Reduction of Musculoskeletal Pain in First Postgraduate Year (PGY1) Medicine Residents: A Randomized Controlled Trial on Improving Work Life with Laptop Ergonomics

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Abstract

Background: Work-related musculoskeletal disorders (WRMSDs) are a widely recognized problem among healthcare professionals. First postgraduate year (PGY1) students are particularly at risk of developing WRMSDs due to the demanding nature of their work. This study aimed to evaluate the effectiveness of an ergonomic intervention in reducing musculoskeletal pain among PGY1 and improving their work life.

Methods: This randomized control trial included participants from incoming first-year residents for the academic year 2022-2023. Exclusion criteria included daily medications for headaches, having a history of neck/spine pain injections, history of chronic pain, or already using laptop stands. Data collection utilized a Google Survey form incorporating pain scales at baseline, 3, and 6 months.

Results: Out of 57 potential candidates, 41 residents were eligible. Four subjects were lost due to dropout, transfer, or leaving the residency program, leaving 37 residents by the end. Significant differences ($p<0.05$) among control and intervention are shown in shoulder pain, lower back pain, taller subjects with wrist/hand pain, and males with upper back pain. Trends ($p<0.10$) existed with heavier subjects, males with upper back and wrist pain and taller subjects with headaches. The other differences in average pain scoring among different treatments, genders, weights, and heights was not statistically significant.

Conclusion: The study findings suggest that the intervention was effective in reducing shoulder, wrist, and lower back pain among residents. However, further research is needed to explore these outcomes.

Keywords: *Medical residents, Neck pain, Shoulder pain, Lower back pain, Wrist/hand pain, Upper back pain*

Introduction

Work-related musculoskeletal disorders (WRMSDs) have emerged as a significant concern for occupational morbidity in modern societies [1]. The adverse consequences of these conditions include absenteeism, increased costs, and reduced productivity. WRMSDs can be described as a wide array of degenerative conditions that impact supporting muscles, ligaments, blood vessels, tendons, and joints [2]. The most common manifestation of these conditions includes pain that is usually experienced in the neck and upper limbs which can lead to functional impairment. Neck pain is common and the fourth greatest contributor to global disability [3]. Based on the data from the Global Burden of Disease Study, a systematic analysis revealed that the incidence of neck pain per 100 000 population was 806.6, and for years lived with disability from neck pain per 100 000 population was 352.0 [4]. Although several factors can contribute to WRMSDs, biomechanical factors are considered to be major contributors [5]. Repetitive movements, mechanical vibration, forceful exertion, awkward postures, and compressions are common kinetic factors that can lead to MSDs. Apart from physical load factors, individual (age, gender, attitude) and organizational factors such as psychological, social, and work-related stress factors (work intensity, long working hours, management behavior, and lack of job satisfaction) can also contribute to MSDs [6,7]. During an injury, psychological risk factors like job stress, and depression increase the risk of disability in affected individuals and can promote the transition from acute to chronic pain [8].

A person suffering from MSD can manifest symptoms such as discomfort, paresthesia, and tiredness. A variety of professions are at risk of MSDs owing to their unique requirements of movements, body loading, and load management. However, healthcare professionals are particularly at risk of developing WRMSDs due to demanding work environments and prolonged working hours. A study by Freimann et al. reported that almost 70% of nurses experienced musculoskeletal pain in the past year. Among those, 57% had back pain whereas 56% had neck pain. Furthermore, higher work demands, low respect in the workplace, and inter-professional conflicts were significant contributors to musculoskeletal pain ($p<0.05$) [9]. Another study showed that more than 80% of surgeons suffer from MSDs across the world [10]. These findings show that healthcare professionals are at heightened risk of WRMSDs. The use of tablets and laptops are a common practice by healthcare professionals to assist in patient care. Healthcare professionals often use computers to seek medical information, guideline adherence, and clinical decision-making [11]. While the extent of computer usage in the medical field may not be as widespread as in other professions, it is nonetheless employed by medical professionals as required [12]. Chronic deconditioning due to occupational stressors from screen usage and bad cervical ergonomics may lead to prominent exostosis projecting from the occipital squama [13]. Furthermore, cervical, thoracic, and upper extremity stress also affects lumbar and pelvic structures and stability during sitting [14]. A significant amount of data has shown that the increased use of computers in inappropriate posture can lead to significant MSDs [15].

