



Smart Ergonomics in Physiotherapy: From Reactive Injury Prevention to Predictive Occupational Health

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Opinion

Volume 10 Issue 3

Received Date: July 22, 2026

Published Date: August 07, 2026

DOI: [10.23880/eoj-16000352](https://doi.org/10.23880/eoj-16000352)

Abstract

Physiotherapists play a fundamental role in maintaining and restoring patients' physical function, yet their own occupational health is frequently compromised by work-related musculoskeletal disorders (WMSDs). Repetitive manual therapy, patient handling, awkward postures, and prolonged static positions contribute to one of the highest injury rates among healthcare professionals. Despite increasing awareness of ergonomic principles, implementation of effective preventive strategies remains limited. Recent advances in wearable technologies, artificial intelligence (AI), computer vision, and digital motion analysis offer an opportunity to transform traditional ergonomics into "smart ergonomics" as a technology-assisted, data-driven approach to occupational health. This opinion article discusses how emerging digital technologies could improve the safety and sustainability of physiotherapy practice while highlighting current barriers to implementation and future research priorities.

Keywords: Physiotherapy; Ergonomics, Occupational Health; Wearable Sensors; Artificial Intelligence; Musculoskeletal Disorders; Digital Health

Introduction

Physiotherapists are trained to improve movement, reduce pain, and enhance patients' quality of life [1]. Ironically, their professional activities often expose them to considerable physical strain. Numerous studies have demonstrated that physiotherapists experience high rates of work-related musculoskeletal disorders, particularly affecting the lower back, neck, shoulders, wrists, and thumbs [2-5]. These injuries not only reduce professional longevity but also contribute to absenteeism, decreased productivity, and reduced quality of patient care. Traditional ergonomic interventions have focused primarily on education, body mechanics, and workplace organization [6]. While these approaches remain important, they rely heavily on individual compliance and subjective assessment. Rapid technological

advances now provide opportunities to continuously monitor physical workload, identify hazardous movement patterns, and deliver personalized ergonomic recommendations in real time [7].

We argue that physiotherapy should embrace the concept of smart ergonomics, integrating digital technologies with ergonomic principles to better protect healthcare professionals.

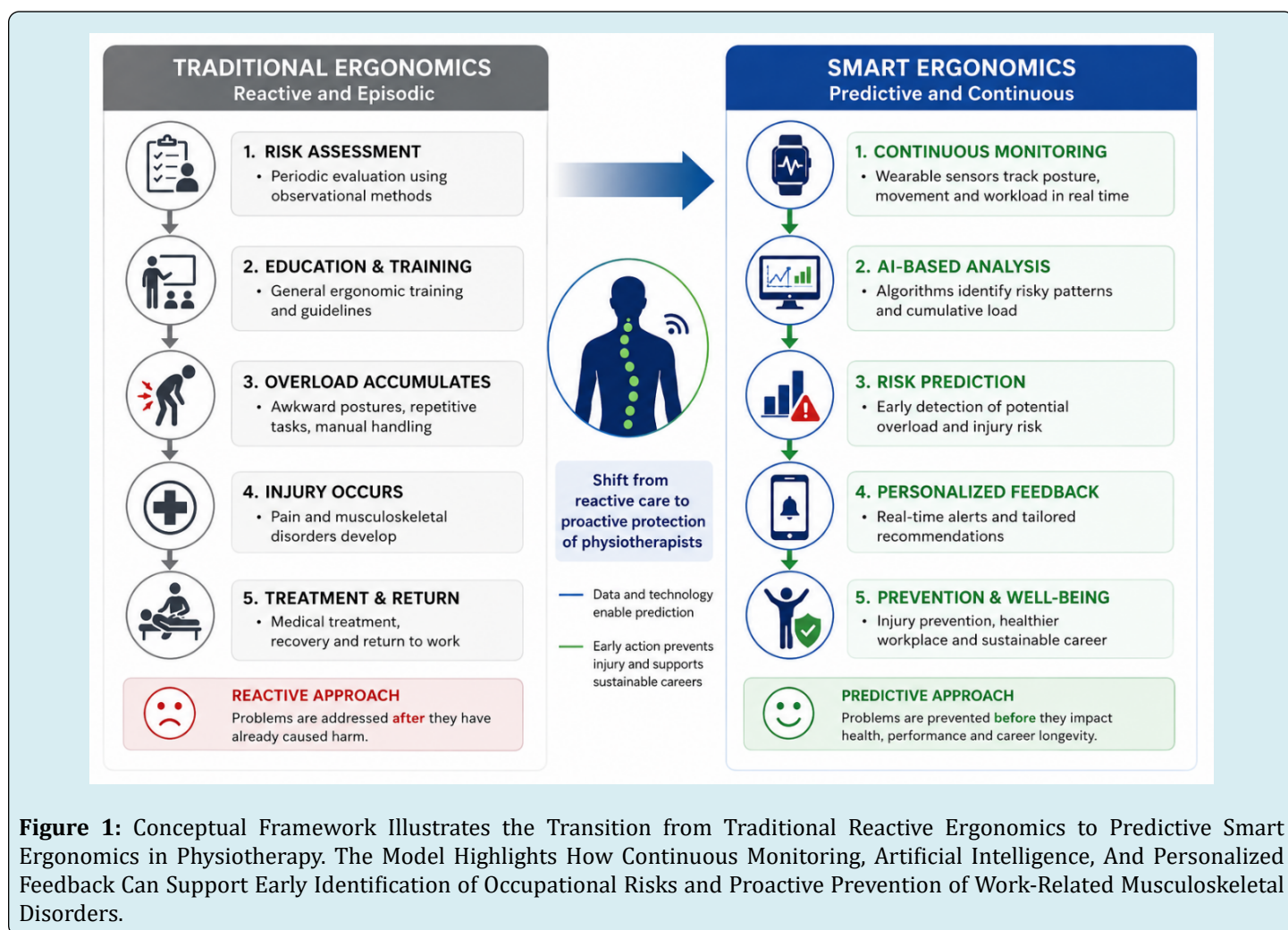
Why Current Ergonomic Approaches are not Enough

