

## Article

# Improving Workplace Safety and Health Through a Rapid Ergonomic Risk Assessment Methodology Enhanced by an Artificial Intelligence System †

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† This paper is an extended version of a paper published in the 2024 IEEE 6th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (IEEE ECBIOS 2024).

**Abstract:** The comfort of a worker while performing any activity is extremely important. If that activity extends beyond a person's capacity to withstand physical and psychological stress, the worker may suffer from both physical and mental ailments. Over time, if the stress persists, these conditions can become chronic diseases and can even be the cause of workplace accidents. In this research, a methodology was developed for the rapid assessment of ergonomic risks and for calculating the level of ergonomic comfort in the workplace. This methodology uses artificial intelligence through a specific algorithm and takes into account a number of factors that, when combined, can have a significant impact on workers. To achieve a more accurate simulation of a work situation or to evaluate an ongoing work situation, and to significantly correlate these parameters, we used logarithmic calculation formulas. To streamline the process, we developed software that performs these calculations, conducts a rapid assessment of ergonomic risks, estimates a comfort level, and proposes possible measures to mitigate the risks and effects on workers. To assist in diagnosing the work situation, we used a neural network with five neurons in the input layer, one hidden layer, and two neurons in the output layer. As a result, most work situations, in any industrial field, can be quickly analyzed and evaluated using this methodology. The use of this new analysis and diagnosis tool, implemented through this new research technology, is beneficial for employers and workers. Moreover, through further developments of this methodology, achieved by increasing the number of relevant input parameters for ergonomics and integrating advanced artificial intelligence systems, we aim to provide high precision in assessing ergonomic risk and calculating the level of ergonomic comfort.

**Keywords:** ergonomics; artificial neural networks; risk assessment; occupational health analysis



**Citation:** Ispășoiu, A.; Milosan, I.; Gabor, C. Improving Workplace Safety and Health Through a Rapid Ergonomic Risk Assessment Methodology Enhanced by an Artificial Intelligence System. *Appl. Syst. Innov.* **2024**, *7*, 103. <https://doi.org/10.3390/asi7060103>

Academic Editors: Teen-Hang Meen, Chun-Yen Chang, Charles Tijus, Po-Lei Lee and Kuei-Shu Hsu

Received: 30 July 2024

Revised: 19 October 2024

Accepted: 24 October 2024

Published: 28 October 2024



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## 1. Introduction

Ergonomics is a science that studies human well-being and the general performance of the entire work system when performing any activity [1–3]. This means that ergonomics takes into account how humans interact with the elements of the system, such as the workspace [4–6], environmental characteristics such as the ambient temperature and lighting, and the positioning of tools and equipment [7–11] in relation to the position of the worker. It also considers existing psychosocial relationships [12–15], with the objective of ensuring that all these elements fit as well as possible with the characteristics and limitations of the worker [16]. To achieve its objective, ergonomics applies principles from various fields, such as engineering, anthropology, biomechanics, psychology, and industrial design. The advantages of applying correct ergonomics include increased worker safety and comfort, which lead to reduced fatigue and enhanced productivity [17,18]. In this article, we present the RERA (Rapid Ergonomic Risk Assessment) methodology, which

helps to quickly identify possible problems related to ergonomics during the performance of any activity by taking into account a wide range of aspects with implications on the comfort and efficiency of the worker in the activity, such as the way in which decisions are made regarding how at least the minimum ergonomic conditions are satisfied. To make this decision, RERA uses an artificial intelligence system based on a neural network that has five inputs (posture index, duration/time index, and three parameters of the work environment: noise and air quality, index of manipulated masses, and index psychosocial states), a hidden layer, and two outputs that represent whether the working situation is acceptable or not and whether remedial actions are required. Once the decision is made (certain AI decisions require human validation), the implementation of the action plan can proceed [19–23].

## 2. The Risk Assessment Methodology

The RERA methodology, in order to achieve its objectives related to workers' comfort and productivity, analyzes each activity separately and takes into account the characteristics and skills of the workers as well as the work environment and the actual workload. One of the main aspects taken into account is the work environment. The characteristics of the work environment in which the activity is carried out are very important because both the comfort of the worker during the activity and productivity depend on them. Therefore, these characteristics must be known before starting the activity itself in order to be able to take appropriate protective measures.