This is particularly important in Postgraduate Year 1 (PGY1) residents who are already prone to MSDs due to high work demands and long working hours. This can hinder their ability to perform optimally and decrease their quality of life. For such individuals, ergonomic interventions can improve work efficiency and reduce musculoskeletal pain. Currently, there is a scarcity of data that has assessed the role of ergonomic intervention to improve work performance in PGY1. This leaves a significant gap in the literature. This study aimed to evaluate if intervention of modern computer ergonomics can reduce headache, musculoskeletal strain/pain, and injuries by decreasing head protraction angle over a 6-month period.

Method

Study design

A randomized controlled trial was undertaken to gather both quantitative and qualitative data utilizing a pain scale [16]. Following the initial measurement of the research variables, the participants were subsequently allocated into two distinct groups: the intervention group and the control group. The intervention was allocated randomly to 50% of the residency cohort. Before commencing the study, informed consent forms and a concise exclusionary survey were disseminated to participants through email. Prior to the implementation of the intervention, pain scales were integrated into a Google Survey form and distributed to the residents. This was done to establish a baseline measurement. Subsequently, follow-up assessments were conducted at 3 and 6 months to evaluate the efficacy of the intervention in terms of reducing headache, musculoskeletal strain/pain, and injuries.

Participants

The participants in the research were residents of the Wright Center who were going to be starting their first year there in the academic year 2022-2023.

Inclusion Criteria

All Family Medicine, Internal Medicine, Psychiatry and Physical Medicine and Rehab residents, PGY-1 during the 2022-2023 academic year were eligible for participation in the study.

Exclusion Criteria

Exclusion criteria included using daily medications for headaches, having a history of pain injections on the neck or spine, having chronic pain issues involving the head/neck/spine, or were already using laptop stands.

Intervention and Data Collection

The investigators of the study collected primary data. The data was collected via a survey conducted on the Google platform. The subjects who provided consent were randomly assigned to either a control group or a study group. Prior to the commencement of the study period, the study group was provided with laptop stands, keyboards, and mice. The researchers collected data by administering a Nordic Musculoskeletal Questionnaire in conjunction with a Visual Analogue Scale, which was incorporated into an online survey form hosted on the Google platform. This data collection process was conducted at three-time points: baseline, 3 months, and 6 months. The data that was gathered was subsequently transferred to an EXCEL file that was password encrypted. The identifying information of the patients was redacted, and subsequently, unique identification numbers were assigned to each patient. Additionally, the data were subjected to a coding process.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS (Statistical Package for Social Sciences (SPSS), Version 22, Chicago, IL). The present study used a mixed-method approach that incorporated both quantitative and qualitative assessments. The quantitative analysis involved propensity score analysis and multivariable regression. Descriptive statistics were calculated for continuous variables. Pain scales were recorded using a Nordic Musculoskeletal Questionnaire and Visual Analogue Scale. Correlations between outcomes of interest were examined through univariate and multivariate analyses. The qualitative assessment consisted of questions related to work habits, physical pain, external influences, workload, and mental-emotional changes, incorporating content and narrative analysis to explore participants' experiences. A p-value of less than 0.05 was considered significant.

Results

Out of 57 possible candidates only 41 joined the study. A total of four subjects were lost during the study from dropout, transfer, or leaving the residency program. The final analysis included data from 37 participants only. Shoulder pain scoring responses among control and intervention is given in Table 1. Among control and intervention, 63 (56.8%) and 48 (43.2%) responses were observed for different severity of shoulder pain (Pain scoring: 1-9) including no pain responses. However, the shoulder pain scoring responses were not different among control and intervention except for 6 months. In 6^{th} month, among control and intervention, 9 (42.9%) and 8 (50%) responded for no pain, 0 (0%) and 5 (31.3%) responded for pain severity score 1, 0 (0%) and 2 (12.5%) responded for pain severity score 2, 3 (14.3%) and 1 (6.3%) responded for pain severity score 3, 3 (14.3%) and 0 (0%) responded for pain severity score 4, 2 (9.5%) and 0 (0%) responded for pain severity score 5 and 6, 1 (4.8%) and 0 (0%) responded for pain severity score 7 and 9, 0 (0%) responded for pain severity score 8 ($p<0.05$).

