

# The significance of using an ergonomic computer workstation in preventing discomfort and physical pain among students

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## ABSTRACT

**Introduction:** In today's work environment, proper workstation adjustment plays a crucial role in preventing muscle tension and maintaining healthy habits. Ergonomic positioning of the office chair, desk, and monitor, including height and tilt adjustments, is essential. Additionally, the alignment of the keyboard, mouse, and room lighting significantly influences comfort and work efficiency. This study analyzes the correlation between the use of ergonomic computer workstation elements and the experience of discomfort and physical pain among students while using a computer.

**Materials and methods:** Students from the third year of computer science programs at Jan Kochanowski University and the Kielce University of Technology were included in the study. An original questionnaire survey comprising 33 questions, including a visual analogue scale (VAS), allowed students to subjectively assess the intensity of pain in various body areas during computer use. Additionally, the 2D Videograph was used to examine changes in the cervical spine depth in standing and sitting positions.

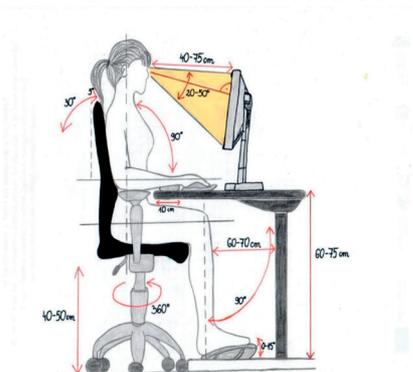
**Results:** The study examined the relationship between workstation setup and pain symptoms among computer-using students. It was found that a proper chair, a desk with sufficient legroom, desk height adjustment, and adequate lighting are essential for reducing pain intensity. The analysis covered various body areas, and the results confirmed the significance of the correlation, especially concerning ergonomic equipment. Third-year students reported higher pain intensity in all areas, particularly in the lumbar spine.

**Conclusion:** The results indicate that desk height, desk type, ergonomic equipment, and proper lighting significantly influence the severity of pain complaints among students using computers. Ergonomic solutions, such as customized desks, ergonomic wrist pads, or monitor adjustments, are associated with significantly lower pain intensity in various body areas. This confirms the role of ergonomics in preventing discomfort related to computer work. Education on proper ergonomic practices can be crucial in preventing health issues among young adults using computers.

**Keywords:** ergonomics; pain; desktop computer; ergonomic chair; desk.

## INTRODUCTION

Incorrect furniture or work equipment arrangement can lead to unhealthy habits, resulting in muscle tension in the upper torso [1]. Therefore, it is important to adjust workplace equipment and ergonomic tools to individual body measurements. Frequent changes in posture are recommended depending on the tasks performed, especially when using electronic devices, as there is a significant relationship between the user's body height, chair, desk, and monitor [2, 3, 4]. The recommended body position during computer use is illustrated in the figure below – Figure 1 [2, 3, 4, 5, 6, 7, 8, 9].



**FIGURE 1.** Recommended body posture during computer use (source: own compilation based on literature [2, 3, 4, 5, 6, 7, 8, 9])

Incorrect workstation setup while using electronic devices can lead to various health consequences, especially if ergonomic principles are not followed. Analyzing the literature, several key issues related to improper workstation arrangement and its impact on the user's body can be observed, such as:

- musculoskeletal disorders – incorrect furniture and equipment arrangement can lead to improper postural habits, resulting in muscle tension in the upper torso. Prolonged maintenance of an incorrect posture can cause musculoskeletal pain and discomfort [1]. Over time, this phenomenon may intensify, leading to back pain, shoulder pain, and a general deterioration of the musculoskeletal system [10, 11, 12]. Improper body posture while using electronic devices can contribute to musculoskeletal disorders, particularly in the neck, back, shoulders, and wrists [2, 3, 4, 5];
- pain and discomfort – resulting from incorrect furniture arrangement, lack of a well-designed chair, and improper positioning of the keyboard or mouse, which may cause pain in the spine, wrists, and other parts of the body [2, 4, 5, 13]. In particular, excessive tilting of the head while using mobile devices can lead to “text neck”, increasing the load on the cervical spine. This can result in pain, numbness, tingling, and overall discomfort in this area [14, 15, 16, 17];

