Call for Action: Why AI in Ergonomics Does not Translate to Improved Work Postures

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Abstract: Lately, the integration of Artificial Intelligence (AI) in ergonomic assessment has shown promise in accurately evaluating human posture and motion with regard to ergonomic risk. As AI becomes more ubiquitous, these techniques aim to substitute observational techniques and make ergonomic risk assessment more accessible. However, current AI methods in ergonomics still require extensive human post-diagnosis. As workers lack expert knowledge to interpret ergonomic evaluation, this approach does not benefit them in improving their work conditions. To bridge this gap, we identified the challenges that have to be addressed to make AI solutions more worker-centric. We propose a novel design blueprint, the EPA Loop, aimed at improving usability and include recommendations on how to design future AI solutions. To truly improve work conditions, we argue that AI-based ergonomics must evolve from mere diagnostics to holistic solutions that directly target workers, fostering their understanding of ergonomic risks and providing actionable guidance on how to improve their work posture.

Keywords: Ergonomics, Postural Assessment, Artificial Intelligence, Interpretability of Ergonomic Risk, Musculoskeletal Disorders

1. Introduction

In the European Union, musculoskeletal disorders (MSDs) are increasingly leading to work disability, absenteeism, presenteeism, and productivity loss (Bevan 2015). Recognising the critical importance of ergonomics, AI techniques have been employed by researchers to tackle these challenges. In particular, Convolutional Neural Networks (CNNs) and Deep Neural Networks (DNNs) have been shown to provide solutions for ergonomic assessment. These algorithms for automated ergonomics estimate human pose and motion with remarkable precision, analyze the recorded posture through calculating body angles, and apply standardized assessment techniques, such as Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA), Ovako Working Posture Analysis System (OWAS) or The European Assembly Work-sheet (EWAS). AI technology can support traditional ergonomic methods and increase precision while reducing the time needed for assessment. Potentially, such AI tools may present a more accessible alternative to expert evaluations, therefore benefiting all stakeholders.

However, while these systems can adeptly identify ergonomic problems, they do not necessarily explain and guide the worker in adjusting their posture. In AI-driven solute-ions, the primary function is limited to highlighting areas of concern or potential risk. This approach does not currently benefit workers, as identifying a problem without a solution leaves them in a quandary. The reliance on human expertise post-diagnosis, much like in the application of EWAS, RULA or REBA, underscores the fact that the automation process in ergonomics is still in its infancy. The real value for workers would come from a system that pinpoints the issues and offers tangible solutions to rectify them.

This position paper examines the methodological challenges of current AI-based tools for automated ergonomics assessment. More specifically, we investigate usability shortcomings of the current state of the technology and how these tools meet the requirements of workers. Based on this, we formulate a new design blueprint to enhance the effectiveness of future automated ergonomics solutions to safeguard the well-being of workers better. Towards a future that moves beyond computational diagnostics, we emphasize corrective ergonomics with a pronounced focus on explainability and adopting interpretable AI techniques in ergonomics. This should ensure that the benefits of ergonomic advancements are felt directly by those on the front lines, fostering a more holistic and practical technology adoption.

2. Background

The integration of Artificial Intelligence (AI) in ergonomics represents a leap in the field, transforming how ergonomic analyses are conducted and implemented. Driven by the advancements in image analysis, AI techniques such as human pose estimation offer an automated way of extracting postural data from video streams. This way, large amounts of data can be generated without human supervision, which can be analyzed using traditional ergonomic risk assessment methods such as EWAS or RULA. The availability of algorithms such as OpenPose (Kim et al. 2021), which are open-source and compute 2D postural data, inspired early applications that apply traditional ergonomics assessment methods like RULA on the body angles computed from the 2D data (Cao et al. 2019). However, the limitations of 2D postural assessment, such as depth perception and the inability to fully interpret complex poses, highlight the need for more accurate methods. This has led to research focusing on 3D models for postural reconstruction, paired with observational assessment techniques, as seen in a study by Paudel et al. (2021), where the paper exemplifies the integration of 3D human pose estimation for ergonomics purposes.

While prior research mostly applied traditional observational techniques to estimate ergonomic scores from AI-computed postural data, a different line of work (Parsa et al. 2019, Parsa & Banerjee 2020) focused on models for classifying movements into low, medium and high-risk motions and predicting the ergonomic scores as a regression problem. Their algorithms aim to improve accuracy and efficiency by using an end-to-end deep learning approach instead of traditional assessment techniques like EWAS or RULA, which might not be well suited for AI-based postural data.

However, as the use of AI has led to increased data generation, the complexity of AI-based ergonomic assessment is constantly rising. This complexity poses high data interpretation requirements. Thus, these algorithms still rely on expert post-diagnosis. To date, research on aiding diagnosis and making AI-based ergonomic assessment more interpretable has been limited. One such work, ErgoExplorer (Fernández et al. 2023), introduced a system that uses AI to assess postures from a video and subsequently presents complex ergonomic data through coordinated multi-dimensional visuals. This enables an in-depth analysis of complex data. ErgoMaps (Kostolani et al.

