

Home ergonomics – lessons learned

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Abstract. The current pandemic conditions generated new ways of working and learning by shifting from face-to-face to remote and online working environment. From an ergonomics perspective, this change involved a large variety of adaptations to ‘the new normal’, especially inappropriate furniture, and inadequate social and physical environment conditions. Therefore, the paper aims to provide a deeper understanding on the role of education in ergonomics on the basis of a study on students at Politehnica University of Timisoara. There is little to no information available on ergonomic conditions in which students attend online classes and prepare their projects. The study involved several steps: (1) attendance to an educational session where they were informed on how to sit and organise their working space; (2) presentation of their current and wished working space; and (3) response to a detailed checklist targeted at understanding both their perception and effects on their health regarding online schooling. The results were, to an extent, predicted by the authors: students do not have adequate furniture and lighting conditions; furthermore, the effects on their health are already visible, although not severe.

1 Introduction

The worrying effects of Covid-19 infection across the globe determined governments to take immediate action to limit the negative outcome of the pandemic. Similar to majority of countries, Romanian government implemented lockdown effective March 15, 2020 (which was maintained for two months), followed by restrictions such as local quarantine, online schooling, teleworking (where possible), limitation of movement at night, shutting down activities that might increase infection rate (such as restaurants, gyms etc.), compulsory wear of facemasks in public spaces, effective for the rest of 2020 and the first part of 2021 (as per mid-March 2021 data).

It has been a year since the Covid-19 outbreak radically changed the manner in which we work and learn. Students were compelled to learn in the online system without any prior preparation and irrespective of conditions they may have at home. This raises serious concerns over equity and access to education. From this point of view, there is a limited number of studies focused on conditions in which students learn and the impact of poor ergonomic conditions on students’ health (both physically and mentally). Despite the long-

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term benefits of using an online learning system, there is limited information on health-related implications of online learning as a permanent or long-term arrangement. In 2020, many governments implemented the shift to online learning without any feasibility analysis and without any capacity to predict long-term implications. However, there are studies on this topic in the context of Covid-19 pandemic, but these were performed soon after WHO declared the Covid-19 outbreak a pandemic and, hence, cannot reveal any long-term implications [1].

The pandemic generated uncertainty for students for a variety of reasons: many student jobs were terminated due to economic stagnation, the shift to online learning involved the move to parental home to save money, the risk of Covid-19 infection and the increasing number of infected individuals generated further concerns, all combined with national sanitary restrictions that would limit even more any links to pre-pandemic lifestyle [2].

On the one hand, the general recommendation is to spend as less time as possible in front of the screens and perform as much physical activity as possible [3]. But the sanitary restrictions imposed in the past year generated exactly the reverse of the recommendations: online learning puts students in a situation where they spend long hours in front of the screen and there are limited options for physical activity (in Romania, for long periods of time, access to parks was restricted, gyms were closed and cold weather of late autumn and winter further limited any remaining options).

On the other hand, conditions in which students learn at home are, in many cases, inadequate from an ergonomic perspective. From inadequate furniture to inappropriate environmental conditions (primarily lighting and noise), an ergonomic assessment would reveal a wide variety of issues. The problem here is that performing ergonomic assessments in private space is a difficult task. From reluctance of those invited to participate in such studies to data privacy concerns, assessing learning spaces at home is a delicate approach.

Nevertheless, this paper focuses on the ergonomic implications of online learning, especially because this is a less-studied side of the “new normal” in education. Also, this study has the ambitious aim of being the first study on wellbeing and role of ergonomics education for university students in Romania.

2 Analysis on impact of education in ergonomic interventions – study methodology

Aiming to deeply understand the importance of education in proper implementation of ergonomic principles as part of ergonomic interventions, during November 2020–January 2021, the authors conducted a cross-sectional study with a population of 120 students at Politehnica University of Timisoara. The study consisted of three **stages**:

1. Participation at a presentation on postures, associated risks and recommendations on how to organise working space for teleworking/work from home scenario;
2. Assessment of the space where students performed learning tasks and attended online classes;
3. Invitation to respond to a detailed survey targeted at assessing effects of online learning in the past year (starting March 2020).

The first stage of the study consisted in a presentation covering the following topics: postural strains and uncomfortable postures (associated with repetitive movements, manual load handling, prolonged standing and sitting), biomechanical principles applied in ergonomics, consequences of inadequate postures, postural assessment, recommendations for posture improvements, ‘tips and tricks’ on how to better organise the working space.

