Work 71 (2022) 319–326
DOI:10.3233/WOR-211052
IOS Press

Almost a year in: Virtual offices remained an ergonomic trouble spot

Susan E. Kotowski[a,*], Kermit G. Davis[b] and Thomas Gerding[b]
[a]*Department of Rehabilitation, Exercise and Nutrition Sciences, College of Allied Health Sciences, University of Cincinnati, Cincinnati, OH, USA*
[b]*Department of Environmental and Public Health Science, College of Medicine, University of Cincinnati, Cincinnati, OH, USA*

Received 20 July 2021
Accepted 2 December 2021

Abstract.
BACKGROUND: Many individuals continued to work from home even after nearly 9 months since the COVID-19 pandemic started in spring of 2020.
OBJECTIVE: To conduct a follow-up survey of the faculty and staff of a large Midwest university to determine whether there had been any changes to their home work environment and health outcomes since a prior survey conducted at the start of the pandemic in spring of 2020.
METHODS: An electronic survey was sent out to all employees, staff, and administration (approximately 10,350 individuals) and was completed by 1,135 individuals.
RESULTS: It was found that not much had changed after nearly 9 months of working at home. Faculty and staff continued to primarily use laptops without an external keyboard, monitor or mouse. Few participants reported using chairs with adjustable armrests. These conditions continued to result in high levels of body discomfort (49% neck and head, 45% low back, and 62% upper back and shoulders having moderate to severe pain).
CONCLUSION: If workers are going to continue to work from home, companies will need to accommodate them with more than a laptop, and should include an external keyboard, monitor, and mouse.

Keywords: Telework, musculoskeletal disorders, keyboards, laptops, breaks human-computer interface

1. Introduction

Almost a year into the COVID-19 pandemic, millions of workers have continued to work virtually from home. Some estimates indicate that more than 55% of these virtual workers workforce will continue work at home during the next two years [1] and likely beyond. Overall, about 45% of the workers in United States have the ability to work virtually, with some occupations being above 70% (financial activities, information, professional and business services) [2].

*Address for correspondence: Susan Kotowski, Department of Rehabilitation, Exercise and Nutrition Sciences, College of Allied Health Sciences, University of Cincinnati, Cincinnati, OH, USA. E-mail: Susan.kotowski@uc.edu.

Virtual office work has many advantages over the traditional brick and mortar offices including work flexibility, improved job satisfaction, improved work-family balance, and improved productivity [3]. In spring, 2020, Gerding and associates [4] conducted a survey assessment of the faculty and staff of the University of Cincinnati to determine the initial working environments within the home as all employees worked virtually at the beginning of the COVID-19 pandemic. It was apparent that many of the faculty and staff suffered from discomfort (40% had severe low/middle back pain, moderate discomfort in eyes/neck/head, and discomfort in the upper back/shoulders). In general, most were sent home with a laptop (85%) with no other traditional office

furniture and devices (e.g. external monitor, keyboard, and mouse) [4]. In a sub-set of employees who voluntarily provided pictures of their workstations, Davis et al. [5] found many poor ergonomic practices such as working at dining table (hard front edge) while sitting in a dining chair (no arms or back support), working on a laptop on the couch, and working on a laptop with no external monitor or keyboard. Many of these workstations resulted in poor postures including neck flexion, trunk flexion without support, and raised arms.

Laptops were designed to be versatile for travel and work outside the office for short durations. Long-term use of laptops has been found to increase the risk of musculoskeletal discomfort when performing office work [6, 7]. Using laptops for full-time work in sub-optimal conditions like working on a couch, dining table, or on one's lap may result in long-term discomfort and disorders due to stress being placed on the upper back and neck when looking down at the screen [8]. Using alternative input devices, such as typing on a tablet device, may result in a variety of awkward postures which can increase the risk of developing musculoskeletal disorders [9].

However, Jacobs and associates [10] found that individuals who utilized an external keyboard and mouse had significantly lower discomfort than those who solely used a laptop.