Table 1. Shoulders pain scoring responses among control and intervention.

Shoulders	No pain	1	2	3	4	5	6	7	8	9	Total	p-value
Baseline												
Cont	10	2	3	0	3	0	3	0	0	0	21	0.55

rol	47.6%	9.5%	14.3%	0%	14.3%	0%	14.3%	0%	0%	0%		
Intervention	6 37.5%	1 6.3%	3 18.8%	2 12.5%	2 12.5%	1 6.3%	1 6.3%	0 0%	0 0%	0 0%	16	
3 months												
Control	9 42.9%	2 9.5%	2 9.5%	3 14.3%	2 9.5%	1 4.8%	0 0%	1 4.8%	1 4.8%	0 0%	21	0.89
Intervention	9 56.3%	2 12.5%	2 12.5%	2 12.5%	1 6.3%	0 0%	0 0%	0 0%	0 0%	0 0%	16	
6 months												
Control	9 42.9%	0 0%	0 0%	3 14.3%	3 14.3%	2 9.5%	2 9.5%	1 4.8%	0 0%	1 4.8%	21	0.03
Intervention	8 50%	5 31.3%	2 12.5%	1 6.3%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	16	
Total												
Control	28 44.4%	4 6.3%	5 7.9%	6 9.5%	8 12.7%	3 4.8%	5 7.9%	2 3.2%	1 1.6%	1 1.6%	63	0.32
Intervention	23 47.9%	8 16.7%	7 14.6%	5 10.4%	3 6.3%	1 2.1%	1 2.1%	0 0%	0 0%	0 0%	48	
Total	51 45.9%	12 10.8%	12 10.8%	11 9.9%	11 9.9%	4 3.6%	6 5.4%	2 1.8%	1 0.9%	1 0.9%	111	

The lower back pain scoring responses among control and intervention are given in Table 2. Among control and intervention, 63 (56.8%) and 48 (43.2%) responses were observed for different severity of lower back pain (Pain scoring: 1-9) including no pain responses. In comparison, 20 (31.7%) and 32 (66.7%) responded with no lower back pain in control and intervention, respectively. Among control and intervention, 4 (6.3%) and 5 (10.4%) responded for pain severity score 1, 9 (14.3%) and 2 (4.2%) responded for pain severity score 2, 4 (6.3%) and 4 (8.3%) responded for pain severity score 3, 5 (7.1%) and 1 (2.1%) responded for pain severity score 4, 8 (12.7%) and 2 (4.2%) responded for pain severity score 5, 9 (14.3%) and 2 (4.2%) responded for pain severity score 6 and 2 (3.2%), 1 (1.6%), 1 (1.6%) responded for pain severity score 7, 8 and 9, respectively for control group ($p<0.01$).

Table 2. Lower back pain scoring responses among control and intervention.

Low Back	**No pain**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**p-value**
Baseline												
Control	6 28.6%	1 4.8%	3 14.3%	2 9.5%	2 9.5%	3 14.3%	3 14.3%	1 4.8%	0 0%	0 0%	21	0.26
Intervention	10 62.5%	0 0%	0 0%	3 18.8%	0 0%	2 12.5%	1 6.3%	0 0%	0 0%	0 0%	16	
3 months												
Control	7 33.3%	2 9.5%	2 9.5%	2 9.5%	0 0%	4 19%	3 14.3%	0 0%	1 4.8%	0 0%	21	0.16
Interventi	12 75%	2 12.5%	1 6.3%	0 0%	0 0%	0 0%	1 6.3%	0 0%	0 0%	0 0%	16	