For **the second stage**, students were invited to submit a presentation of their learning space (regarded as working space from an ergonomic perspective), by covering the following requirements:

- Measurement of the desk and chair (length, width and height of desk; total height, height and width of backrest, depth and height of seat), descriptive characteristics of desk and chair (colour, material, adjustable or not, arm support etc.) and anthropometric measurements (i.e., height, weight, body height sitting, knee length);
- Description of physical environment, with focus on lighting, noise, colours;
- Improvements they would make to current learning space in order to increase level of ergonomic conformity and an estimation of the costs of such improvements.

Students were invited to provide photographs of their current learning space in order to better understand the level of compliance with ergonomic principles. The requirement was not expected to be difficult for students, as they studied ergonomics as part of their curriculum. An important observation here is that majority of parents are not aware of basic ergonomic principles, hence it was expected that majority of students would not have a proper learning space from an ergonomic perspective.

The third stage consisted in assessment of implications of online learning on physical and mental wellbeing of students. The assessment was based on a survey developed by the authors, comprising several categories of questions:

- a) Respondents' profile (gender, age, level of studies, experience in work)
- b) Efforts for organising a working space at home (investments and budget, training and knowledge acquired to organise work)
- c) Impact on health status (level of discomfort associated with MSDs, medical check-ups and treatment, changes in weight, blood pressure and glycaemic index, psychological health, sleep quality, vision difficulties, infection with Covid-19, and work incapacity)
- d) Habits – physical activity and habits during working hours (such as smoking, snacks, brief exercising sessions to reduce muscular strain etc.)

The survey was developed using SurveyMonkey, an online platform that enables creation of surveys and supports results analysis for both corporate and academic purposes. The main advantages of using this platform are the following:

- ease of data collection (possibility to distribute the survey via various channels: email, social media, web link);
- possibility to easily create questions based on pre-defined formats (these are the standard question formats used in surveys, including Likert scale, open-answer questions, checkboxes, multiple answers etc.);
- various design options;
- possibility to generate new surveys using previous surveys as a starting point;
- readily-available results analysis including brief statistical analysis and visual presentation of results (charts and tables);
- data export in formats compatible with statistical analysis software such as SPSS.

The survey was developed with the support of two other researchers who provided inputs on validity and ease of understanding the questions. The researchers also provided support in validation of the survey. Therefore, the current study relies on a survey already validated on a group of 26 respondents [4].

Research hypotheses were as follows: (1) *Education (including trainings and informative sessions) has a significant impact on the success of ergonomic interventions* and (2) *Remote/online working and learning have a negative impact on life quality, with effects on physical and mental health.*

3 Results and discussion

As presented in previous sub-chapter, only the second and third stages of the study have quantifiable outputs. The effects of the training session were expected to reflect in stage 2 results.

3.1 Study stage 2

With regards to the second stage, 77 (24 male and 53 female) students provided information on their learning space – out of the 120 students invited in the study. As per Table 1, the average height is 169.6 cm, the tallest student measuring 192 cm and the smallest measuring 156 cm. A notable aspect is that 10.4% of respondents are overweight (Body Mass Index was calculated using the BMI calculator available on US National Heart, Lung and Blood Institute website and was based on information provided by students).

Table 1. Respondent profile based on stage 2 data.

Indicator	Height (cm)	Weight (kg)	Knee length (cm)	Sitting height (cm)
Average	169.6	63.1	83.6	132.0
Minimum	156	40	59	90
Maximum	192	105	102	167

While majority of students had a proper desk, there were cases where students would use dining or kitchen tables as desks. Besides the absence of an appropriate learning space (learning in the kitchen or in the living room comes, most of the times, with distractions), such tables are not designed to be used for long hours, being either too tall or too small for learning/working. In majority of the cases, desks/tables were made of wood – except for two students who learned on glass dining tables.

Regarding chairs, only 23.4% students used an ergonomic chair, while the others used chairs with certain ergonomic features (but could not be considered ergonomic due to certain drawbacks such as inability to adjust backrest or absence of armrests) or even wooden chairs designed for dining/kitchen tables (even in some cases where students had a desk). 20.8% students had a chair with adjustable backrest and more than half (55.8%) had a chair with adjustable seat height. Also, 61% reported using chairs with armrests.

