DOI: 10.1590/1809-2950/22010829032022EN

ORIGINAL RESEARCH

Ergonomic risks and musculoskeletal symptoms in Instituto Federal Catarinense administrative technicians during telework in the COVID-19 pandemic

Riscos ergonômicos e sintomas musculoesqueléticos em técnicos administrativos do Instituto Federal Catarinense durante o teletrabalho na pandemia da COVID-19

Riesgos ergonómicos y síntomas musculoesqueléticos en técnicos administrativos del Instituto Federal Catarinense durante el teletrabajo en la pandemia del COVID-19

Bruno Guimarães[1], Thiago Silva[2], Diego Munhoz[3], Priscila Landivar[4]

ABSTRACT | This study aimed to evaluate musculoskeletal symptoms and ergonomic risks in telework environments of administrative technicians at the Instituto Federal Catarinense. In total, 142 administrative technicians who answered an online questionnaire about sociodemographic information, task performance, work environment, and musculoskeletal pain participated in the study. Data were analyzed by binary logistic regression separately for each outcome, using pain in the neck, right shoulder and low back pain as dependent variables. The prevalence of pain among administrative technicians was 92.7% and the most frequent regions were the neck, lumbar spine, and right shoulder. Mental overload (stress), inadequate worktable, monitor and work chair, lack of guidance on ergonomic risks and adaptations in the work environment were the main ergonomic risks. An association was observed between neck pain and administrative technicians who were mentally overloaded, did not practice any physical activity, did not have the table at elbow level, had neither forearms support nor used a mouse (but a touchpad instead); and right shoulder pain in administrative technicians who had no forearm support and used a touchpad. Also, low back pain was associated with mentally overloaded women who did not have footrest, table at the elbow level, or a chair with lumbar support and upholstery. The institution should provide adequate equipment and furniture and training the employees on the ergonomic risks at work.

Keywords | COVID-19; Ergonomics; Musculoskeletal Pain; Occupational Health.

RESUMO | O objetivo deste estudo foi avaliar os sintomas osteomusculares e os riscos ergonômicos nos ambientes de teletrabalho dos técnicos administrativos do Instituto Federal Catarinense (IFC). Participaram 142 técnicos administrativos, que responderam um questionário online sobre informações sociodemográficas, realização de tarefas, ambiente de trabalho e dor musculoesquelética. Os dados foram analisados por meio de uma regressão logística binária separadamente para cada desfecho, utilizando como variáveis dependentes as dores no pescoço, no ombro direito e na coluna lombar. A prevalência de dor entre os técnicos administrativos foi de 92,7% e as regiões mais afetadas foram o pescoço, a coluna lombar e o ombro direito. Os principais riscos ergonômicos foram: sobrecarga mental (estresse), mesa, monitor e cadeira de trabalho inadequados, ausência de orientação acerca dos riscos ergonômicos e das adaptações no ambiente de trabalho. Foi observada associação entre dor no pescoço e os técnicos administrativos que apresentaram maior sobrecarga mental (estresse), não fazem atividade física, não trabalhavam com mesa ao nível do cotovelo, não tinham espaço para apoiar os antebraços e utilizavam o *touchpad*; e entre dor no ombro direito e os técnicos administrativos que não tinham espaço para apoiar os antebraços e utilizavam o

[1]Instituto Federal Catarinense (IFC) – São Bento do Sul (SC), Brazil. E-mail: bruno.guimaraes@ifc.edu.br. ORCID-0000-0002-4957-4502
[2]Universidade de Pernambuco (UPE) – Recife (PE), Brazil. E-mail: thiago.silva@upe.br. ORCID-0000-0002-0407-1223
[3]Instituto Federal Catarinense (IFC) – São Bento do Sul (SC), Brazil. E-mail: diego.munhoz.ifc@gmail.com. ORCID-0000-0002-8472-9434
[4]Instituto Federal Catarinense (IFC) – São Bento do Sul (SC), Brazil. E-mail: priscila.landivar1@gmail.com. ORCID-0000-0002-9317-1874

Corresponding address: Bruno Guimarães – Rua Paulo Chapiewski, 931 – São Bento do Sul (SC), Brazil – ZIP Code: 89283-064 – E-mail: bruno.guimaraes@ifc.edu.br – Financing source: IFC campus São Bento do Sul – Conflict of interests: nothing to declare – Presentation: April 15th, 2022 – Accepted for publication: Aug 26th, 2022 – Approved by the Research Ethics Committee: CAAE No. 47672421.2.0000.8049.

touchpad. Ainda, a dor na coluna lombar foi associada às mulheres que não possuíam apoio para os pés, mesa ao nível do cotovelo e cadeira com apoio lombar e estofamento, assim como àquelas que apresentaram maior sobrecarga mental (estresse). Conclui-se que é importante a instituição fornecer equipamentos e mobiliários adequados e oferecer treinamentos sobre os riscos ergonômicos presentes no trabalho.
Descritores | COVID-19; Ergonomia; Dor Musculoesquelética; Saúde do Trabalhador.