Additionally, due to the ongoing pandemic creating the need for a work-from-home environment, increases in depression, stress, and fatigue levels have all been seen over the last year [4, 11]. Providing ergonomic training is of utmost importance to ensure office workers remain healthy and to reduce ergonomic risk while working at home [12].

The current study aims to follow-up on the previous study [4] to determine whether home work conditions and health outcomes (e.g. stress, tiredness, and discomfort) have changed for employees of a Midwest university who continue to work at home during the pandemic.

2. Methods

2.1. Study design

A survey was sent out to all faculty and staff in fall 2020 (October 28 to December 19) that inquired about the home office components and stressors as well as current health. This survey was a follow-up to the survey of the faculty and staff completed in spring 2020 [4]. The survey was almost identical to the first survey with the exception of a couple of additional questions that were added in fall 2020. The analysis compared the results in fall 2020 to what was found in spring 2020 as reported by Gerding et al. [4].

2.2. Study population

As with the survey in spring 2020, the survey was sent out to only the faculty, staff, and administration employed by the University of Cincinnati (approximately 10,350 individuals [13]). A total of 1135 individuals completed the home office surveys which consisted of 520 faculty, 563 staff, 41 administration, and 11 who did not provide occupation information. The majority of the population was female (62.5% or 709 individuals) with majority being between the ages of 31 and 60 (70%).

2.3. Home office survey

The survey format was identical to the survey administered in spring 2020 [4], which was developed in REDCap (Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA). Table 1 provides a summary of the items included within the survey. Four additional questions were added: 1) what is the percentage of time spent at home, 2) did you purchase equipment for your home office, 3) did you bring home office equipment from your university office, and 4) does the chair at your office have lumbar support.

2.4. Data analyses

Descriptive statistics were determined for each variable, including frequency and percentage of samples responded. Simple *t*-tests were used to determine if differences exist between spring 2020 [4] and fall 2020 of the outcome variables.

3. Results

In fall 2020, university faculty and staff continued to work at home extensively, with 72% reporting they worked at home between 75% and 100% of the time. Few people (16.7%) were working the majority of the time (at least 50% of the time) in their normal office. Lumbar support on the chair was being used

Table 1
Components of the survey administered to the employees of the University of Cincinnati

Variable	Responses
Demographics	
Occupation	Faculty, Staff, Administration, No answer
Age (years)	Less than 30, 31 to 40, 41 to 50, 51 to 60, 61 to 70, 71 and above, No response
Gender	Female, Male, Other, Prefer not to answer
Type of computer device used: laptop, desktop, tablet, or another device	Always, Often, Sometimes, Seldom, Never
Type of chair used: office chair with armrests, office chair without armrests, kitchen/dining chair, folding chair, couch or sofa, bed, armchair or recliner, or other types of seating	
Type of monitors used: built-in laptop screen, external monitor, two stand-external monitors, laptop screen-external monitor combination, or other	
Type of input device used: built-in keyboard, external keyboard, traditional mouse, built-in mouse pad, trackball, touch screen, stylus, or other input devices	
Type of worksurface used: traditional desk, makeshift desk, sit/stand workstation store-bought, makeshift sit/stand workstation, not on a work surface, or another work surface	
Lumbar support	Yes-I use a rolled towel or pillow, I'm not sure, I don't know what lumbar support is, Yes-other, Yes-built in, No
Length of time without break	30 minutes or less, 31 to 60 minutes, 61 to 90 minutes, 91 to 120 minutes, More than 120 minutes
Sharp edge	Yes-but not leaning on it, Yes-and leaning on it, No
Stress Tiredness	A lot more than usual, Somewhat more than usual, Slightly more than usual, No more than usual, I normally work from home
Discomfort	
Head/neck/eyes, upper back/shoulders, lower back	None (0), Mild (1 – 3), Moderate (4 – 7), Severe (8 – 10)
Extra questions	
Percentage of time at home	0%, 1 to 25%, 26% to 50%, 51% to 75%, 76% to 100%, No response
Brought equipment home	Yes, No
Bought equipment	Yes, No
Lumbar support in chair at office	Yes, I use a rolled towel or pillow, I'm not sure, I don't know what lumbar support is, Yes, other, Yes, built in, No

similarly during spring and fall, but was significantly lacking as compared to the lumbar support on their normal office chair ($p < 0.05$) (Fig. 1).

