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Exploring Ergonomic Risk Factors and Discomfort Levels in Work-from-Home Settings: A Study during the COVID-19 Pandemic

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Abstract

This study examines the impact of working from home on the ergonomic risk factors and discomfort experienced by workers during the COVID-19 pandemic. Despite the many benefits of working from home, such as increased productivity and flexible working hours, it also presents numerous ergonomic threats, including suboptimal working postures, poor workstation design, uncontrolled working hours, and poor indoor environmental quality. The study aims to identify the risk factors for discomfort among workers who work from home during the COVID-19 pandemic by using an ergonomic assessment tool. The study used an anonymous online questionnaire in Thai, posted on social media platforms, and had a sample size of 303 Thai participants aged 20 years and above, working from home, and using computer for work. Data were obtained through a three-section questionnaire that collected demographic information, workstation assessment, and discomfort scale. The results showed that there is a significant relationship between ergonomic factors and discomfort in the neck, lower back, and legs such as chair, workstation, and breaks. The study concludes that ergonomic assessment tools are essential in identifying potential ergonomic risks and improving the health and safety of workers. Such tools can be tailored to specific industries, job types, or work environments, making them more useful and applicable for different workplaces. This study's findings will help occupational health professionals and policymakers develop and implement effective ergonomic interventions to mitigate ergonomic risks and prevent work-related musculoskeletal disorders (MSDs) among workers who work from home during the pandemic.

Keywords: COVID-19, Work from home, Ergonomics, Workstation, Discomfort

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1. Introduction

The COVID-19 pandemic has drastically altered work patterns, leading to a shift from office-based work to working from home to minimize the risk of infection [1, 2, 3, 4, 5]. While this approach provides benefits such as flexible working hours and increased productivity, it has also posed a significant ergonomic threat due to the lack of proper workstation design, suboptimal working postures, and uncontrolled working hours.

Many people work with awkward postures while using portable laptops in places such as the floor, bed, couch, or chair without proper support, leading to musculoskeletal disorders [6, 7]. The most commonly used workspaces are the living room and bedroom, which often lack furniture designed for prolonged work hours [8]. Furniture commonly found in these rooms, such as chairs, couches, beds, and coffee tables, are not typically designed for prolonged work hours[9].

Although the lockdown campaign has effectively decreased the incidence of COVID-19 cases, it has also presented a new challenge to workers, especially in terms of ergonomic problems [2, 10]. The pros and cons of working from home from the perspective of occupational health and safety have not been thoroughly studied[11]. The limited space and furniture in a home environment can contribute to work-related musculoskeletal disorders (MSDs), compromising workers' health and well-being in the long term.

An ergonomic assessment tool is a valuable resource for evaluating the design and arrangement of workstations, identifying potential ergonomic risks, and improving the health and safety of workers. Such tools help to identify physical and environmental factors that can contribute to musculoskeletal disorders (MSDs) and other health issues.Numerous studies have demonstrated the effectiveness of ergonomic assessment tools in identifying and mitigating ergonomic risks in various workplaces[12, 13]. ergonomic assessment tools can be tailored to specific industries, job types, or work environ-

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ments, making them more useful and applicable for different workplaces. For example, the Computer Workstation Ergonomics Self-Assessment Checklist is widely used to assess the ergonomic risks associated with computer-based workstations in healthcare settings[14].Discomfort symptoms in the context of work-from-home refer to physical sensations or feelings of unease, pain, or discomfort experienced by individuals while performing their work activities at home. These symptoms can manifest in various parts of the body, such as the neck, shoulders, back, arms, wrists, and legs, and may include sensations of muscle stiffness, soreness, tension, numbness, tingling, or a general feeling of discomfort[15, 16, 17].