The work environment requires knowledge of the following elements:

- The work space—directly determines the physical (but also mental) comfort of the worker in carrying out the activity. It must be determined if the working space is sufficient, insufficient, or even tight.
- The ambient temperature—can be optimal, too low (cold), or too high (hot). The optimal temperature depends heavily on the type of activity performed; for example, for an activity where a great physical effort is made, the optimal temperature is lower (e.g., below 18 °C), than that for an activity without significant physical demand, where the optimum could be around 21 °C. Moreover, the optimal temperature, for the same type of effort, can differ from individual to individual, even by 2–4 °C.
- Lighting—is important for the worker's safety, productivity, and the quality of the work performed. Comfortable lighting means a light intensity sufficient for the visual accuracy required to carry out the activity, but also appropriate positioning of the light source(s), so that they do not "blind" the worker during the activity.
- High noise levels—can disturb the worker during activities, create discomfort or even health problems, and reduce the worker's attention to dangers, possibly even leading to accidents.
- Dust/vapors from the work environment—deteriorate the quality of the air, causing great discomfort to the worker during the activity.

From an ergonomic point of view, the posture adopted by the worker during the execution of the activity is very important and takes into account the following factors: neck, shoulders, trunk, legs, and duration of the activity. During some activities, the neck can be tilted, rotated, or in extension. The shoulders, arms, and hands can have different positions during the activity, but the further they are from the neutral position, the greater the effort exerted by the worker, a fact that can create significant discomfort if such a posture is required for a long time. The trunk can be rotated, inclined, in extension, or in different combinations of these. Considering the fact that the main forces act in the upper part of the trunk, and the support point is in the lumbar area, according to the laws of levers, the greater the distance between the support point and the applied force, the greater the force exerted on the point of support is greater, and in the case of the human body, if the demands are high, various ailments, some very serious, may appear at the level of the spine. The legs, during the activity, can be in different positions, depending on the type of activity carried out. The worker can stand, lean on one leg, sit, or even kneel for a

while. The work may require high visual acuity and may require large manipulations of masses. The duration of time in which the activity is performed is a determining parameter in ergonomics, because if this duration is relatively long, corroborated with the rest of the parameters, the worker feels more physical discomfort, possibly leading to pain and even serious injuries. The psychosocial aspect is very important to consider, because the mental state of the worker during the activity motivates or demotivates the worker. This could mean that a generally easy activity seems difficult to the worker with an inappropriate mental state, or, on the contrary, if the worker is in a good mental state, even a heavy workload may seem easy. All these parameters, most of the time, during the activities, act simultaneously, more or less, and their effect is cumulative. Therefore, they must be correlated, but above all, normalized to be able to compare and relate them mathematically with others. That is why, in the mathematical calculations, we used logarithmic scales to normalize and compare the parameters related to the neck, trunk, and legs, but also those related to the environment or duration of the activity, a.o.

For example, we combined parameters related to posture or work environment in a single index for each category, which reflected a general measure of posture and work environment. This index used logarithms to ensure that relative differences were more important than absolute differences, according to Equations (1) to (5):

$$I_{\text{Environment}} = e1 \times \ln(V_{\text{WS}}) + e2 \times \ln(V_{\text{T}}) + e3 \times \ln(V_{\text{L}}) + e4 \times \ln(V_{\text{N}}) + e5 \times \ln(V_{\text{D/S}}) \quad (1)$$

$$I_{\text{Posture}} = p1 \times \ln(V_{\text{PN}}) + p2 \times \ln(V_{\text{PS/A/H}}) + p3 \times \ln(V_{\text{PT}}) + p4 \times \ln(V_{\text{PL}}) \quad (2)$$

$$I_{\text{WorkTask}} = t1 \times \ln(V_{\text{V}}) + t2 \times \ln(V_{\text{M}}) \quad (3)$$

$$I_{\text{Duration}} = d \times \ln(V_{\text{D}}) \quad (4)$$

$$I_{\text{Psychosocial}} = s \times \ln(V_{\text{S}}) \quad (5)$$

where  $e1, e2, e3, e4, e5, p1, p2, p3, p4, t1, t2, d,$  and  $s$  are weights that reflect the relative importance of each parameter. These weights can be adjusted according to the specific context of the ergonomic analysis that we perform.

$\ln$ —natural logarithm;

$V_{\text{WS}}$ —work space;

$V_{\text{T}}$ —ambient temperature;

$V_{\text{L}}$ —ambient lighting;

$V_{\text{N}}$ —noise;

$V_{\text{D/S}}$ —dust/vapor;

$V_{\text{PN}}$ —neck posture;

$V_{\text{PS/A/H}}$ —posture for shoulder, arm, hand;

$V_{\text{PT}}$ —trunk posture;

$V_{\text{PL}}$ —leg posture;

$V_{\text{V}}$ —visual acuity necessary to perform the activity;

$V_{\text{M}}$ —mass handling during the activity;

$V_{\text{D}}$ —the duration of the activity;

$V_{\text{S}}$ —the psychosocial impact felt by the worker during the activity (includes: the worker's comfort in performing the task, the relationship with superiors and colleagues, their support, motivation, etc.).

