

Ergonomics Aspects of Work with Computers

Leena Korpinen, Rauno Pääkkönen, Fabriziomaria Gobba

Abstract—This paper is based on a large questionnaire study. The paper presents how all participants and subgroups (upper- and lower-level white-collar workers) answered the question, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the different body parts during the last 12 months?” 14.6% of participants (19.4% of women and 8.2% of men) reported that they had often or very often physical symptoms in the neck. Even if our results cannot prove a causal relation of symptoms with computer use, show that workers believe that computer use can influence their wellbeing: this is important when devising treatment modalities to decrease these physical symptoms.

Keywords—Ergonomics, work, computer, symptoms.

I. INTRODUCTION

IN recent decades, the use of computers and laptops has increased. At the same time, computer work is widely perceived as a new risk factor for musculoskeletal disorders (MSDs). In European countries, the MSDs have become more frequently diagnosed occupational diseases [1].

Associations between computer work and MSDs have been researched in several studies [2]–[6]. Based on the literature [2]–[6], for example, the 12-month prevalence rates of musculoskeletal pain (MSP) in the neck is 55–69% and in the back 31–54%. In addition, other risk factors for MSPs have been reported: demographic (gender, age) and other personal characteristics (height, smoking, tendency to somatize), and also psychosocial, organizational, and physical aspects of work [2], [7]–[11]. Rempel et al. [12] and Esmaeilzadeh et al [13] reported that a poor body posture and ergonomic design of the workstation can contribute to the occurrence of work-related musculoskeletal disorders in the upper extremity [12], [13].

Yang et al. [14] studied work-related risk factors for neck pain in the US working population. They concluded that their study adds to the evidence that an individual’s occupation and work hours affect workers’ risk for neck pain. Palmer et al. [15] studied the prevalence and occupational associations of neck pain in the British population. They found that construction workers, followed by nurses and armed services members were shown to have higher prevalence for neck pain [15].

The use of personal computers, other technical equipment, such as portable computers, notebooks, cell phones, and, more recently, also tablets, e-readers and smartphones, has increased, which has resulted in new human–computer interactions. For this reason, we performed a study of possible influences of new

technical equipment on the health of the working-age population in 2002. The questionnaire was divided into six sections: (1) background information, such as age, gender, marital status, education, occupation, and home county; (2) the familiarity and mapping the use of given technical devices at leisure and at work, (3) physical loading and ergonomics; (4) psychological welfare; (5) accidents and close-call situations; and (6) an open-ended question: “Other observations concerning technology and health.” The details of the questionnaire have been reported earlier [16], [17].

The aim of this paper is to present how all respondents and subgroups (upper- and lower-level white-collar workers) answered the question, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?” and compare background information, such as gender and the physical symptoms of different groups.

II. METHODS

A. Study Population and Questionnaire

A questionnaire was sent to 15,000 Finns. As the study focused on the working age population, only people aged 18–65 were included. Names and addresses were obtained randomly from the Finnish Population Register Centre. The study design was approved by the local Ethical Committee (Pirkanmaa Health District, Finland, decision R02099).

This paper concentrates on all participants and their answers to Question 14, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months”:

- 14a. in wrists and fingers
- 14b. in elbows and forearms
- 14c. in neck
- 14d. in shoulders
- 14e. in hips and lower back
- 14f. in feet.

The options for Question 14 were, “cannot say,” “not at all,” “sometimes,” “quite often,” “often and very often.”

B. Statistical Analyses

The statistical analysis was performed using IBM SPSS Statistics version 23 software. To compare differences of background information, such as gender and the physical symptoms of different groups (upper-level white-collar workers and lower-level white-collar workers), we used independent samples Mann-Whitney U-test analyses.

In the statistical work, we used the following analyses: (1) comparison of answers to Question 14 between female and male participants (Analysis I); (2) comparison of answers to Question 14 between upper-level white-collar workers and

L Korpinen and R. Pääkkönen are with the Department of Electronics and Communications Engineering, Tampere University of Technology, P.O.Box 692, 33101 Tampere, Finland, Phone: +358 3 3115 11; fax: +358 3 364 1385; e-mail: leena.korpinen@tut.fi, rauno.paakkonen@gmail.com).

