Digital Twin‐Driven, Human‐Centric Ergonomic Risk Forecasting in Manufacturing Assembly: Collective Case Study

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**Abstract.** This study adopts a collective case study methodology to explore the application of digital twin (DT) technologies for human-centric ergonomic risk forecasting in manufacturing assembly environments. By analyzing three dis- tinct automotive and industrial manufacturing companies with varying sizes, sectors, digital maturity levels, and workstation organizations, the research in- vestigates how digital twins (DTs) and associated digital human models (DHMs) are utilized to anticipate, assess, and mitigate ergonomic risks on the assembly line. Through within-case and cross-case analyses, the research identi- fies key themes around ergonomic risk identification, DT deployment, and hu- man–machine interaction strategies tailored to different operational contexts. The findings highlight the role of advanced digital tools, including sensor net- works, biomechanical simulations, and real-time monitoring, in enabling proac- tive ergonomic interventions that align with Industry 5.0 principles. This com- parative approach provides valuable insights into how digital transformation drives ergonomic improvements and worker well-being across diverse manu- facturing settings.

**Keywords:** Ergonomic Risk Forecasting, Collective Case Study; Digital Twin; Human- Machine Collaboration; Manufacturing Assembly, Industry 5.0.