AI-BASED ERGONOMICS APPS

Why Biomechanics Demands a Certified Professional Ergonomist

By Brock Anderson

In today's fast-paced industrial landscape, the allure of ergonomic assessment applications that utilize artificial intelligence (AI) is undeniable. These tools promise rapid screening, attractive dashboards and data-driven prioritization, often at a fraction of the cost of a full, on-site evaluation (Scataglini et al., 2025).

In many organizations, that promise is real: Automated workflows can accelerate first-look assessments, help triage high-volume work areas and support program tracking at scale (Scataglini et al., 2025). Yet, as organizations move from screening to decision-making and from identifying awkward postures to validating risk and selecting controls, one truth remains clear: Certified professional ergonomists (CPEs) offer irreplaceable value that no algorithm can replicate (BCPE, n.d.; IEA, n.d.).

Ergonomics, especially as it pertains to risk, is not a posture-counting exercise. It is applied human science. It blends biomechanics, engineering, work design and cultural adoption (Marras, Lavender et al., 1993; Marras & Sommerich, 1991). When we ask a system to declare something as "high risk," we are implicitly asking it to predict tissue loading, fatigue and exposure severity across time, outcomes that depend on forces and multi-axis movement, not just joint angles (Faber et al., 2018; Marras, Lavender et al., 1993).

This article makes the case for a modern "AI + CPE" model that uses AI for high-velocity screening and workflow efficiency and a BCPE-certified professional to validate findings, contextualize risk and guide sustainable interventions (BCPE, n.d.; Scataglini, 2025). The purpose is not to diminish technology, but to put it in the correct lane. The best ergonomics programs will be those that marry the speed of software with the reasoning and accountability of qualified professionals (BCPE, n.d.; IEA, n.d.).

Properly Used AI Apps Can Improve Ergonomics

AI-based ergonomics tools are improving, and their practical value is easiest to see in three areas.

1. High-velocity screening at scale. Camera-based motion capture and automated scoring workflows can scan many workstations quickly and flag outliers for deeper review (Scataglini, 2025). Systematic review evidence comparing markerless and marker-based camera systems in industrial ergonomic risk analysis highlights the growing feasibility of camera-based approaches—especially as a scalable alternative when used appropriately (Scataglini, 2025).

2. Consistency in basic observational scoring. When the task is primarily to consistently apply a standardized observational rubric, software can reduce variability, particularly among novice users (Balogh et al., 2025). Research comparing rapid entire body assessment scoring by raters of different expertise levels and an AI system found very high repeatability for the software and identified body regions where agreement was stronger or weaker (Balogh et al., 2025).

3. Trend detection and program management. Many tools provide dashboards linking assessment results with injury reports and leading indicators. This can support prioritization, resource allocation and post-implementation tracking (Scataglini, 2025).

These benefits are meaningful, but they live mostly in the screening and workflow lane. The moment an organization expects an app to validate biomechanical risk with confidence, especially across complex manual tasks, the physics becomes unavoidable (Faber et al., 2018; Marras, Lavender et al., 1993).

Biomechanics Risk Is Not Fully Visible in Posture Scores

Many widely used ergonomics methods (e.g., rapid upper limb assessment, rapid entire body assessment, Ovako working posture analysis system) were designed to be practical, quick and observational (Balogh et al., 2025; Scataglini et al., 2025). These ergonomic assessment tools are used to evaluate a person's posture, movement and force exertion, especially related to the upper body (e.g., neck, shoulders, arms, wrists, trunk). They can be valuable for communication and screening, but they also simplify a multifactor loading problem into discrete posture categories (Figure 1), meaning they miss other important factors such as muscle effort (e.g., force) and the repetition of the movement (Scataglini et al., 2025). When an AI app primarily transforms video into posture scores, it risks validating appearance rather than loading (Faber et al., 2018; Marras, Lavender et al., 1993).