RESUMEN | El objetivo fue evaluar síntomas musculoesqueléticos y riesgos ergonómicos en ambientes de teletrabajo de técnicos administrativos de la Instituto Federal Catarinense. Participaron 142 técnicos administrativos que respondieron un cuestionario en línea sobre información sociodemográfica, desempeño de tareas, ambiente de trabajo y dolor musculoesquelético. Los datos se analizaron mediante regresión logística binaria por separado para cada resultado, utilizando el dolor en el cuello, el hombro derecho y la columna lumbar como variables dependientes. La prevalencia de dolor entre los técnicos administrativos fue del 92,7% y las regiones más frecuentes fueron cuello, columna lumbar y hombro derecho. Los principales riesgos ergonómicos fueron: sobrecarga mental (estrés), mesa de trabajo, monitor y silla de trabajo inadecuados, falta de orientación sobre riesgos ergonómicos y adaptaciones en el ambiente de trabajo. Se observó asociación entre el dolor de cuello y los técnicos administrativos que presentaban mayor sobrecarga mental (estrés), no hacían actividad física, no tenían la mesa a la altura de los codos, no tenían espacio para apoyar los antebrazos y usaban el touchpad, dolor en el hombro derecho y técnicos administrativos que no tenían espacio para apoyar los antebrazos y usaban el touchpad. Aún así, el dolor en la columna lumbar se asoció al grupo de mujeres que no apoyaban los pies, que no tenían la mesa a la altura de los codos, la silla no tenía apoyo lumbar y tapizado y presentaban mayor sobrecarga mental (estrés). Es importante que la institución brinde equipo y mobiliario adecuado y realice capacitaciones sobre los riesgos ergonómicos presentes en el trabajo.
Palabras clave | COVID-19; Ergonomía; Dolor Musculoesquelético; Salud Laboral.

INTRODUCTION

When the COVID-19 pandemic emerged in 2020, social distancing measures were adopted. With closed offices, commerce, schools, and universities, telework was implemented worldwide. Thus, workers were transferred to their homes, where they had to organize a workplace from the existing structure that was often inadequate for work, which may result in ergonomic risks and pain[1].

In this context, we observe that the implementation of telework during the pandemic introduced demands and requests that increased occupational risks, such as the occurrence of work-related musculoskeletal disorders (WMSDs) and work-related mental disorders[2]. A review of the health effects caused by telework indicates an increased frequency of WMSDs associated with computer use and stress-related mental disorders[3]. This increased frequency may have occurred because of the risk factors associated with this type of WMSD, such as table, chair, and monitor height; keyboard and mouse use; work postures and organizational factors, like long working hours and computer use per day, besides psychosocial factors, such as stress[4,5].

Notably, WMSDs are one of the main health problems in Brazil, directly correlated with working conditions. These disorders require the implementation of well-being practices[6] since they can cause functional disabilities and are responsible for most work absences in the country.

The activities carried out by university administrative technicians are mostly bureaucratic, demanding great responsibilities and requiring an elevated level of concentration. Such activities may strain the employees if they do not feel capable or do not have the means to perform them[7].

Thus, administrative technicians of the Instituto Federal Catarinense (IFC) teleworked from March 2020 to September 2021. Their work was frequently done in their homes and via computers, which could risk them developing WMSDs. Considering that little is known about telework effects on health, studying it is a priority in occupational health[8], and we must identify the ergonomic risks in this type of work. It would allow using parameters to adapt job places, focusing on preventing pain symptoms and improving workers' life quality[1].

That said, this study aims to evaluate musculoskeletal symptoms and ergonomic risks in the IFC administrative technicians telework. The research hypothesis is the high prevalence of pain and ergonomic risks in the telework environments of IFC workers.

METHODOLOGY

This analytic, exploratory, and quantitative study was conducted in August 2021The sample was composed of IFC administrative technicians, totaling 807 participants. Those individuals who were absent from work or worked 20h per week were excluded. The inclusion criteria were being an administrative technician and signing an informed consent form. The convenience sample consisted of 142 IFC technicians who answered the questionnaire.