- pain syndromes and neuropathic symptoms – prolonged incorrect posture can cause various discomforts such as neuropathic pain, tingling, or numbness in the upper limbs, significantly affecting daily functioning and quality of life [14, 18, 19]. Problems with the upper limbs, associated with improper positioning of hands, wrists, and fingers while using the keyboard and mouse, can lead to excessive strain on the joints and muscles of the upper limbs [2, 3, 4]. Additionally, excessive key pressing on the keyboard and improper hand positioning while typing may result in wrist and finger strain [4];
- spinal problems – working with electronic devices often involves prolonged sitting, which in itself can lead to many health issues. Incorrect chair, desk, and monitor placement can contribute to spinal problems, particularly in the cervical and lumbar regions [4, 6]. Improper seat tilt, chair height, and lack of proper spine support can lead to back pain [4, 13];
- hip and leg problems – improper seat placement and lack of adequate leg support can result in discomfort in the lower body and issues with the hip joints [2, 5];
- eye problems – improper monitor placement and inadequate lighting can lead to eye fatigue, dry eye syndrome, and other vision problems, including headaches [2, 4, 13, 20, 21]. Lack of proper distance between the eyes and the monitor can negatively impact focus, leading to discomfort and vision disorders [22, 23];
- risk of overweight and obesity [14, 24, 25];
- limited mobility and flexibility – the lack of adjustability in the monitor, desk, or chair can limit flexibility in adapting the workstation to the user's individual needs, contributing to maintaining an incorrect posture [3, 4, 26].

According to ergonomic guidelines, adjusting the workstation to the individual needs of the employee is crucial for preventing musculoskeletal disorders. Studies emphasize the necessity of considering chair height, monitor tilt angle, screen distance, and other elements to avoid incorrect body postures that may lead to discomfort and chronic conditions [2, 3]. The workstation equipment should be tailored to the user's anthropometric measurements. Proper adjustment of body height, chair, desk, and monitor is essential for maintaining correct posture, as incorrect setup can lead to excessive strain on specific body areas [2, 3, 4].

The optimal seated posture is one in which the head is aligned straight with the torso, upright, with the eyes slightly downward. The angle between the line of sight and the monitor should be 90°. Incorrect body positioning, such as leaning forward, raising shoulders, or twisting the neck, can result in discomfort and muscle tension [2, 4, 5]. Essential factors such as the monitor's eye level, chair adjustment, desk placement, arrangement of peripheral devices, and the use of wrist supports are crucial for ensuring an ergonomic workstation. Incorrect settings of these elements can lead to excessive body strain and discomfort [1, 27].

Using a laptop does not meet the requirements for prolonged work. Therefore, additional accessories such as docking stations, stands, or supports are recommended. These accessories allow for adjusting screen height and minimizing head tilt. Improper use of a laptop can lead to postural abnormalities and

discomfort [2, 4, 13]. According to Council Directive 90/270/EEC of May 29, 1990, concerning minimum safety and health requirements for work with display screen equipment – the fifth specific directive within the meaning of Article 16(1) of Directive 89/391/EEC – a laptop does not meet the requirements for devices intended for prolonged work. Therefore, it is recommended to avoid excessive laptop use and limit working time. Tablets are also not ideal for prolonged work. To optimize working conditions, using a docking station that allows connection of a mouse, keyboard, and other peripheral devices, as well as a support to adjust the screen tilt angle, is recommended [3, 28].

In summary, improper workstation setup while using electronic devices can lead to various health problems, particularly affecting the musculoskeletal system, emphasizing the need for awareness and adherence to ergonomic principles. Adopting proper postural habits, taking regular breaks, and adjusting equipment to individual anatomical needs can help minimize the risk of health consequences.

The aim of the study was to analyze the relationship between the use of ergonomic computer workstation elements and the experience of discomfort and physical pain among students when using a computer.

## MATERIALS AND METHODS

Third-year students of computer science programs at Jan Kochanowski University and Świętokrzyska University of Technology in Kielce were included in the study. A total of 228 participants took part, including 39 women and 189 men, aged 19–29. The study was approved by the Bioethics Committee (approval number: Resolution No. 28/2018).

The research tool utilized was a custom questionnaire that included questions regarding time spent in front of the computer, body posture (standing and sitting positions), and the use of computer workstation equipment (chair, desk, monitor, keyboard and mouse pads, lighting).

To assess pain intensity, the visual analogue scale (VAS) was used. This scale measures pain on a scale of 0–10, where 0 indicates no pain, 5 represents moderate pain, and 10 signifies severe pain. Students evaluated the intensity of pain experienced while using the computer in various body areas, including: the head, eyes, cervical, thoracic, and lumbar spine, shoulders, forearms, wrists, fingers, hips, knees, and feet.

Additionally, a 2D Videograph was used to assess changes in the depth of the cervical spine in both standing and sitting positions.

### Inclusion criteria for the study

1. Full-time and part-time students of computer science programs at Jan Kochanowski University in Kielce and Kielce University of Technology;
2. consent to participate in the study.

### Exclusion criteria for the study

1. Individuals receiving treatment at specialized medical clinics for various reasons;

2. individuals taking long-term medications;
3. individuals who did not attend follow-up examinations.

