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The impact of increased computer screen time during the COVID-19 pandemic on the occurrence of upper part of musculoskeletal diseases among health personnel

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Health personnel who played a key role in the fight against the pandemic stayed during it burdened with increased working time using a computer. We analyzed the impact of increased computer working time during the COVID-19 pandemic on the occurrence of the upper part of musculoskeletal diseases among health personnel. The study group consisted of 418 health personnel, divided according to the time they worked at the computer during the pandemic: up to 2 h a day, from 3 to 5 h a day, and more than 6 h a day. The ICF profile analyzed symptoms of dysfunction of structures of the upper part of the musculoskeletal system (head and cervical spine, shoulder girdle, elbow joint, wrist joint). Employees working more than 6 h daily had a higher risk of developing restrictions in tone of isolated muscles and muscle groups $p < 0.001$), range of motion of the shoulder girdle ($p < 0.001$), increased tension of paraspinal muscles ($p < 0.001$), weakened shoulder girdle muscle strength ($p < 0.001$), elbow joint pain ($p = 0.016$), wrist joint pain ($p < 0.001$), coordination disorders ($p = 0.004$), difficulties in arm and hand use ($p < 0.001$), lifting and carrying objects ($p = 0.008$) and paraesthesia ($p < 0.001$) compared to those working less than 2 h daily. Additionally, working for 3–5 h and above 6 h compared to health personnel working up to 2 h was associated with a greater risk of headaches and cervical spine pain ($p < 0.001$), shoulder girdle pain ($p < 0.001$), limited mobility in the wrist joint ($p = 0.003$), and tremors ($p < 0.001$), that working below 2 h. Prolonged computer working time among health personnel during the COVID-19 pandemic is significantly associated with an increased risk of dysfunction and pain in structures of the upper part of the musculoskeletal system. Effective preventive measures are necessary to improve the functioning of the musculoskeletal system during extended periods of computer use.

Keywords Health personnel, COVID-19 pandemic, Screen time, Musculoskeletal diseases, International Classification of Functioning, Disability and Health

The COVID-19 pandemic has brought about changes not only in the way we function socially[1], but also in our workplaces[2–4]. Health personnel who played a key role in the fight against the pandemic stayed during it burdened with increased screen time using a computer[5]. This trend resulted from the need to conduct remote consultations, and provide telemedicine services and administrative tasks related to managing the pandemic. However, long-term work at a computer may result in various health problems[6], mainly affecting the upper part of the musculoskeletal system[7]. Previous research has shown that chronic computer work is associated with an increased frequency of ailments in the cervical spine, shoulder girdle and wrist joint due to improper workstation ergonomics and extended working hours[8,9]. These discomforts, including cervical spine pain and muscle tension, can significantly affect the work comfort and quality of life of health personnel[10]. The rise in musculoskeletal problems can also lead to increased absenteeism among workers[11]. Therefore, implementing effective preventive methods and early identification of health problems is essential[12]. Adopting appropriate risk management and health promotion strategies can help minimize the negative effects of computer work[13], thereby improving the efficiency of the entire healthcare system[14]. In this context, the International Classification of Functioning,

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Disability and Health (ICF) can be a valuable tool for researching health personnel who spend a significant part of their working time in front of a computer. By using the ICF, it is possible to identify factors causing the aforementioned problems and develop appropriate treatment and prevention protocols to improve the health and work comfort of these workers[15,16].

To date, there have been only two studies on remote work during the lockdown focused on office workers, with no research addressing the impact on health personnel[17,18]. This study aims to fill that gap by analyzing the impact of increased computer screen time during the COVID-19 pandemic on the upper musculoskeletal system among health personnel. In this article, we aim to classify the discomforts and limitations according to ICF classification categories experienced by health personnel using the computer during their professional duties.

Materials and methods

Study protocol

The study was prospective and conducted following the ethical principles of biomedical research outlined in the Helsinki Declaration. Each participant was informed about the purpose and methodology of the study and gave written informed consent to participate in it. Participants had the right to withdraw from the study at any stage. The study was approved by the Ethics Committee of the Karol Marcinkowski University of Medical Sciences in Poznań (Approval No. 173/20 dated February 12, 2020). The research has been officially registered within the Clinical Trials Registry under the identification number NCT04521010, accessible via the following link: https://clinicaltrials.gov/ct2/show/NCT04521010.

The study was conducted among employees of the Orthopedic and Rehabilitation Clinical Hospital named after Wiktor Dega in Poznań from March 2020 to May 2020 and consisted of three stages. In the first stage, a survey was conducted among all 1200 hospital employees (including medical personnel: doctors, nurses, physiotherapists, and non-medical personnel: office workers, technical and economic staff) regarding their health status in relation to the pandemic and whether they used a computer during work before the pandemic. Subsequently, a group of 460 employees who did not work on a computer during their professional duties before the pandemic but were required to work using a computer due to restrictions during the pandemic was identified. In the next stage, a clinical examination was performed by a medical rehabilitation physician and an orthopedist to confirm reported pain symptoms associated with computer work. The examination was extended to include imaging diagnostics to exclude previous injuries. Based on the inclusion and exclusion criteria, a total of 418 employees were ultimately included in the study.

The inclusion criteria were as follows: (1) employees whose computer work hours were extended during the pandemic, (2) employees who reported experiencing discomfort related to computer work in the questionnaire survey, and (3) employees in whom discomfort associated with computer work was confirmed in the clinical examination conducted by a rehabilitation physician and orthopedist.

