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SERA: A Digital Risk Management Tool as the Basis of OSHM

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Abstract

Purpose of the article The purpose of the article is to present "Safety and Ergonomic Risk Assessment", SERA as a new digital overall risk assessment tool in the field of occupational safety and health management. This method will be used for the first time in the automotive industry and will close the existing gap in the overall risk and stress assessment.

Methodology/methods In order to clarify the research questions, a qualitative research based on a comprehensive literature review of the legal and normative requirements for OSH risk management tools was conducted, complementary requirements were mapped in the context of expert discussions, and a benchmarking of existing digital solutions, the framework for the development of a digital solution, was created.

Scientific aim Scientific aim of the research proposed was to find the best possible method for the overall risk management of hazards and stresses in production workplaces or to close the existing gap in this respect.

Findings Due to existing research and market gap, a self-development was indispensable. Therefore, in the context of the expert discussions with 15 participants, and a requirement list was developed during 10 workshops. Based on this concept an Excel-based demonstrator version was developed, tested, and optimized with more than 120 users. Finally, a web-based software was developed on this basis, using an agile approach.

Conclusions SERA, like every other digital solution, should be enhanced to better serve users. The capacity of observers to identify stresses due to repeated assembly activities is limited. Use of sensor technology might considerably increase the system's efficacy and objectivity. Connectivity to mobile devices might be explored since the application is Windows-based. SERA can be applied in all industries in production, especially when the repetitive activities play a major role, but for the sectors in which the hazards' short-term impacts are more significant, system adaptability should be explored.

Keywords: occupational safety and health management, risk assessment, OSH digitalization, efficiency, personnel management, productivity, performance measurement, safety and ergonomics, working conditions, occupational safety law, working conditions, supply chain management

JEL Classification: D24, K31, M11, M12, M54

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Introduction

Occupational safety and health (OSH) mostly in industry has become more important in most nations' regulatory frameworks. Existing harm-reduction approaches are generally based on risk methodology, that is, the reduction of consequence or possibility of damage. The risk assessments approach and its variances demonstrate this (Ji, Pons, Pears, 2018a, p.1). The implementation of an OSH management system (OSHMS) allows for long-term optimization of workplace safety via monitoring and control. Target agreements, continuous improvement, employee engagement, and frequent performance assessments are all conventional management ideas that are consistently translated into OSH (Hamacher, 2002). The overall approach has centered on preventing accidents via technological design, such as plant layout design, equipment design, safety system design, maintenance design, and risk management (Ji, Pons, Pears, 2018a, p.1). Safety training and signage are two further accident-prevention strategies (Ji, Pons, Pears, 2018a, p.1). Government entities and international groups have developed a variety of safety and health complaint mechanisms. These systems give comprehensive tools that cover a wide range of OSH issues (Abad, 2013). Nevertheless, it is necessary that each industry adopts and adapts these general principles to meet the needs of the industry.

In addition, the digitization aspect should be considered. One of the most essential demands in this period is the instant availability of substantial information. As a result, OSHM like all other sectors of management, is experiencing significant transformation. Top management expects them to be able to make choices as rapidly as feasible. This requires extensive data and information.

The aim of this paper is to present a new digital risk management tool in the field of OSH management. This method will be used for the first time in the automotive industry and will close the existing gap in the overall risk and stress assessment. This approach meets at the same time the requirements of top management in providing the speed and precision necessary for decision-making in the automotive industry.