As per Table 2, the minimum height of a desk was 49 cm, corresponding to a student who used a coffee table as desk (see Figure 1). Another notable example was a 44 cm stool used by a female student who was 175 cm tall.

Materials used for chairs were wood, leather and textile.

Table 2. Quantitative description of furniture.

Indicator	Desk			Chair				
	Height (cm)	Width (cm)	Length (cm)	Total height (cm)	Backrest width (cm)	Backrest height (cm)	Seat depth (cm)	Seat height (cm)
Average	76.2	64.6	121.4	96.3	43.4	55.3	48.8	50.2
Minimum	49	36	60	44	32	17	39	32
Maximum	100	140	200	138	62	95	63	105

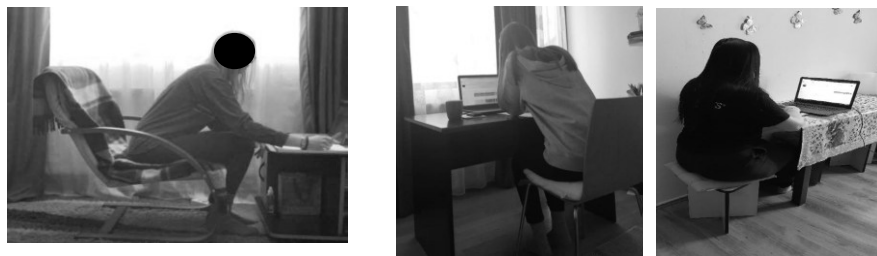


Fig. 1. Examples of vicious positions determined by inappropriate furniture.

Figure 1 presents a few examples of vicious positions generated by use of inadequate furniture. As previously mentioned, these images were provided by the students involved in the study. Compliance with ergonomic principles involves adaptation to individual characteristics; therefore, when the authors assessed whether chairs were ergonomic or not, they considered dimensions, adjustability and students' position at the desk.

A similar study at the University of Cincinnati indicates that a quarter of respondents sat on dining chairs for online classes and a small share of participants used tables instead of desks [5]. Also, another similarity of the current study with [5] approach is that participants submitted pictures of their position at the desk for ergonomic assessed.

Further, analysis of environmental conditions revealed some other interesting observations:

- 98.7% students had both natural and artificial lighting;
- 20.8% had natural lighting coming from back or front of the desk (which can generate shadows and flashes);
- a few students reported noise coming from cars, constructions nearby or other family members attending online classes or working from home;
- brown, black and white were the main colour options for both furniture and walls; only 18.2% students indicated pink, blue or yellow as chromatic options.

In conclusion, majority of students did not have an ergonomic learning (working) space: chairs were not suited for individual's height and could not be adjusted in any manner, dining and kitchen tables would be used as desks, lighting was inappropriate (coming from the front or from behind, insufficient or absence of natural light), some students even reported noise as perturbing element.

However, as per students reports, since the Covid-19 outbreak some of them invested in upgrades to improve learning conditions. For those using highly inappropriate desks and chairs, the economic factor holds a major importance, as students are often financially dependent on their family and, hence, decisions on investments in furniture and devices for online learning are not necessarily theirs only despite awareness on the topic. This is consistent with results of a study on 186 children and teenagers in India, revealing that very few parents understand what is the correct sitting position (6%), eye-monitor ergonomics (1%) laptop ergonomics (3%) and necessity of breaks (38%) [6].

With regards to potential investments that students would make to improve their learning space, most of them focused on buying chairs, desk lamps, green plants as well as adjustable desks. While the average value of such investments was ~2,253 lei (equivalent of 461 euro), the lowest investment value was 89 lei (~18 euro) and the highest investment value was 25,000 lei (~5,126 euro).

3.2 Study stage 3

In the third stage of the study, from the 120 students invited to respond only 83 completed the survey – with a response rate of 69.2%.

Table 3. Respondent profile as per survey data.