The exclusion criteria were: (1) employees who worked full-time at a computer before the pandemic, (2) employees who did not work on a computer before the pandemic but had a medical history suggestive of chronic shoulder pain (e.g., previous shoulder injury, humerus fracture), elbow joint injury, or wrist joint injury, (3) employees with chronic neck pain syndrome (e.g., employees who had undergone cervical spine surgery), (4) employees with pre-pandemic neck, shoulder, elbow, or wrist pain confirmed in imaging studies conducted before the pandemic, (5) employees with nerve or muscle damage in the upper limb caused by stroke or compressive neuropathy (e.g., carpal tunnel syndrome), and (6) employees with diagnosed autoimmune inflammatory rheumatic diseases (e.g., rheumatoid arthritis, systemic connective tissue diseases).

The first group (Group 1) consisted of 125 employees (86 women and 39 men) who worked a maximum of 2 h per day on a computer during their professional duties due to the pandemic. The second group (Group 2) consisted of 154 employees (120 women and 34 men) whose computer screen time ranged from 3 to 5 h per day. The third group (Group 3) consisted of 139 employees (120 women and 19 men) whose computer screen time during their professional duties exceeded 6 h. In the next stage, identified deficits in the upper musculoskeletal system were coded into categories and qualifiers of the International Classification of Functioning, Disability and Health. Subsequently, an ICF profile was created, graphically presenting the percentage distribution of deficits in the studied groups depending on the time spent working on a computer. Additionally, the total frequency of deficits was analyzed depending on the computer screen time after the pandemic. A detailed study schema is presented in Fig. 1.

Basic set of International Classification of Functioning, Disability and Health categories in the assessment of musculoskeletal deficits

Individual categories of deficits within the upper part of the musculoskeletal system included in the analysis were assigned appropriate code numbers and qualifiers according to the International Classification of Functioning, Disability and Health and developed by the WHO ICF Research Branch—Musculoskeletal ICF Core Sets profile[19–21].

Deficits of the cervical spine assessed using ICF categories:

s710 Structure of head and neck—Qualifier 0 was assigned if no structural disorders confirmed by imaging diagnostics were found, Qualifier 1 if disc herniation without compression of nerve roots was visualized in imaging diagnostics, Qualifier 2 if discopathy at one level was visualized in imaging diagnostics, Qualifier 3 if multilevel discopathy with nerve root compression was visualized in imaging diagnostics, Qualifier 4 if multilevel nucleus pulposus herniation was visualized in imaging diagnostics.

b28010 Pain in head and neck—Qualifier 0 was assigned if no headaches or neck pain occurred, Qualifier 1 if headaches and neck pain occurred due to work with a score of 1–2 on the VAS scale, Qualifier 2 if headaches and

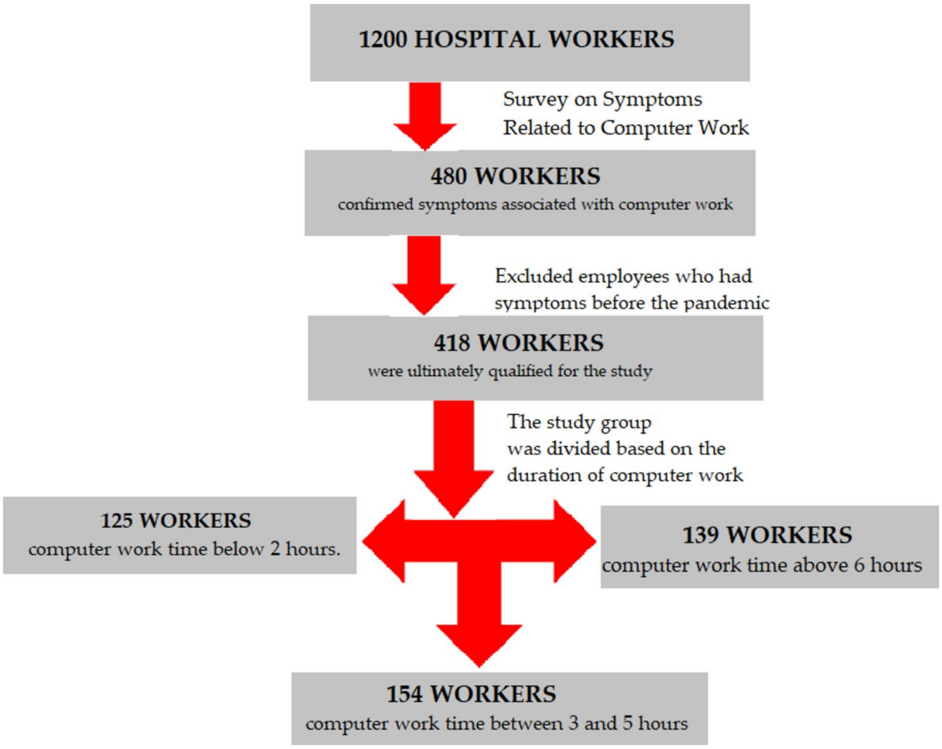

Fig. 1. Research group schema.

neck pain occurred with a score of 3–5 on the VAS scale, Qualifier 3 if headaches and neck pain occurred with a score of 5–9 on the VAS scale, Qualifier 4 if headaches and neck pain occurred with a score of 10 on the VAS scale.

b7100 Mobility of joint functions—Qualifier 0 was assigned if the range of motion of the cervical spine was: extension 37–40 degrees, flexion 37–40 degrees, lateral bending 41–45 degrees, rotation 41–45 degrees, Qualifier 1 if the range of motion of the cervical spine was: extension 27–36 degrees, flexion 27–36 degrees, lateral bending 30–40 degrees, rotation 30–40 degrees, Qualifier 2 if the range of motion of the cervical spine was: extension 10–20 degrees, flexion 10–20 degrees, lateral bending 11–29 degrees, rotation 11–29 degrees, Qualifier 3 if the range of motion of the cervical spine was: extension 5 degrees, flexion 5–9 degrees, lateral bending 5–9 degrees, rotation 5–10 degrees, Qualifier 4 if the range of motion of the cervical spine was below 5 degrees in each plane.

b7350 Tone of isolated muscles and muscle groups—Qualifier 0 was assigned if there was normal muscle tension, Qualifier 1 if there was mild tension of the paravertebral muscles, Qualifier 2 if there was moderate tension of the paravertebral muscles, Qualifier 3 if there was significant tension of the paravertebral muscles, Qualifier 4 if there was stiffness in the cervical spine.