Based on related research found in a literature review, an online questionnaire was elaborated via Google Forms containing sociodemographic questions, such as telework environments and musculoskeletal symptoms related to the telework period. Illustrations were included and associated with the questions about the telework environment in order to make the questionnaire understandable by volunteers, like those used by Guimarães et al.[1].

After developing the questionnaire, an online pre-test was conducted via Google Forms, in which nine IFC administrative technicians participated. They were instructed to answer the instrument and to inform what was misunderstood. Based on the volunteers' answers, the research team adjusted the questions. The final version of the questionnaire was validated by the pre-test respondents. Then, IFC's Communication Coordination emailed the questionnaire link to all IFC administrative technicians.

Binary logistic regression was used isolated for each outcome, and the dependent variables were neck, right shoulder, and lumbar spine pain. The power of the sample was calculated a posteriori using the GPower software version 3.1, reaching a 0.80 β and a 0.34 effect size. The data were analyzed using SPSS 22.0 software and a 5% significance level ($p \leq 0.05$) was adopted for all analyses.

RESULTS

Volunteers' mean age was 39.87±8.10 years. Table 1 shows all results.

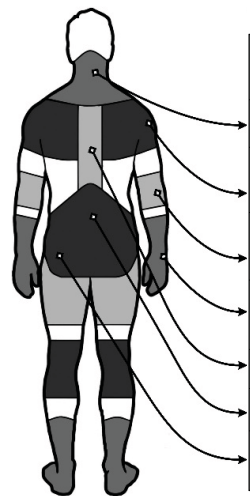
Table 1. Descriptive statistics in absolute and relative frequency

Characteristic		Total n (%)	Men n (%)	Women n (%)
Years working at IFC	≤15 years	139 (91.4)	53 (38.1)	86 (61.9)
	>15 years	13 (8.6)	5 (30.8)	9 (69.2)
Practices physical activity	yes	72 (47.4)	23 (31.9)	49 (68.1)
	no	80 (52.6)	34 (42.5)	46 (57.5)
Mental overload (stress)	≤	46 (30.5)	24 (52.2)	22 (47.8)
	>	105 (69.5)	32 (30.5)	73 (69.5)
Take a break	yes	98 (64.9)	40 (40.8)	58 (59.2)
	no	53 (35.1)	16 (30.2)	37 (69.8)
Knows about ergonomics	yes	101 (67.3)	42 (41.6)	59 (58.4)
	no	49 (32.7)	14 (28.6)	35 (71.4)
Received guidance on ergonomic risks	yes	48 (32.4)	21 (43.8)	27 (56.2)
	no	100 (67.6)	33 (33)	67 (67)
Uses borrowed equipment	yes	63 (42.0)	26 (41.3)	37 (58.7)
	no	87 (58.0)	30 (34.5)	57 (65.5)
Works with a footrest	yes	94 (63.5)	43 (45.7)	51 (54.3)
	no	54 (36.5)	11 (20.4)	43 (79.6)
Uses chair with lumbar support	yes	47 (31.3)	22 (46.8)	25 (53.2)
	no	103 (68.7)	33 (32)	70 (68)
Uses chair with adjustable height	yes	84 (56.4)	36 (42.9)	48 (57.1)
	no	65 (43.6)	20 (30.8)	45 (69.2)
Uses upholstered chair	yes	91 (60.7)	37 (40.6)	54 (59.3)
	no	54 (59.3)	19 (32.2)	40 (67.8)
Works with the table at elbow level	yes	68 (45.0)	31 (45.6)	37 (54.4)
	no	83 (55.0)	25 (30.1)	58 (69.9)
Has space to support forearms	yes	68 (45.0)	32 (47.0)	36 (53.0)
	no	83 (55.0)	24 (28.9)	59 (71.1)
Use mouse or touchpad	mouse	116 (76.8)	48 (41.4)	68 (58.6)
	touchpad	35 (23.2)	8 (22.8)	27 (77.1)
Type of keyboard used	External keyboard	68 (45.0)	25 (44.6)	43 (45.3)
	Notebook keyboard	83 (55.0)	31 (55.4)	52 (54.7)
Eye-level monitor	yes	68 (45.0)	29 (42.6)	39 (57.3)
	no	83 (55.0)	27 (32.5)	56 (67.4)

(continues)

Table 1. Continuation

The prevalence of pain was 92.7%. Figure 1 shows the distribution of symptoms.