Variable		No of respondents	% of respondents	Median	Mean	Standard deviation
Gender	Male	32	38.6%	2.00	1.61	0.49
	Female	51	61.4%			
Age distribution (years)	<25	67	80.7%	1.00	1.34	0.75
	25-35	6	7.2%			
	35-45	8	9.7%			
	45-55	2	2.4%			
Work experience (years)	No	32	38.6%	4.00	4.72	2.94
	<1	15	18.1%			
	1-3	17	20.5%			
	3-5	6	7.2%			
	>5	13	15.6%			
Level of Education	Bachelor's Degree	47	56.6%	2.00	2.42	1.62
	Master's Degree	34	41.0%			
	PhD	2	2.4%			
Type of employment	Part-time	4	12.5%	-	-	-
	Full-time	28	87.5%			

According to Table 3, majority of students are young and with little work experience. However, there are students working either full-time or part-time, meaning that part of health issues they reported might have a dual cause.

As per survey results, 33.7% students were employed part-time and 4.8% were employed full-time; majority of them are entry-level employees (up to 3 years of experience). 61.5% were female and 38.5% were male. 80.7% are students aged below 25 years old.

Since March 2020, 81.9% respondents were exclusively in the online scenario; 78.3% of students were in the online scenario for more than 6 months (this reveals that majority of respondents were at least in the second school year when they attended only online classes).

More than half of respondents (63.9%) did not participate in any training/informing session/webinar dedicated to online working/learning. However, 90.4% students searched on their own for information to properly organise their activity: preferred sources were multimedia materials and demonstrative videos (such as YouTube videos) and discussions with peers and acquaintances in similar situation (see Figure 2).

When asked about the investments they had to make to adapt to online learning/teleworking, 44.6% students declared they did not do any investment. On the other side, 37.4% students invested in electronic equipment (such as PC, laptops and performant smartphones), 21.7% invested in furniture and another 21.7% spent money to reorganise or prepare an adequate space for online learning/teleworking (see Figure 3). Regarding students' budget, they spent up to 1,000 lei (~200 euro) or even more. As per Figure 4, the largest share of students who made investments spent 500–1,000 lei (~100–200 euro) and more than 1,000 lei (14.5% and 28.9%, respectively). Considering that minimum wage

amounts to 2,300 lei (471 euro), these investments can be regarded as a significant financial effort [12].

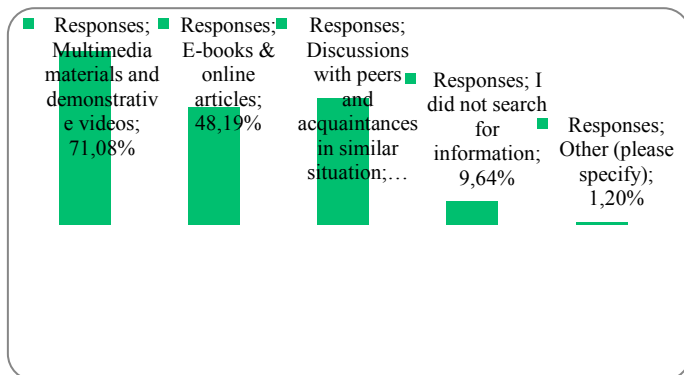


Fig. 2. Sources of information for individual study and activity organisation.

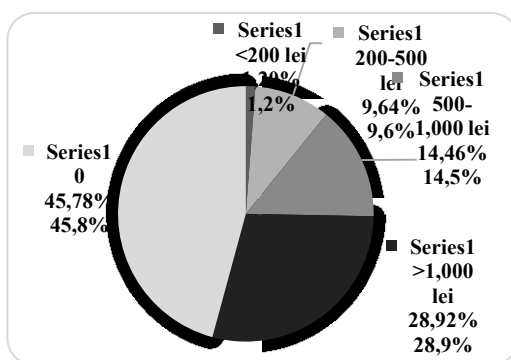
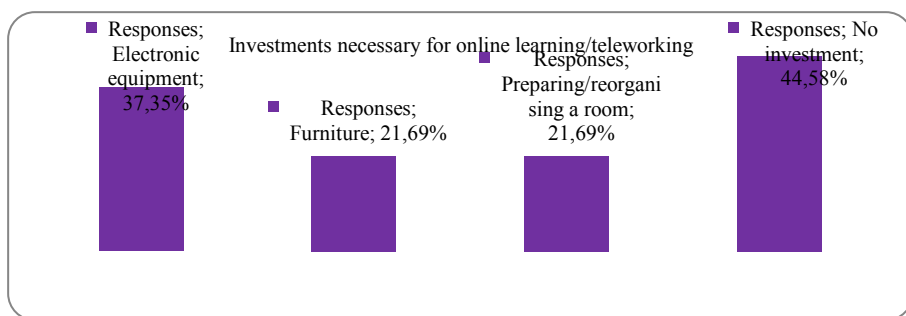


Fig. 3. Types of investments made for adapting to online learning/telework.

