 65% of the workstations, the monitor sat at an angle to the window (at least 1 m away). Over 21% of the monitors were facing the window, whereas 13% were against the window.

Over 45% of the participants had the upper edge of the computer screen below their eye level, 35% at the eye level and 19% above the eye level.

At 78% of the workstations, there were no reflections of windows or light fixtures on the screen. On 92% of the monitors, the picture was stable, without flickering or other forms of instability.

3.3.4. Additional equipment

An external mouse (75%), external keyboard (22%) and pointing device (touch pad, touch screen, etc.) (16%) were the most frequently used additional computer equipment. No participants used a docking station and only one person had a notebook stand. Most notebook users (~97%) did not have a footstool or were not able to use it.

4. DISCUSSION

The results of the study support the observation that workers changed the original use of a notebook from additional computer to the main computer used in the company. Over 67% of the participants worked with a notebook every day and ~50% used it for over 5 h daily. A notebook was used at a stationary office workstation, which was often non-ergonomic. It is very worrying that ~70% of participants used a notebook not only in the office but also for occupational purposes at home and 77% of them used a notebook on days off.

The results of the study showed departures from ergonomic working conditions with a computer screen among workers who use a notebook in their work. Most participants at analysed workstations with a notebook could not adjust the working surface. A notebook usually sat on an ordinary desk and there was no docking station or footstool. Irregularities were also observed in the use of chairs on which workers spend most of their working time. Over 75% of the participants had chairs with five wheels. Most participants (50%) had chairs with armrests but most of them did not have any regulation mechanisms and a substantial minority had only adjustable height and distance of armrests.

Irregularities at workstations with a computer screen and extended duration of work with a notebook cause musculoskeletal pain [9, 10, 5, 11, 12]. According to our previous studies, the most frequently reported musculoskeletal disorders among notebook users are pain in lumbar and sacral spine (38%), pain in cervical spine (35%), pain in lower limbs (21%), arm and wrist pains (17%) and pain in shoulder joint (11%).

The use of an external keyboard is especially important as it has a statistically significant influence on a decrease in the risk of shoulder disorders [5]. According to Sommerich, Starr, Smith, et al. using additional devices such as an external keyboard and mouse while working with a notebook results in a decrease in tension of the cervical spine muscles [13].

Punnet, Bergqvist [14] and Klipstein, Huwiler, Widmer [15] discussed the meaning of ergonomic working conditions with a notebook in reducing musculoskeletal disorders caused by working with a notebook. According to other studies, non-ergonomic working conditions (including a monitor above eye level, reflections and light fixtures, incorrect sitting posture or wrong organization of the workstation) are risk factors for developing musculoskeletal disorders such as pain in cervical, lumbar and sacral spine or in lower limbs [16, 17, 18, 19]. According to Konarska, Wolska, Widerszal-Bazyl, et al. improving working conditions results in less eye pain, headache, pain in the neck and back [20]. Marcus, Gerr, Monteilh, et al. pointed out that correct height of a computer desk, presence of armrests and correct position of a neck during work were factors decreasing the risk of pain in the neck and shoulders [6]. Other studies showed that an ergonomic workstation resulted in a decrease in muscle activity determined with electromyography (EMG), leading to a decrease in pain in shoulders, neck and lumbar spine [21, 20]. Studies clearly show that organization of the workstation is statistically significant in preventing musculoskeletal disorders among notebook users.

To ensure ergonomic conditions, a notebook workstation should be equipped with appliances like an external keyboard, mouse, computer stand and/or docking station. Such workstation could function as a desktop computer workstation and it could help to eliminate or significantly reduce musculoskeletal pain. Fulfilling these requirements would also help to maintain the correct posture of the head, cervical spine and upper limbs. Correct sitting posture during work with a notebook would decrease pain in the lumbar and sacral spine. To prevent incorrect sitting posture,

external equipment should be placed within the range of the upper limbs; while operating the keyboard a right angle should be kept between the forearm and the arm, and there should be sufficient space for the legs under the tabletop.

Ensuring correct working conditions with a notebook is a simple way to prevent office workers from experiencing health problems. Improving working conditions decreases musculoskeletal strain at work, which later results in a reduced number of workers complaints and sick leaves. Improved working conditions also result in a reduction in work costs and in an increase in work efficiency and income. Improved would be also the socioeconomic status and the quality of work.

Conclusions

The results of the research show that most participants use a notebook as a basic working tool. The most important irregularities include

- unadjustable working surface;
- no space for legs under tabletop;
- unadjustable height, seat pan, backrest of the chair and unadjustable height and distance between armrests;
- no additional ergonomic devices, such as external keyboard, docking station, notebook computer stand or footstool.

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