Shoulder girdle deficits assessed using the International Classification of Functioning, Disability and Health categories:

s720 Structure of the shoulder region: Qualifier 0 was assigned if no abnormalities of the shoulder girdle structure were detected in imaging diagnostics, Qualifier 1 if joint effusion was visualized in imaging diagnostics, Qualifier 2 if signs of shoulder girdle muscle overload were visualized in imaging diagnostics, Qualifier 3 if partial damage to the rotator cuff muscles was visualized in imaging diagnostics, Qualifier 4 if complete damage to the rotator cuff muscles and/or fracture of the scapular bone was visualized in imaging diagnostics.

b28014 Pain in upper limb: Qualifier 0 was assigned if there were no pain complaints in the shoulder girdle, Qualifier 1 if pain complaints occurred related to work with a VAS score of 1–2 points, Qualifier 2 if pain complaints occurred with a VAS score of 3–5 points, Qualifier 3 if pain complaints occurred with a VAS score of 5–9 points, Qualifier 4 if pain complaints occurred with a VAS score of 10 points.

b7100 Mobility of joint functions: Qualifier 0 was assigned if the range of motion of the shoulder girdle was: abduction 48–50 degrees, flexion 160–170 degrees, abduction 160–170 degrees, adduction 160–170 degrees, external rotation 80–90 degrees, internal rotation 75–80 degrees, Qualifier 1 if the range of motion of the shoulder girdle was: abduction 34–47 degrees, flexion 115–159 degrees, abduction 115–159 degrees, adduction 115–159 degrees, external rotation 60–79 degrees, internal rotation 55–74 degrees, Qualifier 2 if the range of motion of the shoulder girdle was: abduction 25–33 degrees, flexion 85–114 degrees, abduction 85–114 degrees, adduction 85–114 degrees, external rotation 45–59 degrees, internal rotation 40–54 degrees, Qualifier 3 if the range of motion of the shoulder girdle was: abduction 6–24 degrees, flexion 20–84 degrees, abduction 20–84 degrees, adduction 20–84 degrees, external rotation 10–44 degrees, internal rotation 10–40 degrees, Qualifier 4 if the range of motion of the shoulder girdle was: abduction below 5 degrees, flexion, abduction/adduction below 20 degrees, external/internal rotation below 10 degrees.

b7301 Muscle Strength: Qualifier 0 was assigned if the muscle strength of the shoulder girdle was 5 according to the Lovette scale, Qualifier 1 if the muscle strength was 4 according to the Lovette scale, Qualifier 2 if the muscle strength was 3 according to the Lovette scale, Qualifier 3 if the muscle strength was 1 or 2 according to the Lovette scale, Qualifier 4 if the muscle strength was 0 according to the Lovette scale.

Elbow joint deficits assessed using International Classification of Functioning, Disability and Health categories:

s730 Structure of upper extremity—elbow: Qualifier 0 was assigned if no changes were observed in imaging diagnostics, Qualifier 1 if joint effusion was detected in imaging diagnostics, Qualifier 2 if signs of joint overload were observed in imaging diagnostics, Qualifier 3 if inflammation of the lateral or medial epicondyle was demonstrated in imaging diagnostics, Qualifier 4 if structural changes in the ulnar bone were detected in imaging diagnostics.

b28014 Pain in upper limb—elbow: Qualifier 0 was assigned if there were no pain complaints in the elbow joint, Qualifier 1 if pain complaints occurred related to work with a VAS score of 1–2 points, Qualifier 2 if pain complaints occurred with a VAS score of 3–5 points, Qualifier 3 if pain complaints occurred with a VAS score of 5–9 points, Qualifier 4 if pain complaints occurred with a VAS score of 10 points.

b7100 Mobility of joint functions: Qualifier 0 was assigned if the range of motion of the elbow joint was: extension 145–150 degrees, flexion 145–150 degrees, supination 85–90 degrees, pronation 75–80 degrees, Qualifier 1 if the range of motion of the elbow joint was: extension 135–144 degrees, flexion 135–144 degrees, supination 80–84 degrees, pronation 72–74 degrees, Qualifier 2 if the range of motion of the elbow joint was: extension 75–134 degrees, flexion 75–134 degrees, supination 46–79 degrees, pronation 40–71 degrees, Qualifier 3 if the range of motion of the elbow joint was: extension 20–74 degrees, flexion 20–74 degrees, supination 10–45 degrees, pronation 10–39 degrees, Qualifier 4 if the range of motion of the elbow joint was: extension and flexion below 20 degrees, supination and pronation below 10 degrees.

Wrist joint deficits assessed using the International Classification of Functioning, Disability and Health categories:

s730 Structure of upper extremity—wrist: Qualifier 0 was assigned if no changes were observed in wrist joint imaging diagnostics, Qualifier 1 if joint effusion was detected in imaging diagnostics, Qualifier 2 if signs of joint overload were observed in imaging diagnostics, Qualifier 3 if features of carpal tunnel syndrome were demonstrated in imaging diagnostics, Qualifier 4 if structural changes in the wrist joint and metacarpophalangeal bones of the hand were detected in imaging diagnostics.

b28014 Pain in upper limb—wrist: Qualifier 0 was assigned if there were no pain complaints in the wrist joint, Qualifier 1 if pain complaints occurred related to work with a VAS score of 1–2 points, Qualifier 2 if pain complaints occurred with a VAS score of 3–5 points, Qualifier 3 if pain complaints occurred with a VAS score of 5–9 points, Qualifier 4 if pain complaints occurred with a VAS score of 10 points.