BODY PART	MEN n (%)	WOMEN n (%)	TOTAL n (%)
NEEK	32(57,1)	72(75,8)	104(68,9)
SHOULDER (RIGHT/LEFT)	25(44,6)/ 15(31,9)	49(51,6)/ 32(68,1)	74(49,0)/ 47(31,1)
ELBOW (RIGHT/LEFT)	11(19,6)/ 3(5,4)	13(13,7)/ 8(8,4)	24(15,9)/ 11(7,3)
FIST (RIGHT/LEFT)	16(28,6)/ 8(14,3)	46(48,4)/ 13(13,7)	62(41,1)/ 21(13,9)
DORSAL	19(33,9)	30(31,6)	49(32,5)
LUMBAR	33(58,9)	60(63,2)	93(61,6)
HIP (RIGHT/LEFT)	5(8,9)/ 5,(8,9)	12(12,6)/ 11(11,6)	17(11,3)/ 16(10,6)

Figure 1. Prevalence of pain within studied individuals (n=140)

Table 2 presents the binary logistic regression models for each outcome, using as dependent variables the regions with the highest prevalence of pain.

The main ergonomic risks found were: increased mental overload (stress); inadequate monitor height (upper edge of the monitor was not at the eye level); inadequate work table (i.e., table higher or lower than elbow level, sharp corners and lack of space to support forearms); inadequate work chair (absence/inadequacy of lumbar support); and lack of IFC guidance on ergonomic risks and the necessary adaptations to the workplace.

Table 2. Raw and adjusted logistic regression models for variables neck pain, right shoulder, and low back pain

Outcome	Characteristic	Raw LR	95%CI	p-value	Adjusted LR	95%CI	p-value	p
Neck pain	Mental overload (stress)							
	Less/equal	1			1			
	Higher	0.45	0.22–0.93	0.03	0.51	0.23–1.2	0.11	
	Practices physical activity							
	yes	1			1			
	no	1.19	0.60–2.38	0.62	1.25	0.57–2.74	0.57	
	Works with the table at the elbow level							
	yes	1			1			0.00
	no	0.25	0.12–0.52	0.00	0.41	0.18–0.91	0.03	
	Has space to support forearms							
	yes	1			1			
	no	0.25	0.12–0.52	0.00	0.32	0.14–0.70	0.00	
	Uses:							
	Mouse	1			1			
	Touchpad	0.05	0.14–0.38	0.05	0.51	0.18–1.45	0.21	
Low back pain	Sex							
	Male	1			1			
	Female	1.19	0.61–2.35	0.61	0.79	0.36–1.75	0.57	
	Works with footrest							
	yes	1			1			
	no	0.48	0.23–0.98	0.04	0.63	0.28–1.40	0.25	
	Works with the table at elbow level							
	yes							
	no	1			1			
		0.41	0.94–3.72	0.01	0.69	0.31–1.50	0.35	0.00
	Uses chair with lumbar support							
	yes	1			1			
	no	0.30	0.15–0.62	0.00	0.45	0.19 - 1.07	0.07	
	Uses upholstered chair							
	yes	1			1			
	no	0.33	0.16–0.69	0.00	0.57	0.24–1.34	0.20	
	Mental overload (stress)							
	Less/equal	1			1			
	Higher	0.44	0.22–0.90	0.02	0.48	0.22–1.05	0.07	
Pain in the right shoulder	Has space to support forearms							
	yes	1			1			
	no	0.45	0.23–0.87	0.02	0.47	0.24–0.90	0.02	0.04
	Uses:							
	Mouse	1			1			
	Touchpad	0.65	0.30-1.40	0.27	0.74	0.34-1.61	0.45	

Adjusted for the variables neck pain, right shoulder pain and lumbar spine pain.

DISCUSSION

The prevalence of pain was 92.7%, similarly to the studies by Guimarães et al.[1] and Oliveira and Keine[9] with teleworkers during the pandemic, which had a 95% and 94.7% frequency, respectively. The most painful body part was the neck (68.9%), the lumbar spine (61.6%), and the right shoulder (49%), corroborating the study with administrative technicians of the Universidade Federal de Alagoas, where the highest prevalence of pain was in the neck (66%), lumbar spine (52%) and shoulders (43%)[10]. A survey made with employees of a university found a prevalence of: 55.7% for low back pain, 51.3% pain in the shoulders, and 49.9% in the neck[11].