F. Gobba is with the Department of Diagnostic, Clinical and Public Health Medicine, University of Modena and Reggio Emilia Italy, Modena, Italy (e-mail: f.gobba@unimore.it).

lower-level white-collar workers (Analysis II); (3) comparison of answers to Question 14 between female and male upper-level white-collar workers (Analysis III); (4) comparison of answers to Question 14 between female and male lower-level white-collar workers (Analysis IV).

III. RESULTS

We received responses 6121 persons (the response percent 41 %). To Question 14, we obtained the following number of responses: 14a, (in wrists and fingers) 5885; 14b, (in elbows and forearms) 5879; 14c, (in neck) 5893; 14d, (in shoulders) 5866; 14e, (in hips and lower back), 5877; and 14f; (in feet) 5872. Figs. 1-3 show the “yes” responses of all, female, and male participants to Question 14. “Yes” responses included answers “often” and “very often.”

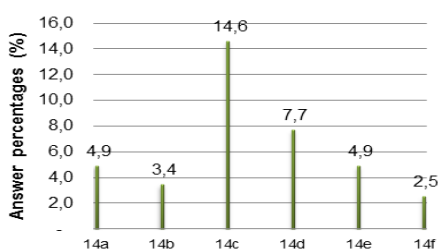


Fig. 1 “Yes” responses of all participants

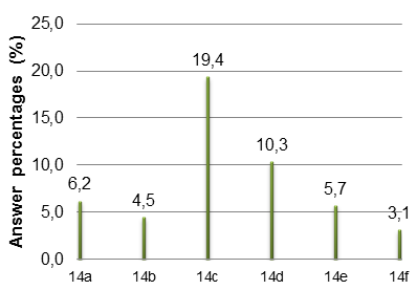


Fig. 2 “Yes” responses of all female participants

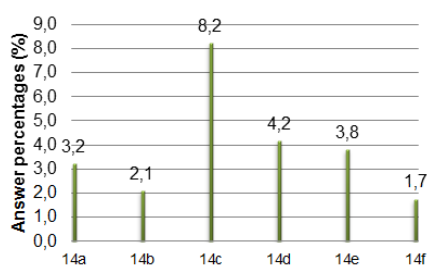


Fig. 3 “Yes” responses of all male participants

We received responses from 1121 upper-level white-collar workers and from 1425 lower-level white-collar workers. Figs. 4, 5, and 6 show the “yes” responses of all upper-level white-collar workers, female upper-level white-collar workers, and male upper-level white-collar workers to Question 14.

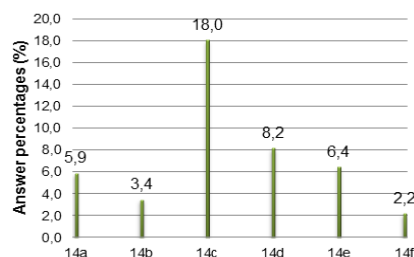


Fig. 4 “Yes” responses of all upper-level white-collar workers

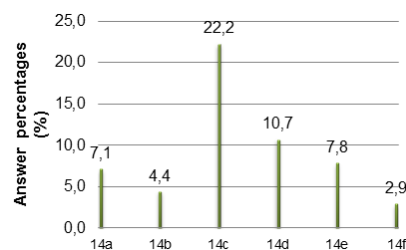


Fig. 5 “Yes” responses of female upper-level white-collar workers

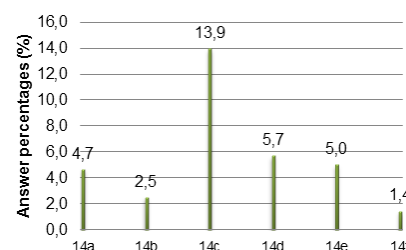


Fig. 6 “Yes” responses of male upper-level white-collar workers

Figs. 7-9 show the “yes” responses of all upper-level white-collar workers, female lower-level white-collar workers, and male upper-level white-collar workers to Question 14.