We chose to use logarithms to normalize the values obtained because these data have a large variation, and quite a few have extreme values within certain activities.

The choice to frame parameters related to working conditions and the environment within specific intervals can be made by the evaluator, based on their observations and the opinions of the workers being assessed. Workers' perceptions of these conditions, in relation to the tasks they perform, play a key role in this process. How a worker perceives their work environment is an especially important factor in ergonomics and must be included as an input to the neural network for accurate analysis.

### Decision Making with the Help of Artificial Intelligence

Because, in many practical situations, the problem arises of making the best possible decision with a high degree of objectivity, based on a large amount of information that often includes elements that are directly dependent on each other and generate at least cumulative effects, we chose to use an artificial intelligence system, implemented through a neural network (Artificial Neural Networks), to model and solve the problems related to the ergonomic parameters and make the decision of if, based on these input elements, the activity is appropriate or not from an ergonomic point of view.

Since we had 5 indices related to ergonomics, we created a neural network with 5 inputs, a hidden layer, and 2 outputs that represented the decision itself.

For this neural network, we used sigmoidal activation functions and implemented a feedforward network, as shown in Figure 1.

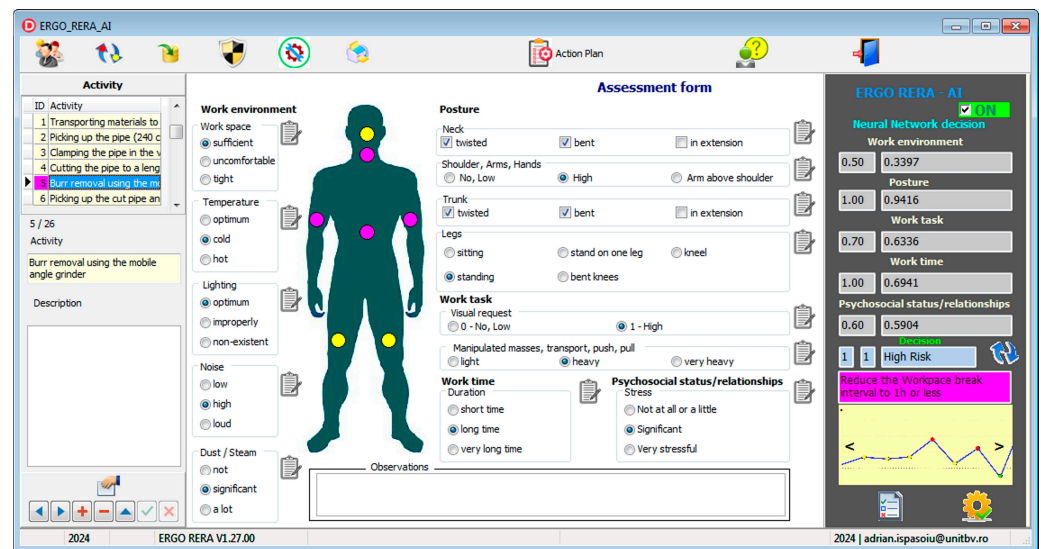


Figure 1. Screenshot from the ERGO RERA software application—AI V1.27.00.

The ERGO RERA-AI software application was developed with the help of the RAD Studio 10.4 programming environment, using the Delphi programming language.

The sigmoid activation function was implemented by a function with a simple code of the form:

```
function Sigmoid (x: Double): Double;
begin
Result := 1.0/(1.0 + Exp(-x));
end;
```

The neural network was properly trained on datasets from activities similar to those evaluated in this production hall.

The steps taken in the RERA methodology are presented in Figure 2.

As can be seen in Figure 2, the activities that the workers perform are identified and chosen. It is recommended that the risk assessment starts with those activities where the workers already complain about ergonomic problems.

During the activity, it is observed if masses are handled, and the time required for the execution of the activity is recorded.

Regarding the information about the work environment, it can be obtained either through sensors (readings can be done either wirelessly or by reading directly to the sensor) or through direct observation and recording in the evaluation form.