1 Theoretical background

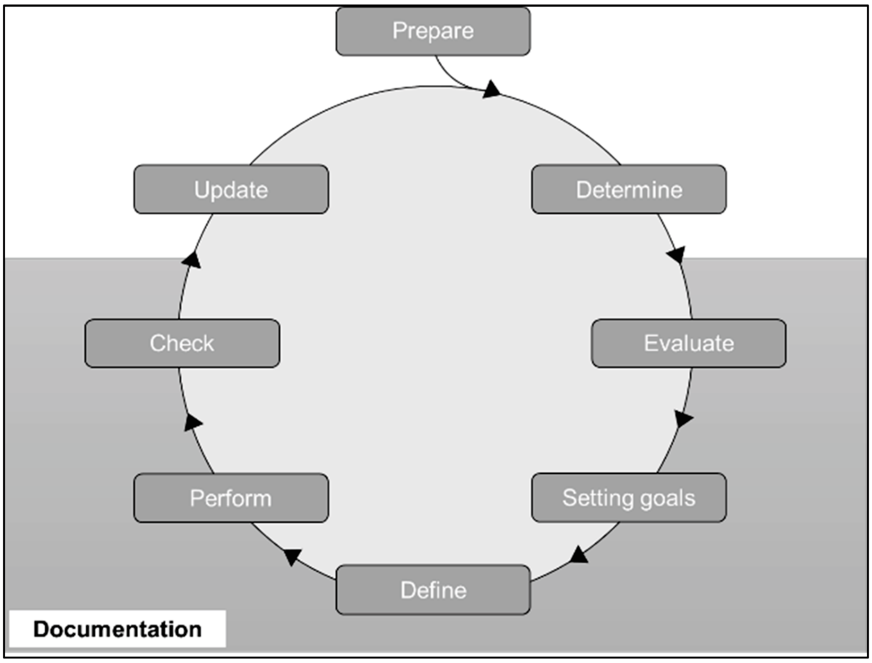
1.1 Modern OSHM approach

OSHMS are increasingly being recognized as a way to enhance OSH in enterprises. OSHMS, like other management systems, are only successful if goal-oriented control and improvement activities are included. The goals must be specified in such a manner that the level of performance can be established and assessed in terms of outcomes control (Hamacher, 2002). OSHM Systems aid in the achievement of OSH objectives, such as improving OSH, preventing workplace accidents and diseases, and making work more humane (LASI, 2013, p.5). Governments, companies, and employees have all recognized the benefits of establishing such a system at the organizational level, both in terms of reducing hazards and risks and increasing productivity (ILO, 2009, p.1). The legal obligations imposed on entrepreneurs are likewise complicated, affecting both the normative, strategic, and operational management levels (Brauweiler, Zenker-Hoffmann, 2019, p.1). When a company implements an OSHM system, it ensures that senior management is on board and that OSH regulations are taken into ac-count in all of the company's procedures (Ritter, 2009, p.1). In this sense, one significant concern is how top management may effectively regulate the system. OSH professionals give information and perform analyses on important indicators to management in order to enhance awareness and reflect visible support for safety involvement in the workplace (Costin, 2019, p.3). Management strategies, in general, are defined as a series of choices and activities aimed at improving OSH performance while also benefitting workers and the environment (Živkovic 2015, p.667). OSHM methodologies have evolved through time as a result of social, political, techno-logical, and economic changes (Mambwe, 2021, p.2). According to the available research, OSHM plays a critical role in overcoming safety and health issues, promoting occupational safety, reducing workplace risk, and preparing a safer working environment (Podgrski, 2015, p.144). According to Mwanaumo and Mambwe, key aspects in influencing OSH include training, employee engagement, preventive activities, OSH policy, reporting of accidents and near-misses, risk management, and a culture of continuous improvement (Mwanaumo, 2019, p.27). They emphasized that management should include OSH decision-making in the firm's decision-making process since it reduces or eliminates risks while also addressing safety culture and motivating issues (Mwanau-mo,2019, p.27). The contemporary OSH approach is built on comprehensive knowledge of OSH: It emphasizes an organization's, managers', and employees' personal responsibility for OSH, involves managers more closely in OSH, relies on regular evaluation with the goal of continuous improvement, integrates occupational safety into operational processes, and views it as a process, and views it as a process (Hamacher, 2002, p.33). In this setting, key performance indicators (KPIs) are crucial. One of the most critical aspects in ensuring OSH is risk assessment.

Occupational safety specialists document and analyze current hazards and ergonomic stresses on behalf of the company using various techniques and devices. Many assessment characteristics are collected, evaluated, and countermeasures are established in the risk assessment.