Fig. 4. Budget for investments.

Further, the survey focused on analysis of physical and mental health status. Respondents were asked to rate from 1 to 5 (where 1 equals no pain and 5 represents unbearable pain) the intensity of discomfort identified in certain body regions: neck, shoulders, elbows, arm wrists, upper and lower back, hips, knees and ankles. Upper and lower back, neck and shoulders were the regions where students predominantly reported discomfort: 25.3% reported moderate pain (ranking level 3) in lower back, 22.9% reported slight pain (ranking level 2) in upper back, 22.2% reported moderate pain in neck area, and

20.7% reported slight pain in shoulders area. Nevertheless, hardly bearable (ranking level 4) and unbearable pain (ranking level 5) were also reported in neck, shoulders, elbows, upper and lower back, as well as in hips region. It is worth mentioning that cases of level 4 and 5 intensity of pain were not frequent, as none of these amounted for more than 9.6% of all cases. For these MSDs symptoms, 14.6% students required medical assistance and 9.9% had to interrupt their activity for more than three days; also, 27.5% students declared that they had the symptoms in the past 7 days. These results are supported by [6-8], indicating that students learning online suffer of pain in upper and lower back, shoulders and hands, as well as headaches and eye strain.

Physical health was negatively impacted, as shown by a series of indicators: 67.5% students reported weight gains, 24.1% had changes in blood pressure, 20.5% reported increase of glycaemic index, 55.4% had poor-quality sleep (insomnia, difficulty of falling asleep, parasomnias), 31.3% indicated visual difficulties and 21.7% were infected with Covid-19.

With regards to mental health, the most frequent symptoms reported were exhaustion (34.9%), headaches (33.7%), anxiety (30.1%), insomnia (25.3%), irascibility and tendency of self-isolation (21.7%), difficulties or communication mistakes (21.7%) and incapacity to relax (20.5%). This is further supported by [9] highlighting a direct connection between stressors such as academic stress and institutional dissatisfaction, and increasing severity of depressive symptoms.

For all the above (physical and mental), 34.9% students went to the doctor, but only 21.7% followed treatment. Finally, 22.9% students interrupted their activity, majority of them for a short period of time (a few days–a week).

A positive aspect revealed by the survey is that two-thirds of students have an active lifestyle: since Covid-19 outbreak, 39.8% performed moderately intense activities (such as swimming, cycling, aerobic etc.) and 28.9% performed vigorous physical activities (such as basketball, football, jogging, hiking etc.). 69.9% declared that they used perform physical activities before the Covid-19 outbreak. This contradicts the results of [10] which indicates high prevalence of sedentary students among the research sample (202 students in Turkey).

Regarding breaks, the preferred activities during breaks were standing up and looking out the window, having snacks (which explains the weight gain), smoking (with impact on blood pressure) and doing something else without getting up from the chair.

4 Further implications and conclusions

The study is a preliminary research on importance and utility of education in ergonomics among university students. Definitely, the training session in which students were informed on various aspects of organising a working space at home and correct sitting increased awareness on ergonomic aspects as well as on health concerns.

Assessing the effects of one year of online learning revealed that, despite their young age, students gained weight, reported MSD symptoms (some of them had severe pain in certain body regions) and felt stressed, anxious and had sleep issues. This rings a bell on the long-term effects of online learning and should encourage governments to be cautious when performing the cost-benefit analysis of this educational option.

Also, the current situation presented in this paper reflects the necessity of deep structural changes in education to minimise financial limitations of poor families (minimum wage in Romania is lower than the average investment value reported in the current study [11]), as well as the negative health outcome generated by lack of ergonomic knowledge on organising a learning space at home. While the role of trainings is significant (as proved in the case study), the educational system should ensure fluidity and adaptability for rapid shifts between physical and online learning systems [12].

The results of this study should be treated with caution, as it is a cross-sectional study and its conclusions might not hold true in other circumstances. However, the relevance of this study consists in revealing effects of online learning on students and the impact on life quality and overall wellbeing. These would complete the picture of useful insights regarding usefulness of ergonomic education in improving wellbeing and increasing effectiveness of ergonomic interventions.

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