To date, limited research has focused specifically on the ergonomic risk factors and body discomfort experienced by workers in their home workstations during the COVID-19 pandemic. There is a critical knowledge gap regarding the prevalence and severity of MSDs and body perceived discomfort in work from home settings, as well as the specific risk factors associated with these conditions. The study will utilize an ergonomic assessment tool to evaluate the workstation that contribute to MSDs and body discomfort [18, 19]. By gaining a deeper understanding of these risk factors, effective interventions and recommendations can be developed to promote healthier and more ergonomic home work environments for remote workers

The aim of this study is to survey the conditions of workstations at home and describe the risk factors for discomfort among workers during the COVID-19 pandemic when working from home.

2. Methods

2.1 Study design

This study isan observational cross-sectional. The study was carried out for seven-monthperiod (January to July 2020). The data were obtained through an anonymous online questionnaire (Google Forms) in Thai language. The time of distribution was July 2020. The questionnaire was posted on social networks such as Facebook and LINE application. According to the criteria, the data comes from 303Thai participants. The sample size was calculated using the following formula[20]:

$$n = \left(\frac{Z^2_{1-\frac{\alpha}{2}} \cdot p(1-p)}{d^2} \right) \quad (1)$$

Where: $Z_{1-\frac{\alpha}{2}} = 1.96$ (C.I. 95%, $\alpha = 0.05$)

$p = 0.76$ (the ratio of affected population from COVID-19 in China[21].)

$d = 0.05$

The results determined a sample size of 281. With a consideration of a 10% dropout rate, the authors expected 310 participants. The inclusion criteria for the study were as follows: 1) male or female aged 20 years, 2) working from home during the pandemic, 3) using a computer (PC only) for work, 4) able to communicate in Thai, and 5) must respond to the consent form. The exclusion criteria were as follows: 1) workers who did not complete the questionnaire and 2) those who did not want to participate in the study (for ethical purpose). The content validity of all questions was checked by three experts in the fields of occupational health, public health, and health science. The item-objective congruence (IOC) of the content validity ranged from 0.8 to 1.0.

2.2 Computer workstation checklist

The questions were distributed in the Thai version of the Computer Workstation Ergonomics Self-Assessment Checklist, which was originally developed by the National Institutes of Health, Office of Research Service, Division of Occupational Health and Safety, USA[14]. The checklist is commonly used to assess workstations for proper comfort and performance. Basically, this checklist has been designed for use as a self-assessment on individual's behalf. This means general people are able to assess their own workstation and perform simple adjustment to reach comfort. Since, this study was conducted via online, the authors intended to ensure that the participants can undertake the questions. Therewere 5 sections with 19 questions in total.All questions were dichotomous, requiring a Yes or No response.

2.3 Discomfort Survey

The discomfort survey used in this study was adapted from the MSD Prevention Guideline for Ontario, Part 3B: MSD Prevention Toolbox[22]. Participants were asked to rate their level of discomfort during the work from home period from January to July 2020 by checking off a box. In this study, participants were asked to rate their discomfort levels for three body region, which were the highest perceived discomfort [17]: neck, lower back, and legs, using a scale of 0 to 10, where 0 indicates no discomfort and 10 indicates the worst discomfort. The data were analyzed using multiple linear regression.

2.4 Analysis

All the data were collected via Google Forms and exported into R version 4.2.3 for statistical analysis. Descriptive analysis was used to summarize the data distribution. To evaluate the relationship among demographic information, workstation assessment, and discomfort scales, we conducted multiple linear regression analysis by including all factors for model generation, and we considered a p-value of 0.05 as statistically significant.

2.5 Ethics

The protocol for this study was approved by the Ethics Committee on Research of School of Health Science, Sukhothai Thammathirat Open University (STOU), Thailand (IRB-SHS 2020/1004/69). All ethical issues were complied with accordingly, and all participants were fully informed about the study and asked for their consent prior to participation.