b7100 Mobility of joint functions: Qualifier 0 was assigned if the range of motion of the wrist joint was: extension 48–50 degrees, flexion 58–60 degrees, supination 19–20 degrees, pronation 28–30 degrees, Qualifier 1 if the range of motion of the wrist joint was: extension 35–47 degrees, flexion 40–57 degrees, supination 13–18 degrees, pronation 20–27 degrees, Qualifier 2 if the range of motion of the wrist joint was: extension 25–34 degrees, flexion 31–39 degrees, supination 10–12 degrees, pronation 15–19 degrees, Qualifier 3 if the range of motion of the wrist joint was: extension 6–24 degrees, flexion 15–30 degrees, supination 2–9 degrees, pronation 3–14 degrees, Qualifier 4 if the range of motion of the wrist joint was: extension and flexion below 5 degrees, supination and pronation below 2 degrees.

b7301 Power of isolated muscles and muscle groups—right hand and left hand: Qualifier 0 was assigned if muscle strength measured by dynamometer was 34–36 Newtons, Qualifier 1 if muscle strength measured by dynamometer was 25–33 Newtons, Qualifier 2 if muscle strength measured by dynamometer was 10–24 Newtons, Qualifier 3 if muscle strength measured by dynamometer was 4–9 Newtons, Qualifier 4 if muscle strength measured by dynamometer was below 4 Newtons.

b7602 Coordination of voluntary movements: Qualifier 0 was assigned if there were no disturbances in coordination of voluntary movements, Qualifier 1 if discrete signs of motor coordination disorder of one non-dominant upper limb were present, Qualifier 2 if slight clumsiness in movement execution in one dominant upper limb predominated, Qualifier 3 if coordination disturbances and clumsiness occurred in one upper limb, Qualifier 4 if significant disturbances in coordination and execution clumsiness occurred in both upper limbs.

b7651 Tremor: Qualifier 0 was assigned if anintentional tremor of limbs was not observed, Qualifier 1 if a slight tremor of the non-dominant limb was observed, Qualifier 2 if a slight tremor of the dominant limb was observed, Qualifier 3 if an asymmetrical tremor of one upper limb was observed, Qualifier 4 if tremors of both upper limbs were observed.

b798 Neuromusculoskeletal and movement-related functions, other specified—paraesthesia: Qualifier 0 was assigned if there were no symptoms of hand numbness, Qualifier 1 if numbness of one finger in one hand occurred, Qualifier 2 if thumb numbness occurred bilaterally, Qualifier 3 if numbness of fingers II-V occurred bilaterally, Qualifier 4 if numbness of all fingers occurred bilaterally.

International Classification of Functioning, Disability and Health categories were applied to assess deficits in activity and participation:

d430 Lifting and carrying objects: Qualifier 0—if the worker had no difficulty lifting and carrying objects, Qualifier 1—if there were difficulties in lifting objects, Qualifier 2—if the worker lifted but did not carry the object, Qualifier 3—if there were difficulties in carrying objects, Qualifier 4—if there were significant difficulties in lifting and carrying objects.

d440 Fine hand use: Qualifier 0—if the worker had no difficulty with the precision of movement hand, Qualifier 1—if there were slight disturbances in the precision of movement in one limb, Qualifier 2—if there were disturbances in the precision of movement bilaterally, Qualifier 3—if there were disturbances in the precision of movement such as writing or drawing, Qualifier 4—if there were significant disturbances in the precision of movement.

d445 Hands and arms use: Qualifier 0—if there were no difficulties in using hands and arms, Qualifier 1—slight difficulties in using hands and arms on one side of the body, Qualifier 2—moderate difficulties in using hands and arms on both sides of the body, Qualifier 3—significant difficulties in using hands and forearms, e.g., patient has difficulty dressing upper body and buttoning shirts, Qualifier 4—if significant assistance is required with personal care tasks such as washing hair.

Next, a graphical representation was provided, showing the percentage distribution of qualifiers using color coding to emphasize differences in the type and frequency of deficits in the upper part of the musculoskeletal system depending on computer work time: Qualifier 0—no deficits in the assessed category, represented by dark green color if the percentage distribution ranges from 0 to 4%. Qualifier 1—low frequency of deficit occurrence in the assessed category, represented by light green color if the percentage distribution ranges from 5 to 24%. Qualifier 2—moderate occurrence of deficit in the assessed category, represented by yellow color if the percentage distribution ranges from 25 to 49%. Qualifier 3—high frequency of deficit occurrence in the assessed category, represented by orange color if the percentage distribution ranges from 50 to 95%. Qualifier 4—extremely high frequency of deficit occurrence in the assessed category, represented by red color if the percentage distribution ranges from 96 to 100%.

Statistical analysis

We provided the statistical assessment with Statistica 13.3 (TIBCO Software Inc., 2017, Palo Alto, CA, USA, http:/statistica.io). The categorical variables are presented as counts and frequencies. The parameters of descriptive statistics are reported as mean values with standard deviations (SD) and median, minimum, and maximum levels. The Shapiro–Wilk test was used to assess the normality of test score distributions. The significance of differences in quantitative data between the three groups was evaluated using the non-parametric Kruskal–Wallis test. Post hoc analysis was conducted when statistically significant differences in measurements were found, using the Dunn test with Bonferroni correction. *P*-values less than 0.05 were considered to be statistically significant. The chi-square test (maximum likelihood) was applied to compare differences between 3 groups for categorical variables. *P*-values less than 0.05 were considered to be statistically significant. For post-hoc pairwise comparisons, we used two proportions test. We applied a Bonferroni correction and set the *p*-value cut-off as 0.017.