A posture score can look "moderate" while internal loading is high due to:

- load magnitude and load moment arm (e.g., reach distance; Marras, Lavender et al., 1993; Waters et al., 1994)
- acceleration and deceleration (e.g., dynamic effects; Marras, Lavender et al., 1993)
- asymmetry and trunk twisting (Marras, Lavender et al., 1993; Waters et al., 1994)
- co-contraction patterns (e.g., a stiffening strategy that elevates spine loading; Marras, Knapik et al., 2009)
- friction and push and pull force demands (ISO 2007; Marras, Knapik et al., 2009)
- individual anthropometrics and technique (Waters et al., 1993; Waters et al., 1994)

Occupational biomechanics has repeatedly demonstrated that dynamic, three-dimensional trunk motion characteristics coupled with workplace factors distinguish high-risk from low-risk lifting jobs (Marras, Lavender et al., 1993). That means static snapshots and single-plane assumptions can miss key risk drivers (Marras, Lavender et al., 1993; Marras & Sommerich, 1991).

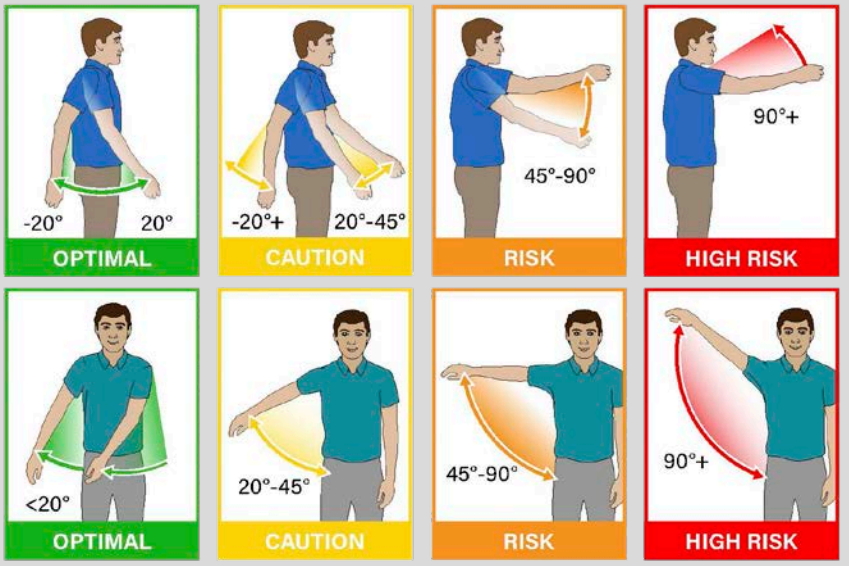
Validation Requires Forces & Multi-Axis Kinematics, Not Just Joint Angles

In biomechanics and engineering, "validation" is not a marketing label. It refers to whether a method produces results that remain accurate under the conditions in which it will be used, and whether those results correspond to meaningful physical quantities (Faber et al., 2018; Scataglini et al., 2025). Risk validation requires that the model be consistent with physics:

- kinematics: how segments move in three dimensions (including velocity and

FIGURE 1

POSTURE SCORE POSITIONING EXAMPLES (SHOULDERS & ARMS)



acceleration; Faber et al., 2018; Marras, Lavender et al., 1993)

•external forces: what loads are applied, in what direction and through what moment arms (Faber et al., 2018; ISO 2007)

•kinetics: the resulting net joint moments, powers and internal loading estimates (Faber et al., 2018)

A cornerstone method in biomechanics is inverse dynamics, where measured kinematics and external forces are used to calculate net joint torques and powers (Faber et al., 2018). However, even in controlled research settings, kinematics and forces may be inconsistent due to modeling assumptions and measurement error—prompting research into algorithms that enforce mechanical consistency between kinematics and external forces (Faber et al., 2018). The important takeaway for workplace ergonomics is simple: If we do not measure or estimate forces, and if we do not capture multi-axis movement accurately, our risk estimates can be physically incomplete (Faber et al., 2018; Marras, Lavender et al., 1993).

In occupational settings, the spine is not a two-dimensional problem. Biomechanical models have long emphasized that real work imposes loads under dynamic, three-dimensional conditions (Marras, Lavender et al., 1993; Marras & Sommerich, 1991). Researchers described a model capable of estimating lumbar compression, shear and torsional forces continuously throughout an exertion, because occupational tasks frequently involve asymmetric and multi-plane motion (Marras & Sommerich, 1991). If a system cannot represent multi-axis loading, it can underrepresent risk in exactly the types of tasks that drive musculoskeletal disorders (Marras, Lavender et al., 1993; Marras & Sommerich, 1991).