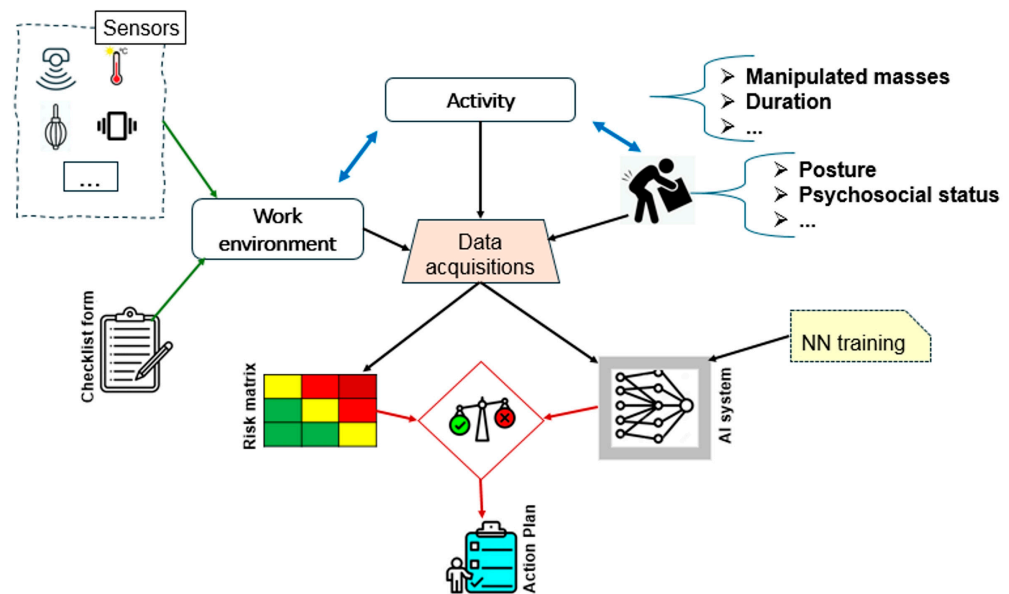


Figure 2. The steps of the RERA methodology.

The worker's posture is observed, and they are interrogated regarding how they perceive the effort they are subjected to during the activity. All these data and information are stored in the database.

The processing of the obtained data and the decisions can be made either by classical algorithms or by using a neural network that is already trained for the situation.

Decisions can be: (1) acceptable situation—no additional actions are required; (2) acceptable situation—improvement measures will be taken; (3) unacceptable situation—work will be stopped, and remedial measures will be taken until the situation becomes acceptable.

The action plan, as implemented in the ERGO RERA–AI V1.27.00 software application, includes information about the actions that must be taken, about the resources necessary for their implementation, about who should execute them, and how long they should be taken. The neural network is trained to be able to propose appropriate actions for the work situation.

### 3. Data Collection for RERA Methodology

The RERA methodology was used and tested on eight mechanics in a metalworking workshop. For three days, the activities performed by these mechanics were analyzed. Initially, 82 distinct activities that mechanics performed were highlighted, but following an optimization analysis regarding the evaluation of ergonomic risks, 76 activities were evaluated.

The parameters of the work environment were measured with the help of sensors and entered into the database.

An activity with significant risks, both regarding ergonomics and safety, is burr removal. This activity is quite frequent for the eight workers and makes ergonomic demands of them both through the awkward or forced posture that they have to adopt and through the duration of the activity, which very often exceeds 20 s for a single awkward posture.

At the same time, this activity generates many contaminants (smoke, sparks, hot particles), high temperatures, and projected incandescent shrapnel. The activity is carried out with an angle grinder that weighs about 4.8 kg, requiring both hands to grip, high grip strength, and long-lasting postural demands, especially for the back, neck, and shoulders.

Table 1 shows the corresponding parameters for the “Burr removal using the (mobile) angle grinder” activity, where L1 to L8 represent the eight evaluated workers. The characteristics of the workers are presented in Table 2.

Table 1. Corresponding parameters for the “Burr removal using the (mobile) angle grinder” activity.

Table Head	Workers							
	L1	L2	L3	L4	L5	L6	L7	L8
Work environment								
Workspace	1	2	1	1	1	1	1	1
Temperature	2	2	2	2	3	2	3	2
Lighting	1	1	1	1	2	1	2	1
Noise	2	3	2	4	5	2	2	3
Dust/steam	2	2	2	2	5	2	3	2
Posture								
Neck	2	3	3	2	3	2	3	3
Shoulders/arms/hands	2	2	2	2	2	2	2	2
Trunk	2	3	4	3	3	2	3	3
Legs	2	2	2	2	2	2	2	2
Work task								
Visual request	1	1	1	1	1	1	1	1
Manipulated masses, transport	2	2	2	2	3	2	2	2
Work time (Duration)	3	3	3	2	3	2	2	3
Psychosocial status/relationships	2	3	2	2	3	2	3	3

where the numbers 1 to 5 represent the scores obtained from each worker for the parameters of the work environment in which they carried out their activity and to which they were exposed. A lower score indicated a more favorable outcome.