### Study limitations

1. Lack of preliminary assessment of participants for musculo-skeletal dysfunction, which may impact the results obtained;
2. absence of consideration for potential obesity among participants, which could affect the variables analyzed;
3. no evaluation of participants for malnutrition, which could also influence the study results;
4. lack of assessment of participants' vision health, which may impact result accuracy, especially if visual materials were involved;
5. potential disruption of results due to undetected health factors, limiting the full interpretation and generalization of findings.

### Statistical methods

The analysis of the obtained results was based on statistical evaluation of both measurable (quantitative) and non-measurable (qualitative) features. For all quantitative parameters, key

descriptive statistics, including mean, median, and standard deviation, were calculated. When exactly 2 groups were present concerning the independent variable, the Mann-Whitney U-test was applied. Relationships between quantitative variables were assessed through correlation analysis using Spearman's rho test. The significance level was set at  $p < 0.05$ , indicating the presence of statistically significant associations or differences. The analysis was conducted using SPSS 26 and Statistica 13.3 software.

## RESULTS

The analysis focused on the relationship between the occurrence of pain in different body parts and the adjustment of desk height to students' height while using the computer.

Pain intensity  $>1$  (on a scale of 0–10) was observed in nearly all analyzed body areas and was significantly associated with the adjustment of desk height to the individual's body while using the computer. The highest pain intensity (3.73) was reported for eye pain and was linked to improper desk height adjustment. Young adults using desks tailored to their body height experienced significantly lower pain intensity. Details are presented in Table 1.

TABLE 1. The level of pain perception among computer users and desk dimensions adjusted to students' body height

Location of pain sensations	Desk dimensions adjusted to body height	n	M	SD	U	p
Head	correct	146	1.73	1.86	5265.00	0.13
	incorrect	82	2.02	1.89		
Eyes	correct	146	3.19	2.00	5305.50	0.15
	incorrect	82	3.73	2.21		
Cervical spine	correct	146	2.12	1.64	4523.00	<b>0.00</b>
	incorrect	82	2.95	1.92		
Shoulders	correct	146	2.06	1.69	4800.00	<b>0.01</b>
	incorrect	82	2.64	1.78		
Thoracic spine	correct	146	1.47	1.55	5306.00	0.15
	incorrect	82	1.82	1.80		
Lumbar spine	correct	146	2.82	2.22	4739.50	<b>0.00</b>
	incorrect	82	3.62	2.23		
Forearms	correct	146	2.32	1.60	4423.00	<b>0.00</b>
	incorrect	82	3.26	1.97		
Wrists	correct	146	1.78	1.43	4719.00	<b>0.00</b>
	incorrect	82	2.37	1.56		
Fingers	correct	146	1.13	1.28	4981.50	<b>0.03</b>
	incorrect	82	1.52	1.46		
Hips	correct	146	1.35	1.42	5061.50	<b>0.05</b>
	incorrect	82	1.74	1.63		
Knees	correct	146	1.63	1.97	4700.50	<b>0.00</b>
	incorrect	82	2.32	2.22		
Feet	correct	146	0.78	1.10	5215.50	0.10
	incorrect	82	1.07	1.37		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann-Whitney U-test result; p – significance level

The relationship between desk type (with leg space vs. without leg space) and pain intensity in different body areas during computer use was analyzed. Desks with leg space were considered correct, while those without leg space were classified as incorrect.

Students using desks without leg space reported higher pain intensity. Pain intensity >1 (on a scale of 0–10) was observed in all analyzed body areas and was significantly associated with the absence of leg space. The highest pain intensity (3.80) was reported in the lumbar spine and was linked to the lack of leg space. Young adults using desks with leg space experienced significantly lower pain intensity (Tab. 2).

Analyzing the results of the Mann–Whitney U test, statistically significant relationships were found between pain symptoms and the type of desk, considering the available surface space during computer use. A correct desk had appropriate dimensions for the monitor, keyboard, and mouse, while an incorrect desk was too narrow and short, making it difficult to properly position these elements.

Pain intensity >1 (on a scale of 0–10) was observed in nearly all analyzed body areas and was significantly associated with the type of desk, specifically regarding surface space during

computer use. The highest pain intensity (3.92) was reported for eye pain and was linked to insufficient desk space. Young adults using a sufficiently wide and long desk experienced significantly lower pain intensity. Details are presented in Table 3.

After analyzing the results of the Mann–Whitney U test, statistically significant correlations were identified between computer users and the level of perceived pain in different body parts, considering the type of wrist pads used. Ergonomic wrist pads, designed to conform to the wrist, were classified as correct, while regular, flat pads or the absence of wrist pads were considered incorrect.