Laptop computers continued to be the primary computer used at home in fall (about 75% in fall as compared to 70% in spring being used 'Always') (Fig. 2). In general, a traditional desk and makeshift desk continued to dominate usage at home, there was no statistical difference between spring and fall (53% at always or often for traditional desk and 30% at 'Always' or 'Often' for makeshift in fall as compared to 53% and 38% in spring, respectively). One positive result was the more prevalent usage of office chairs with arm rests (up to 52% using 'Always' or 'Often' in the fall as compared to 42% in spring) (see Fig. 3). This change seemed to have resulted from less use of dining chairs (drop to 25% for 'Always' and 'Often' in the fall as compared to 35% in spring). Couches were still used routinely (9% using 'Always' and 'Often' in both fall and spring).

A built-in laptop monitor continues to be the primary monitor for home offices (69% 'Always' and 'Often' in fall as compared to 71% in spring, not significantly different) (see Fig. 4). External or desktop monitors were utilized 23% ('Always' and 'Often') in fall which was the same as spring (22%). There was a significant change in using two monitors, with use being higher in fall (19%) versus spring (11%) ($p < 0.05$). Changes in usage of the keyboards and mouse were found in fall ($p < 0.05$) where use of a laptop keyboard and internal mouse was lower (58% 'Always' and 'Often' in fall versus 66% in spring; 33% 'Always' and 'Often' in fall versus 39% in spring, respectively) (Fig. 5). The opposite trend was found for use of a traditional keyboard and mouse (48% in fall vs. 43% in spring for keyboards, 65%

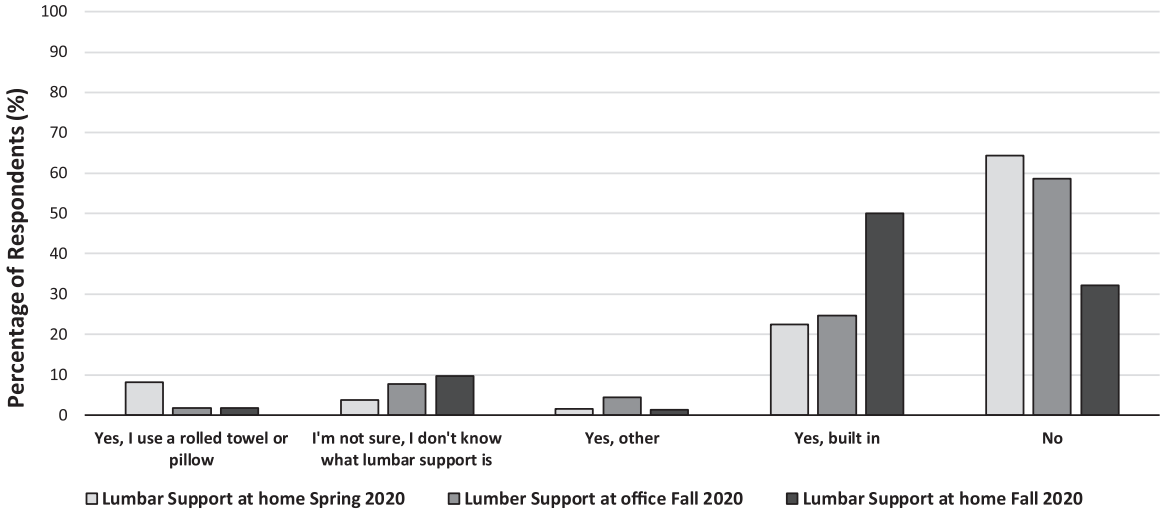

Fig. 1. Presence and use of a lumbar support in the chair in home in spring and fall, and in office in fall.