Table 2. Characteristics of workers.

Workers	Age [Years]	Gender [M/F]	Height [cm]	Weight [Kg]	Physical Condition [Good, Athletic, Weak]	Experience [Years]
L1	48	M	171	88	G	16
L2	36	M	164	80	G	11
L3	32	M	178	77	A	3
L4	51	F	167	74	G	8
L5	28	M	182	95	W	5
L6	31	F	162	71	G	3
L7	52	M	175	98	W	21
L8	51	M	168	87	G	17

Table 3 shows the characteristics of the workers. The height and weight of the workers were measured with the workers wearing protective footwear, but without helmets, glasses, gloves, or the warning vest.

Table 3. Optimal working surface height range.

Workers	Gender	Height [cm]	Physical Condition	Optimal Working Surface Height Range		Compared with 69.5 cm
				min	max	
L1	1	171	1.00	71.95	81.95	▲
L2	1	164	1.00	68.80	78.80	✓
L3	1	178	1.10	82.61	93.61	▲
L4	0.9	167	1.00	63.14	72.14	✓
L5	1	182	0.70	53.83	60.83	▼
L6	0.9	162	1.00	61.11	70.11	✓
L7	1	175	0.70	51.63	58.63	▼
L8	1	168	1.00	70.60	80.60	▲

Legend: ✓—the work surface is optimal, ▲—the work surface is too high, ▼—the work surface is too low.

In general, in a production hall, parameters such as temperature, lighting, noise, dust, etc. have similar values for comparable activities. However, even within the same production hall, quite often, there are situations where these parameters can differ significantly.

For example, the lighting in certain areas may be insufficient, or the noise may be stronger if the worker is near a noisier machine or near some activities that produce loud noises. The ambient temperature may also vary significantly, especially near entrance doors that frequently open, creating air currents.

For each activity, following the evaluation, it is determined whether the activity is carried out safely or not, an aspect highlighted in the graph in Figure 3. In this determination, the length of time during which the activity is carried out is taken into account. Time, the duration and frequency at which the worker is subjected to the identified efforts, is a determining factor, because if the duration of exposure is short, then the worker is not affected.

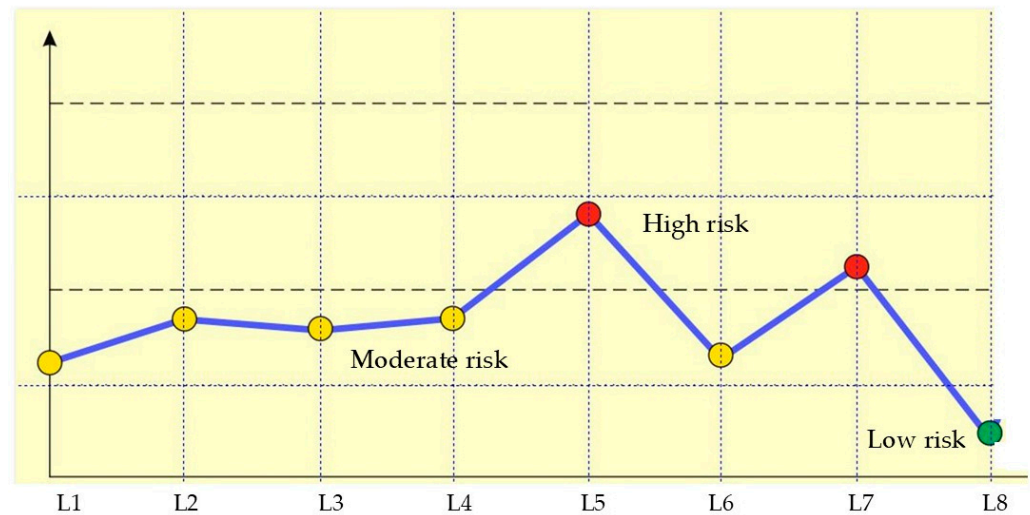


Figure 3. Ergonomic risk levels obtained from the workers (L1–L8) for the studied activity.