Pain intensity >1 (on a scale of 0–10) was observed in nearly all analyzed body areas and was significantly associated with the type of wrist pads. The highest pain intensity (3.69) was reported for eye pain and was linked to improper workstation equipment. Young adults using ergonomic wrist pads experienced significantly lower pain intensity in all body areas. Details are presented in Table 4.

In the further part of the study, the focus shifted to examining the relationship between monitor characteristics, specifically the presence of vertical and horizontal adjustment

**TABLE 2.** The level of pain perception among computer users and the availability of leg space under the desk

Location of pain sensations	Leg space under the desk	n	M	SD	U	p
Head	correct	164	1.80	1.94	4729.00	0.23
	incorrect	64	1.94	1.71		
Eyes	correct	164	3.27	2.04	4670.50	0.19
	incorrect	64	3.70	2.22		
Cervical spine	correct	164	2.22	1.85	3795.50	<b>0.00</b>
	incorrect	64	2.94	1.54		
Shoulders	correct	164	2.10	1.73	4096.00	<b>0.00</b>
	incorrect	64	2.72	1.69		
Thoracic spine	correct	164	1.51	1.60	4633.50	0.15
	incorrect	64	1.83	1.79		
Lumbar spine	correct	164	2.85	2.18	4031.50	<b>0.00</b>
	incorrect	64	3.80	2.32		
Forearms	correct	164	2.46	1.78	4112.00	<b>0.01</b>
	incorrect	64	3.20	1.76		
Wrists	correct	164	1.85	1.50	4171.50	<b>0.01</b>
	incorrect	64	2.39	1.48		
Fingers	correct	164	1.22	1.35	4765.50	0.26
	incorrect	64	1.41	1.41		
Hips	correct	164	1.34	1.45	4051.50	<b>0.00</b>
	incorrect	64	1.89	1.59		
Knees	correct	164	1.66	2.03	3910.50	<b>0.00</b>
	incorrect	64	2.44	2.18		
Feet	correct	164	0.79	1.17	4319.00	<b>0.02</b>
	incorrect	64	1.14	1.30		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

TABLE 3. The intensity of pain perception among computer users and the space on the desk

Location of pain sensations	Space on the desk	n	M	SD	U	p
Head	correct	161	1.69	1.81	4373.50	<b>0.04</b>
	incorrect	67	2.11	1.82		
Eyes	correct	161	3.14	1.95	4166.50	<b>0.01</b>
	incorrect	67	3.92	2.22		
Cervical spine	correct	161	2.12	1.72	3510.50	<b>0.00</b>
	incorrect	67	3.12	1.72		
Shoulders	correct	161	2.01	1.69	3651.50	<b>0.00</b>
	incorrect	67	2.89	1.71		
Thoracic spine	correct	161	1.40	1.50	4139.50	<b>0.01</b>
	incorrect	67	2.05	1.90		
Lumbar spine	correct	161	2.79	2.17	3772.50	<b>0.00</b>
	incorrect	67	3.89	2.24		
Forearms	correct	161	2.41	1.73	3925.00	<b>0.00</b>
	incorrect	67	3.26	1.78		
Wrists	correct	161	1.78	1.46	3883.00	<b>0.00</b>
	incorrect	67	2.48	1.50		
Fingers	correct	161	1.19	1.28	4856.00	0.37
	incorrect	67	1.45	1.55		
Hips	correct	161	1.27	1.34	3887.50	<b>0.00</b>
	incorrect	67	1.98	1.72		
Knees	correct	161	1.66	2.05	3956.50	<b>0.00</b>
	incorrect	67	2.43	2.14		
Feet	correct	161	0.73	1.02	4194.50	<b>0.01</b>
	incorrect	67	1.28	1.56		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

functions, and the intensity of pain in different body areas during computer use. Adjusting the screen in both directions was considered correct, while adjusting only vertically (up/down), adjusting only horizontally (side to side), or the lack of adjustment options were considered incorrect.

Pain intensity >1 (on a scale of 0–10) was observed in nearly all body areas and was significantly associated with the monitor adjustment function in both vertical and horizontal directions during computer use. The highest pain intensity (3.79) was reported for eye pain and was linked to incorrect screen adjustment. Young adults who had the ability to adjust the monitor both vertically and horizontally experienced significantly lower pain intensity in all body areas. Details are presented in Table 5.

The relationship between monitor placement during computer use and the intensity of pain in different body areas was analyzed. Positioning the monitor with the back to the window was considered correct, while positioning the monitor facing or sideways to the window was considered incorrect.

Pain intensity >1 (on a scale of 0–10) was observed in nearly all analyzed body areas and was significantly associated with monitor placement during computer use. The highest pain

intensity (3.54) was reported for eye pain and was linked to placing the monitor facing the window. Young adults who positioned the monitor with the back to the window experienced significantly lower pain intensity. Details are presented in Table 6.