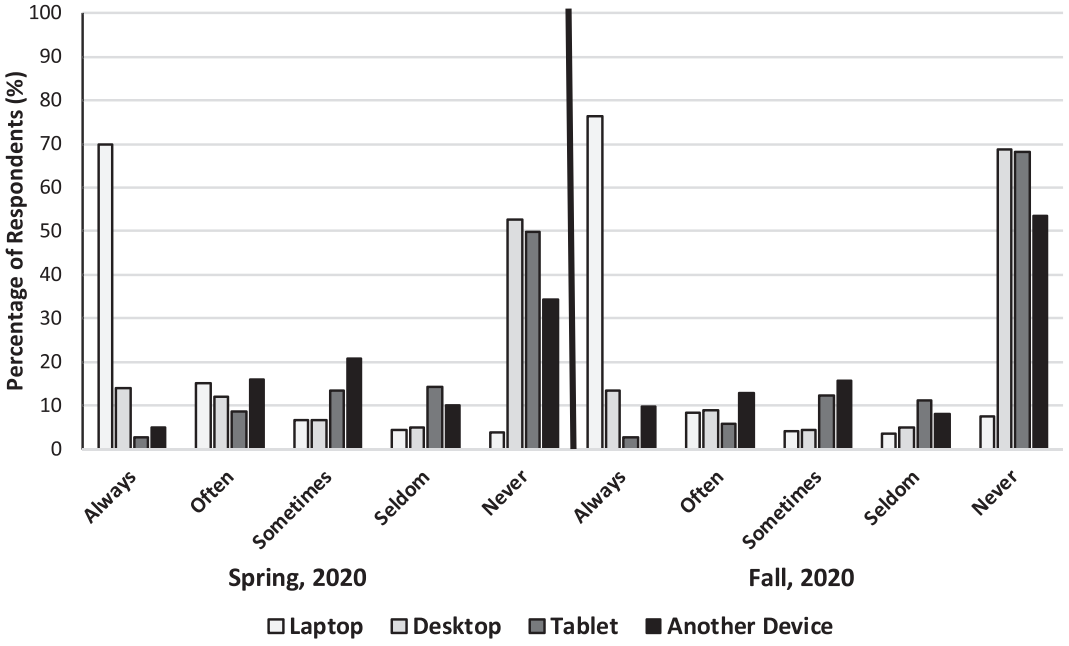

Fig. 2. Computer usage at home in the spring [4] and fall (current).

in fall vs. 62% in spring for mouse, significant at $p < 0.05$).

The ergonomic postures (e.g. bent (flexed) back, neck/head tilted forward, neck/head tilted sideways) were almost identical (not significant) from the results in the spring where back (about 30%) and neck/head were bent forward 'Sometimes' (about 40%). Glare and not having contact with the back of the chair appear to be very similar concerns both in spring and fall (53% having glare at least sometimes, 73% not having back in contact with the back of the chair at least sometimes). The engagement of a sharp edge on the workstation was virtually identical for spring and fall with about 56% having a sharp edge.

Stress seemed to have dropped slightly in fall as compared to spring (12% in fall vs. 16% in spring for 'A lot more stress,' 21% in fall vs. 18% in Spring for 'Somewhat more,' 16% in fall vs 19% in spring for 'Slightly more,' 50% in fall vs 41% in spring for 'No