on												
6 months												
Control	7 33.3%	1 4.8%	4 19%	0 0%	3 14.3 %	1 4.8%	3 14.3%	1 4.8%	0 0%	1 4.8%	21	0.21
Intervention	10 62.5%	3 18.8%	1 6.3%	1 6.3%	1 6.3%	0 0%	0 0%	0 0%	0 0%	0 0%	16	
Total												
Control	20 31.7%	4 6.3%	9 14.3%	4 6.3%	5 7.9%	8 12.7%	9 14.3%	2 3.2%	1 1.6%	1 1.6%	63	0.01
Intervention	32 66.7%	5 10.4%	2 4.2%	4 8.3%	1 2.1%	2 4.2%	2 4.2%	0 0%	0 0%	0 0%	48	
Total	52 46.8%	9 8.1%	11 9.9%	8 7.2%	6 5.4%	10 9%	11 9.9%	2 1.8%	1 0.9%	1 0.9%	111	

The wrist/hand pain scoring responses among males and females are given in Table 3. Among males and females, 75 (67.6%) and 36(32.4%) responses were observed for different severity of wrist/hand pain (Pain scoring: 1-8) including no pain responses. However, overall wrist/hand pain scoring responses showed an increasing trend in males as compared to females (p=0.07). For pain scoring 2 and 3, only 2 (40%) and 1 (12.5%) responses were observed from females.

Table 3. Wrist/hands pain scoring responses among male and female.

Wrist/Hands	No pain	1	2	3	4	6	7	8	Total	p-value
Baseline										
Male	15 60%	2 8%	1 4%	3 12%	0 0%	3 12%	1 4%	0 0%	25	0.33
Female	11 91.7%	0 0%	1 8.3%	0 0%	0 0%	0 0%	0 0%	0 0%	12	
3 months										
Male	16 64%	2 8%	0 0%	3 12%	3 12%	0 0%	1 4%	0 0%	25	0.35
Female	10 83.3%	0 0%	1 8.3%	1 8.3%	0 0%	0 0%	0 0%	0 0%	12	
6 months										
Male	16 64%	0 0%	2 8%	1 4%	2 8%	3 12%	0 0%	1 4%	25	0.33
Female	12 100%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	12	
Total										
Male	47 62.7%	4 5.3%	3 4%	7 9.3%	5 6.7%	6 8%	2 2.7%	1 1.3%	75	0.07
Female	33 91.7%	0 0%	2 5.6%	1 2.8%	0 0%	0 0%	0 0%	0 0%	36	
Total	80 72.1%	4 3.6%	5 4.5%	8 7.2%	5 4.5%	6 5.4%	2 1.8%	1 0.9%	111	

The upper back pain scoring responses among males and females are given in Table 4. Among males and females, 75 (67.6%) and 36 (32.4%) responses were observed for different severity of upper back pain (Pain scoring: 1-7) including no pain responses. In the 6th month, upper back pain scoring responses were on trend and higher in males as compared to females (P=0.09). In comparison, 32 (42.7%) and 26 (72.2%) responded with no upper back pain in males and females, respectively. Among males and females, 10 (13.3%) males responded for pain severity score 1, 15 (20%) and 2 (5.6%) responded for pain severity score 2, 8 (10.7%) and 3 (8.3%) responded for pain severity score 3, 4 (5.3%) and 2 (5.6%) responded for pain severity score 4, 2 (2.7%) and 1 (2.8%) responded for pain severity score 6, 4 (5.3%) and 1 (2.8%) responded for pain severity score 7 and 1 (2.8%) female responded for pain severity score 8 ($p<0.05$).

Table 4. Upper back pain scoring responses among male and female.