The height of the work plans where these activities were carried out varied between 177 cm and 24 cm, and the arithmetic mean weighted by the number of measurements was about 69.5 cm.

To compare this average height with the characteristics of the workers (height and gender), equation 6 was used:

$$H_{SH} = (H_{worker} \times F + C) \times S \times P \tag{6}$$

where

$H_{SH}$ —The optimal height of the work surface;

$H_{worker}$ —The height of the worker;

$F$ —Adjustment factor depending on the type of activity. In this case, the activity required force, so  $F = 0.45$  was used;

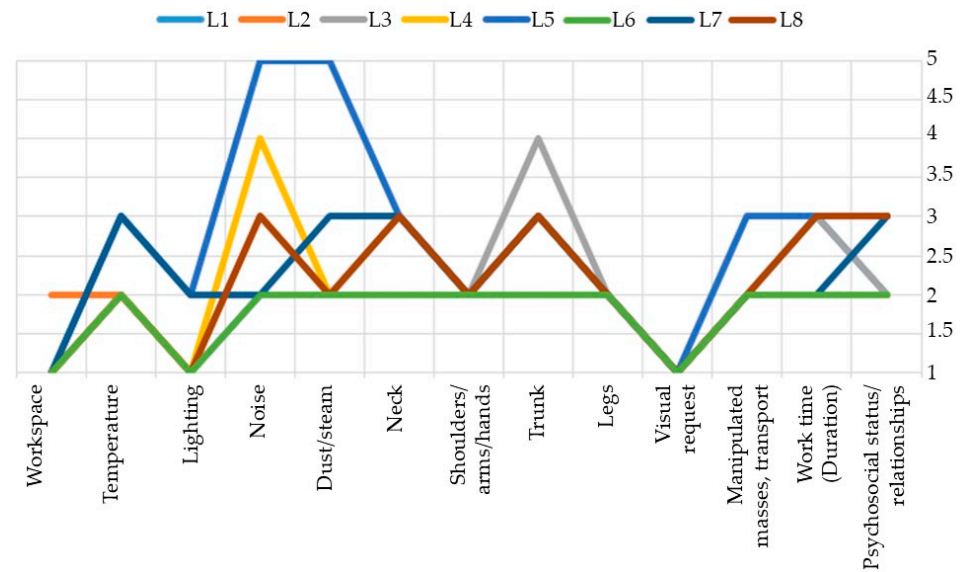
$C$ —Adjustment constant for the specific type of activity.  $C = \pm 5$  cm was used;

$S$ —Adjustment factor for gender ( $S = 0.90$  for women and  $S = 1.0$  for men);

$P$ —The physical condition of the worker (Good = 1, Athletic = 1.10, Weak = 0.70).

In this way, the table of optimal values (Table 3) for the working surface of the workers was obtained depending on the height and gender of the worker and the time of the activity. In the present case, the activity involved physical strength in the arms in particular.

The values of the parameters of the ergonomic risk factors presented in Table 1 are represented graphically in Figure 4.



**Figure 4.** A graphic representation of the values of the parameters of the ergonomic risk factors for the polishing operation (deburring, smoothing) for each worker.

From the values represented, the parameters for the elements of the workers' body stand out, even specifically for certain workers, such as:

- The trunk—which, depending on the height of the worker and the height of the work plane, is generally bent, rotated, and inclined;
- The work environment, in which certain elements often change quickly and significantly;
- Noise—which is generated at a high level by each worker's work equipment;
- Smoke—generated by the metal processing itself and is in close proximity to the worker who causes it.

During the activity, all of these parameters have cumulative effects on the workers.

The methodology allows, with the help of adjustable parameters, the evaluation of a wide range of activities, and the software application greatly facilitates and eases the adaptation of the RERA method to a concrete situation that needs to be evaluated.

#### 4. Discussion

The RERA methodology can be applied in all fields of activity and in all activities where workers already complain about problems related to ergonomics. It can also be used as a simulation in designing jobs or planning activities. Using the software application ERGO RERA-AI V1.27.00, quickly identify possible situations in which there are deficiencies on the part of ergonomics. Considering that sensors can be present in the work area, results can be obtained and decisions can be made in real time, so that measures can be taken as soon as deficiencies start to appear. The RERA methodology offers results with high precision, but it depends on the settings of some values of the weights for certain parameters, and this in turn depends on the experience of the evaluation team members. For example, setting a higher weighted value for posture than for environmental parameters indicates that the team wants the importance of posture to be greater than that of environmental parameters in the evaluation, a judgement that can be argued. However, the difference between the two set values depends greatly on the specifics of the activity and the experience of the members of the evaluation team during the evaluation period.