1.2 Safety and Ergonomics Risk Assessment

Hazards in safety and health are defined as "a source or a condition that has the potential to cause harm to humans, property, the environment, or a combination of these" (Ji, Pons, Pears, 2018b, p.2). One of the most key elements in assuring OSH is risk assessment (Knöll, 2020). It is characterized as "systematic hazard detection and assessment" (Hamacher, 2002, p.33). This may be done in both a retrospective and prospective manner. Because of its predictive risk appraisal for the prevention of accidents or prospective hazards, Schlick et al. recommend that preventive OSH be prioritized (Schlick, 2018). Risk assessment in compliance with regulatory standards (e.g., the German Occupational Safety and Health Act) is a concept for improving safety and health. As a result, the improvement of working conditions will be guided by the primary objectives. This allows for the justification and effective control of target management for overall corporate activity (Hamacher, 2002). Figure 1 depicts the systematic methodology for assessing working conditions in accordance with sections 5 and 6 of the German Occupational Safety and Health Act.



Source: own illustration based on Hamacher, 2002

Figure 1 Methodical approach for risk assessment

Traditional risk assessment approaches are primarily focused on safety occurrences that might cause immediate damage to individuals, such as acute injury consequences, rather than long-term (or chronic) health problems (Ji, Pons, Pears, 2018b, p.1). Screening methods have been developed to determine the nature and extent of emerging exposures or possible health hazards with reasonable effort and without special qualifications. The goal of ergonomic evaluation of workstations are summarized as follows: Design considering anthropometry and biomechanics, document and evaluate work situations (real and planned) regarding their stress, ensure favorable ergonomic work situations through standardized problem tracking systems, and comply with legal regulations on labor law.

1.3 Major Progress in Health and Safety Research

The academic literature on approaches for evaluating overall safety and ergonomics risks in the industry is limited. Most of safety research focuses on reducing risk and preventing accidents. Methods for assessing long-term ergonomic and health effects, in particular, are lacking. The connection between hazards and consequences is often overlooked and without emphasis on long-term consequences in the workplace, and as a result, prevention and treatment are neglected (Ji, Pons, Pears, 2018b, p.3).

2 Methodology

This article presents a digital method for risk management (risk and stress assessment, documentation, action tracking, reporting, etc.) in the automotive industry, which meets the requirements of the modern working world and Industry 4.0, in addition to global legal frameworks.

The aim of this IT solution is, among other things, to enable top management to make strategic decisions on the shaping of future workstations in production areas on the basis of the generated data and key performance indicators, and to enable OSH specialists to effectively support the work areas they are responsible for. Furthermore, this digital solution will reduce the user effort in collecting and assessing the workstations while increasing the objectivity of the results.

The following research questions (Q) were addressed in this context:

- Q1) What requirements do the users (executives, OSH specialists, production technologies, etc.) have for a modern IT solution for risk management.
- Q2) What are the legal, normative, and company-internal framework conditions that a globally applicable tool should fulfill?
- Q3) Which comparable Risk Assessment (RA) tools exist that meet these requirements (Benchmarking)?
- Q3.1) If there is no suitable IT solution available, what could it look like (Proof of concept and Demonstration)?
- Q3.2) What is the development and implementation process?

Figure 2 shows the corresponding steps to clarify the research questions.

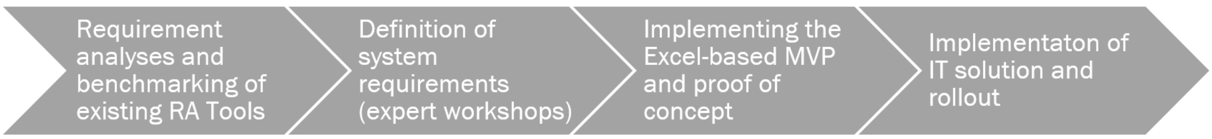


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Figure 2 Research Design.