3. Results

3.1 Demographic

The demographic information of the participants is presented in Table 1. A total of 303 participants were included in the study (97.7%), of whom 192 (63.4%) were female, and 111 participants were male. The average age of the participants was 34.28 years (SD ± 8.28), with the highest age range being 30-39 years old (44.22%). Most participants were single (74.59%), held a master's degree (38.61%), and spent 5-8 hours per day looking at a computer screen (68.32%).

3.2 Self-assessment checklist

Table 2 displays the results of a questionnaire given to study participants regarding their workstation assessment. The checklist includes five sections: chair (C), keyboard and mouse (KM), work surface (WS), breaks (B), and accessories (A).

In the chair section, it is revealed that 77.23% of participants had their feet fully supported by the floor when seated, while only 34.32% sat without feeling pressure from the chair seat on the back of the knees.Around half of the participants possessed other items about chair such as adjustability (45.21%), back support (53.14%), and armrest (52.81%).

Regarding the keyboard and mouse section, 88.78% of participants reported being able to position frequently used items within their reach range, while 84.16% had their mouse at the same level and close to the keyboard. Other factors such as having straight wrists and relaxed upper arms while using the keyboard and mouse (60.73%), having the keyboard, mouse, and work surface at elbow height (67%), and the mouse being comfortable to use (71.95%) were also reported by a significant proportion of participants.

In the work surface section, 92.74% of participants had their monitor positioned directly in front of them, but only 38.28% had appropriate lighting for reading and writing documents. Other factors related to the work surface, such as having a glare-free monitor/work surface (69.31%), the monitor height being below eye level (67.33%), and the monitor being placed at least an arm's length away (75.25%), were reported by more than half of the participants.

In the breaks and accessories sections, 63.04% of participants reported using a headset or speakerphone while talking on the phone, 63.70% had a document holder, 63.37% took postural breaks every 30 minutes, and 75.91% performed regular eye breaks when looking at the monitor.

According to the multiple linear regression analysis, the result of neck discomfort is significantly associated with having no posture break every 30 minutes ($p < 0.05$), which seems to be a significant discomforting factor for back and legs as well. The results have also showed that having no armrest and straight wrist posture are associated with back discomfort.

3.3 Discomfort scale

The participants were asked to rate their discomfort into 0-10 scale regarding working from home. Figure 1 presented the discomfort results of participants for their neck. The number and percentage of responses were also showed in the figure. The top three discomfort scales under working from home condition were 2, 7, and 3, respectively.

Figure 2 presented the discomfort results of participants for their lower back. The top three discomfort scales under working from home condition were 7, 8, and 2, respectively.

Figure 3 presented the discomfort results of participants for their legs. The top three discomfort scales under working from home condition were 1, 0, and 2, respectively.

4. Discussion

The present study aimed to assess the working conditions at home and the resulting levels of discomfort among workers during the COVID-19 pandemic. The findings revealed several significant results that contribute to our understanding of ergonomic risk factors and their impact on body discomfort in the home work environment. Additionally, we will discuss the hypotheses that explain the findings and provide a comparison to previous studies, as well as implications and suggestions for further research. Regarding the working conditions at home, the study highlighted the need for improvement in the "chair" section, with the highest number of participants (65.68%) reporting that they were not able to sit without feeling pressure from the chair seat on the back of their knees. The immediate improvement would be to add a back support and optimize the seat pan to allow for better posture and comfort[23, 24, 25].By implementing these modifications, workers can reduce the risk of developing long-term physical problems associated with poor sitting posture[17].