Upper back	No pain	1	2	3	4	5	6	7	Total	p-value
Baseline										
Male	12 48%	4 16%	3 12%	4 16%	0 0%	1 4%	1 4%	0 0%	25	0.17
Female	7 58.3%	0 0%	2 16.7%	0 0%	2 16.7%	0 0%	1 8.3%	0 0%	12	
3 months										
Male	11 44%	3 12%	6 24%	3 12%	1 4%	0 0%	1 4%	0 0%	25	0.17
Female	9 75%	0 0%	0 0%	2 16.7%	0 0%	0 0%	0 0%	1 8.3%	12	
6 months										
Male	9 36%	3 12%	6 24%	1 4%	3 12%	1 4%	2 8%	0 0%	25	0.09
Female	10 83.3%	0 0%	0 0%	1 8.3%	0 0%	1 8.3%	0 0%	0 0%	12	
Total										
Male	32 42.7%	10 13.3%	15 20%	8 10.7%	4 5.3%	2 2.7%	4 5.3%	0 0%	75	0.04
Female	26 72.2%	0 0%	2 5.6%	3 8.3%	2 5.6%	1 2.8%	1 2.8%	1 2.8%	36	
Total	58 52.3%	10 9%	17 15.3%	11 9.9%	6 5.4%	3 2.7%	5 4.5%	1 0.9%	111	

The wrist/hands pain scoring responses among individuals of 58-67 inches and above 68 inches are given in Table 5. Among both, 51 (45.9%) and 60 (54.1%) responses were observed for different severity of wrist/hand pain (Pain scoring: 1-8) including no pain responses. At baseline, wrist/hands pain scoring responses were higher at the trend among 68-up inches people as compared to 58-67 inches people (p=0.06). Among individuals of height between 58 to 67 inches, 4 (7.8%) responses were observed for pain score 1. Among individuals of 58-67 inches and above 68, 3 (5.9%) and 2 (3.3%) responded for pain score 2, 2 (3.9%) and 6 (10%) responded for pain score 3. Among individuals of height above 68 inches, 5 (8.3%), 6 (10%), 2 (3.3%), and 1 (1.7%) responded to pain scores 4, 6, 7, and 8, respectively (p<0.01).

Table 5. Wrist/hands pain scoring responses among different heights.

Wrist/Hands	No pain	1	2	3	4	6	7	8	Total	p-value
Baseline										
58-67 inches	13 76.5%	2 11.8%	2 11.8%	0 0%	0 0%	0 0%	0 0%	0 0%	17	0.06
68-up inches	13 65%	0 0%	0 0%	3 15%	0 0%	3 15%	1 5%	0 0%	20	
3 months										
58-67 inches	13 76.5%	2 11.8%	0 0%	2 11.8%	0 0%	0 0%	0 0%	0 0%	17	0.23
68-up inches	13 65%	0 0%	1 5%	2 10%	3 15%	0 0%	1 5%	0 0%	20	
6 months										
58-67 inches	16 94.1%	0 0%	1 5.9%	0 0%	0 0%	0 0%	0 0%	0 0%	17	0.19
68-up inches	12 60%	0 0%	1 5%	1 5%	2 10%	3 15%	0 0%	1 5%	20	
Total										
58-67 inches	42	4	3	2	0	0	0	0	51	<0.01

	82.4%	7.8%	5.9%	3.9%	0%	0%	0%	0%		
68-up inches	38 63.3%	0 0%	2 3.3%	6 10%	5 8.3%	6 10%	2 3.3%	1 1.7%	60	
Total	80 72.1%	4 3.6%	5 4.5%	8 7.2%	5 4.5%	6 5.4%	2 1.8%	1 0.9%	111	

Head pain scoring responses among individuals of 100-159 pounds and more than 160 pounds are given in Table 6. Among both, 60 (54.1%) and 51 (45.9%) responses were observed for different severity of head pain (Pain scoring: 1-6) including no pain responses. However, at 3 months and overall head pain scoring responses were trending among individuals of 100-159 pounds and more than 160 pounds (p=0.07).

Table 6. Head pain scoring responses among different weights.