In order to clarify these questions, a comprehensive requirements analysis was carried out in the first place to collect the ideas, best practices, and expectations of future users, from managers to OSH specialists and workstation planners. In this context, the requirements of the respective production technologies (press shop, body in white, paint, assembly, powertrain, and logistics) were collected in expert discussions and workshops from a total of 18 international production sites of an automotive manufacturer.

In addition to the requirements analysis, a comprehensive literature review was carried out regarding global legal and normative requirements for a risk management tool. The existing system in the company was also examined in detail and analyzed for weaknesses.

In this context, occupational health and safety laws and regulations of Austria, Brazil, China, Germany, Great Britain, India, Mexico, South Africa, Thailand, and the USA were investigated. In addition, the relevant norms and standards for ergonomics and occupational safety were analyzed. The results were summarized and discussed with experts from the respective production sites in a workshop. To remain efficient and cost-effective, the hazard and stress assessment tools available on the market from well-known suppliers in USA and Europe were investigated and benchmarked.

It took 10 expert workshops with 15 participants to create a requirement documentation (business concept) after the research phase. For testing, an Excel-based version of the requirements document was utilized. As a result of this, the demonstration was created in Excel, allowing users with minimal IT expertise to utilize it. The IT product was iteratively developed based on input from 120 test users. Using the functional requirements as a guide, user stories were developed and iterated. Aside from collecting user input on the MVP, further requirement packages (epics) were created and deployed concurrently after the first development phase was completed.

3 Result

The results of this work, based on the research questions, are summarized as follows:

3.1 User Requirements

During the expert workshops with the individual production technologies and future users, more than 150 different requirements were collected. These can be summarized in the following categories:

1- Technology specific requirements,

2- Technical requirements for new reporting and evaluation features,

3- Best practices and lessons learned from the existing system,

4- General software ergonomics requirements for the user interface.

3.2 Legal and normative requirements

Based on the expert discussions, the following regulations were considered as the basis for the risk management requirements. Wherever local regulations were stricter than global regulations, these were considered separately as local requirements (Table 1).

Table 1 An excerpt from legal, normative, and company-internal framework for OSH risk management

External Regulation	Company internal regulation
German occupational health and safety law	Group VA 2.3/2 Facilities and machine safety
ASR A3.4	Group VA 2.3/3 Ergonomics
ASR A3.5	Group VA 2.3/4 Occupational safety Logistics
BGI 571 (A 017)	Group VA 2.3/6 Identification and evaluation of hazards
BGI 688	
BGIA-Report 3/2009	
DIN EN 1005-3	
DIN EN 1005-4	
EAWS (European Assembly Worksheet)	
EN-614-1	
German key indicator methods	
ISO 31000,	
NIOSH	

Source: own illustration based on existing regulations, see references

3.3 System benchmark

The systems currently in operation target only those hazards that cause short-term injuries and/or damage and do not assess the risks of hazards and stresses that have long-term consequences for employees and the environment or focus only on ergonomic stresses without considering other hazards present in the workstation. However, for regulatory and ethical compliance reasons, both types of risks must be addressed, regardless of the short-term and long-term consequences. Therefore, large industries usually use two parallel methods of hazard and stress assessment, which is neither economic nor efficient. In addition, this separate risk management con-fuses top management in making strategic decisions about the design of production workplaces. On the other hand, these tools are either too simple and broad, so that only smaller companies can use them and sometimes so complex that no one but experts can handle them (and that too at a great cost in their time), and on the other hand they do not meet the requirements of the digitalization era.

The IT systems available on the market could not meet the users' requirements. It became clear that, at the time of the investigation, there was no single IT solution available that was able to comprehensively record both hazards and ergonomic stresses. The only tool available was the company's existing system, which served as the basis for the in-house development of the new IT software.

