Ergonomics elements and their influence in the garment industry

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Abstract. Apart from the strict elements related to the organization of the work place of the equipment and operated machines, the productivity of an operator or factory is addiction on other elements of ergonomics such as: temperature and relative humidity of the air, speed of air currents, noise level, level vibrations and their directions, CO₂ level, brightness, radiation level, chromatic from the production hall, ambient music and its volume. In this paper we analyzed the influence of light intensity and ambient music on productivity in a clothing section in which 70-80 workers manufacture sports equipment in which dark colours predominate, for children, women and men. Some levels of light intensity were chosen, different from those provided in standards (400 lx for light colours and 700 lx for dark colours), and for ambient music we chose as a volume level, with 5-10 dB above the average noise level in the production hall. We mention that in this section is not used ambient music currently. We mention that all the laboratory equipment used are in the SIProM laboratory, (study, hygiene and labor protection), within the Faculty of Engineering, and the collective of this study was an interdisciplinary one formed by researchers from the Textile Industry field and a researcher from the Accounting field. Initially, timings were made to determine the execution times for certain technological phases, namely: the overlock machine, the elastic applicator machine and the simple machine, for zipper application. These measurements were made under the usual working conditions in this hall production, for lighting levels of 550-750 lx and without ambient music. At the end of the study, data on labour efficiency were processed and calculations were made regarding labour costs for workers who served the three types of machines. For a complete image of the activity of the entire section, production department, the information was processed for the entire section, both in terms of productivity per worker, for each machine, and the costs for manpower were calculated for the nine weeks of the our study. For a more complete information of the activity of the whole section, the results were extended for the whole section, both in terms of efficiency per worker, for each machine and the costs for the work of the entire group of workers were calculated.

1. Introduction
Ergonomics have proven to be increasingly important for improving jobs, enabling workers to feel more comfortable and safe, along with improving the quality of products or services [1].
By creating a job leading to this performance, taking into account the health and safety, design and productivity of the work, the implementation of ergonomics can become one of the sustainable competitive advantages of the clothing industry [2].

Apart from the ergonomics of the workplace with regard to the machines being operated and the arrangement of work objects for a more comfortable service possible, the microclimate conditions in the workplace greatly influence the health of the workers. We refer here to temperature, relative humidity, noise level, vibration level, speed of air currents, CO₂ content, electromagnetic field intensity, chromatic, light intensity and ambient music. If one or more of these elements are not adequate, the health condition may be affected, and consequently there are repercussions for work efficiency and even occupational diseases can occur. The textile clothing industry causes professional diseases in particular musculoskeletal disorders. The application of the culture of technical ergonomics and ergonomic analysis methods shall be performed in order to reduce the risk of disease [3].

Improving people’s lifestyles and promoting a healthy diet and wellbeing are important, but the importance of work-related diseases (MSD) should be not neglected. Musculoskeletal disorders (MSD) are among the most common work-related health problems. Ergonomists already assess risk factors and suggest changes in workplaces. However, existing methods are mainly based on visual observations, which have a relatively low reliability and cover only part of the workday. These suggestions concern the overall workplace and the organization of work, but rarely include individuals’ work techniques [4].

The various problems of a work place faced by industrial workers in general, are inadequate illumination, excessive noise that does not help in the interface between the operators and machinery. This creates a dissatisfaction of the operator in carrying out its function, causing professional problems, triggering with this medical leave [5].

In frame of this paper, we will analyze the influence of ambient music and light intensity at the workplace.

There are numerous studies that address the relationship between music and work performance. One study focused on the influence of ambient music and has shown that auditory stimuli affect performance in the workplace [6]. Also, through observations and analyzes at the workplace it was concluded, that listening to music creates positive states at work and the presence of music improves the results of work [7].

There have also been studies that have shown that performance does not differ significantly depending on music, noise or quiet [8].

Lighting is very important because it conditions the proper reception of information. The intensity of the light should not be too low because it would overload the body for adaptation, but not too strong because it also overloads the body. When proper visibility is not ensured, a tiredness of the body and eyes appears, and the risk of accidents at work occurs.