Similarly, 61.72% of participants reported that they did not have appropriate light for reading or writing documents. This can be addressed by adding a desk lamp, placing it on the left side if the participant is right-handed, and on the right side if the participant is left-handed. This aligns with previous research that emphasizes the importance of appropriate lighting in

Table 1. Demographic variables

Characteristics	n	%
Gender		
Male	111	36.63%
Female	192	63.37%
Age (years)		
20-29	99	32.67%
30-39	134	44.22%
40-49	50	16.50%
50-59	20	6.60%
Mean (± SD)	34.28 (±8.28)	
Marital status		
Single	226	74.59%
Married	68	22.44%
Widowed/Divorced/During a separation	9	2.97%
Education		
bachelor's degrees or lower	106	34.98%
master's degree	117	38.61%
Doctorate degree	80	26.40%
Hours/day on computer screen		
1-4	33	10.89%
5-8	207	68.32%
9-12	59	19.47%
>12	4	1.32%

Table 1. Demographic variables

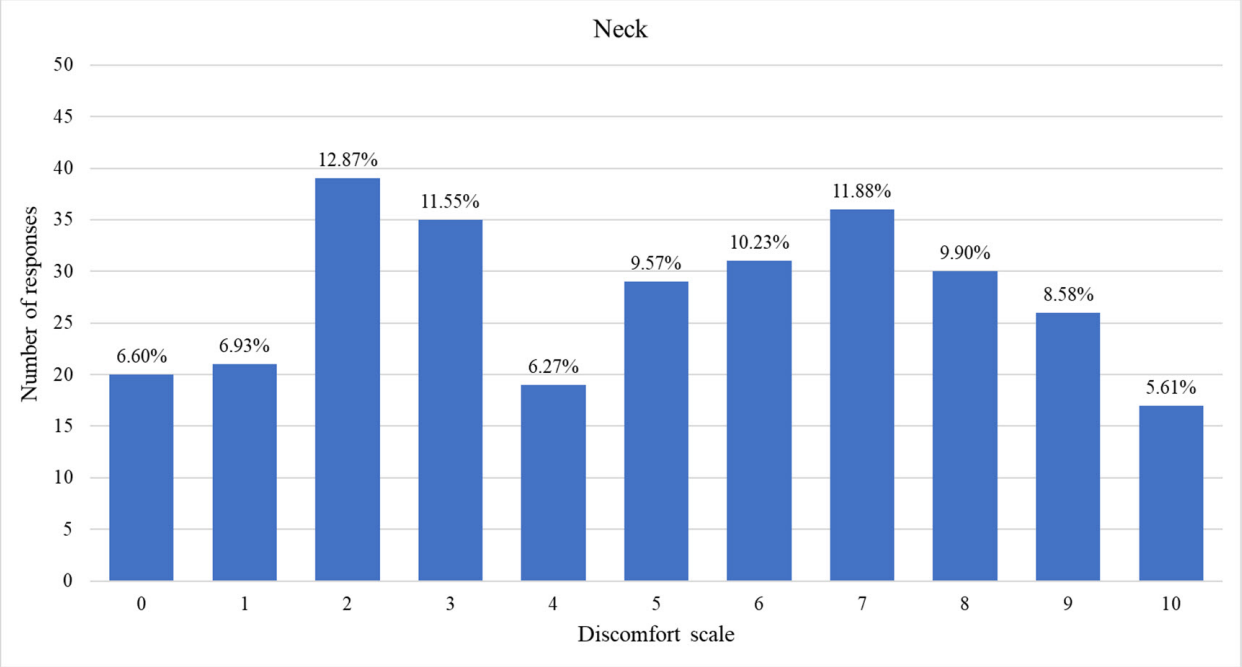

Figure 1: Self-reported discomforts regarding working at computer workstation: Neck

reducing eye strain and improving visibility during work tasks[26].Adding a desk lamp and positioning it correctly based on the participant's dominant hand can alleviate this issue[27].

It is recommended that they obtain a regular adjustable chair to allow for proper adjustments to be made to fit the individual's body type and height. This will not only improve comfort but also prevent long-term physical problems associated with poor posture[24].