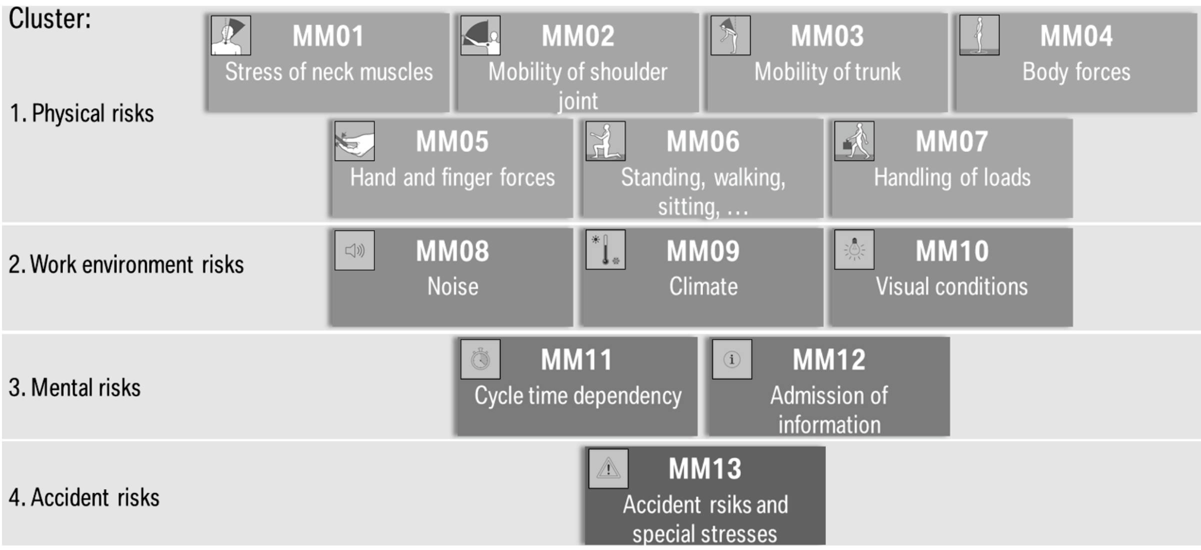
3.4 SERA as the first globally applicable assessment method for hazard and risk management

Thus, the SERA (Safety and Ergonomic Risk Assessment) project was launched with the following objectives as the first IT solution for a comprehensive ergonomics and safety assessment tool in the automotive industry:

- More accurate stress and risk assessment based on the latest scientific findings,
- Phase-adequate assessment processes for vehicle projects,
- User-friendly interface design,
- Implementation of an improved reporting and steering system,
- Extensive administration options,
- Intelligent roles and rights concept.

Marking the end of the inquiry phase, which included literature study and expert discussion, the next stage was to build a business model with all applicable technical and normative criteria over the course of 10 expert workshops with a total of 15 participants. This requirements document served as the foundation for creating an Excel-based test version to ensure that the criteria were met. The demonstration was built on an Excel platform because, on the one hand, adapting and developing mathematical functions in Excel was straightforward and rapid, and on the other hand, the sample application could be used by those with little or no prior IT experience. The IT tool was further developed and iteratively put out within two years after receiving input from 120 test subjects as part of an agile approach: User stories were designed based on the functional requirements and implemented iteratively in this stage. The MVP was pushed out once the first development phase was completed, and further requirements packages (epics) were written and built-in conjunction with the gathering of user input on the MVP.

As mentioned, the assessment of the workstations is based on current findings in occupational science as well as national and international legal regulations. These requirements are grouped into 13 criteria. The analysis results can be evaluated at different evaluation levels. While at the level of criteria, all 13 criteria, from "neck strain" to "accident risks", can be viewed individually, it is also possible to evaluate the cluster levels "physical stress", "workstation environment", "mental stress", and "accident risks" (Figure 3).