Probably the most harmful factor of the environment is noise, as it can cause fatigue, and implicitly, the decrease of productivity in work, both from a quantitative and qualitative point of view. Noise is a consequence of the disordered overlapping of sounds with different frequencies and intensities.

2. Initial conditions. Materials and methods.

Starting from the fact that the opinions are divided on the influence of ambient music and functional lighting at work, we proceeded to our own experiments in the Cottontex clothing factory in Timisoara. The main activity of this factory is the manufacture of sports equipment. Aim of our study was to analyze the performances of the workers after changing the microclimate conditions.

To begin with, we measured a series of microclimate parameters during the eight working hours, namely: light intensity using a Voltcraft LX-1108 digital luxmeter; relative temperature and humidity using a thermohygrograph, Voltcraft PL-100TRH; noise level in the area of each machine both at idle, for the preparation of the textile material, as well as during the operation, using a digital sound level meter Voltcraft SL-451 with datalogger; air speed using a propeller anemometer, Voltcraft PL-130.
AN, CO₂ content using a CO₂ level meter, Volcraft CM-100, and for the runtime we used a professional digital stopwatch, iSport JG021. The values of the measured parameters are presented in the table 1.

Table 1. The values of the microclimate parameters in the production hall.

| The measured parameter                  | Unit of measurement | The value       |
|-----------------------------------------|---------------------|-----------------|
| Light intensity                         | lx                  | 550-750         |
| Temperature                             | °C                  | 20.3-24         |
| Relative humidity                       | %                   | 50-53           |
| Local noise level without the machine running | dB               | 58-60           |
| Local noise level during machine operation | dB               | 65-85           |
| Speed of air currents                   | m/s                 | 0               |
| CO₂ content                             | ppm                 | 850-1470        |

Within the department 70-80 female workers are employed with ages ranging from 40-60 years. Lighting is a combination between natural, with side windows, and artificial, with fluorescent lamps, and no ambient music is used. There is no possibility to change the light intensity depending on the color of the processed textile materials or the complexity of the operations. Some machines were equipped with additional lamps for local lighting. The standards for lighting is 700 lx for dark colors and 400 lx for light colors.

3. Own experiments

For our experiments we used a local lighting installation with a Philips 15W LED bulb, 1521 lm, connected to a voltage regulator, an installation that allowed us to modify the local lighting.

To reduce the light intensity we suspended a fluorescent lamp, but the workers said that the light is too low and they cannot work. So we could only experiment with a higher intensity where there was a light deficit.

As ambient music we utilized several songs, but the song *Coming back to life* by David Gilmour was running more often. This song is quite long, 7.06 min, it has a variable rhythm, it alternates instrumental parts with word parts, so it is not monotonous. We adjusted the volume of ambient music so that on average, the noise level should exceed with 5-10 dB the noise level in the absence of ambient music.

Figure 1. The elements that are assembled at the machines.
We randomly chose three workplaces, as follows: Worker 1. Overlock sewing machine, for four operations: assembling of the blouse on the side; sleeve application; assembling front with back collar; sleeve assembling. The first two operations are performed together, so the time required for material preparation decreases. The elements that are assembled are shown in the figure 1. The values of the normed execution times and the average times recorded during the use of ambient music are presented in the table 2. Worker 2. Machine for elastic application - operation: application of siliconised elastic, 40 cm long at the front sides and back. The elements that are assembled are shown in the figure 1, the same as above. The values of the normed execution time without music and the average time recorded with the use of ambient music are presented in the table 2. Worker 3. Simple sewing machine - operation: application of a 60 cm zipper. The elements that are assembled are shown in the figure 1. The values of the normed execution time without music and average time with ambient music are presented in the table 2.