Head	No pain	1	2	3	4	5	6	Total	p-value
Baseline									
100-159 pounds	12 60%	1 5%	2 10%	2 10%	1 5%	1 5%	1 5%	20	0.81
160-up pounds	10 58.8%	1 5.9%	1 5.9%	4 23.5%	0 0%	0 0%	1 5.9%	17	
3 months									
100-159 pounds	13 65%	3 15%	2 10%	0 0%	2 10%	0 0%	0 0%	20	0.07
160-up pounds	9 52.9%	0 0%	2 11.8%	2 11.8%	0 0%	3 17.6%	1 5.9%	17	
6 months									
100-159 pounds	13 65%	2 10%	2 10%	1 5%	2 10%	0 0%	0 0%	20	0.47
160-up pounds	9 52.9%	0 0%	2 11.8%	1 5.9%	2 11.8%	1 5.9%	2 11.8%	17	
Total									
100-159 pounds	38 63.3%	6 10%	6 10%	3 5%	5 8.3%	1 1.7%	1 1.7%	60	
160-up pounds	28 54.9%	1 2%	5 9.8%	7 13.7%	2 3.9%	4 7.8%	4 7.8%	51	0.08
Total	66 59.5%	7 6.3%	11 9.9%	10 9%	7 6.3%	5 4.5%	5 4.5%	111	

Head pain scoring responses among individuals of 58-67 inches and above 68 inches are given in Table 7. Among both, 51 (45.9%) and 60 (54.1%) responses were observed for different severity of head pain (Pain scoring: 1-6) including no pain responses. However, head pain scoring responses were not different among individuals of 58-67 inches and above 68 inches.

Table 7. Head pain scoring responses among different heights.

Head	Height (58-67 in.)	Height (>68 in.)	Total
No pain	32 (48.5%)	34 (51.5%)	66
1	6 (85.7%)	1 (14.3%)	7
2	4 (36.4%)	7 (63.6%)	11
3	3 (30%)	7 (70%)	10
4	4 (57.1%)	3 (42.9%)	7
5	1 (20%)	4 (80%)	5
6	1 (20%)	4 (80%)	5
Total	51 (45.9%)	60 (54.1%)	111
Pearson Chi-Square = 9.123, df = 6, p-value = 0.16			

Average pain scoring among different treatments, genders, heights and weights are given in Table 8 and Figure 1. Average pain scoring was higher for head, neck, shoulders, upper and lower back for the control as compared to intervention (p<0.05). The wrist/hand pain and the lower back average pain scoring was higher among males as compared to females (p<0.05). For height above 68 inches, the wrist/hand pain and lower back average pain scoring was higher (p<0.05). However, the upper back average pain scoring also showed increasing trend for the individuals having height above 68 inches (p=0.06). The head, neck and lower back average pain scoring was higher for the individuals having more than 160 pounds body weight (p<0.05).

However, average pain scoring of shoulders, wrist/hand and upper back also showed increasing trend among individuals of above 160 pounds body weight (p=0.06-0.08).

Table 8. Average pain scoring (Mean±SE) among different treatments, genders, heights and weights.

Variables	Head	Neck	Shoulders	Wrist/Hand	Upper Back	Lower Back
Treatment						
Control	1.6±0.2	2.4±0.3	2.2±0.3	1.3±0.3	1.8±0.3	2.8±0.3
Intervention	0.8±0.2	1.4±0.3	1.3±0.2	0.8±0.3	0.8±0.2	1±0.2
p-value	0.02	0.02	0.01	0.16	<0.01	<0.01
Gender						
Male	1.4±0.2	1.9±0.3	1.7±0.2	1.5±0.3	1.5±0.2	2.3±0.3
Female	1±0.3	2.1±0.4	2±0.4	0.2±0.1	1.1±0.3	1.4±0.4
p-value	0.31	0.71	0.57	<0.01	0.24	0.05
Height						
58-67 in.	1±0.2	1.7±0.3	1.6±0.3	0.3±0.1	1±0.2	1.5±0.3
>68 in.	1.5±0.3	2.2±0.3	2±0.3	1.7±0.3	1.7±0.2	2.5±0.3
p-value	0.11	0.26	0.34	<0.01	0.06	0.04
Weight						
100-159 lb.	1±0.2	1.5±0.3	1.5±0.3	0.8±0.2	1.1±0.2	1.5±0.3
>160 lb.	1.6±0.3	2.5±0.4	2.2±0.3	1.4±0.3	1.7±0.3	2.7±0.4
p-value	0.05	0.05	0.08	0.08	0.06	0.01

Overall average pain scoring among different treatments (Figure 1), genders (Figure 2), weights (Figure 3), and heights (Figure 4). Average pain scoring among different treatments, genders, weights and heights was not different.