The multiple linear regression analysis revealed several significant factors associated with discomfort in various body regions among participants. The findings support previous studies conducted in other coun-

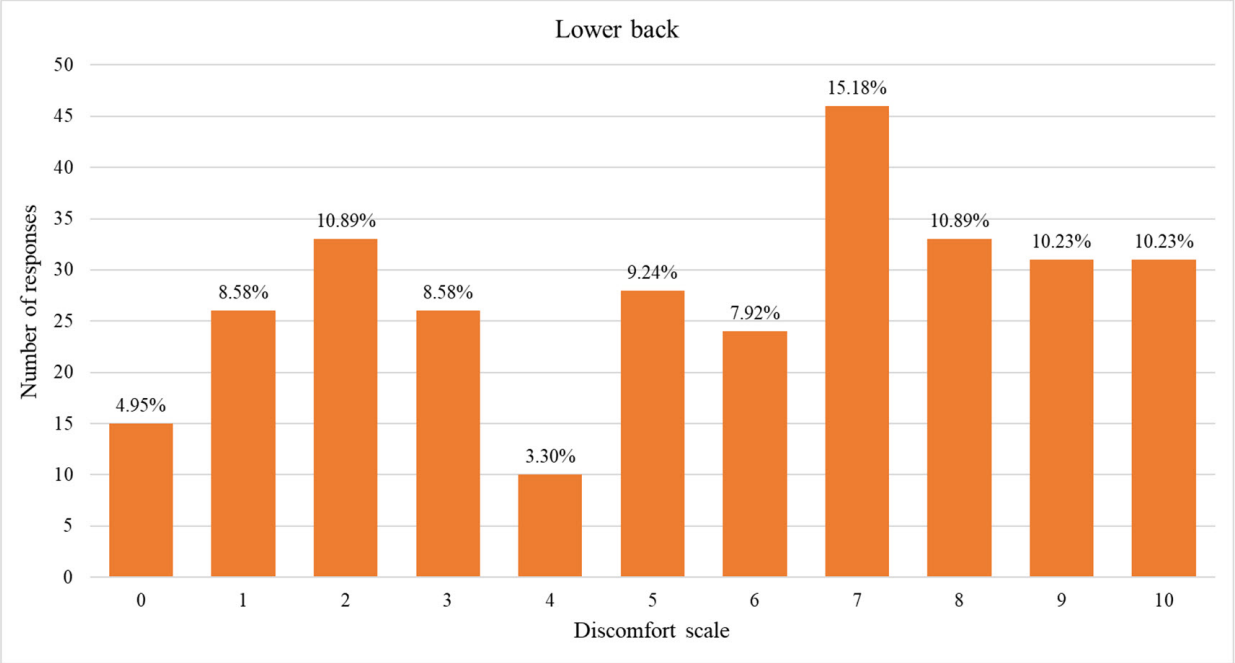

Figure 2: Self-reported discomforts regarding working at computer workstation: Neck

