**Research Project**

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# AI-Enhanced Ergonomic Risk Assessment: Application of AI-Based Posture Recognition for Preventing Work-Related Musculoskeletal Disorders

## 1. Introduction

Work-related musculoskeletal disorders (WMSDs) are one of the most common occupational health concerns globally, contributing to significant disability, absenteeism, and reduced productivity. According to the World Health Organization (WHO, 2023), over 1.7 billion people worldwide suffer from musculoskeletal conditions, many linked to occupational risk factors such as poor posture, repetitive strain, and prolonged static positions.

In the modern digital era, the shift toward desk-based and remote work environments has amplified these risks. Studies have reported that up to 70% of office workers experience neck, shoulder, or lower back discomfort due to sustained poor ergonomics (Punnett & Wegman, 2019). Conventional ergonomic assessments, which rely on manual observation or self-reporting, are limited by subjectivity, time constraints, and small sample coverage.

Recent advancements in Artificial Intelligence (AI)—particularly in computer vision and machine learning—offer transformative opportunities for occupational health. AI-based posture recognition systems can analyze real-time video feeds, identify postural deviations, and deliver personalized ergonomic feedback without requiring physical supervision. Integrating this technology with physiotherapy expertise and public-health frameworks creates a novel, scalable approach for preventing WMSDs at a population level.

## 2. Background and Rationale

Physiotherapy plays a pivotal role in the prevention and management of musculoskeletal disorders through evidence-based rehabilitation, ergonomic education, and functional restoration. However, due to limited access to physiotherapists in workplaces—especially in low-resource or remote areas—preventive care often occurs too late, after symptoms develop.

Meanwhile, public health aims to promote well-being and prevent disease across communities, aligning perfectly with the physiotherapy goal of early intervention. Combining physiotherapy with AI-driven digital tools enables data-driven public health surveillance, identifying ergonomic risks before they become clinical issues.

AI-based posture recognition systems, using frameworks such as OpenPose, MediaPipe, or TensorFlow PoseNet, can analyze joint positions, detect spinal alignment errors, and quantify ergonomic deviations. When integrated with physiotherapy guidelines, these systems can

provide automated risk assessment and tailored corrective advice—empowering individuals and organizations to take preventive action.

# 3. Research Aim

To develop and evaluate an AI-based posture recognition system capable of detecting poor ergonomic patterns among desk-based workers and providing corrective feedback to prevent work-related musculoskeletal disorders.

# 4. Objectives

1. To determine the prevalence and nature of postural deviations in office and remote-working populations.
2. To design and implement an AI computer-vision model for automatic posture recognition and ergonomic risk classification.
3. To incorporate physiotherapy-based corrective feedback algorithms into the AI system.
4. To compare the accuracy and effectiveness of AI-based assessments with manual ergonomic evaluations.
5. To evaluate the usability, preventive outcomes, and scalability of the system from a public-health perspective

# 5. Research Questions

1. How accurately can AI-based posture recognition detect ergonomic risk factors compared to physiotherapist assessment?
2. Can automated feedback based on physiotherapy principles improve posture and reduce WMSD symptoms?
3. What is the potential of AI-enhanced ergonomic assessment as a preventive public-health intervention?

# 6. Methodology

## 6.1 Study Design

A quantitative, comparative validation study conducted in an occupational setting over 8–10 weeks.

## 6.2 Population and Sampling

- Participants: 150 desk-based workers (aged 20–45 years), including both office and remote employees.
- Sampling Technique: Stratified random sampling based on work type and duration of computer use.
- Inclusion Criteria: Adults working ≥6 hours/day in sedentary environments with no acute musculoskeletal injury.
- **6.3 Intervention & Procedure**

**Phase 1: Baseline Assessment**

- Participants will undergo an ergonomic assessment using two methods:

1. **Manual evaluation** by a licensed physiotherapist using standardized tools (Rapid Upper Limb Assessment – RULA and REBA).
2. **AI-based assessment** using a computer-vision model (MediaPipe / OpenPose) via webcam recordings during work tasks.