Results

Demographic analysis revealed that women constituted the majority of participants in each age group, with the group working more than 6 h, characterized by the oldest age, having the largest number of women. The studied groups significantly differed in gender distribution ($p = 0.003$) and age ($p < 0.001$). Analyzed groups of workers did not differ in anthropometric parameters: height, body weight, and BMI. The characteristics of the studied groups are presented in Table 1.

In Table 2, the results of the analysis regarding the occurrence of various categories of dysfunctions within the upper part of the musculoskeletal system are presented, including the cervical spine and head, shoulder girdle, elbow joint, wrist joint, and hand, in three examined groups using a computer: up to 2 h (Group 1), from 3 to 5 h (Group 2), and above 6 h (Group 3), as well as the results of comparisons between these groups.

		Study groups			***p***
		Group 1	**Group 2**	**Group 3**	
Computer screen time (h/day)		**up to 2 h**	**from 3 h-5 h**	**>6 h**	
Size of the study group		n (%)	125	154	139
GENDER n (%)	Females	86 (68.8%)	120 (77,9)	120 (86.3%)	0,003
	Males	39 (31,2%)	34 (22,1%)	19 (13,7%)	
AGE (years)	Average ± SD	38.5 ± 11.7	43.3 ± 11.4	46.9 ± 10.7	< 0.001
	Median	35	44	48	
	Min–Max	23,0–64,0	22,0–68,0	22,0–68,0	
HEIGHT (cm)	Average ± SD	169.0 ± 8.5	169.5 ± 9.0	168.6 ± 8.2	0,773
	Median	169	168	168	
	Min–Max	148,0–195,0	153,0–196,0	152,0–195,0	
BODY WEIGHT (kg)	Average ± SD	75.1 ± 17.8	75.9 ± 15.5	76.1 ± 17.4	0,724
	Median	73	74	73	
	Min–Max	46,0–122,0	46,0–130,0	45,0–142,0	
BMI	Average ± SD	26.2 ± 5.4	26.3 ± 4.7	26.7 ± 5.6	0,787
	Median	25,3	26	25,5	
	Min–Max	16,6–45,1	17,7–50,8	15,8–47,4	

Table 1. Characteristics of the study groups. Chi2, Kruskall-Wallis, *BMI* Body Mass Index, *p* statistical significance, *SD* Standard devation.

		Study groups n (%)				p^2		
ICF category		**Group 1**	**Group 2**	**Group 3**	p^1	**1 vs 2**	**1 vs 3**	**2 vs 3**
Cervical spine								
s710 Structure of head and neck	n (%)	2 (1.6%)	11 (7.1%)	10 (7.2%)	0.040*	0.030^	0.029^	0.974^
b28010 Pain in head and neck	n (%)	33 (26.4%)[a, b]	70 (45.5%)[a]	75 (54.0%)[b]	< 0.001*	0.001^	< 0.001^	0.146^
b7100 Mobility of joint functions	n (%)	81 (65.3%)	117 (76.0%)	109 (78.4%)	0.043*	0.050^	0.018^	0.625^
b7350 Tone of isolated muscles and muscle groups	n (%)	8 (6.5%)[a]	21 (13.6%)	33 (23.7%)[a,]	< 0.001*	0.054^	< 0.001^	0.026^
Shoulder region								
s720 Structure of the shoulder region	n (%)	5 (4.0%)	6 (3.9%)	6 (4.3%)	0.984*			
b28014 Pain in upper limb	n (%)	3 (3.4%)[a, b]	19 (12.3%)[a]	27 (19.4%)[b]	< 0.001*	0.007^	< 0.001^	0.095^
b7100 Mobility of joint functions	n (%)	5 (4.0%)[a]	15 (9.7%)	27 (19.4%)[a,]	< 0.001*	0.066^	< 0.001^	0.018^
b7301 Muscuar Strength	n (%)	3 (2.4%)[a,]	13 (8.4%)[a]	22 (15.8%)[b]	< 0.001*	0.032^	< 0.001^	0.051^
Elbow joint								
s730 Structure of upper extremity -elbow	n (%)	4 (3.2%)	9 (5.8%)	6 (4.3%)	0.563*			
b28014 Pain in upper limb -elbow	n (%)	1 (0.8%)[a]	1 (0.6%)[b]	9 (6.5%)[a, b]	0.003*	0.841^	0.016^	0.005^
b7100 Mobility of joint functions	n (%)	1 (0.8%	3 (1.9%)	5 (3.6%)	0.272*			
Wrist joint								
s730 Structure of upper extremity- wrist	n (%)	3 (2.4%)	9 (5.8%)	5 (3.6%)	0.329*			
b28014 Pain in upper limb -wrist	n (%)	7 (5.6%)[a]	16 (10.4%)[b]	33 (23.7%)[a,b]	< 0.001*	0.247^	< 0.001^	0,002^
b7100 Mobility of joint functions	n (%)	4 (3.2%)[a, b]	21 (13.6%)[a]	18 (12.9%)[b]	0.003*	0.003^	0.004^	0.860^
b7301 Power of isolated muscles and muscle groups -hand right	Average ± SD	38.1 ± 12.0[a]	35.3 ± 12.2	32.8 ± 10.9[a]	< 0.001**	0.076^^	< 0.001^^	0.103^^
	Median	36	32	30				
b7301 Power of isolated muscles and muscle groups -hand left	Average ± SD	36.4 ± 12.1[a]	34.1 ± 11.8[b]	30.5 ± 10.9[a, b]	< 0.001**	0.643^^	< 0.001^^	0.006^^
	Median	34	31	29				
	Min–Max	20.0–78.0	10.0–80.0	0.0–78.0				
b7602 Coordination of voluntary movements	n (%)	0 (0.0%)[a,]	6 (3.9%)	9 (6.5%)[a]	0.003*	0.026^	0.004^	0.314^
b7651 Tremor	n (%)	4 (3.2%)[a,b]	18 (11.7%)[a]	25 (18.0%)[b]	< 0.001*	0.009^	< 0.001^	0.128^
b798 Neuromusculoskeletal and movement-related functions, other specified—paraesthesia	n (%)	7 (5.6%)[a]	16 (10.4%)[b]	33 (23.7%)[a, b]	< 0.001*	0.147^	< 0.001^	0.002^
Activity and participation								
d430 Lifting and carrying objects	n (%)	7 (5.6%)[a]	16 (10.4%)	22 (15.8%)[a]	0.024*	0.147^	0.008^	0.169^
d440 Fine hand use	n (%)	2 (1.6%)	10 (6.5%)	11 (7.9%)	0.036*	0.045^	0.018^	0.643^
d445 Hands and arms use	n (%)	8 (6.4%)[a]	22 (14.3%)[b]	42 (30.2%)[a,b]	< 0.001*	0.034^	< 0.001^	< 0,001^