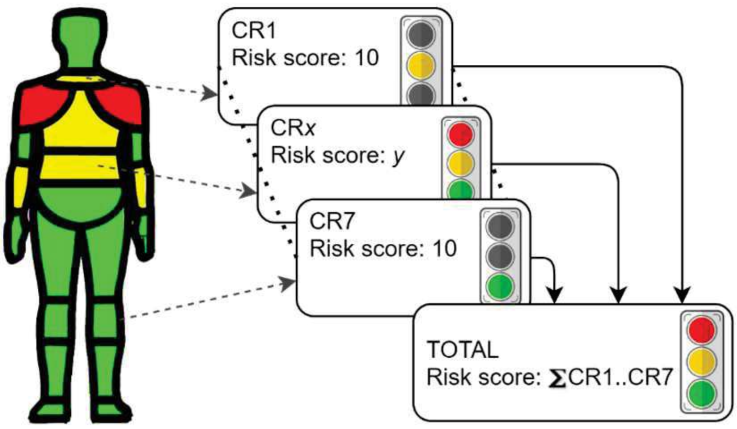
Source: own illustration

Figure 3 SERA structure

The result of the evaluation is shown by a traffic light classification in green, yellow, and red. The traffic light colors are defined as follows:

- Green: Low strain, health risk from physical overstraining is unlikely. The design goal is fulfilled.
- Yellow: Increased strain, overstraining is possible even for persons with an average stress tolerance, the design goal is not fulfilled. In the case of a yellow traffic light color, countermeasures are not necessarily required, however, one should regularly (i.e., annually) check possibilities to improve the stresses and fulfill the design goal (green traffic light color).
- Red: Significantly increased strain, overstraining is likely for persons with an average stress tolerance, the design goal is not fulfilled. Design counter measures are urgently required. In the case of a red traffic light color, one should document the reason for this stress in the respective comment fields. Countermeasures to improve the stresses and fulfill the design goal should be implemented, within the current framework, e.g., vehicle project goals.

In addition, the SHI (Stress and Hazard Index) provides a way to look at ergonomic risk in overall terms. The SHI of an analysis can range from 0 (low risk/stress) to 150 (high risk/stress). A determination of stresses is made based on the traffic light color of the workplace analysis. Figure 4 shows an example of the composition of the ergonomic stresses and a visualization of it. The overall ergonomics for a workplace is characterized by the sum of risk ratings for ergonomics criteria, as well as a rule-based traffic light.



Source: own illustration

Figure 4 Visual representation of the ergonomics criteria in SERA.

3.5 Generated KPIs by SERA

As mentioned earlier, one of the goals of implementing this IT solution was to enable management to make strategic decisions to meet the company's goals regarding keeping employees healthy and sustainable production. In this regard, a study was conducted. In the context of a pilot project in the production technologies „Tech 1"and „Tech 2", the ergonomic improvements were accompanied for 8 month and the performance increase was verified with potential KPIs. Two KPIs were identified for the transparent presentation of the status:

- Proportion of assessed workstations (PAW): Number of workstations evaluated in SERA / total number of workstations in the technology, where 100% is the best result.
- Proportion of red workstations (PRW): Number of red workstations in SERA / Total number of work-stations in SERA, where 0% is the best result.

A fundamentally positive development of the ergonomics KPIs was observed for both fields. The development of the KPIs can be seen in the following table.

Table 2 Piloting results of the ergonomics KPIs.

	Tech 1	Tech 2	Total
PAW	100% → 100%	69% → 99%	64% → 100%
PRW	3,5% → 3,5 %	45% → 40%	25% → 21%

Source: own illustration

Based on these results, target values for the improvement of the KPIs were set and measures that had in-creased performance were included and are monitored regularly. These were decided in plant management circle.

A similar approach was taken for vehicle projects. Here, the framework conditions for ergonomics were dis-cussed in an expert workshop with 14 participants. The summary is as follows:

Target and Purpose

- The target is to achieve sustainable improvement in ergonomics to further the long-term health and productivity of employees. The consideration of ergonomics occurs per technology and is based on the previous project.
- In accordance with the continuous improvement of working conditions required by the occupational health and safety act, the ergonomics target process also aims to continuously improve the ergonomics from project to project (e.g., 5% improvement of the ergonomics compared to the previous project as an initial attempt).
- In addition of the three mandatory dimensions of the ergonomics KPIs, basic premises and test assignments can also be included in the target.
- In an attached document per technology (e.g., ppt-file), the targeted values of the key figures are listed.
- Different target values per plant are possible for the same derivative.
- The so-called ergonomics map contains the relevant SERA analysis as well as potential measures and thus serves to control the ergonomics target process.