Conventional ergonomic training teaches physiotherapists how to lift patients safely, maintain neutral posture, and organize their workplace efficiently

[8]. However, these recommendations often prove difficult to implement consistently in busy clinical environments. Patient characteristics vary substantially, treatment sessions are dynamic, and many manual techniques require sustained force production or awkward positioning [9]. Consequently, even experienced clinicians frequently adopt biomechanically unfavorable postures without recognizing them. Moreover, ergonomic risk assessment is commonly performed only occasionally using observational methods [10]. Such evaluations provide valuable information but cannot capture cumulative physical loading occurring throughout weeks, months, or years of professional practice.

Smart Ergonomics: A New Perspective

Smart ergonomics extends traditional ergonomic principles through continuous monitoring, intelligent data analysis, and personalized feedback [11]. Unlike conventional ergonomic approaches, which are primarily reactive, smart ergonomics integrate wearable sensors, artificial intelligence, and digital health technologies to predict occupational risks before injuries occur. The conceptual transition from traditional to smart ergonomics is illustrated in Figure 1.



Several emerging technologies have particular relevance for physiotherapy. Wearable inertial sensors can continuously measure body posture, trunk inclination, joint angles, movement frequency, and cumulative physical workload [12]. Real-time feedback may alert clinicians whenever harmful postures persist beyond predefined thresholds [13]. Computer vision systems combined with marker less motion capture allow detailed biomechanical analysis without

requiring cumbersome laboratory equipment [14]. Such systems could objectively evaluate therapists' movement patterns during clinical procedures. Artificial intelligence algorithms may identify hidden patterns associated with injury risk by integrating biomechanical, occupational, and environmental data [15]. Predictive models could estimate cumulative overload before symptoms develop, enabling preventive interventions [16]. Smart pressure sensors

incorporated into treatment tables or footwear may provide additional information regarding weight distribution and therapist positioning during manual therapy [17]. Together, these technologies shift ergonomics from reactive injury management toward proactive injury prevention.

Opportunities for Clinical Practice

The integration of digital technologies into physiotherapy offers several practical benefits. First, objective monitoring enables individualized ergonomic assessment rather than relying solely on generalized recommendations [18]. Second, real-time feedback encourages behavioral modification during routine clinical practice rather than after injuries have already occurred [19]. Third, longitudinal monitoring allows early identification of increasing biomechanical strain, supporting timely workplace modifications [20]. Finally, aggregated data collected from multiple therapists could inform evidence-based redesign of clinical workstations, treatment protocols, and educational programs [21]. Importantly, these technologies should complement not replace the clinical expertise and professional judgment of physiotherapists.