Table 2. Frequency of disorders within the upper part of the musculoskeletal system depending on computer working hours. *ICF* International classification of functioning, disability and health, *n* Number of individuals with dysfunction, *p* Statistical significance, *SD* Standard deviation. p^1 comparison between 3 groups, *the maximum likelihood chi^2 test ($p < 0.05$),**Kruskal–Wallis test ($p < 0.05$); p^2- post hoc analysis, ^—two proportion test ($p < 0.017$), ^^ the Dunn test with Bonferroni correction ($p < 0.05$); [a,b] significance difference between two groups (after post hoc analysis).

In the examined groups, no significant difference was found in the occurrence of disorders in the structure of the shoulder girdle, elbow joint, or wrist joint. Employees who worked on the computer for less than 2 h showed significantly greater hand muscle strength ($p < 0.001$) and the lowest frequency of assessed disorders.

In individuals working over 6 h compared to those working up to 2 h, restricted range of motion of the shoulder girdle ($p < 0.001$), increased tension of paraspinal muscles ($p < 0.001$), weakened shoulder girdle muscle strength ($p < 0.001$), elbow joint pain ($p = 0.016$), wrist joint pain ($p < 0.001$), (coordination disorders ($p = 0.004$), difficulties in arm and hand use ($p < 0.001$) neuromuscular function disorders ($p < 0.001$), and limitations in lifting and carrying objects ($p = 0.008$) were significantly more frequently diagnosed. No significant difference was observed between employees working over 6 h and those working from 3 to 5 h in the above-mentioned aspects, such as range of motion of the shoulder girdle ($p = 0.018$), tension of paraspinal muscles ($p = 0.026$), shoulder girdle muscle strength ($p = 0.051$), coordination disorders ($p = 0.314$), and limitations in lifting and carrying objects ($p = 0.169$).

However, in the groups of employees using the computer for 3 to 5 h and above 6 h compared to health personnel working up to 2 h, head and cervical spine pain were significantly more frequent ($p < 0.001$), as well as shoulder girdle pain ($p < 0.001$ and limitations in wrist joint mobility ($p = 0.003$), and tremors ($p < 0.001$).

Additionally, in the group of employees working over 6 h compared to those working from 3 to 5 h, elbow joint pain ($p = 0.005$), wrist joint pain ($p = 0.002$), hand and arm use ($p = 0.001$) and neuromuscular function disorders ($p = 0.002$) were significantly more frequently diagnosed.

The pattern of upper limb deficits in computer workers presented in Table 3 illustrates the percentage distribution of the frequency of these deficits considering computer usage time.

ICF Category		PERCENTAGE DISTRIBUTION OF QUALIFIERS
Cervical spine		
s710 Structure of head and neck	<2h	2% | 2% | 96%
	3-5h	2% | 2% | 96%
	>6h	2% | 2% | 2% | 94%
b28010 Pain in head and neck	<2h	2% | 2% | 96%
	3-5h	10% | 12% | 45% | 33%
	>6h	10% | 20% | 14% | 25% | 31%
b7100 Mobility of joint functions p=0,008	<2h	14% | 50% | 36%
	3-5h	4% | 18% | 54% | 24%
	>6h	4% | 20% | 32% | 22% | 22%
b7350 Tone of isolated muscules and muscle groups p<0,001	<2h	6,50% | 93,50%
	3-5h	13% | 87%
	>6h	23,70% | 76,30%
Shoulder region		
s720 Structure of the shoulder region	<2h	2% | 2% | 96%
	3-5h	2% | 2% | 96%
	>6h	2% | 2% | 2% | 94%
b28014 Pain in upper limb	<2h	2% | 2% | 96%
	3-5h	2% | 2% | 2% | 94%
	>6h	4% | 8% | 10% | 10% | 68%
b7100 Mobility of joint functions p<0,001	<2h	2% | 4% | 94%
	3-5h	2% | 4% | 6% | 8% | 80%
	>6h	2% | 12% | 12% | 14% | 60%
b7301 b7301 Muscle Strength p<0,001	<2h	2% | 98%
	3-5h	2% | 4% | 6% | 88%
	>6h	2% | 2% | 14% | 14% | 68%
Elbow joint		
s730 Structure of upper extermitty -elbow	<2h	4% | 96%
	3-5h	6% | 94%
	>6h	2% | 4% | 94%
b28014 Pain in upper limb -elbow p=0,002	<2h	100%
	3-5h	2% | 98%
	>6h	2% | 2% | 4% | 92%
b7100 Mobility of joint functions	<2h	100%
	3-5h	2% | 2% | 96%
	>6h	2% | 4% | 94%
Wrist joint		
s730 Structure of upper extremity-wirst	<2h	100%
	3-5h	2% | 2% | 96%
	>6h	2% | 4% | 94%
b28014 Pain in upper limb -wirst p<0,001	<2h	2% | 98%
	3-5h	2% | 2% | 96%
	>6h	2% | 12% | 18% | 68%
b7100 Mobility of joint functions p<0,001	<2h	2% | 98%
	3-5h	4% | 96%
	>6h	2% | 8% | 20% | 70%
b7301 Power of isolated muscles and muscle groups -hand right	<2h	2% | 4% | 19% | 75%
	3-5h	2% | 8% | 36% | 64%
	>6h	2% | 11% | 22% | 65%
b7301 Power of isolated muscles and muscle groups -hand left	<2h	2% | 6% | 18% | 74%
	3-5h	4% | 6% | 25% | 75%
	>6h	2% | 2% | 10% | 18% | 68%
b7602 Coordination of voluntary movements p=0,018	<2h	100%
	3-5h	2% | 2% | 2% | 94%
	>6h	2% | 4% | 6% | 88%
b7651 Tremor p<0,001	<2h	3,20% | 96,80%
	3-5h	11,70% | 88,30%
	>6h	18% | 82%
b798 Neuromusculoskeletal and movement-related functions, other specified -parasthesia p<0,001	<2h	5,60% | 94,40%
	3-5h	10,40% | 89,60%
	>6h	23,80% | 76,20%
Activity and particination		
d430 Lifting and carrying objects p=0,020	<2h	2% | 4% | 94%
	3-5h	2% | 4% | 4% | 88%
	>6h	4% | 10% | 4% | 82%
d440 Fine hand use	<2h	2% | 98%
	3-5h	2% | 2% | 94%
	>6h	2% | 2% | 2% | 94%
d445 Hands and arms use p<0,001	<2h	4,80% | 95,20%
	3-5h	2% | 4,50% | 8,50% | 85%
	>6h	2% | 6% | 12% | 10% | 70%