Analyzing the workstation equipment of computer-using students, sitting on an office chair with armrests or an ergonomic chair with height adjustment and lumbar support was considered appropriate. Conversely, using a stool or a chair without back support was deemed inappropriate.

An analysis was conducted on the relationship between the type of chair used during computer use and the intensity of pain in the head, eyes, neck, shoulders, chest, lumbar spine, forearms, wrists, fingers, hips, knees, and feet. Students experienced higher pain intensity (>1 on a scale of 0–10) in all analyzed body areas, with the highest intensity (4.10) reported in the lumbar spine, associated with inappropriate equipment. Proper equipment was significantly associated with lower pain intensity in young adults. Details are presented in Table 7.

To verify the relationship between the depth of the cervical spine section and the intensity of pain during computer use, an analysis was conducted using Spearman's rho test. However,

TABLE 4. The intensity of pain perception among computer users and the type of wrist pads used

Location of pain sensations	Types of wrist pads	n	M	SD	U	p
Head	correct	50	1.06	1.74	2762.50	0.00
	incorrect	178	2.05	1.85		
Eyes	correct	50	2.30	1.91	2751.50	0.00
	incorrect	178	3.69	2.04		
Cervical spine	correct	50	1.58	1.87	2671.50	0.00
	incorrect	178	2.65	1.70		
Shoulders	correct	50	1.42	1.48	2725.00	0.00
	incorrect	178	2.51	1.73		
Thoracic spine	correct	50	1.24	1.81	3288.00	0.00
	incorrect	178	1.70	1.60		
Lumbar spine	correct	50	1.98	2.31	2594.00	0.00
	incorrect	178	3.43	2.13		
Forearms	correct	50	1.64	1.54	2566.50	0.00
	incorrect	178	2.95	1.76		
Wrists	correct	50	1.22	1.40	2652.50	0.00
	incorrect	178	2.21	1.46		
Fingers	correct	50	0.70	1.35	2520.00	0.00
	incorrect	178	1.43	1.32		
Hips	correct	50	1.08	1.71	3118.00	0.00
	incorrect	178	1.61	1.43		
Knees	correct	50	0.94	1.67	2548.50	0.00
	incorrect	178	2.14	2.12		
Feet	correct	50	0.56	1.32	3082.00	0.00
	incorrect	178	0.98	1.16		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

no significant correlations were observed ( $p > 0.05$ ). Details are presented in Table 8.

Analyzing the use of lighting while using a computer, composite lighting (a combination of general and local lighting) was considered correct, while general lighting (illumination of the entire room) and local lighting (e.g., only illuminating the keyboard) were deemed incorrect.

The most commonly used lighting among students was local lighting (32.89% of third-year students), followed by general lighting (41.23%). Correct lighting, which combines general and local lighting, was used by 25.88% of students. Students typically maintained their lighting habits throughout their years of study. A significant proportion of students using incorrect lighting did not change their habits (17.54%).

## DISCUSSION

Long-term computer use has been linked to an increased intensity of pain, as indicated by research. Sabeen et al. reported that after a 3-month observation period, the majority of individuals

experienced neck and cervical pain ( $p = 0.00$ ) [29]. Dockrell et al. found that over half of the participants frequently experienced neck, upper and lower back pain, as well as wrist pain ( $p = 0.04$ ) [30]. Binboğa and Korhan demonstrated that laptop use leads to unfavorable postural changes, such as neck flexion and forward head tilt (protraction), resulting in wrist and neck discomfort [31]. Similar findings related to lower back pain were observed in the study by Smith and Starnes among 39 office workers (80%) [32].

According to Binboğa and Korhan, approx. 62% of respondents lacked the ability to adjust the height of their desks [31]. Our research revealed that users of electronic devices with desks adjusted to their body height experienced fewer pain complaints compared to those using desks that were too high or too low. The highest pain intensity was reported in the cervical spine ( $p = 0.00$ ) and lumbar spine ( $p = 0.01$ ), shoulders ( $p = 0.00$ ), forearms ( $p < 0.00$ ), wrists ( $p = 0.02$ ), hips ( $p = 0.04$ ), and knees ( $p = 0.01$ ).