**Phase 2: Feedback & Correction**

1. The AI system will analyze postures and generate feedback such as:

- Real-time notifications for slouching or forward head posture.
- Suggested ergonomic adjustments (chair height, monitor angle).
- Prescribed micro-stretching exercises curated by physiotherapists.

**Phase 3: Follow-Up Evaluation**

1. After 4 weeks, participants will be reassessed using both manual and AI evaluations. Self-reported discomfort and ergonomic awareness will also be recorded through the **Nordic Musculoskeletal Questionnaire (NMQ)**.

### 6.4 Tools and Technology

- AI Framework: OpenPose / MediaPipe (for joint detection and posture analysis).
- Programming Environment: Python, TensorFlow, OpenCV.
- Statistical Software: SPSS for data analysis.

### 6.5 Data Analysis

- Descriptive Statistics to determine prevalence of postural deviations.
- Paired t-test for pre-post intervention differences.
- Cohen's Kappa coefficient to evaluate agreement between AI and physiotherapist assessments.
- Regression Analysis to determine predictors of ergonomic improvement.

## 7. Expected Outcomes

1. Development of a validated AI posture-assessment tool capable of detecting ergonomic deviations with ≥90% accuracy.
2. Statistically significant reduction in self-reported musculoskeletal discomfort after four weeks of AI-guided feedback.
3. Evidence supporting the cost-effectiveness and scalability of AI for workplace health promotion.
4. A framework for integrating AI-driven ergonomic surveillance into occupational health and tele-rehabilitation programs.

## 8. Public Health Significance

Work-related musculoskeletal disorders impose substantial economic and health burdens, particularly in developing countries where access to ergonomic interventions is limited. Implementing an AI-based posture recognition system offers several public-health benefits:

- Early Detection & Prevention: Enables proactive risk identification before clinical symptoms arise.
- Scalability: AI-based monitoring can reach large populations across diverse workplaces.
- Equity: Low-cost digital accessibility ensures inclusion of remote and underserved populations.
- Policy Integration: Data generated can inform national occupational health policies and ergonomic regulations.

This aligns with the goals of the WHO Rehabilitation 2030 initiative, which advocates integrating rehabilitation and preventive care into universal health coverage, and supports Sustainable Development Goal 3: Good Health and Well-Being.

## 9. Role of Physiotherapy

Physiotherapists will play an essential role in ensuring clinical accuracy, safety, and relevance of AI interventions:

- Defining biomechanical parameters (joint angles, ergonomic thresholds).
- Providing ground-truth data for AI model training and validation.
- Designing evidence-based corrective exercises and ergonomic advice.
- Evaluating improvement outcomes and patient adherence.

This collaboration highlights how AI amplifies physiotherapy precision while physiotherapists provide the human clinical judgment AI alone cannot replicate

## 10. Ethical Considerations

- Informed Consent: Participants will be informed about data recording and confidentiality.
- Data Privacy: Video data will be anonymized and securely stored.
- Non-Maleficence: AI feedback will be validated by physiotherapists to prevent misuse or injury.
- Ethical Approval: To be obtained from an institutional review board before commencement .

## 11. Limitations

- Dependence on camera quality and environmental lighting. AI’s
- limited ability to detect internal muscular strain or fatigue.
- Short-term duration may not reflect long-term postural habits.

## 12. Conclusion

Artificial Intelligence is redefining the landscape of preventive healthcare. By combining AI's computational power with physiotherapy's human insight and public health's population focus, this research envisions a future where digital ergonomics becomes a global preventive health tool.

The proposed AI-based posture recognition system is not merely a technological innovation—it is a public health advancement, capable of reducing the burden of musculoskeletal disorders, promoting workplace wellness, and supporting inclusive, data-driven rehabilitation strategies for all.

## References (APA 7th Edition)


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