Challenges and Ethical Considerations

Despite considerable promise, implementation of smart ergonomics presents several challenges. Cost remains a significant limitation, particularly for smaller rehabilitation clinics [22]. Healthcare organizations must evaluate whether technological investments produce measurable improvements in occupational health and long-term economic benefits [23]. Privacy is another important issue. Continuous monitoring generates sensitive information regarding workers' performance and behavior [24]. Data governance policies must ensure that monitoring serves injury prevention rather than employee surveillance [25]. Artificial intelligence systems also require rigorous validation before clinical implementation [26]. Algorithms trained using limited datasets may not generalize across different patient populations, healthcare settings, or therapeutic techniques [27]. Finally, successful adoption depends on user acceptance. Technologies perceived as intrusive or overly complex may encounter resistance from healthcare professionals [28].

Future Directions

The future of physiotherapy ergonomics will likely involve increasingly integrated digital ecosystems. Wearable devices, motion analysis systems, electronic health records, and AI-powered decision support may eventually function together to create individualized ergonomic risk profiles for every therapist [29]. Virtual reality and augmented reality

platforms may further improve ergonomic education by providing immersive training environments where clinicians can practice optimal body mechanics while receiving immediate feedback [30]. Future research should move beyond descriptive studies toward prospective clinical trials evaluating whether smart ergonomic interventions reduce injury incidence, improve work satisfaction, and extend professional careers [31]. Interdisciplinary collaboration among physiotherapists, ergonomists, engineers, computer scientists, and occupational health specialists will be essential to realize these opportunities [32].

Conclusion

Physiotherapists dedicate their professional lives to improving the physical health of others, yet their own occupational health often remains insufficiently protected. Traditional ergonomic strategies, although valuable, are no longer sufficient to address the complexity of modern clinical practice. Smart ergonomics represents an important evolution, combining wearable technologies, artificial intelligence, computer vision, and continuous biomechanical monitoring to create proactive, personalized approaches to injury prevention. The successful implementation of these technologies requires scientific validation, ethical governance, and close collaboration between healthcare professionals and technology developers. Rather than replacing human expertise, smart ergonomics should empower physiotherapists to work more safely, sustainably, and effectively. Protecting the health of physiotherapists is ultimately an investment in the quality, continuity, and resilience of patient care.

References

1. Khalid MT, Sarwar MF, Sarwar MH, Sarwar M (2015) Current role of physiotherapy in response to changing healthcare needs of the society. *Int J Educ Inf Technol* 1(3): 105-110.
2. Cromie JE, Robertson VJ, Best MO (2000) Work-related musculoskeletal disorders in physical therapists: prevalence, severity, risks, and responses. *Phys Ther* 80(4): 336-351.
3. Vieira ER, Schneider P, Guidera C, Gadotti IC, Brunt D (2016) Work-related musculoskeletal disorders among physical therapists: A systematic review. *J Back Musculoskelet Rehabil* 29(3): 417-428.
4. Buczaj A, Pecyna A, Krzywicka M, Kobus Z, Choina P, et al. (2024) Analysis of work-related ailments affecting physiotherapists. *Ann Agric Environ Med* 31(3): 417-425.