About 89% of those surveyed by Foszcz and Bac had leg space under their desks [33]. Our research showed a statistically significant relationship between pain perception and

**TABLE 5.** The intensity of pain perception among computer users and the vertical and horizontal adjustment of the monitor

Location of pain sensations	Vertical and horizontal adjustment function of the monitor	n	M	SD	U	p
Head	correct	85	1.10	1.50	3761.50	<b>0.00</b>
	incorrect	143	2.27	1.94		
Eyes	correct	85	2.71	2.02	4167.50	<b>0.00</b>
	incorrect	143	3.79	2.04		
Cervical spine	correct	85	1.63	1.56	3460.00	<b>0.00</b>
	incorrect	143	2.88	1.76		
Shoulders	correct	85	1.83	1.93	4239.00	<b>0.00</b>
	incorrect	143	2.53	1.56		
Thoracic spine	correct	85	1.02	1.29	3919.00	<b>0.00</b>
	incorrect	143	1.94	1.75		
Lumbar spine	correct	85	2.38	2.20	4136.00	<b>0.00</b>
	incorrect	143	3.54	2.17		
Forearms	correct	85	2.07	1.76	4148.50	<b>0.00</b>
	incorrect	143	3.02	1.72		
Wrists	correct	85	1.54	1.53	4207.00	<b>0.00</b>
	incorrect	143	2.27	1.42		
Fingers	correct	85	0.83	1.18	3969.50	<b>0.00</b>
	incorrect	143	1.53	1.40		
Hips	correct	85	1.12	1.35	4585.00	<b>0.00</b>
	incorrect	143	1.71	1.56		
Knees	correct	85	1.30	1.69	4454.00	<b>0.00</b>
	incorrect	143	2.22	2.23		
Feet	correct	85	0.48	0.79	4255.00	<b>0.00</b>
	incorrect	143	1.13	1.34		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

desk type. Individuals with desks offering ample leg space experienced lower pain levels compared to others. For users whose desks lacked sufficient leg space, pain was observed in the hips ( $p = 0.00$ ), knees ( $p = 0.00$ ), feet ( $p = 0.02$ ), cervical spine ( $p = 0.00$ ), shoulders ( $p = 0.00$ ), forearms ( $p = 0.01$ ), and wrists ( $p = 0.01$ ).

The results of the Foszcz and Bac study revealed that approx. 83% of respondents declared having sufficient desk space for spreading documents [33]. In our research, it was observed that narrow and short desks, as well as the lack of space for a monitor and mouse, contributed to higher levels of pain among students. Most participants experienced pain in the cervical ( $p < 0.00$ ), thoracic ( $p = 0.01$ ), and lumbar spine ( $p = 0.00$ ), eyes ( $p = 0.01$ ), shoulders ( $p < 0.00$ ), forearms ( $p = 0.00$ ), wrists ( $p = 0.00$ ), hips ( $p = 0.00$ ), knees ( $p = 0.00$ ), and feet ( $p = 0.01$ ). Pain levels in the group with appropriately long and wide desks were significantly lower than those in the group with too narrow and short desks.

Foszcz and Bac noted that the majority of respondents (71%) could rest their wrists while typing on the keyboard [33]. In our

study, it was observed that most students remained consistent with their equipment choices (about 70% did not use any wrist pads, about 47% had ergonomic ones, and about 51% used regular ones). However, Kanchanomai et al. described the use of an additional ergonomic keyboard and mouse connected to a laptop along with a pad, improving work comfort and reducing wrist pain [34]. The results of our study showed that the type of wrist pads used is crucial for the level of perceived pain. Individuals using ergonomic pads experienced a lower level of pain compared to those using flat pads or none. Pain was observed in the wrist area ( $p < 0.00$ ), fingers ( $p < 0.00$ ), forearms ( $p < 0.00$ ), shoulders ( $p < 0.00$ ), cervical spine ( $p < 0.00$ ), thoracic spine ( $p = 0.00$ ), and lumbar spine ( $p < 0.00$ ).

The relationship between the arrangement of the screen, mouse, keyboard, and discomfort has been confirmed in the studies of Kanchanomai et al. [34]. Research conducted by Bartuzi and Kamińska analyzed 53 individuals who had the ability to adjust their workstations to their needs. Surface electromyography (EMG) was used to examine the impact of body position during computer use on the musculoskeletal

**TABLE 6.** The intensity of pain perception among computer users and the placement of the monitor relative to the window