Furthermore, the data for each activity and for each worker are entered into a database and represent inputs for the decision module based on artificial intelligence. The decisions provided by the neural network were similar to the decisions established by the classical methodology. The advantages of using the neural network, at this stage, are adaptability to relatively similar situations in the assembly, but with some very different and important

specific features compared with other situations. The neural network learned very well from the feedback provided by the evaluation team, continuously improving its performance and accuracy.

## 5. Conclusions

The proposed RERA ergonomic risk assessment methodology proved to be useful, with a high degree of precision and coverage in many fields of activity, but in particular, it proved to be effective in providing a proper diagnosis of the assessed situation using artificial intelligence, a fact that contributes to easier appropriate identification of measures to improve and remedy ergonomic risks. Unlike other established methods for evaluating ergonomic risks, RERA uses logarithmic calculation, normalizing the values of the parameters for easier comparison, consequently increasing the accuracy of the method. Future actions based on the application of this method will consist of direct and real-time intervention in the work situation when certain parameters go out of the admissible area and the workers may be affected. These interventions will consist mainly of light and acoustic alerts, even going as far as safely stopping the working equipment. At the same time, the automatic acquisition of data specific to workers' characteristics (such as height, temperature, and pulse) will be implemented, facilitating the recognition of what demands are placed upon the worker in performing an activity.

**Author Contributions:** Conceptualization, A.I.; methodology, A.I. and I.M.; software, A.I.; validation, I.M. and C.G.; writing—original draft preparation, A.I.; writing—review and editing, I.M. and C.G.; supervision, I.M. and C.G. All authors have read and agreed to the published version of the manuscript.

**Funding:** The APC was funded by Transilvania University of Braşov, Romania. Our work was presented at the 2024 IEEE 6th Eurasia Conference on Biomedical Engineering, Healthcare, and Sustainability (IEEE ECBIOS 2024) Committees, <https://www.ecbios.asia/> (accessed on 24 July 2024). Participation in the conference was financially supported by Transilvania University of Braşov, Romania.

**Institutional Review Board Statement:** All the authors assert that all methods contributing to this work comply with the ethical standards of the national and institutional committees on human rights, with the regulations on and rights of the workers, and with the Helsinki Declaration of 1975, as revised in 2008. The registration number of the ethical declaration is AEX2580 from 7 July 2023.

**Informed Consent Statement:** the article is based on the information and actions that took place in companies where professional risk assessments were carried out in accordance with the obligations arising from the Romanian legislation: Law 319/2006—Law on safety and health at work and Government Decision no. 1425/2006 which provides the rules for the application of Law 319/2006.

**Data Availability Statement:** The necessary data are presented in this article. Other data and information about certain aspects of interest presented in this article are available upon request from the corresponding author.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

1. Dul, J.; Bruder, R.; Buckle, P.; Carayon, P.; Falzon, P.; Marras, W.S.; Wilson, J.R.; van der Doelen, B. A strategy for human factors/ergonomics: Developing the discipline and profession. *Ergonomics* **2012**, *55*, 377–395. [[CrossRef](#)] [[PubMed](#)]
2. Jaffar, N.; Abdul-Tharim, A.H.; Mohd-Kamar, I.F.; Lop, N.S. A Literature Review of Ergonomics Risk Factors in Construction Industry. *Procedia Eng.* **2011**, *20*, 89–97. [[CrossRef](#)]
3. Tavakkol, R.; Kavi, E.; Hassanipour, S.; Rabiei, H.; Malakoutikhah, M. The global prevalence of musculoskeletal disorders among operating room personnel: A systematic review and meta-analysis. *Clin. Epidemiol. Glob. Health* **2020**, *8*, 1053–1061. [[CrossRef](#)]
4. Niu, S. Ergonomics and occupational safety and health: An ILO perspective. *Appl Ergon.* **2010**, *41*, 744–753. [[CrossRef](#)]
5. Gerr, F.; Fethke, N.B.; Anton, D.; Merlino, L.; Rosecrance, J.; Marcus, M.; Jones, M.P. A prospective study of musculoskeletal outcomes among manufacturing workers: II. Effects of psychosocial stress and work organization factors. *Hum. Factors* **2014**, *56*, 178–190. [[CrossRef](#)]