5. Kotnik P, Koprivnik N (2024) Musculoskeletal Disorders in the Workplace of Physiotherapists: Occupational Risk Factors and Their Role in Prevention and Management: A Systematic Review. *Open Access Maced J Med Sci* 12(2): 347-355.
6. Adiga U (2023) Enhancing occupational health and ergonomics for optimal workplace well-being: a review. *Int J Chem Biochem Sci* 24(4): 157-164.
7. Hilmi AH, Hamid ARA, Ibrahim WARAW (2024) Recent advancements in ergonomic risk assessment: integration of artificial intelligence, wearable technology, and industry-specific approaches. *Malaysian Journal of Ergonomics* 6: 65-75.
8. Harithasan D, Pei Sean L, Singh DKA (2025) Unveiling the key elements of effective preventive strategies: Insights into addressing work-related musculoskeletal disorders among physiotherapists. *Work* 82(1): 130-143.
9. Ede SS, Sinclair JK, Dickinson M, Chohan A (2026) Challenges and best practices during manual handling for patient positioning in long-term care settings: a scoping review. *Phys Ther Rev* 31(3): 163-179.
10. Nyman T, Rhén IM, Johansson PJ, Eliasson K, Kjellberg K, et al. (2023) Reliability and Validity of Six Selected Observational Methods for Risk Assessment of Hand Intensive and Repetitive Work. *Int J Environ Res Public Health* 20(8): 5505.
11. Płaza G, Kabiesz P, Thatcher A, Jamil T (2025) Ergonomics/human factors in the era of smart and sustainable industry: industry 4.0/5.0. *Manag Syst Prod Eng* 33(2): 229-238.
12. Huang X, Xue Y, Ren S, Wang F (2023) Sensor-Based Wearable Systems for Monitoring Human Motion and Posture: A Review. *Sensors* 23(22): 9047.
13. Figueira V, Silva S, Costa I, Campos B, Salgado J, et al. (2024) Wearables for Monitoring and Postural Feedback in the Work Context: A Scoping Review. *Sensors* 24(4): 1341.
14. Wade L, Needham L, McGuigan P, Bilzon J (2022) Applications and limitations of current markerless motion capture methods for clinical gait biomechanics. *PeerJ* 10: e12995.
15. Souaifi M, Dhahbi W, Jebabli N, Ceylan Hİ, Boujabli M, et al. (2025) Artificial Intelligence in Sports Biomechanics: A Scoping Review on Wearable Technology, Motion Analysis, and Injury Prevention. *Bioengineering* 12(8): 887.
16. Nagra H, Goel A, Goldner D (2022) Reducing treatment burden among people with chronic conditions using machine learning. *JMIR Biomed Eng* 7(1): e29499.
17. Afolabi TO, Mbada CE, Jubril A, Timothy A, Egwu OM (2023) Development and Validation of Digital Pressure Sensor Machine to Measure Forces Applied During Manual Therapy-A Preliminary Study. *J Pain Manage Therapeutic Care* 2(1): 109.
18. Brosche J, Wackerle H, Augat P, Loedding H (2024) Individualized workplace ergonomics using motion capture. *Appl Ergon* 114: 104140.
19. Nirvik P, Kertai MD (2022) Future of perioperative precision medicine: integration of molecular science, dynamic health care informatics, and implementation of predictive pathways in real time. *Anesth Analg* 134(5): 900-908.
20. Babangida AA, Caraballo-Arias Y, Decataldo F, Violante FS (2025) Advancing occupational medicine through wearable technology: A review of sensor systems for biomechanical risk assessment and work-related musculoskeletal disorder prevention. *ACS Sensors* 10(8): 5410-5432.
21. Chawla K, Furlong R, Kamo N, Gerbino I, Smith D, et al. (2022) Clinical spotlight intervention to accelerate translation of evidence-based practices in primary care. *BMJ Open Qual* 11(4): e002032.
22. Jordan N, Deutsch A (2022) Why and how to demonstrate the value of rehabilitation services. *Arch Phys Med Rehabil* 103(7): S172-S177.
23. Bushnell PT, Pana-Cryan R, Howard J, Quay B, Ray TK (2022) Measuring the benefits of occupational safety and health research with economic metrics: Insights from the National Institute for Occupational Safety and Health. *Am J Ind Med* 65(5): 323-342.
24. Shi G, Pang H, Xie Z (2024) How does workplace digital monitoring activate employees' unethical behavior. *Curr Psychol* 43(46): 35390-35405.
25. Khan MNI (2022) A Systematic Review of Legal Technology Adoption in Contract Management, Data Governance, And Compliance Monitoring. *Am J Interdiscip Stud* 3(01): 01-30.
26. El Arab RA, Abu-Mahfouz MS, Abuadas FH, Alzghoul H, Almari M, et al. (2025) Bridging the Gap: From AI Success in Clinical Trials to Real-World Healthcare Implementation—A Narrative Review. *Healthcare* 13(7): 701.

27. Abdel-Jaber H, Devassy D, Al Salam A, Hidaytallah L, EL-Amir M (2022) A Review of Deep Learning Algorithms and Their Applications in Healthcare. *Algorithms* 15(2): 71.
28. Iyanna S, Kaur P, Ractham P, Talwar S, Islam AN (2022) Digital transformation of healthcare sector. What is impeding adoption and continued usage of technology-driven innovations by end-users? *J Bus Res* 153: 150-161.
29. Mehmood F, Mumtaz N, Mehmood A (2025) Next-Generation Tools for Patient Care and Rehabilitation: A Review of Modern Innovations. *Actuators* 14(3): 133.
30. Chu CH, Pan JK, Chen YW (2025) Ergonomic workplace design based on real-time integration between virtual and augmented realities. *Robot Comput-Integr Manuf* 92: 102859.
31. Krishnanmoorthy G, Rampal S, Karuthan SR, Baharudin F, Krishna R (2025) Effectiveness of participatory ergonomic interventions on work-related musculoskeletal disorders, sick absenteeism, and work performance among nurses: Systematic review. *JMIR Hum Factors* 12(1): e68522.
32. Kakaraparthi VN, Gannamaneni VK, Reddy RS, Alahmari KA, Tedla JS, et al. (2025) Enhancing physiotherapy department design to prevent work-related musculoskeletal disorders: Vision of future research. *Work* 81(3): 3083-3087.