Location of pain sensations	Monitor placement in relation to the window	n	M	SD	U	p
Head	correct	64	1.59	1.83	4623.50	0.16
	incorrect	164	1.93	1.89		
Eyes	correct	64	3.00	1.97	4461.00	0.07
	incorrect	164	3.54	2.12		
Cervical spine	correct	64	2.00	1.51	4375.50	<b>0.05</b>
	incorrect	164	2.58	1.86		
Shoulders	correct	64	2.09	1.77	4793.50	0.31
	incorrect	164	2.34	1.72		
Thoracic spine	correct	64	1.29	1.63	4323.50	<b>0.03</b>
	incorrect	164	1.71	1.65		
Lumbar spine	correct	64	2.54	2.06	4237.50	<b>0.02</b>
	incorrect	164	3.33	2.29		
Forearms	correct	64	2.21	1.68	4150.00	<b>0.01</b>
	incorrect	164	2.84	1.81		
Wrists	correct	64	1.76	1.51	4533.50	0.11
	incorrect	164	2.09	1.49		
Fingers	correct	64	0.96	1.24	4243.50	<b>0.02</b>
	incorrect	164	1.39	1.39		
Hips	correct	64	1.35	1.51	4845.50	0.36
	incorrect	164	1.54	1.51		
Knees	correct	64	1.42	1.80	4319.00	<b>0.03</b>
	incorrect	164	2.06	2.17		
Feet	correct	64	0.67	1.06	4364.00	<b>0.04</b>
	incorrect	164	0.97	1.25		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

system. Respondents reported pain in the lumbar and cervical spine, wrists, shoulders, and head. Almost half leaned their backs against the backrest, and 68% rested their wrists. Additionally, 45% of participants improperly positioned the monitor relative to their eyes, placing it above rather than at eye level [35]. In the study by Choi et al., it was demonstrated that adjusting the monitor's height prevents leaning the head forward [36]. Foszcz and Bac observed that a significant portion of participants (around 83%) had the screen and keyboard set directly in front of them [33]. Dennerlein's analyses suggest that a laptop screen positioned higher improves device comfort, eliminating pain associated with head and neck posture [37].

The more monitor adjustment options available, the better the user experience. Our research showed that placing the device screen directly in front of the user resulted in a lower level of pain in the cervical and lumbar spine, shoulders, and wrists compared to when the monitor was placed to the left or right of the desk. We also analyzed whether the respondents' monitors had the ability to adjust both vertically and horizontally to eye level. Individuals whose upper screen edge was at eye level experienced lower pain levels in the cervical

spine, shoulders, forearms, wrists, knees, and feet compared to those whose monitor was positioned above or below eye level. Respondents without monitor adjustment capabilities reported higher levels of head, eye, shoulder, cervical, thoracic, and lumbar spine pain. Additionally, it was noted that individuals who had the monitor facing the window experienced pain more frequently, possibly due to excessive leaning forward (causing shoulder, forearm, eye, and head pain) as sunlight reflecting on the screen affected visibility. The change in the depth of cervical lordosis was significantly smaller in individuals who had the monitor facing the window ( $M = 85.37$ ;  $SD = 21.14$ ) compared to the group that placed the monitor to the side of the window ( $M = 97.54$ ;  $SD = 23.06$ ). Forearm pain was lower in respondents who had the monitor facing away from the window compared to those who had it facing toward or to the side of the window.

According to the study by Foszcz and Bac, the majority of participants (around 90%) had chairs with seat adjustment, and about 66% had adjustable backrests [33]. To reduce pain associated with computer work, researchers including Workineh and Yamaura developed a prototype ergonomic chair, which

**TABLE 7.** Intensity of pain in relation to the type of chair used during computer use

Location of pain sensations	Type of chair used during computer use	n	M	SD	U	p
Head	correct	161	1.52	1.68	3637.50	<b>0.00</b>
	incorrect	67	2.59	2.08		
Eyes	correct	161	3.16	2.01	4364.00	<b>0.02</b>
	incorrect	67	3.92	2.21		
Cervical spine	correct	161	2.03	1.54	3340.00	<b>0.00</b>
	incorrect	67	3.34	2.01		
Shoulders	correct	161	2.02	1.67	3860.00	<b>0.00</b>
	incorrect	67	2.86	1.77		
Thoracic spine	correct	161	1.35	1.57	3575.00	<b>0.00</b>
	incorrect	67	2.19	1.71		
Lumbar spine	correct	161	2.70	2.15	3419.00	<b>0.00</b>
	incorrect	67	4.10	2.19		
Forearms	correct	161	2.38	1.67	3819.00	<b>0.00</b>
	incorrect	67	3.34	1.91		
Wrists	correct	161	1.73	1.45	3491.00	<b>0.00</b>
	incorrect	67	2.64	1.45		
Fingers	correct	161	1.06	1.28	3621.50	<b>0.00</b>
	incorrect	67	1.76	1.42		
Hips	correct	161	1.26	1.37	3841.00	<b>0.00</b>
	incorrect	67	2.04	1.69		
Knees	correct	161	1.63	1.96	3981.00	<b>0.00</b>
	incorrect	67	2.47	2.27		
Feet	correct	161	0.68	1.08	3543.00	<b>0.00</b>
	incorrect	67	1.38	1.37		

n – group size; M – mean pain intensity on a scale of 1–10; SD – standard deviation; U – Mann–Whitney U-test result; p – significance level