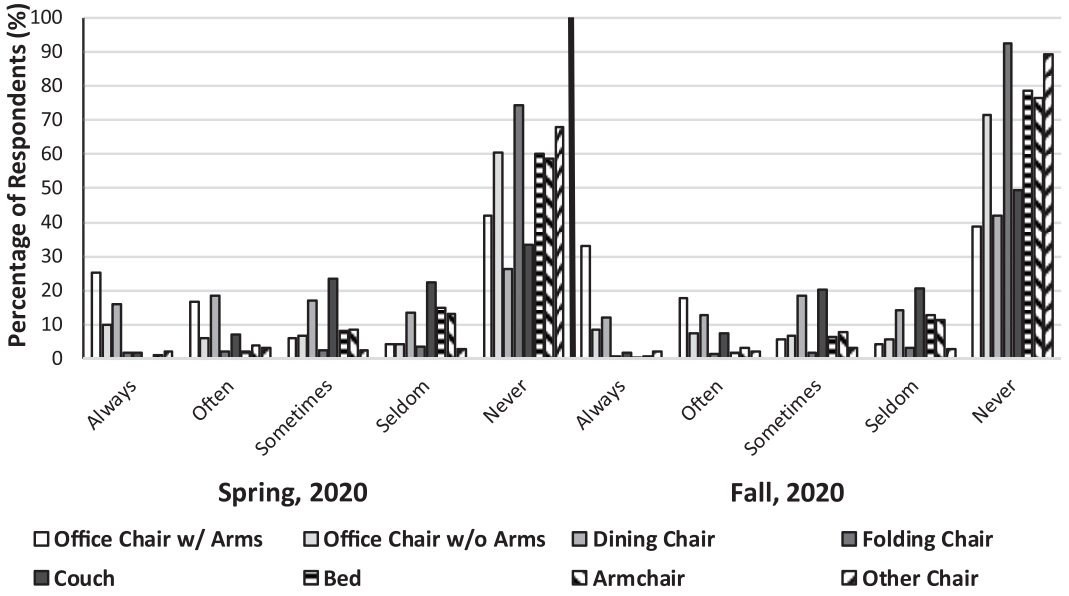

Fig. 3. Chair usage at home in the spring [4] and fall (current).

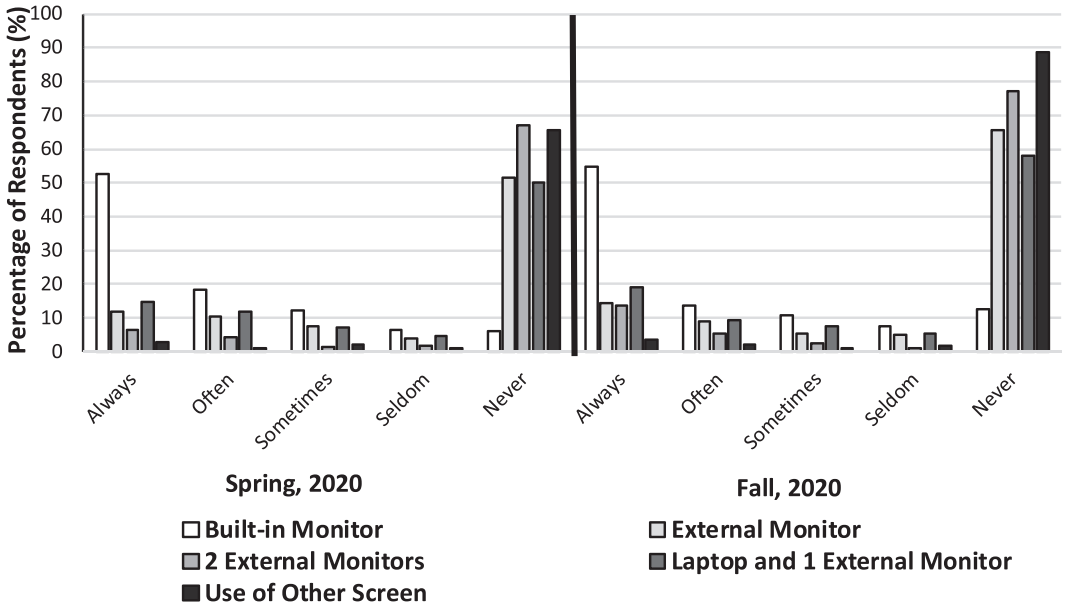

Fig. 4. Monitor usage at home in the spring [4] and fall (current).

more than usual,' significant differences at $p < 0.05$). Similar trends were found for tiredness (decrease of 3% for 'A lot more,' decrease 6% for 'Somewhat,' decrease of 2% for 'Slightly,' and increase of 11% for 'No more than usual').