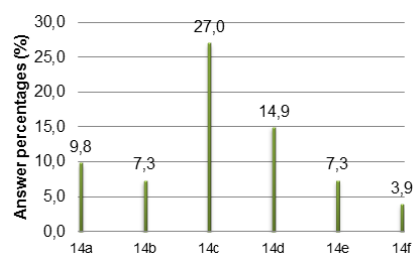


Fig. 7 “Yes” responses of all lower-level white-collar workers

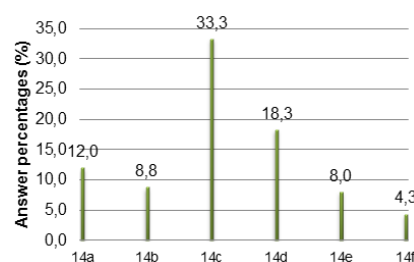


Fig. 8 “Yes” responses of female lower-level white-collar workers

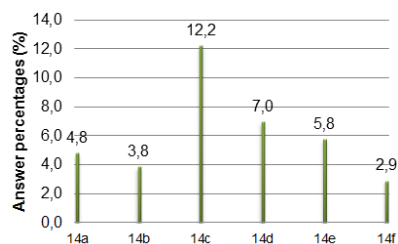


Fig. 9 “Yes” responses of male lower-level white-collar workers

Table I shows the results of Analysis I (comparison between female and male participants) using the answers to Question 14, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?” (with independent samples Mann-Whitney U-test analyses).

Symptoms	Asymp. Sig.(2-tailed)
14a. in wrists and fingers	<0.001*
14b. in elbows and forearms	<0.001*
14c. in neck	<0.001*
14d. in shoulders	<0.001*
14e. in hips and lower back	<0.001*
14f. in feet.	<0.001*

* significant at $p < 0.05$

Table II shows the results of Analysis II (comparison between upper-level white-collar workers and lower-level white-collar workers), using the answers to Question 14, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?” (with independent samples Mann-Whitney U-test analyses).

Symptoms	Asymp. Sig.(2-tailed)
14a. in wrists and fingers	<0.001*
14b. in elbows and forearms	<0.001*
14c. in neck	<0.001*
14d. in shoulders	<0.001*
14e. in hips and lower back	<0.001*
14f. in feet.	<0.001*

* significant at $p < 0.05$

Table III shows the results of Analysis III (comparison female and male upper-level white-collar workers), using the answers to Question 14, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?” (with independent samples Mann-Whitney U-test analyses).

Table IV shows the results of Analysis IV (comparison between female and male lower-level white-collar workers), using the answers to Question 14, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?” (with independent samples Mann-Whitney U-test analyses).

Symptoms	Asymp. Sig.(2-tailed)
14a. in wrists and fingers	0.855
14b. in elbows and forearms	0.774
14c. in neck	<0.001*
14d. in shoulders	0.068
14e. in hips and lower back	0.270
14f. in feet.	0.252

* significant at $p < 0.05$

Symptoms	Asymp. Sig.(2-tailed)
14a. in wrists and fingers	<0.001*
14b. in elbows and forearms	<0.001*
14c. in neck	<0.001*
14d. in shoulders	<0.001*
14e. in hips and lower back	0.002*
14f. in feet.	0.006*

* significant at $p < 0.05$

IV. DISCUSSION

The focus of this paper was the question, “Have you had an ache, pain, or numbness, which you associate with desktop computer use, in the following body parts during the last 12 months?”, which included the assumptions that the use of computers can influence physical symptoms. The question could lead the participants to think that the use of computers could possibly increase their symptoms. This limitation is important to this take into account when analyzing of results.

Figs. 1–7 show that participants associated most symptoms in the neck with desktop computer use. However we did not perform statistical analyses between different symptoms; therefore, we cannot say if the differences are significant. We have reported the results of neck symptoms in our earlier article [18].

The statistical analyses show that there were significant differences in the answers between female and male participants and in the group of lower-level white-collar workers. However, in the group of upper-level white-collar workers, there were significant differences between women and men only on Question 14c (symptoms in neck). Female participants reported more symptoms than male participants.

Nowadays white-collar workers use computers, Smartphones, and other mobile devices very often. They typically also sit much of the day, which can also influence to their well-being.

The smartphone health effects have been also studied [18], [19]. Kim [19] has studied the influence of neck pain on cervical movement in the sagittal plane during smartphone use. He concluded that his findings suggest that young adults with mild neck pain (MNP) are more careful and more frequently utilize a neutral neck posture than young adults without MNP when using a smartphone while sitting. Park et al. [20] also investigated the effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles, and depression. They

found that heavy smartphone use may produce considerable stresses on the cervical spine, and then it is possible that the pain threshold of the muscles around the neck. They also described that smartphones could also cause negative effects on a person's psychological status, such as depression. [20]

Experienced symptoms in the neck and shoulders should be relieved, for example, by looking for preventive medical inspections, by better solutions for keyboards, displays, and working postures. Also computer programs should be used so that reading is as easy as possible by, for example, larger fonts. Regular breaks during working and analyzing sedentary behavior are means to self-awareness actions.

