

## **A preventive and participatory approach to ergonomics through simulated and immersive environments**

Maria Pia Cavatorta <sup>1</sup>

Federico Manuri <sup>2</sup>

Andrea Sanna <sup>2</sup>

Sebastiano Lamacchia <sup>3</sup>

Chiara Carnazzo <sup>4</sup>

Stefania Spada <sup>4</sup>

<sup>1</sup>Politecnico di Torino, Department of Mechanical and Aerospace Engineering, Torino, Italy

<sup>2</sup>Politecnico di Torino, Department of Control and Computer Engineering, Torino, Italy

<sup>3</sup>Digital Factory, Competence Industry Manufacturing 4.0, Torino, Italy

<sup>4</sup>Wellbeing and Health & Safety – Ergonomics, Stellantis Enlarged Europe, Torino, Italy

**Introduction:** Promoting musculoskeletal health through preventive ergonomics is essential in a manufacturing world of increasing competitiveness, demand for high productivity and flexibility, and steadily increasing worker age.

Virtual Reality (VR) technologies are transforming ergonomics and the way companies can assess human-workplace interaction and hazards at the early stage of design, enabling significant reductions in the time and high cost of physical prototypes.

**Methods:** An HTC Vive headset and Leap Motions controllers allow users to immerse themselves in the virtual environment and to manipulate digital objects with hand movements. Data from RGB cameras and wireless IMU sensors track and register the whole-body movements and postures of the user, which is reconstructed as a mannequin in the virtual environment. Visual cues, i.e. highlighted and colour-coded elements in the 3D space, facilitate interaction between the user and the simulated environment and enhance the immersive experience.

**Results:** Use cases developed in the company explored simulated and immersive environments for a variety of applications, which included workplace design, automated risk assessment and on-the-job training. A Unity-based framework implements several modules to support the various applications. Thus, for example, motion capture data can be returned in terms of values of the joint angles defined according to relevant ISO and CEN standards and support ergonomists in compiling risk assessment methods, become instant feedback to workers in training through colour-coded visual cues, or animate virtual mannequins of different anthropometric percentiles to test reachability and body space issues in workplace design.

**Discussion:** Recent studies have shown the potential of integrating new technologies into ergonomic assessment and training, however, the transition from the laboratory stage to implementation in industrial settings poses points of attention that need to be addressed to foster adoption. Engagement and discussion with the various stakeholders, i.e. manufacturing engineers, ergonomists, work analysts, and workers, are necessary for understanding their needs and what aspects need to be improved to promote industrial applicability.

**Conclusion:** In a changing world of work, the same new technologies that are contributing to its transformation can provide valuable assistance in promoting a preventive and participatory approach to ergonomics and inclusive workplaces and possibly to prevent musculoskeletal disorders. VR technologies available today provide immersive and interactive environments that can support compliance with ergonomics principles at the early design stage and serve for workers to identify potential hazards to their musculoskeletal health and adopt safer work practices.