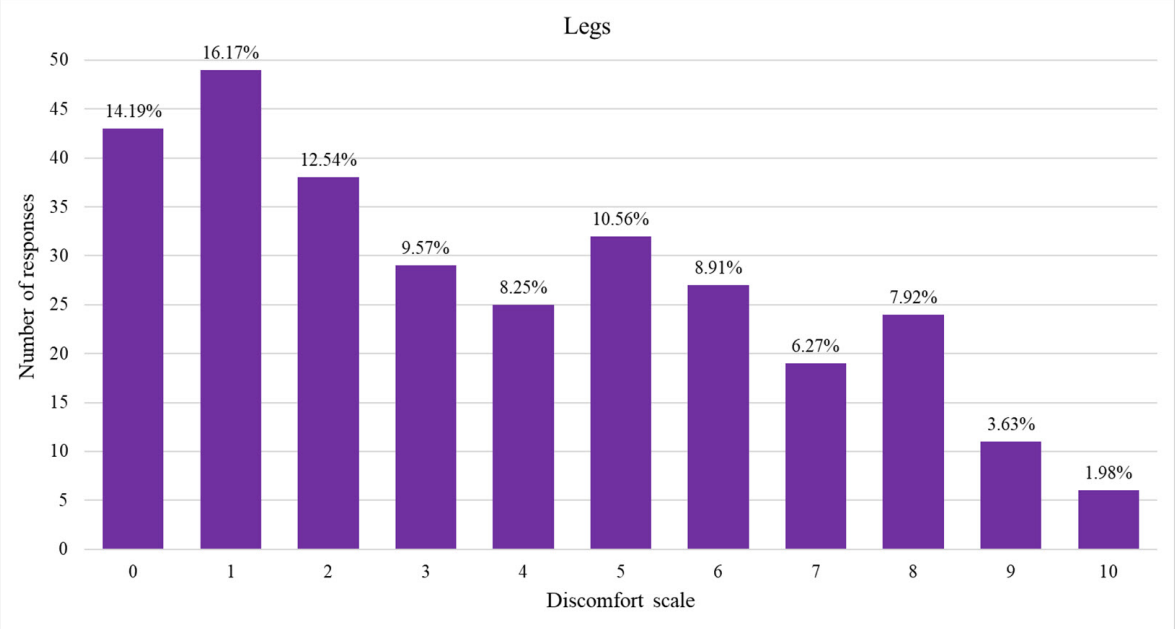

Figure 3: Self-reported discomforts regarding working at computer workstation: Legs

tries and provide valuable insights into ergonomic risk factors and their impact on specific body regions[7, 28, 29, 30]. For instance, the study found that gender and taking postural breaks every 30 minutes were significantly associated with neck discomfort. Specifically, female participants who did not take postural breaks were more likely to report neck discomfort. This emphasizes the importance of incorporating regular postural breaks, especially for female workers, to prevent the development of neck discomfort.

Moreover, the analysis revealed that the absence of armrests, improper wrist positioning and upper arm relaxation when using keyboard and mouse, and not taking postural breaks every 30 minutes were significantly associated with lower back discomfort ($p < 0.05$). These findings underscore the importance of providing ergonomic equipment such as chairs with armrests and positioning keyboard and mouse in a way that ensures proper wrist positioning and upper arm relaxation. Additionally, it is crucial to incorporate reg-

ular postural breaks in work routines to alleviate and prevent lower back discomfort. It is also worth noting that placing a keyboard on an elevated surface, such as its legs, can lead to awkward wrist angles, which can further exacerbate lower back discomfort.

Finally, the analysis suggests that taking postural breaks every 30 minutes was the only significant factor associated with legs discomfort ($p < 0.05$). This highlights the importance of incorporating regular postural breaks to relieve pressure on the legs and prevent discomfort in this region[31, 32]. In comparing our findings to previous studies, we observed consistent patterns and associations between ergonomic risk factors for computer workstation and body discomfort. This strengthens the validity of our results and contributes to the existing body of knowledge on ergonomic risks in the home work environment. However, it is important to note that our study specifically focused on the unique context of the COVID-19 pandemic, which necessitated remote work arrangements. This distinguishes our findings from previous studies conducted in traditional office settings.

Implications of this study are twofold. Firstly, it emphasizes the need for organizations and employers to prioritize the implementation of ergonomic interventions and guidelines for workers who continue to work from home. These interventions should address the identified risk factors, such as improper seating, inadequate lighting, and the absence of adjustable furniture. By providing the necessary support and resources, employers can promote a safe and healthy work environment that reduces the likelihood of discomfort and musculoskeletal issues among workers.

Secondly, the study highlights the importance of individual awareness and self-care in the home work environment. Workers should be encouraged to be proactive in optimizing their workstations and incorporating regular postural breaks into their routines. This can help alleviate discomfort and improve overall well-being.