6. Stefana, E.; Marciano, F.; Rossi, D.; Cocca, P.; Tomasoni, G. Wearable Devices for Ergonomics: A Systematic Literature Review. *Sensors* **2021**, *21*, 777. [[CrossRef](#)]
7. Charles, L.E.; Ma, C.C.; Burchfiel, C.M.; Dong, R.G. Vibration and ergonomic exposures associated with musculoskeletal disorders of the shoulder and neck. *Saf. Health Work* **2018**, *9*, 125–132. [[CrossRef](#)]
8. Da Costa, B.R.; Vieira, E.R. Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. *Am. J. Ind. Med.* **2010**, *53*, 285–323. [[CrossRef](#)]
9. Arvidsson, I.; Dahlqvist, C.; Enquist, H.; Nordander, C. Action Levels for the Prevention of Work-Related Musculoskeletal Disorders in the Neck and Upper Extremities: A Proposal. *Ann. Work Expo. Health* **2021**, *65*, 741–747. [[CrossRef](#)]
10. Coenen, P.; Douwes, M.; van den Heuvel, S.; Bosch, T. Towards exposure limits for working postures and musculoskeletal symptoms—a prospective cohort study. *Ergonomics* **2016**, *59*, 1182–1192. [[CrossRef](#)]
11. Nordander, C.; Ohlsson, K.; Åkesson, I.; Arvidsson, I.; Balogh, I.; Hansson, G.-Å.; Strömberg, U.; Rittner, R.; Skerfving, S. Risk of Musculoskeletal Disorders among Females and Males in Repetitive/Constrained Work. *Ergonomics* **2009**, *52*, 1226–1239. [[CrossRef](#)] [[PubMed](#)]
12. Buckle, P.W.; Devereux, J.J. The nature of work-related neck and upper limb musculoskeletal disorders. *Appl. Ergon.* **2002**, *33*, 207–217. [[CrossRef](#)] [[PubMed](#)]
13. Punnett, L. Musculoskeletal disorders and occupational exposures: How should we judge the evidence concerning the causal association? *Scand. J. Public Health* **2014**, *42*, 49–58. [[CrossRef](#)]
14. Hauke, A.; Flintrop, J.; Brun, E.; Rugulies, R. The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: A review and metaanalysis of 54 longitudinal studies. *Work Stress* **2011**, *25*, 243–256. [[CrossRef](#)]
15. Devereux, J.; Vlachonikolis, I.; Buckle, P. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. *Occup. Environ. Med.* **2002**, *59*, 269–277. [[CrossRef](#)]
16. Mathiassen, S.E. Diversity and variation in biomechanical exposure: What is it, and why would we like to know? *Appl. Ergon.* **2006**, *37*, 419–427. [[CrossRef](#)]
17. Chiasson, M.È.; Imbeau, D.; Aubry, K.; Delisle, A. Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *Int. J. Ind. Ergon.* **2012**, *42*, 478–488. [[CrossRef](#)]
18. Vijayakumar, R.; Choi, J.-H. Emerging Trends of Ergonomic Risk Assessment in Construction Safety Management: A Scientometric Visualization Analysis. *Int. J. Environ. Res. Public Health* **2022**, *19*, 16120. [[CrossRef](#)]
19. Fernández, M.M.; Álvaro Fernández, J.; Bajo, J.M.; Delrieux, C.A. Ergonomic risk assessment based on computer vision and machine learning. *Comput. Ind. Eng.* **2020**, *149*, 106816.
20. Donisi, L.; Cesarelli, G.; Pisani, N.; Ponsiglione, A.M.; Ricciardi, C.; Capodaglio, E. Wearable Sensors and Artificial Intelligence for Physical Ergonomics: A Systematic Review of Literature. *Diagnostics* **2022**, *12*, 3048. [[CrossRef](#)]
21. Aldoseri, A.; Al-Khalifa, K.N.; Hamouda, A.M. Methodological Approach to Assessing the Current State of Organizations for AI-Based Digital Transformation. *Appl. Syst. Innov.* **2024**, *7*, 14. [[CrossRef](#)]
22. Majjate, H.; Bellarhmouch, Y.; Jeghal, A.; Yahyaouy, A.; Tairi, H.; Zidani, K.A. AI-Powered Academic Guidance and Counseling System Based on Student Profile and Interests. *Appl. Syst. Innov.* **2024**, *7*, 6. [[CrossRef](#)]
23. Rahman, M.N.A.; Mohamad, S.S. Review on pen-and-paper-based observational methods for assessing ergonomic risk factors of computer work. *Work* **2017**, *57*, 69–77. [[CrossRef](#)] [[PubMed](#)]

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