| Operation | Norm, [unit/h] | Average time without music, [s] | Average time with music, [s] |
|-----------|---------------|--------------------------------|-----------------------------|
| Worker 1  |               |                                |                             |
| assembling of the blouse on the side | 70 + 30 | 142                     | 119                        |
| sleeve application | | | |
| assembling front with back collar | 120 | 28                     | 23                         |
| sleeve assembling | 109 | 22                     | 18                         |
| Worker 2  |               |                                |                             |
| application of siliconised elastic at the front sides and back; cutting of the elastic | 130 | 27                     | 23                         |
| Worker 3  |               |                                |                             |
| application of a 60 cm zipper | 25 | 142                     | 130                        |

Comparing the execution times, we observe an increase of labor productivity, in the case of the three workers, between 8% and 23%, which represents an average increase of 15.56%. If we extend these results to the entire department, to all the work stations in the technological flow, we can expect an increase of the monthly physical production in the same proportion.

For the workers, under the terms of the pay in direct agreement, the salary is directly proportional to the number of products made, the increase of the number of pieces per unit of time will generate a corresponding increase of the salary. For example, for a net salary of 2350 RON, the increase in productivity will generate a salary of 2700 RON.

4. Workers' perception on ambient music

To analyze the opinion of the workers involved in the study on ambient music, we applied a questionnaire consisting of 6 questions. A number of 72 people agree to answer the questionnaire.

For the question 1 "What would you like to listen during working hours?" three answers could be chosen: radio, recorded music and "I might express myself after an experiment", figure 2. We notice that almost all workers know what they would like, 90% of them, and most, 62%, would like to listen to radio. This answer comes as a desire to listen some news too, maybe they were also under the influence of events that took place during that period, namely the spread of Covid 19 virus. Further,
for the next question, 2, "What kind of music would you like to listen at work?" with lyrics or without lyrics, figure 3, 81% would like with lyrics, considering that only instrumental music would be more boring and annoying.

![Figure 2. The answers for question 1.](image1.png)

![Figure 3. The answers for question 2.](image2.png)

At the question 3, "What kind of music would you like to listen at work?", figure 4, 62% said they would like to listen to disco, pop music. The explanation for this behavior may be attributed to the fact that 85-90% of the workers are women, with high school education, with ages between 40 and 60 years. This kind of worker generally likes disco music from the 80s and 90s.

At the question 4, "How long during 8 hours of work would you like to listen to music?", figure 5, the majority, 60%, response that when they feel the need, so depending on the mental or the fatigue state. The other respondents, in almost equal proportions, would like to listen to music 1-2 hours, 3-4 hours or all the time.

![Figure 4. The answers for question 3.](image3.png)

![Figure 5. The answers for question 4.](image4.png)

At the question 5, "How would you like the music to be delivered?", figure 6, almost 80% of them replied they would like personalized, each to listen to what he wants, when he wants and how much he wants. Of course, this behavior is also determined due to the fact that all workers have smartphones, and most have access to the internet, some even unlimited. During our analysis in that factory many times we saw workers using headphones to listen to music or news by the phone. Probably, installing a few routers in the production section would be useful for many workers to have access to wi-fi internet.

When asked "Do you think favorite music would increase work efficiency?", question 6, a great majority of 57% had a positive answer (said "yes"), figure 7.

![Figure 6. The answers for question 5.](image5.png)

![Figure 7. The answers for question 6.](image6.png)
5. Conclusions
By applying the questionnaire, having similar workers in terms of age and professional training, high school study, we can say that most would like to listen to radio, so also news and music, they would like to listen to disco, pop with lyrics, when they feel the need, personalized according to the mental state and the fatigue state, being convinced that this would increase their work efficiency.

Of course, personalized music is impossible to ensure, but by installing some routers it can ensure wi-fi access to the internet and each worker can listen to what he wants using his own smartphone.

About the use of ambient music we can say that the workers felt good, which has had a good impact in their performances.

By using ambient music we calculated an increase of the efficiency of the workers with an average of 15.56%, and this aspect leads to an increase of the salaries of the workers from 2350 RON/month to 2700 RON/month, with favorable implications on the profit of the company.

These results allow us to recommend that the company implement a system that allows listening to music during working hours.

6. References
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