In the future, it is important to consider that physical symptoms of workers who use heavy desktop computers, laptops, smartphones or other mobile devices can be partly or fully caused by their use of computers. It is also useful and important to develop computer ergonomics.

V. CONCLUSION

In our questionnaire study, a significant proportion of participants (about 15%) reported that they had often or very often an ache, pain, or numbness in the neck, which they associated with desktop computer use, during the last 12 months. The symptoms were more frequent in women: the proportion was more than double compared to men: 19% vs. 8% respectively. The prevalence of symptoms was higher in lower-level white-collar workers: 27% vs. 18% in upper-level white-collar workers; in both groups the prevalence confirmed higher in women. Similar results were obtained also in shoulders, but with a lower overall prevalence: 8% (10 and 4% respectively in women and men). These results are based on a subjective evaluation of the correlation of symptoms to the use of computers, accordingly do not prove a causal relation with computer use, but show on a large sample that persons, especially lower-level white-collar women workers, believe that computer use can influence their wellbeing: this belief should be included among factors to be considered in future studies.

ACKNOWLEDGMENT

The assistance of the staff (Noomi Suuronen, Jari Latva-Teikari, and Riitta Lehtelä) of the Environmental Health group, Tampere University of Technology is gratefully acknowledged. Special thanks go to Professor Irma Virjo, Faculty of Medicine, Tampere University, for her advice on designing the questionnaire.

REFERENCES

- [1] European Agency for Safety and Health at Work: OSH in figures: work-related musculoskeletal disorders in the EU-facts and figures. European risk observatory report 2010. (<https://osha.europa.eu/en/publications/reports/TERO09009ENC/view>)
- [2] K. Kristel Oha, L. Animägi, M. Pääsuke, D. Coggon, and Merisalu E. "Individual and work-related risk factors for musculoskeletal pain: a cross-sectional study among Estonian computer users," *BMC Musculoskeletal Disorders*, vol. 15, p. 181, May 2014; <http://www.biomedcentral.com/1471-2474/15/181>
- [3] A. Klusmann, H. Gebhardt, F. Liebers, and M. A. Rieger, "Musculoskeletal symptoms of the upper extremities and the neck: a