2022) presents a different approach, which also uses AI to evaluate postural data paired with RULA for ergonomic assessment, followed by visualizations in the form of heatmaps. Unlike ErgoExplorer, which is suited for in-depth analysis, ErgoMaps aims to break down the complexity of the generated data, offering an easily interpretable result. Although both approaches aim to support diagnosis and understanding, they mainly aim at experts. Adopting AI technologies that facilitate understanding and support workers in implementing correct ergonomic movements is necessary to improve workplace ergonomics and prevent musculoskeletal disorders.

3. EPA Loop: From Postural Diagnostics towards Actionable Hints

Current advancements in AI research have led to sophisticated solutions that generate extensive data. While this offers immense potential for in-depth analysis, the complexity of such data can be overwhelming for workers, making it difficult for them to grasp and utilize these insights effectively and limiting the usability of such applications. In response to this usability crisis in AI-based ergonomics, we summarize the challenges in a new design blueprint called the EPA Loop. The EPA Loop encompasses Evaluation, Problem Identification, and Action and aims to enhance practical and understandable AI solutions designed for workers instead of ergonomic experts. Rather than viewing the EPA as a rigid framework, we see it as a set of challenges that need to be addressed in future research. The EPA Loop is presented in Figure 1. In this approach, we envision the future of AI-based ergonomics, not just as diagnostic applications. We believe that diagnostics, although necessary, cannot accomplish the goal of ergonomics on its own. Instead, AI solutions should offer holistic solutions to ergonomic challenges, such as explaining problem areas to the worker or guiding workers towards practical corrective actions. This would mark a significant shift from traditional ergonomic assessments, which often stop at quantifying ergonomic risk, leaving workers without clear guidance on how to improve their work environment and work posture.

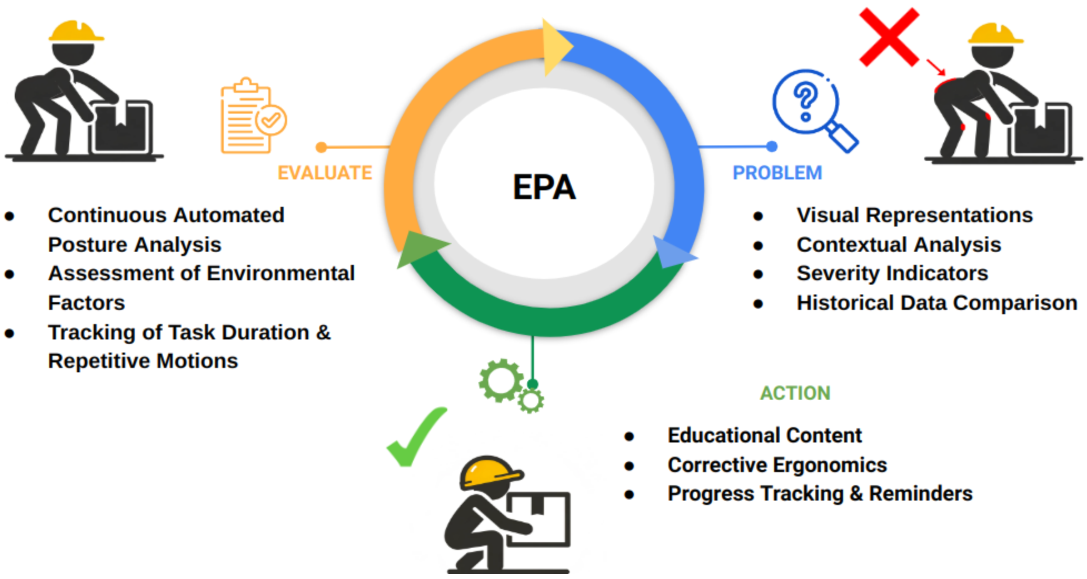

Figure 1: *Proposed EPA Loop, including future building blocks for each stage*

3.1 Evaluation

The Evaluation phase of the EPA Loop serves to quantify the severity of ergonomic risk at the workplace. Prior works (Paudel et al. 2021, Parsa et al. 2019) have shown that AI-based techniques can be deployed for precise risk quantification. However, the quantification of postural risk represents the current endpoint in current ergonomic research. We believe that AI-based ergonomic tools should go beyond simple observation by incorporating environmental assessment tools that provide insights into the workspace setup, a crucial factor in ergonomic health. Such environmental factors can include assessment of light conditions or noise levels, both possible via cameras and acoustic feature extraction. Moreover, we believe that continuous or periodic monitoring is a key feature for tackling MSDs. This would enable the system to track changes and adjust recommendations as necessary. We suggest using cameras for continuous monitoring, unlike many researchers that utilize wearable sensors like IMUs, as cameras are less obtrusive and do not require any calibration.