5. Conclusion

In conclusion, the study underscores the importance of optimizing the work environment at home to ensure better health and comfort for remote workers. Failure to properly design and arrange the workstation could lead to discomfort and pain in various body regions such as the neck, lower back, and legs. The study highlights that chair height adjustment was the most common ergonomic issue, which can be easily resolved by providing appropriate ergonomic equipment like an adjustable chair or a footrest. Furthermore, the lack of a footrest was associated with lower back discomfort, emphasizing the importance of proper foot support to alleviate pressure on the lower back. Additionally, the study stresses the significance of taking regular postural breaks every 30 minutes in preventing discomfort in the neck, lower back, and legs. Employers should prioritize providing ergonomic equipment and encouraging regular postural breaks to foster a safe and healthy work environment for their workers. Overall, addressing ergonomic issues and promoting regular postural breaks can result in improved well-being and productivity for remote workers.

6. Limitations

It is important to note that this study utilized a cross-sectional design, which means that it is difficult to establish a cause-and-effect relationship between ergonomic-related discomfort and workstation issues. There may be multiple factors contributing to the workers' discomfort, making it challenging to pinpoint a single underlying cause with certainty. Therefore, caution should be noted when interpreting the results of this study.

7. Conflicts of interest

The authors declare no conflicts of interest

8. Funding

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References

[1] Ekpanyaskul C, Padungtod C. Occupational health problems and lifestyle changes among novice working-from-home workers amid the COVID-19 pandemic. Safety and health at work. 2021;12(3):384-9.

[2] Fadinger H, Schymik J. The effects of working from home on covid-19 infections and production a macroeconomic analysis for germany. Covid Economics. 2020;9(24):107-39.

[3] Kodama M. Digitally transforming work styles in an era of infectious disease. International Journal of Information Management. 2020;55:102172.

[4] Radhakrishnan G. Work from Home (WFH) Scenario and Ergonomic Arrangements. Nolegein-Journal of Organizational Behavior and Management. 2020:23-31.

[5] Radulović AH, Žaja R, Milošević M, Radulović B, Luketić I, Božić T. Work from home and musculoskeletal pain in telecommunications workers during COVID-19 pandemic: a pilot study. Archives of Industrial Hygiene and Toxicology. 2021;72(3):232-9.

[6] Davis KG, Kotowski SE, Daniel D, Gerding T, Naylor J, Syck M. The home office: ergonomic Lessons From the "new normal". Ergonomics in Design. 2020;28(4):4-10.

[7] Gerding T, Syck M, Daniel D, Naylor J, Kotowski SE, Gillespie GL, et al. An assessment of ergonomic issues in the home offices of university employees sent home due to the COVID-19 pandemic. Work. 2021(Preprint):1-12.

[8] Grozdanovic M, Pavlovic-Veselinovic S, editors. Framework for teleworking. 5th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Service TELSIKS 2001 Proceedings of Papers (Cat No 01EX517); 2001: IEEE.

[9] Cuerdo-Vilches T, Navas-Martín MÁ, Oteiza I. Working from home: Is our housing ready? International Journal of Environmental Research and Public Health. 2021;18(14):7329.