Table 3. Profile of ICF classification categories based on computer working time. *p* Statistical significance, Kruskal–Wallis test ($p < 0.05$).

In the case of the left-hand extremely high frequency of deficit occurrence in all studied groups, increased muscle tension, limb tremors, and finger tremors were observed. In the group above 3 h and 6 h, shoulder girdle pain and limited shoulder range of motion were observed. In the group of workers working above 6 h, deficits were significantly more common: structural body disorders, headaches and neck pain, limited cervical range of motion, weakened shoulder girdle muscle strength, weakened left-hand muscle strength, and difficulties in using arms and hands.

In the category of high frequency deficit occurrence, weakened muscle strength in both hands was more frequently observed in all studied groups. In the group working above 3 h and 6 h, occurrences of headaches, cervical spine pain, shoulder girdle pain, limited shoulder range of motion, weakened shoulder girdle muscle strength, impaired coordination of voluntary movements, difficulties in lifting and carrying objects, and difficulties in using arms and hands were observed. In the group working above 6 h, more frequent occurrences of structural head and cervical spine disorders, shoulder girdle pain, elbow and wrist joint pain, limited wrist joint range of motion, and impaired precision of movement hand were observed.

In the category of moderate frequency deficit occurrence, moderate intensity of structural head and cervical spine disorders, headaches and neck pain, moderate limitation of cervical spine range of motion, shoulder girdle structural disorders, shoulder girdle pain, and limited mobility, as well as weakened muscle strength in both hands and difficulties in lifting and carrying objects, were observed in all studied groups. In the group working above 3 h and 6 h, weakened shoulder girdle muscle strength, limited elbow joint mobility, wrist joint structural disorders, wrist joint pain, impaired execution of voluntary movements, precision of movement hand, as well as difficulties in using arms and hands were observed. In the group of workers working above 6 h, structural elbow joint disorders, elbow joint pain, and limited wrist joint range of motion were observed.

Analyzing the cumulative distribution of deficit frequencies (Fig. 2), significantly more deficits were diagnosed in employees working over 6 h on the computer ($p < 0.001$). On average, 1.5 ± 1.3 deficits were diagnosed in employees working up to 2 h, 2.8 ± 1.7 deficits in those working from 3 to 5 h, and 3.7 ± 2.1 deficits in employees working over 6 h within the upper part of the musculoskeletal system.

Discussion

The COVID-19 pandemic has triggered long-term consequences among health personnel, partly due to increased working hours. Previous literature has described the impact of prolonged stress resulting from the pandemic on the health of health personnel[22], as well as the prevalence of depression and occupational burnout[23]. However, the influence of computer screen time on health status and work quality has not been analyzed before. The results of our study suggest that increased computer working time during the COVID-19 pandemic may lead to a greater number of musculoskeletal complaints among health personnel. Our study results indicate that employees working over 6 h on the computer had the highest cumulative frequency of deficits (Fig. 2). How can this be explained? Already Ijamker et al.[24], claimed we ought to undertake further studies to better understand the impact of computer work time on the occurrence of negative symptoms. Existing scientific literature indicates that computer users are at increased risk of musculoskeletal diseases[25,26]. As demonstrated by Gerr et al.[27], complaints in the cervical spine, shoulders, arms, and hands may result from the user's posture and the number of hours spent using the computer per day or week. In our study, among employees using the computer for 3–5 h and above 6 h compared to health personnel working up to 2 h (Table 2 headache and cervical spine pain ($p < 0.001$), shoulder girdle pain ($p < 0.001$), limitations in wrist joint mobility ($p = 0.003$) and tremors ($p < 0.001$)) were significantly more frequent, along with coordination disorders of voluntary movements ($p = 0.003$), tremors ($p < 0.001$), impaired precision of movement hand ($p = 0.036$), and difficulties in using arms and hands ($p < 0.001$). Our results are in some respects consistent with the findings of Borhany et al.[28], which demonstrate that over 40% of office workers using the computer for at least 3 h a day experienced headaches and cervical spine pain. Additionally, Alkahami et al.[29] claim that neck pain is the most common type of musculoskeletal problem among computer users. It is worth noting that these studies focused on office workers, while our study pertains to health personnel who have duties beyond seated work. Furthermore, demographic analysis showed that women constituted the majority of respondents in each study group, with the group working over 6 h characterized by the oldest age (Table 1). Similarly, Malińska et al.[30] identified prolonged computer screen time and older age as major factors contributing to neck pain among office workers.