The discomfort continued to be relatively high with virtually no difference ($p < 0.05$) between spring 2020 and fall 2020 (See Fig. 6). The following is a summary of the percentage of workers who reported moderate to severe discomfort for Eyes, Neck, and Head (49%), Upper Back and Shoulders (52%), Upper Arms and Elbows (19%), Lower Arms, Wrists, and Hands (26%), Middle Back (30%), Lower Back (45%), Hips and Upper Legs (28%), Knees and Lower Legs (19%), and Ankles and Feet (13%).

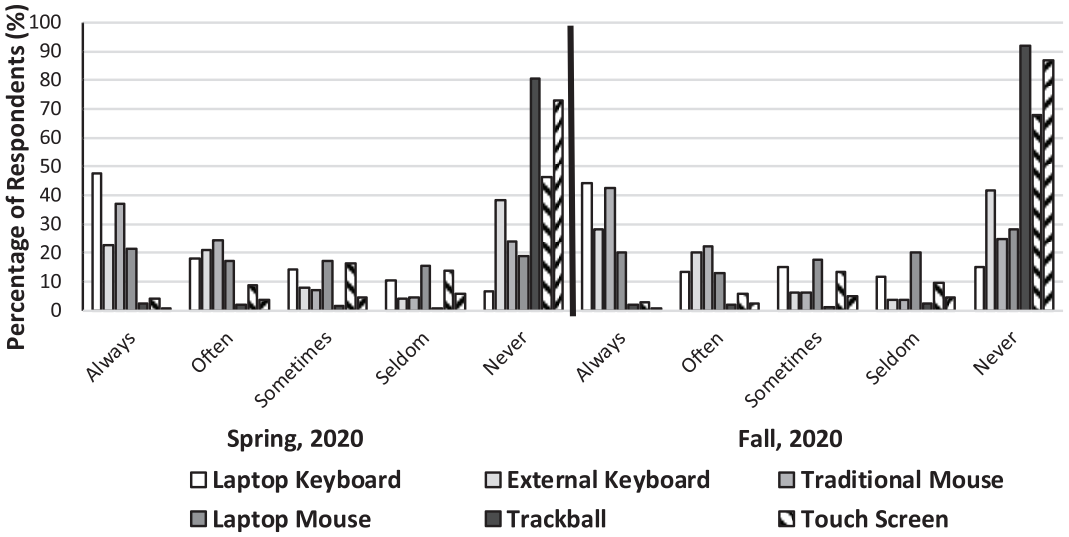

Fig. 5. Input device usage at home in the spring [4] and fall (current).