[10] Morikawa M. Work-from-home productivity during the COVID-19 pandemic: Evidence from Japan. Economic Inquiry. 2022;60(2):508-27.
[11] Sarsak HI. Working from home: Self-assessment computer workstation set-up. World Federation of Occupational Therapists Bulletin. 2022;78(1):59-66.
[12] Sadeghi Yarandi M, Soltanzadeh A, Koohpaei A, Sajedian AA, Ahmadi V, Sakari S, et al. Effectiveness of three ergonomic risk assessment tools, namely NERPA, RULA, and REBA, for screening musculoskeletal disorders. Archives of Hygiene Sciences. 2019;8(3):188-201.
[13] Zelik KE, Nurse CA, Schall Jr MC, Sesek RF, Marino MC, Gallagher S. An ergonomic assessment tool for evaluating the effect of back exoskeletons on injury risk. Applied ergonomics. 2022;99:103619.
[14] DOHS. computer workstation self-assessment: National Institutes of Health; cited 2023. Available from: https://ors.od.nih.gov/sr/dohs/HealthAndWellness/Ergonomics/Pages/evaluation.aspx.
[15] Erdinc O, Hot K, Ozkaya M. Turkish version of the Cornell Musculoskeletal Discomfort Questionnaire: cross-cultural adaptation and validation. Work. 2011;39(3):251-60.
[16] Lan L, Wargocki P, Wyon DP, Lian Z. Effects of thermal discomfort in an office on perceived air quality, SBS symptoms, physiological responses, and human performance. Indoor Air. 2011;21(5):376-90.
[17] Waongenngarm P, van der Beek AJ, Akkarakittichoke N, Janwantanakul P. Perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers. Applied Ergonomics. 2020;89:103225.
[18] Gerr F, Marcus M, Monteilh C. Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography and Kinesiology. 2004;14(1):25-31.
[19] Marcus M, Gerr F, Monteilh C, Ortiz DJ, Gentry E, Cohen S, et al. A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. American journal of industrial medicine. 2002;41(4):236-49.
[20] Enderlein G. Daniel, Wayne W.: Biostatistics—A Foundations for Analysis in the Health Sciences. Wiley Sons, New York—Chichester—Brisbane—Toronto—Singapore, 1995, 780 S.,£ 58.—, ISBN 0–471–58852-0 (cloth). Wiley Online Library; 1995.
[21] Zhang Y, Ma ZF. Impact of the COVID-19 pandemic on mental health and quality of life among local residents in Liaoning Province, China: A cross-sectional study. International journal of environmental research and public health. 2020;17(7):2381.
[22] Ontario TOHaSCo. Part 3: the MSD Prevention Toolbox2007. 50 p.
[23] Toxiri S, Näf MB, Lazzaroni M, Fernández J, Sposito M, Poliero T, et al. Back-support exoskeletons for occupational use: an overview of technological advances and trends. IISE Transactions on Occupational Ergonomics and Human Factors. 2019;7(3-4):237-49.
[24] Shikdar AA, Al-Hadhrami MA. Smart workstation design: an ergonomics and methods engineering approach. International Journal of Industrial and Systems Engineering. 2007;2(4):363-74.
[25] Rasmussen J, Tørholm S, de Zee M. Computational analysis of the influence of seat pan inclination and friction on muscle activity and spinal joint forces. International Journal of Industrial Ergonomics. 2009;39(1):52-7.
[26] Shikdar AA, Al-Kindi MA. Office ergonomics: deficiencies in computer workstation design. International Journal of Occupational Safety and Ergonomics. 2007;13(2):215-23.
[27] Preto S, Gomes CC, editors. Lighting in the workplace: Recommended illuminance (LUX) at workplace environs. International Conference on Applied Human Factors and Ergonomics; 2018: Springer.
[28] Akrouf Q, Crawford J, Al Shatti A, Kamel M. Musculoskeletal disorders among bank office workers in Kuwait. EMHJ-Eastern Mediterranean Health Journal, 16 (1), 94-100, 2010. 2010.
[29] Dagne D, Abebe SM, Getachew A. Work-related musculoskeletal disorders and associated factors among bank workers in Addis Ababa, Ethiopia: a cross-sectional study. Environmental health and preventive medicine. 2020;25(1):1-8.
[30] Wu S, He L, Li J, Wang J, Wang S. Visual Display Terminal Use Increases the Prevalence and Risk of Work-related Musculoskeletal Disorders among Chinese Office Workers: A Cross-sectional Study. Journal of occupational health. 2012;54(1):34-43.
[31] Morris D, Brush AB, Meyers BR, editors. SuperBreak: using interactivity to enhance ergonomic typing breaks. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems; 2008.
[32] Koshy K, Syed H, Luckiewicz A, Alsoof D, Koshy G, Harry L. Interventions to improve ergonomics in the operating theatre: a systematic review of ergonomics training and intra-operative microbreaks. Annals of Medicine and Surgery. 2020;55:135-42.