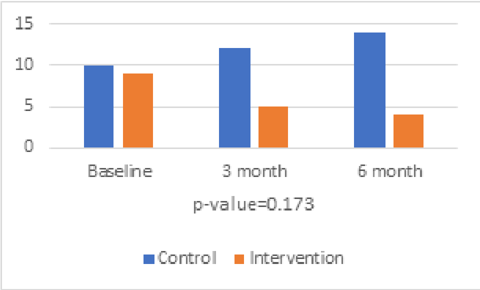

Figure 1. Pain scoring comparison between control and intervention groups.

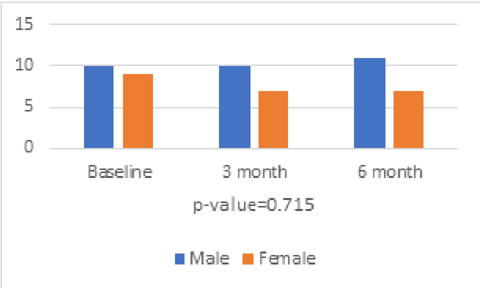

Figure 2. Pain scoring comparison between male and female participants.

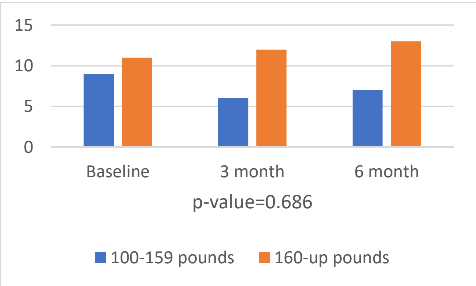

Figure 3. Pain scoring comparison between 100-159 pounds and 160-up pounds.

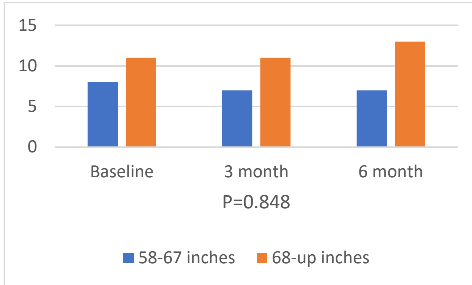

Figure 4. Pain scoring comparison between 58-67 inches and 68-up individual height.

Discussion

The lower back, neck, and shoulders are the most prone areas for the development of musculoskeletal symptoms among computer users [17,18]. Pain in the neck, shoulder region, and lower back is often manifested due to the static loading of the spine by prolonged sitting or standing [19]. Office workers who exhibit higher neck flexion angles tend to experience heightened activity in the upper trapezius muscle, which is also linked to neck and shoulder discomfort [20]. A study by Calick et al. reported that the most painful areas associated with higher desktop computer use were the upper back, neck, lower back, and shoulder respectively [21]. The “Laptop Sniffing” Position (face down forward head posture) or “Text Neck” may compromise the resting spinal column’s double "S-shape" affecting the entire spine and neck. This cervical/upper extremity stress also affects lumbar and sacral/pelvic structures which allow stability during sitting [22]. Similarly, a 3D motion analysis showed that tablet and laptop use was associated with greater neck and upper trunk flexion compared to desktop computers [23]. However, pain can be decreased by balancing the spine through physical activity or using ergonomic equipment [24]. Factors that may play into laptop-related musculoskeletal symptoms and disorders include the lack of adjustability of the keyboard and screen (unlike the desktop) which leads to more pronounced neck and trunk flexion when typing inversely related to the size of the device [25].

The present study investigated the reduction in musculoskeletal pain by using ergonomic interventions (laptop stand and wireless mouse/keyboard) while using laptops in clinical situations. Our findings showed that these ergonomic interventions significantly improved shoulder pain ($p=0.03$), lower back pain ($p=0.01$), wrist/hand pain for tall subjects >68 inches ($p<0.01$) and upper back pain in males ($p=0.04$).

The present results align with previous studies that demonstrated the effectiveness of workstation adjustments in reducing musculoskeletal pain [26,27]. A study by Shariat et al. reported that ergonomic adjustments in the workplace resulted in reduced pain in the neck, right shoulder, left shoulder, and lower back compared to the control group [27].