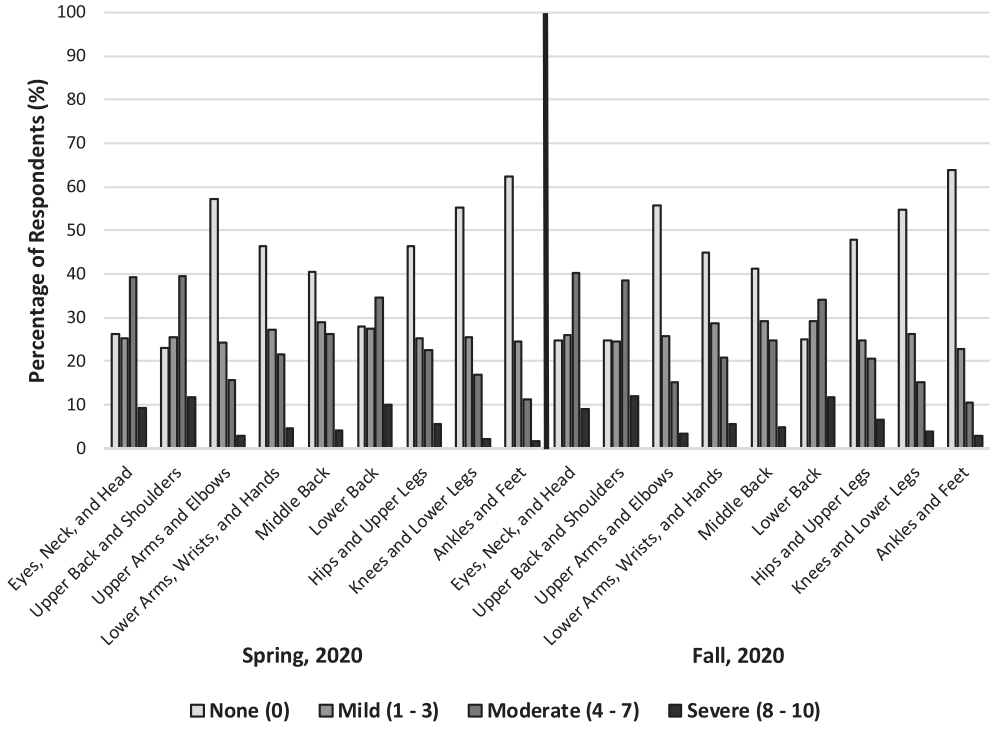

Fig. 6. Discomfort in body parts for office workers in the spring [4] and fall (current).

4. Discussion

As the COVID-19 pandemic continued to have millions of office workers at home, many of the concerns that plagued the home office at the start remained almost 9 months later. At the University of Cincinnati, 72% of the faculty and staff continued to work at home more than 75% of the time. Furthermore, these virtual workers continued to predominantly work on laptops (85% always or often), and the majority of the time these laptops were used with no external devices (e.g. keyboard, monitor, or mouse). This high usage

of laptop computers may be the reason behind the consistent (as compared to spring 2020) but high level of body discomfort (49% neck and head, 45% low back, and 62% upper back and shoulders having moderate to severe pain). Others have reported increased discomfort when solely using laptop devices [10].

Very few changes occurred in the home office since being sent home due to the pandemic in spring 2020. The biggest change occurred with the greater usage of office chairs with armrests and less usage of dining chairs and couches. This may have been reflective of more than half the respondents (55%) saying they brought office equipment home from work. Another smaller change between spring and fall was the decrease in stress and tiredness in the fall (about 10% decrease in 'A lot, Somewhat, and Slightly more' translating into 10% increase in 'No more than usual').

The bottom line is results of the survey continue to show a somewhat bleak picture of the home offices. It appears there is a real need for more training into how to set-up a home office that reduces the negative postures and many of the adverse ergonomic considerations (e.g. glare, sharp edge on worksurface, poor chair characteristics, and laptop usage).

There are a few considerations that need to be remembered when interpreting these results. First, the survey was a sample of convenience in that it focused on faculty and staff of a single university, which may have unique attributes with regard to resources and office equipment. Home office workers from industry potentially have access to better equipment if they are allowed to take it home from their office. Either way, the results indicate that virtual workers need access to more than a laptop.

Second, as with all surveys, the responses rely on the subjective perception of the participants. There is some potential for negative effect that leads to increased ratings of health outcomes like discomfort, stress, and tiredness. However, the prospective nature with two assessments for two different populations would reduce the likelihood of bias for the outcome variables in this study. Future work should conduct more direct observation of the home offices.

Third, as with spring 2020 [4], the number of participants was less than 15% of the university faculty and staff population. While 1135 participants represent a large subject population for an online survey, a large percentage of the 10,350 members of the eligible people for the study would have increased the confidence and robustness of the results.

5. Conclusion

Many people have continued to work from home more than 8 months into the COVID-19 pandemic. The current study conducted a follow-up survey of the faculty and staff of a large Midwest university and found that not much has changed after nearly two-thirds of a year of working at home. The faculty and staff continue to primarily use laptops without any external keyboards, monitors, or mouse devices. Few participants reported using the chairs with adjustable armrests. These conditions continue to result in high level of body discomfort (49% neck and head, 45% low back, and 62% upper back and shoulders having moderate to severe pain). If workers are going to continue to work from home, companies will need to accommodate them with more than a laptop. Additional resources should include an external keyboard, monitor, and mouse devices, as well as an adjustable chair.