Furthermore, we believe it is important to include factors such as task duration and repetitive movements. These factors are already considered in most observational methodologies, such as the European Assembly Worksheet (EAWS), and they are acknowledged as key factors contributing to musculoskeletal disorders. Although the recognition of task duration is already possible with state-of-the-art AI models, AI-based ergonomic research still does not include this assessment. Therefore, to enable more sophisticated risk analysis, we propose the integration of human action recognition into ergonomic assessment. Overall, we sum up three methodological recommendations for future research on AI-based ergonomic evaluation:

- Implement continuous or periodic monitoring to track changes over time and adjust recommendations accordingly.
- Strive for an assessment beyond postural analysis, including AI-based recognition of noise level or assessment of light conditions via cameras.
- Consider the duration of tasks and the presence of repetitive motions, which can be recognised via human action recognition.

3.2 Problem Identification

Prior works in AI-based ergonomic research stop at the evaluation phase, which results in quantifying risk scores. However, computing numerical risk levels does not necessarily transfer to a better understanding of the underlying risk factors. Therefore, we believe that the Problem Identification phase of the EPA Loop is essential for educating workers about the risks associated with their posture and work habits. In this phase, data visualization can be crucial in simplifying and clarifying the ergonomic issues identified during the Evaluation phase. Techniques like heat maps and coloured key point diagrams can be used to pinpoint specific problem areas, making it easier for workers to understand the impact of their postures on their health. This phase highlights the problematic aspects and provides context and education about the potential long-term effects of poor ergonomics. Moreover, solutions should guide workers in understanding the severity of the risk. This would enable workers to focus on the most important ergonomic issue. By visually representing the data, this phase aims to enhance workers’ awareness and comprehension of ergonomic risks, setting the stage for effective corrective actions in the subsequent phase. We provide four recommendations on how to foster more efficient problem understanding:

- Use visual representations like heat maps or coloured key points to highlight problem areas visually.
- Classify problems by severity with easily understandable colour coding (e.g., red for high risk).
- Provide context for why certain practices are problematic, linking to potential health issues or decreased productivity.
- Compare historical data and show trends over time, indicating whether the ergonomic situation is improving or worsening

3.3 Action

After understanding the underlying risks for MSDs, workers will need actionable guidance in implementing countermeasures. In the Action phase of the EPA Loop, we advise implementing personalized interactive guides demonstrating corrective ergonomics and making complex adjustments understandable and applicable.

Progress should be continuously tracked to achieve optimal ergonomics in the long run, with the system sending reminders for reassessment or alerting workers to poor ergonomic practices. Workers should also gain access to educational materials about ergonomics, enhancing their understanding of good practices. These may involve possible adjustments to workstations, changes in work practices, or specific exercises to reduce strain and encourage better posture over time.

The phase culminates with tailored corrective ergonomic advice and strategies, directly addressing identified issues and promoting healthier work habits. With the progress in large language models, we believe that AI that generates textual explanations might be a viable approach for implementing actionable guidance. This would ensure that ergonomic improvements are identified and implemented in the workplace. Hence, we formulate three recommendations for future research:

- Include corrective ergonomic advice and strategies, such as interactive personalized tutorials, to offer workers actionable guidance. These can be implemented via novel AI models, such as textual recommendations based on image detection.
- Implement a system to track progress and send reminders for reassessment when poor ergonomic behavior is detected.
- Provide access to educational materials about ergonomics.

4. Discussion and Future Work

Workers are not only the ones who are affected by MSDs but also the ones who need to adjust their work posture and work habits to prevent MSDs in the long run. However, current research on AI techniques in ergonomics is mostly aimed at improving diagnostics and evaluation. As such research tools are designed for expert ergonomists, we do not believe this will translate into better work conditions. In this paper, we highlight the challenges that need to be overcome for workers to benefit from novel AI techniques in ergonomics. In particular, we identified problem identification, understanding of ergonomic risks, and providing actionable guidance as the main factors for future research. Most importantly, we stress the need to focus on workers as the most relevant stakeholders in ergonomic research, making AI solutions worker-centric rather than expert-centric.

In the future, we aim to develop new methods per the proposed EPA Loop. Our current work focuses on creating educational visualizations based on the camera stream, analyzing workers' postures in real-time. To make AI-based ergonomics techniques more ubiquitous, we aim to deploy this method as a mobile app to increase outreach and make ergonomic research more accessible to those on the front lines. Future work could also implement novel corrective ergonomics methods, such as generative AI, that can transform incorrect work postures into correct ones and highlight the differences.

5. Conclusion

Our position paper highlights the need for additional support to translate ergonomic diagnostics into actionable steps for workers. Ergonomics technology must become more accessible to the everyday worker rather than exclusive to ergonomics professionnals. Our proposed design blueprint aims to guide future research in AI-based ergonomics to make the researched solutions more user-friendly for workers. This accessibility ensures that the benefits of ergonomic advancements are felt directly by those on the front lines, fostering a more holistic and practical technology adoption.

6. Literature

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