4 Discussion

With the goal of offering a global safety and ergonomics risk assessment, the screening tool SERA was created using scientifically established procedures. The instrument provides a whole-body ergonomic assessment, as well as an evaluation of the job environment, mental pressures, and a hazard and risk assessment. After completion of the research phase (literature study, expert discussions on requirements identification, and benchmarking), the demands for a modern IT tool were identified. In addition, it was discovered that a global risk and exposure assessment tool has not yet been developed. This gap in the market has led the company to push for a self-developed solution. For this reason, the company has further developed the risk assessment method in the automotive industry under the following premises:

- Setting uniform safety and ergonomic standards, processes, and methods within the group,
- Adaptation of the safety and ergonomic strategy in response to dynamic circumstances within the group,
- Internationalization of the applied safety and ergonomic assessment methods,
- Overall coordination of safety and ergonomic support for vehicle projects,
- Development of future fields in OSHM,
- Scheduling and realization of regular exchange appointments in the group network of OSH.

SERA has a significant benefit over traditional, widely used ergonomic screening techniques such as EAWS, KIM, REBA, and others in that it can be customized to stresses, enabling all contemporary production stressors to be covered while ignoring unneeded stresses. Furthermore, employing a web-application-based method allows SERA to have an easy user interface, data connections to workplace planning systems, and a database of stressors for all industrial workplaces, allowing for comparisons and reporting at any level of the organization. In SERA, a workplace evaluation consists of 13 criteria, seven of which concentrate on different aspects of physical ergonomics, such as postures, forces, and loads. Each of these seven ergonomics criteria focuses on a different body part or force/load type. All criteria are multidimensional, with at least the repetition/frequency and severity of a specific stress included in. Each criterion yields a numeric risk score as well as a traffic light color (red, yellow, and green, to represent low-, medium-, and high-risk workstations respectively). The aggregate of risk ratings for the ergonomics criteria, as well as a rule-based traffic light, are used to characterize the overall ergonomics for a workplace. Despite the fact that SERA (the criteria, body parts, stresses, and so on) is based on well-established ergonomics, there is a strong need to both further validate the system and use the quantity of data to identify priority areas across all workplaces.

SERA will be the first comprehensive risk management software used in the automotive industry. This technique has been developed especially for manufacturing areas and is utilized in a group that also includes instruments for office workplace assessment and psychological risk assessment.

Only risks and stresses that are objectively quantifiable and directly linked to the workstation have been considered in this tool. I.e., psychological stressors were expressly avoided, with the exception of mental stresses such as cycle time dependence or information admission. Because, at the moment, risk assessment techniques for psychological stress vary greatly throughout the globe, and in certain businesses, only occupational doctors are permitted to evaluate these risks. Another consideration is that psychological stress depends on the individual and may be induced by circumstances outside of the workplace. As a result, this kind of stress was specifically avoided in the first phase.

Given the above, this method is too complicated for evaluating office workplaces (due to simple activities compared to manufacturing) and is inappropriate for assessing psychological risks.

Conclusion

Like any other digital solution, SERA will be further optimized. User feedback will play a major role in this context. The goal should be to make it faster and more pleasant to use. The detection of repetitive activities in assembly, which are timed on a second-by-second basis, will challenge the observers in detecting the loads. An automatic detection of such activities with the help of sensor technology (motion capturing and force measuring sensors) will drastically increase the efficiency and objectivity of the system. In this case, many new technologies such as artificial intelligence can support further development. Another possible field of investigation would be the connection to mobile devices (iOS or Android), as the tool is Windows-based. SERA is based on the latest scientific findings and meets all legal and normative frameworks. For this reason, it can be applied in all industries in production, especially when the repetitive activities play a major role, but for the industries (such as oil and mines) where the short-term consequences of the hazards play a greater role, it should be considered to what extent the system should be adapted.

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