**TABLE 8.** Correlation of the depth of the cervical spine section with the intensity of pain in various body parts among computer users

Location of pain sensations	Depth of the cervical spine section – sitting position (mm)	
	rho	p
Head	0.01	0.80
Eyes	–0.03	0.55
Cervical spine	0.05	0.38
Shoulders	0.11	0.08
Thoracic spine	0.03	0.56
Lumbar spine	0.07	0.23
Forearms	0.07	0.29
Wrists	0.00	0.93
Fingers	0.03	0.62
Hips	0.02	0.68
Knees	0.02	0.69
Feet	0.06	0.30

rho – Spearman's rank correlation coefficient value; p – significance level

they compared with a traditional office chair. Individuals using the office chair reported headaches, neck pain, lower back pain, leg pain, and foot pain, whereas users of the prototype, tailored to the human silhouette, experienced significantly greater comfort [38]. Our study confirmed that the type and adjustment of the chair impacted the level of perceived pain. Individuals using an ergonomic chair reported lower pain levels compared to users of a regular office chair, a chair with a backrest, or a stool ( $p > 0.05$ ). The lack of amenities in other seating arrangements resulted in complaints of eye pain, neck pain, shoulder pain, forearm pain, wrist pain, and finger pain.

In both measurements, students using an ergonomic chair reported lower levels of pain in the head (VAS = 0.92), eyes (VAS = 2.24), neck (VAS = 1.41), shoulders (VAS = 1.37), chest (VAS = 0.82), lower back (VAS = 1.92), forearms (VAS = 1.63), fingers (VAS = 0.59), wrists (VAS = 1.06), hips (VAS = 0.76), knees (VAS = 0.86), and feet (VAS = 0.24) compared to those using a stool, a chair with a backrest, or an office chair with armrests.

Lighting issues are also crucial when using electronic devices. Foszcz and Bac showed that as many as 91% of respondents used both natural and artificial light when working at the computer [33].

Our research confirmed that students rarely changed their lighting setup, maintaining their initial choices from the first year of study (almost 21.5% used full-room lighting, over 22% used only local lighting, and nearly 9% used composite lighting).

Referring to scientific literature on the impact of electronic device use on body posture, it is worth noting that this study employed different measurement tools than those in existing publications. It was observed that neck angle increased with prolonged device use, while torso angle decreased, leading to a forward torso tilt among computer users. This resulted in reported pain and discomfort in the neck and torso [39, 40]. These findings align with previous studies [41, 42, 43].

It was also observed that factors such as workstation ergonomics, the number of hours worked, and break time during computer use may contribute to experiencing pain and influence the development of irregularities in body posture [39, 40, 44, 45]. In the studies by Argus and Pääsuke, it was proven that keeping the head in alignment with the torso axis relieves muscle activity, in contrast to the situation when the head is tilted forward ( $p < 0.05$ ) [40]. Hansraj reached similar conclusions [16].

The results of the conducted research confirm that the arrangement of various elements of the workstation, such as the desk, chair, monitor, and wrist pads, has a significant impact on perceived pain. The study demonstrated a relationship between the equipment used and pain complaints. The analysis of the results showed a correlation between pain intensity and changes in the depth of the cervical spine in students, where greater depth changes correlated with higher pain levels on the VAS. In the standing position, the depth change was weakly and positively correlated with headaches, lumbar spine pain, forearms, and fingers. There were also weak, positive correlations in pain perception in other areas. In the sitting position, the degree of cervical spine deviation was weakly and positively correlated with headaches, lumbar spine pain, and shoulders, but there was no correlation in individuals using computers.

The study results may be used to develop preventive programs and create curriculum standards on ergonomics for working with electronic devices aimed at students and pupils.

The study did not take into account the time participants spent on the computer or their preferred working postures, which could influence the results, especially concerning musculoskeletal strain. Additionally, the lack of analysis regarding potential obesity or malnutrition may introduce variables that affect the final outcomes. Vision health was also not assessed, which could impact the accuracy of the data, particularly when working with visual materials. Undetected health factors may distort interpretation and limit the generalizability of the findings. These limitations, along with the complexity of the studied variables, necessitate further analysis in future research projects.

## CONCLUSIONS

1. The results of the analyses indicate that adjusting desk height, desk type, ergonomic equipment, and proper

lighting significantly influences the severity of pain complaints among students using computers.

2. Ergonomic solutions, such as customized desks, ergonomic wrist pads, and monitor adjustments, are associated with significantly lower pain intensity in various body areas. This confirms the role of ergonomics in preventing discomfort related to computer work.
3. Education on proper ergonomic practices can be crucial in preventing health issues among young adults using computers.

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