When averaging pain scores and comparing between control and intervention, control groups had significantly higher scores consistently for head, neck, shoulders, upper and lower back ($p<0.05$). Males had significantly more pain that females in wrists ($p<0.05$) and lower back ($p<0.05$), taller subjects had significantly more wrist ($p<0.05$) and lower back pain ($p<0.05$) and heavier subjects had significantly higher head ($p<0.05$), neck ($p<0.05$) and lower back pain ($p<0.05$).

Trends (p-values between 0.05 to 0.10) existed with males with upper back ($p=0.09$) and wrist pain ($p=0.07$) and headaches in both taller (>68 inches, $p=0.06$) and heavier subjects (>160 lb, $p=0.07$ at 3 months and $p=0.08$ total) with headaches. The other differences in average pain scoring among different treatments, genders, weights, and heights was not statistically significant. Our results deviate from a previous study by Lee et al. that used ergonomic intervention involving furniture modifications [28]. Their findings showed that the lower back pain did not reduce with ergonomic intervention; however, the intervention was successful in reducing shoulder, wrist, neck, and upper back pain ($p<0.05$). Our results can be explained by the fact that physical ergonomics reduce physiological and physical stress on the body while working.

Furthermore, previous research has shown that the positioning of the scapula at rest can be significantly influenced by ergonomic risk factors. Scapular protrusion, for instance, can lead to reductions in the subacromial space and rotator cuff strength, while also increasing tension in the anterior glenohumeral ligaments and scapular stabilizing muscles [29,30]. The present intervention including laptop stand, keyboard and mouse is effective in improving positioning of scapula that can reduce upper back pain. A previous study by Price et al. showed that there was a notable inclination observed among users who did not utilize an external monitor or keyboard to display a heightened degree of neck flexion or a more prominent downward gaze. The analysis of upper arm angle data revealed that participants exhibited a greater extent of reaching movements in conditions where external monitors or keyboards were not utilized [31]. Similarly, a study by Gold et al. showed that prone posture during laptop use resulted in a significantly higher level of perceived discomfort intensity. Prone posture can be characterized by neck extension and non-neutral positioning of the shoulders, elbows, and wrists [32].

Study Limitations

There are several limitations of the study that should be considered while interpreting the results of the study. Due to the absence of consistent monitoring, it is conceivable that certain employees may have made alterations to their respective workstations. The measurement of the sitting period and the frequency of adjustments from sitting to standing was not conducted. An objective analysis of pain may give more accurate results. However, pain monitoring devices would have been costly and impractical in a residency program. Finally, our study was limited by the number of residents available at the time of the study and may explain the shift within the trend when comparing weight and height. The power analysis revealed that the sample size should be 45 per group which was not achieved in our current study. This can explain the high p-value in our results. However, we intend to replicate this randomized controlled experiment for an additional two to four more years to increase the number of subjects and power of our study.

Conclusion

There was a significant indication that the implementation of ergonomic equipment resulted in a reduction of individual pain. This study presents empirical evidence to residency programs regarding the potential benefits of implementing ergonomic equipment to mitigate the occurrence and alleviate the discomfort associated with musculoskeletal injuries resulting from prolonged laptop usage among their PGY-1 workforce, who experience a demanding workload during their initial year of physician training. These findings may be considered for any profession where extended laptop usage is required and where preservation of workforce musculoskeletal health is important. The implementation of strategies aimed at mitigating work-related pain has the potential to enhance productivity and reduce the financial burden on residency programs by minimizing absenteeism and healthcare expenses. These results are significant for promoting the well-being and comfort of medical professionals during their training under stressful and demanding work conditions and may lay down good habits to be incorporated into future practice both at the workplace and in their respective patient populations.

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Statements and Declarations

I declare that this thesis has been composed solely by our team and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

Ethics Approval
This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of The Wright Center for GME (June 4, 2022/1927081-1).

Competing Interests
The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article.

Consent to participate
Informed consent was obtained from all individual participants included in the study.