- cross-sectional study on prevalence and symptom-predicting factors at visual display terminal workstations," *BMC Musculoskeletal Disorders*, vol. 9, pp. 1–16, June 2008.
- [4] V. Woods, "Musculoskeletal disorders and visual strain in intensive data processing workers," *Occup Med*, vol. 55, pp. 121–127, 2005.
 - [5] P. Janwantanakul, P. Praneet, V. Jiamjarasrangsri, and T. Sinsongsok: "Prevalence of self-reported musculoskeletal symptoms among office workers," *Occup Med*, vol. 58, pp. 436–438, September 2008.
 - [6] J. Sillanpää, S. Huikko, M. Nyberg, P. Kivi, P. Laippala, and J. Uitti, "Effect of work with visual display units on musculoskeletal disorders in the office environment," *Occup Med*, vol. 53, pp. 443–451, July 2003.
 - [7] A. Grimby-Ekman, E. Anderson, and M. Hagberg, "Analyzing musculoskeletal neck pain, measured as present pain and periods of pain, with three different regression models: A cohort study," *BMC Musculoskeletal Disorders*, vol. 10, no. 73, pp. 1–11, June 2009.
 - [8] S. Eltayeb, J. B. Staal, A. Hassan, and R. A. De Bie, "Work related risk factors for neck, shoulder and arms complaints: a cohort study among Dutch computer office workers," *J Rehabil*, vol. 19, pp. 315–322, December 2009.
 - [9] C. Jensen, C. U. Ryholt, H. Burr, E. Villadsen, and H. Christensen, "Work-related psychosocial, physical and individual factors associated with musculoskeletal symptoms in computer users," *Work Stress*, vol. 16, no. 2, pp. 107–120, 2002.
 - [10] B. R. Da Costa, and E. R. Viera, "Stretching to reduce work-related musculoskeletal disorders: A systematic review," *J Rehabil Med*, vol. 40, pp. 321–328, Month 2008.
 - [11] B. R. Da Costa, and E. R. Viera, Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies," *Am J Ind Med*, vol. 53, pp. 285–323, March 2010.
 - [12] D. Rempel, N. Krause, R. Goldberg, D. Benner, M. Hudes, and G. U. Goldner, "A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators," *Occup Environ Med*, vol. 63, pp. 300–306, May 2006.
 - [13] S. Esmailzadeh, E. Ozcan, and N. Capan, "Effects of ergonomic intervention on work-related upper extremity musculoskeletal disorders among computer workers: A randomized controlled trial," *Int Arch Occup Environ Health*, vol. 87, pp. 73–83, January 2014.
 - [14] H. Yang, S. Haldeman, A. Nakata, et al. "Work-Related Risk Factors for Neck Pain in the US Working Population", *SPINE*, vol. 40, pp 184 – 192, February, 2015.
 - [15] K. T. Palmer, K. Walker-Bone, M. J. Griffin, et al. "Prevalence and occupational associations of neck pain in the British population". *Scand J Work Environ Health*, vol. 27, 49–56, 2001.
 - [16] L. Korpinen, and R. Pääkkönen, "Mental symptoms and the use of new technical equipment," *Int J Occup Safety and Erg*, vol. 15, pp. 385–400, 2009.
 - [17] L. Korpinen, N. Suuronen, J. Latva-Teikari, and R. Pääkkönen, "A questionnaire on the health effects of new technical equipment," *Int J Ind Erg*, vol. 39, pp. 105–114, January 2009.
 - [18] L. Korpinen, R. Pääkkönen, F. Gobba, "Self-reported neck symptoms and use of personal computers, laptops, and cell phones among Finns aged 18–65," *Ergonomics*, vol. 56, pp. 1134–1146, July 2013.
 - [19] M.-S. Kim, "Influence of neck pain on cervical movement in the sagittal plane during smartphone use," *J. Phys. Ther. Sci.*, vol. 27, pp. 15–17, June 2015.
 - [20] J.-H. Park, J.-H. Kim, J.-G. Kim, K.-H. Kim, N.-H. Kim, I.-W. Choi, S.-J. Lee, and J.-E. Yim "The effects of heavy smartphone use on the cervical angle, pain threshold of neck muscles and depression," *Advanced Science and Technology Letters*, vol. 91 (Bioscience and Medical Research), pp. 12–17, 2015; <http://dx.doi.org/10.14257/astl.2015.91.03>

Professor Leena Korpinen is a multidisciplinary scientist who is a licensed doctor of medicine and holds a PhD in technology. Her doctorates handle electric power engineering, more precisely the health effects of exposure to low frequency EMF on employees in work settings. In 1998, she was awarded a professorship in electric power engineering. From 2001–2007, Dr. Korpinen led the Laboratory of Electrical Engineering and Health at TUT, and due to structural changes at TUT in 2008, her professorship has since been in environmental health, more specifically researching "the environmental effects of energy production and distribution, and of traffic." She is also a member of the Bioelectromagnetics Society (BEMS), the European BioElectromagnetics Association (EBEA), and the Conseil International des Grands Réseaux

Electriques (CIGRE), and she serves as the Secretary of the Scientific Committee on Radiation and Work of the International Commission on Occupational Health (ICOH).

Rauno Pääkkönen is an Adj. Professor, DSc, at Tampere University of Technology and is the CEO of his own company. He also works as a counselor in environmental issues at the Finnish Supreme Administrative Court. His research has been focused on work environmental factors and well-being. He has contributed to more than 380 scientific texts and 160 popular articles. Earlier he was a director of the theme that included all types of well-being solutions at work at the Finnish Institute of Occupational Health.

Professor Fabriziomaria Gobba, Associate Professor of Occupational Health, is the Chair of the Scientific Committee on Radiation and Work of the International Commission on Occupational Health (ICOH), the Vice President of the Italian Association for Medical Radioprotection (AIRM), and a member of the national board of the Italian Society of Occupational Medicine (SIMLII). He has 30 years of experience in epidemiological studies on adverse effects of chemical and physical risk factors in workers. For about 20 years, he has been performing research on occupational and environmental exposure to Non-Ionizing Radiations, and on possible adverse health effects, and he has published several papers on this topic in international scientific journals.