The most frequent ergonomic risks were increased mental overload (stress), inadequacies in the height of

the monitor, table, and chair used for work, and absence of IFC's guidance on ergonomic risks and adaptations in the work environment. This result was similar to two other studies conducted with education workers who were teleworking due to the COVID-19 pandemic. In the study by Gerding et al.[12], most respondents reported increased stress and inadequacies at monitor height and chairs. In the study by Guimarães et al.[1], 85.7% had higher mental overload (stress), 69.3% worked with the monitor at inadequate height, 60% did not have tables at elbow height, and 52% did not have enough space to support their forearms at the table. In the study by Oliveira and Keine[9], more than 50% of the workers did not receive any training on risks and ergonomic adaptations of the telework environment. According to Bernaards et al.[13], instructing workers about the importance of breaks, tasks organization, and the correct relation between body positioning and equipment seems to reduce some ergonomic and stress risks. Moreover, changes in the workplace made by a physical therapist can significantly reduce musculoskeletal disorders of the lumbar spine, neck, and shoulders[14]. Therefore, institutions should conduct ergonomic training with their teleworkers to prevent the development of WMSDs.

We found an association between neck pain and administrative technicians who were mentally overloaded (stressed) and neither practiced physical activity, worked with the table at the elbow level, nor had forearm support or used a mouse (but a touchpad instead). Our result is similar to a survey conducted with administrative technicians of a university, which also found a positive relationship between stress and pain in the neck and lumbar spine[11]. This occurs because stress alters periods of muscle activation and causes increased tension[15]. Furthermore, when using the computer, the worktable should be at elbow height[16]—when it is taller, it causes an elevation of the shoulders and scapula, increasing the painful symptoms in the neck[17]. Additionally, forearm support during computer use has shown effectiveness in reducing muscle overloads in the neck and shoulders and the incidence of musculoskeletal disorders and discomfort in these regions[4,18].

Right shoulder pain was significantly related to those administrative technicians who had no forearm support and used a touchpad. Touchpad use increases musculoskeletal overload because the user must maintain an immovable posture in the upper limb[19] to allow for stabilization and precision—and, consequently, discomforting the shoulder and neck[20].

Low back pain was associated with mentally overloaded women who neither had a footrest, a table at the elbow level nor a chair with lumbar support and upholstery. Similarly, the literature suggest an association between low back pain and females[1]. At the same time, Wang et al.[21] showed a decrease in biomechanical load in the lumbar spine when there is a footrest and a lumbar spine support[21], which decreases pain in this region. Evidence shows that women have more backpain[1], stress, and musculoskeletal disorders due to the greater accumulation of domestic work[22]. This may be aggravated by telework during the pandemic, as suggested by the higher prevalence of pain and stress found among women.

This study results are limited to IFC administrative technicians and therefore cannot be generalized to other institutions. Future studies should investigate the differences between sexes in another educational institution, with a larger sample.

CONCLUSION

Our hypothesis was confirmed. We found ergonomic risks and a high prevalence of musculoskeletal pain among administrative technicians—especially women—in addition to factors associated with neck, lumbar spine, and right shoulder pain. Based on the results, the institution should implement measures to prevent pain symptoms, such as providing adequate equipment and furniture and conducting training on ergonomic risks at work.

REFERENCES

1. Guimarães B, Chimenez T, Munhoz D, Minikovski H. Pandemia de COVID-19 e as atividades de ensino remotas: riscos ergonômicos e sintomas musculoesqueléticos dos docentes do Instituto Federal Catarinense. Fisioter Pesqui. 2022;29(1):96-102. doi: 10.1590/1809-2950/21020229012022PT.
2. Araújo TM, Lua I. O trabalho mudou-se para casa: trabalho remoto no contexto da pandemia de COVID-19. Rev Bras Saude Ocup. 2021;46:e27. doi: 10.1590/2317-6369000030720.
3. Bouziri H, Smith DRM, Descatha A, Dab W, Jean K. Working from home in the time of COVID-19: how to best preserve occupational health? Occup Environ Med. 2020;77(7):509-10. doi: 10.1136/oemed-2020-106599.
4. Cook C, Burgess-Limerick R, Papalia S. The effect of upper extremity support on upper extremity posture and muscle activity during keyboard use. Appl Ergon. 2004;35(3):285-92. doi: 10.1016/j.apergo.2003.12.005.
5. Klussmann A, Gebhardt H, Liebers F, Rieger MA. Musculoskeletal symptoms of the upper extremities and the neck:

a cross-sectional study on prevalence and symptom-predicting factors at visual display terminal (VDT) workstations. BMC Musculoskelet Disord. 2008;9:96. doi: 10.1186/1471-2474-9-96.