Conflict of interest

The authors have no potential conflicts of interest to disclose.

Funding

This work was partially supported by the National Institute for Occupational Safety and Health through the Intergovernmental Personnel Act (IPA) Agreement. Partial support was also provided by the CCTST at the University of Cincinnati, which is funded by the National Institutes of Health (NIH) Clinical and Translational Science Award (CTSA) program, grant 2UL1TR001425-05A1.

References

[1] Global Work-from-Home Experience Survey. Global Workplace Analytics; 2020. Available from https://globalworkplaceanalytics.com/work-at-home-after-covid-19-our-forecas Accessed 2/25/2021.

[2] Bureau of Labor Statistics, U.S. Department of Labor, 2020. Available from: https://www.bls.gov/opub/mlr/2020/article/ability-to-work-from-home.htm#_edn19, Accessed 2/25/2021.

[3] de Macêdo TA, Cabral EL, Silva Castro WR, de Souza Junior CC, da Costa Junior JF, Pedrosa FM, da Silva AB, de Medeiros VR, de Souza RP, Cabral MA, Másculo FS. Ergonomics and telework: A systematic review. Work. 2020 Aug 17(Preprint):1-1.

[4] Gerding T, Syck M, Daniel D, Naylor J, Kotowski SE, Gillespie GL, Freeman AM, Huston TR, Davis KG. An assessment of ergonomic issues in the home offices of university employees sent home due to the COVID-19 pandemic. Work. 2021;10(4):981-92.

[5] Davis KG, Kotowski SE, Daniel D, Gerding T, Naylor J, et al. The Home Office: Ergonomic Lessons From the "New Normal". Ergon Des. 2020; https://doi.org/10.1177/1064804620937907

[6] Asundi K, Odell D, Luce A, Dennerlein JT. Notebook computer use on a desk, lap and lap support: Effects on posture and comfort. Ergonomics. 2010;53:74-82. Available from: https://doi.org/10.1080/00140130903389043.

[7] Jacobs K, Foley G, Punnett L, Hall V, Gore R, et al. University Students' Notebook Computer Use: Lessons Learned Using E-diaries to Report Musculoskeletal Discomfort. Ergonomics. 2011;54(2):206-19. Available from: https://doi.org/10.1080/00140139.2010.544764.

[8] Werth AJ, Babski-Reeves K. Assessing Posture While Typing on Portable Computing Devices in Traditional Work Environments and at Home. Proceedings of the Human Factors and Ergonomics Society 56th Annual Meeting. 2012. Available from: https://doi.org/10.1177/1071181312561223.

[9] Lin MB, Hong R, Chang J, Ke X. Usage Position and Virtual Keyboard Design Affect Upper-Body Kinematics, Discomfort, and Usability During Prolonged Tablet Typing. PLoS One. 2015;10(12):e0143585. Available from: https://doi.org/10.1371/journal.pone.0143585

[10] Jacobs K, Johnson P, Dennerlein J, Peterson D, Kaufman J, et al. University Students' Notebook Computer Use. Appl. Ergon. 2009;40:404-9. Available from: https://doi.org/10.1016/j.apergo.2008.11.009.

[11] Majumdar P, Biswas A, Sahu S. COVID-19 Pandemic and Lockdown: Cause of Sleep Disruption, Depression, Somatic Pain, and Increased Screen Exposure of Office Workers and Students of India. Chronobiol Int. 2020;37(8):1191-200. Available from: https://doi.org/10.1080/07420528.2020.1786107.

[12] Baydur H, Ergor A, Demiral Y, Akalin E. Effects of Participatory Ergonomic Intervention on the Development of Upper Extremity Musculoskeletal Disorders and Disability in Office Employees Using a Computer. J Occup Health. 2016;58(3):297-309. Available from: https://doi.org/10.1539/joh.16-0003-OA.

[13] UC Facts. University of Cincinnati; 2019 [cited 2020 May 18]. Available from https://www.uc.edu/about/factsheet.html.