The obtained results presented in graphical comparison according to the International Classification of Functioning, Disability and Health (ICF) classification (Table 3) indicate the frequency of deficits. Due to the extremely high frequency of deficits in all studied groups, the most frequently observed symptoms were increased muscle tension and tremors of limbs and fingers. In the groups with over 3 h and 6 h of computer use, pain in the shoulder girdle and limited range of shoulder movement were also frequently observed. Among employees working more than 6 h, deficits in the following ICF categories were significantly more frequent: disorders of the cervical spine and shoulder structure, headaches and neck pain, limited range of motion of the cervical spine, reduced strength of the shoulder girdle muscles, weakened muscle strength of the left hand, and impaired use of hands. Our results are consistent with Moreira et al.[31], who observed a significantly increased frequency of musculoskeletal complaints among computer workers during lockdown, particularly concerning the neck, shoulders, and hands/wrists. The results of the detected frequency of deficits emphasize the importance of being aware of and subsequently implementing preventive actions and monitoring the health of healthcare workers, especially in the

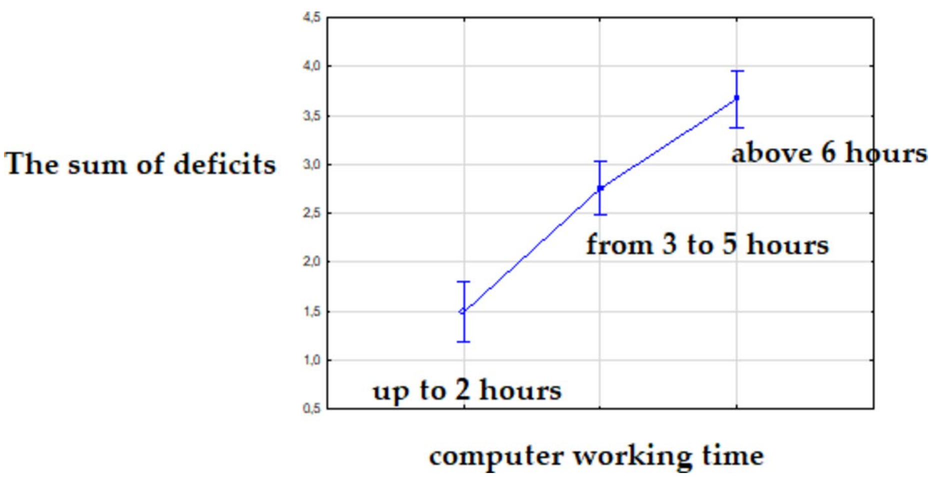

Fig. 2. Cumulative distribution of deficits depending on computer screen time.

context of computer work, to reduce the risk of developing musculoskeletal diseases. We believe that it is worth paying attention to the research tool we use, the International Classification of Functioning, Disability and Health (ICF). It seems that the ICF questionnaire used in our study, combined with a medical examination, can provide many objective insights into deficits resulting from computer work, which may facilitate the implementation of preventive actions. According to Shete et al.[32], a multidisciplinary approach yields better results compared to a conventional approach. As demonstrated by Bertelman et al.[33], informing healthcare workers and employers about the frequency of complaints resulting from computer work is necessary to develop an appropriate strategy for preventing musculoskeletal disorders. Healthcare institutions and those responsible for occupational risk prevention among computer workers must consider multiple factors underlying musculoskeletal complaints in healthcare workers who work with computers.

Further research is needed, but it seems clear that there is a need to implement exercise programs to promote physical activity, considering the well-documented association between physical activity and health. Persistent or increased physical inactivity is likely to have medium or long-term implications for physical and mental health, as well as for the quality of life of individuals. More efforts should be made in occupational health to increase levels of physical activity in the workplace, particularly for groups at higher risk of inactivity or reduced physical activity, such as computer workers. Physically active individuals are more satisfied and alert[34]. Scientific literature provides evidence that physical exercise is beneficial for mental health because of reducing depression, negative mood, anxiety and improves self-esteem and cognitive function[35].

The study has several limitations that should be noted. Firstly, it does not take into account other factors that may influence the occurrence of musculoskeletal disorders, such as the intensity of physical exertion outside computer work, lifestyle, or individual anatomical characteristics. The focus was solely on computer work time, neglecting other aspects of work such as the type of tasks performed, breaks taken, or ergonomic facilities used, all of which could affect the occurrence of musculoskeletal diseases. Additionally, the study lacks long-term follow-up of participants, preventing an assessment of the long-term impact of increased computer screen time on the musculoskeletal system. Furthermore, the study did not include a control group of healthcare personnel who were not exposed to increased computer screen time during the COVID-19 pandemic. The absence of such a comparative group makes it challenging to accurately determine to what extent the observed effects are directly related to increased computer screen time. Considering these limitations, further research is essential. This research should consider a broader range of risk factors and include a control group to provide a more precise assessment of the impact of computer screen time on the health of healthcare personnel.

Conclusions

Prolonged screen time at the computer is associated with an increased risk of limited range of motion of the cervical spine, shoulder girdle, pain in the wrist joints limited mobility, and impaired coordination during precise movements. The International Classification of Functioning, Disability and Health questionnaire supplemented with a medical examination enables the identification of the frequency of deficits associated with computer work. There is an urgent need for effective preventive measures to reduce the impact of prolonged computer use on the health of workers.

Data availability

The availability of the data underpinning this study can be accessed upon request from the corresponding author.

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