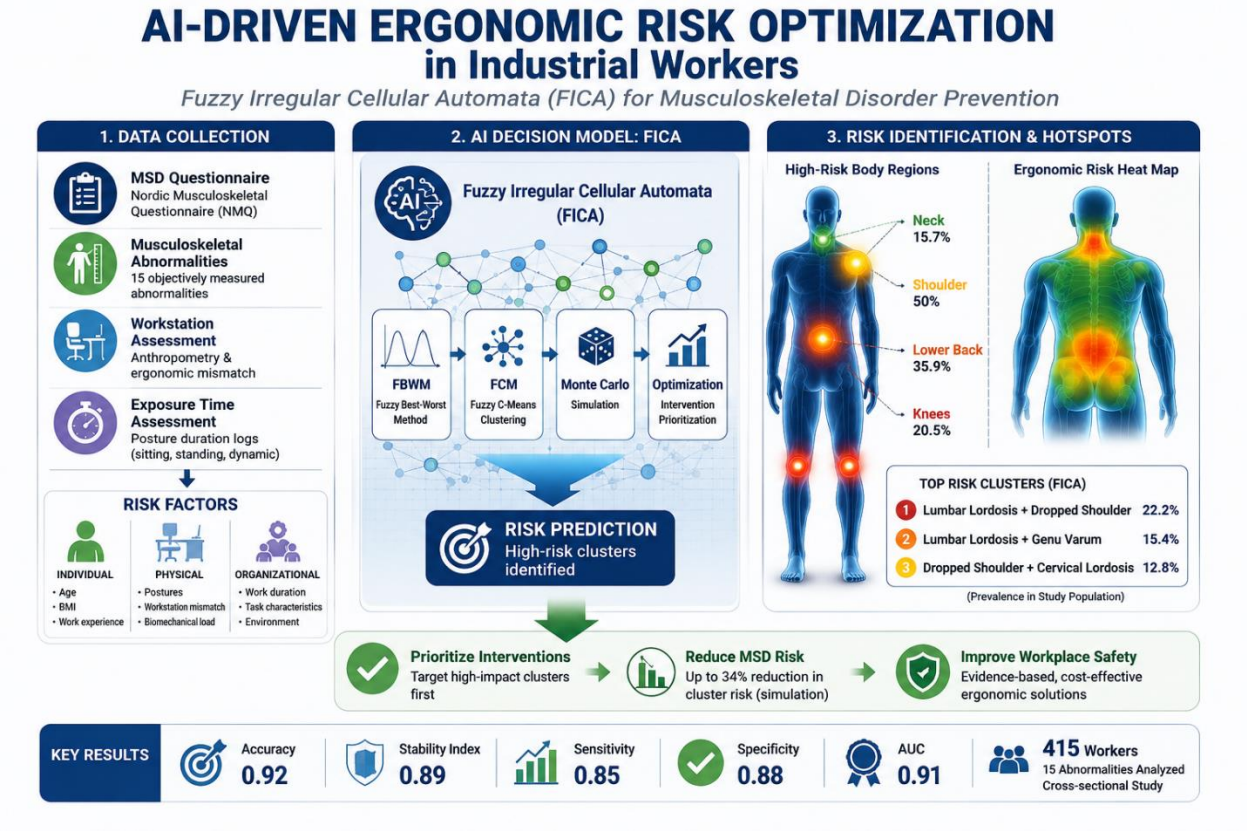
Post in x

This study demonstrates that integrating artificial intelligence with ergonomic risk assessment provides a powerful approach for identifying and prioritizing the factors contributing to work-related musculoskeletal disorders in industrial workers. By combining advanced decision-making and predictive modelling techniques, the proposed framework enables more accurate risk evaluation, supports evidence-based intervention planning, and helps optimize preventive strategies. The findings highlight the potential of AI-driven ergonomics to improve occupational health, reduce musculoskeletal injury risk, and promote safer and more sustainable workplaces.
DOI: 10.1038/s41598-025-28916-4



scientific reports

OPEN

Optimizing ergonomic risk assessment using fuzzy irregular cellular automata: a novel approach to modeling musculoskeletal disorders in industrial workstations

Mostafa Kashani[1], Asma Zare[2]✉, Seddigheh Barzekar[3], Masoud Bagheri Jaamebozorgi[4], Mohammad Ali Moradpour[5] & Mojtaba Sadeghi[6]

Musculoskeletal disorders (MSDs) and structural musculoskeletal abnormalities cause substantial work-related pain, disability, and productivity loss in industrial workforces; traditional screening tools and single-variable analyses can miss complex, interdependent risk patterns that arise from combined biomechanical exposures, workstation mismatches, and worker characteristics. We aimed to develop and validate a data-driven framework — Fuzzy Irregular Cellular Automata (FICA) — to integrate multi-modal ergonomic measurements, detect high-risk abnormality clusters, quantify their associations with MSDs and demographic predictors, and prioritize targeted ergonomic interventions. Comprehensive data were collected from 415 supervisory/administrative workers (15 objectively measured abnormalities; self-reported MSDs via the Nordic questionnaire; workstation anthropometry; exposure-time logs). FICA represented the inputs as a fuzzy graph and applied Mamdani inference with a voting/colouring routine (FICAVCA) to identify clusters and rank interventions. Model validation used repeated 10-fold cross-validation and benchmarking against alternative algorithms. FICA identified interpretable high-risk clusters (e.g., lumbar lordosis + dropped shoulder, 22.2%) and demonstrated strong predictive performance (accuracy = 0.92; stability index = 0.89). Multivariate analyses confirmed BMI, age, and work experience as key predictors (R^2 = 0.43, $p < 0.001$); BMI ≥ 30 increased odds of lumbar lordosis (OR = 2.3) and genu varum (OR = 1.9). Model-based intervention simulations estimated prioritized workstation and exercise interventions could reduce cluster risk by up to ≈ 34% (scenario projections). FICA provides an interpretable, scalable method to translate multimodal ergonomic data into prioritized, resource-efficient interventions. Longitudinal trials are needed to validate projected intervention effects.

Keywords Musculoskeletal disorders, Musculoskeletal abnormalities, Fuzzy irregular cellular automata, Ergonomic risk assessment, Occupational health