6. Melo BF, Souza ACAG, Ferrite S, Bernardes KO. Atuação do fisioterapeuta nos Centros de Referência em Saúde do Trabalhador: indicadores das notificações dos Dort. Fisioter Pesqui. 2017;24(2):136-42. doi: 10.1590/1809-2950/16439824022017.
7. Lopes VS, Silva MC. Estresse ocupacional e fatores associados em servidores públicos de uma universidade federal do sul do Brasil. Cienc Saude Colet. 2018;23(11):3869-80. doi: 10.1590/1413-812320182311.28682015.
8. Benavides FG, Amable M, Cornelio C, Vives A, Milián LC, Barraza D, et al. O futuro do trabalho após a COVID-19: o papel incerto do teletrabalho no domicílio. Rev Bras Saude Ocup. 2021;46:e31. doi: 10.1590/2317-6369000037820.
9. Oliveira M, Keine S. Aspectos e comportamentos ergonômicos no teletrabalho. Revista Produção Online. 2020;20(4):1405-34. doi: 10.1590/S1809-29502013000300004.
10. Oliveira DCG, Guimarães B. Análise da carga de trabalho e de sintomas osteomusculares em técnicos administrativos de instituições de ensino superior do estado de alagoas. Anais do VI Congresso Brasileiro de Fisioterapia do Trabalho; 2015; Florianópolis. Florianópolis: [publisher unknown]; 2015.
11. Almeida LMS, Dumith SC. Association between musculoskeletal symptoms and perceived stress in public servants of a Federal University in the South of Brazil. BrJP. 2018;1(1):9-14. doi: 10.5935/2595-0118.20180004.
12. 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;68(4):981-92. doi: 10.3233/WOR-205294.
13. Bernaards CM, Ariëns GA, Simons M, Knol DL, Hildebrandt VH. Improving work style behavior in computer workers with neck and upper limb symptoms. J Occup Rehabil. 2008;18(1):87-101. doi: 10.1007/s10926-007-9117-9.
14. Pillastrini P, Mugnai R, Farneti C, Bertozzi L, Bonfiglioli R, Curti S, et al. Evaluation of two preventive interventions for reducing musculoskeletal complaints in operators of video display terminals. Phys Ther. 2007;87(5):536-44. doi: 10.2522/ptj.20060092.
15. Magnavita N, Elovainio M, De Nardis I, Heoniemi T, Bergamaschi A. Environmental discomfort and musculoskeletal disorders. Occup Med (Lond). 2011;61(3):196-201. doi: 10.1093/occmed/kqr024.
16. Cook C, Burgess-Limerick R. Guidelines for computer workstations. Ergonomics Australia. 2003;17(1):19-37.
17. Faucet J, Rempel D. VDT-related musculoskeletal symptoms: interactions between work posture and psychosocial work factors. Am J Ind Med. 1994;26(5):597-612. doi: 10.1002/ajim.4700260503.
18. Rempel DM, Krause N, Goldberg R, Benner D, Hudes M, Goldner GU. A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. Occup Environ Med. 2006;63(5):300-6. doi: 10.1136/oem.2005.022285.
19. Conte C, Ranavolo A, Serrao M, Silvetti A, Orengo G, Mari S, et al. Kinematic and electromyographic differences between mouse and touchpad use on laptop computers. Int J Ind Ergon. 2014;44(3):413-20. doi: 10.1016/j.ergon.2014.01.001.
20. Kelaher D, Nay T, Lawrence B, Lamar S, Sommerich CM. An investigation of the effects of touchpad location within a notebook computer. Appl Ergon. 2001;32(1):101-10. doi: 10.1016/S0003-6870(00)00020-X.
21. Wang X, Lavender SA, Sommerich CM, Rayo MF. The effects of using a footrest during computer tasks varying in complexity and temporal demands: a postural and electromyographic analysis. Appl. Ergon. 2022;98:103550. doi: 10.1016/j.apergo.2021.103550.
22. Fantini AJE, Assunção AA, Machado AF. Dor musculoesquelética e vulnerabilidade ocupacional em trabalhadores do setor público municipal em Belo Horizonte, Brasil. Cienc Saude Colet. 2014;19(12):4727-38. doi: 10.1590/1413-812320141912.02872013.