Dynamic Three-Dimensional Motion & Force Drive Injury Risk

Dynamic three-dimensional trunk motion predicts low back disorder risk beyond static guidelines. In large-scale in vivo industry research spanning hundreds of repetitive lifting jobs, Marras, Lavender et al. (1993) found that a combination of workplace and trunk motion factors such as lifting frequency, load moment, trunk lateral velocity, trunk twisting velocity and trunk sagittal angle distinguished high-risk from low-risk jobs. Importantly, the authors noted that current ergonomic techniques relying on static assessments may be problematic because dynamic characteristics can increase spine loading and injury risk.

Pushing and pulling are not automatically safer than lifting. Marras, Knapik et al. (2009) showed that anterior and posterior shear forces along the lumbar spine can be substantial and influenced by speed, control requirements, load magnitude and handle height. These findings matter because organizations sometimes utilize "lift-to-push" as an intervention; however, if the push requires high force or control under awkward geometry, shear loading can remain concerning (ISO, 2007; Marras, Knapik et al., 2009).

Standards emphasize force as central, not optional. ISO 11228-2, Ergonomics—Manual Handling Part 2: Pushing and Pulling provides recommended limits for whole-body pushing and pulling and bases its guidance on experimental studies of musculoskeletal loading, discomfort and pain, and endurance and fatigue (ISO, 2007). Likewise, the revised NIOSH lifting equation is grounded in biomechanical, physiological and psychophysical criteria and incorporates task variables such as asymmetry, coupling, frequency and duration (Waters et al., 1993; Waters et al., 1994). The entire point of these approaches is that risk is multi-factorial and cannot be reduced to posture alone (Waters et al., 1993; ISO, 2007).

Why Markerless Systems Struggle Where Risk Often Lives

Even if it is agreed that kinematics and forces matter, the reality of measurement—that field environments are messy—remains (Brunner et al., 2022; Scataglini et al., 2025).

Markerless systems can struggle with occlusion and rotation. Occupational tasks often involve tools, boxes, racks, PPE and partial views (Brunner et al., 2022; Steinebach et al., 2020). Research

USING AI WITH HUMAN OVERSIGHT

•**Use AI for screening.** Deploy AI tools to rapidly screen high-volume work areas, flag outliers and prioritize tasks for deeper ergonomic review.

•**Look beyond posture scores.** Do not treat a posture score as a complete measure of risk; consider load magnitude, reach distance, acceleration, twisting, friction, push and pull forces, repetition, and individual differences.

•**Validate forces and motion.** For higher-stakes risk decisions, ensure that the assessment accounts for external forces and dynamic, three-dimensional movement—not just joint angles or static postures.

•**Check measurement conditions.** Before relying on camera-based results, evaluate whether lighting, viewpoint, occlusion, clothing and task conditions could compromise accuracy, particularly for trunk rotation.

•**A CPE should make decisions.** Use a certified professional ergonomist to interpret findings, determine when more rigorous analysis is needed, apply relevant standards and translate data into practical interventions.

•**Build an AI + CPE workflow.** Let AI accelerate screening and prioritization, then have a CPE validate exposures, guide controls and periodically reassess whether interventions are producing sustained risk reduction.

evaluating markerless motion capture for occupational practice found major inaccuracies in capturing axial trunk rotation, raising the concern that health risks could be underestimated (Brunner et al., 2022). Another study reported that occlusion can significantly decrease accuracy for certain markerless systems (Steinebach et al., 2020).

Even marker-based motion capture has limitations due to soft tissue artifact. Biomechanics literature has been direct about this: Markers placed on skin move relative to bone due to skin deformation and soft tissue movement. Reviews of stereophotogrammetry and soft tissue artifact caution that motion about axes other than primary flexion and extension can be especially unreliable (Camomilla et al., 2017; Leardini et al., 2005). If high-control laboratory methods must work hard to manage these artifacts, real-world industrial video inputs must be treated with appropriate caution (Camomilla et al., 2017; Scataglini et al., 2025).

The implication is not that motion capture is useless, rather that validity is conditional. A responsible program asks under what lighting, viewpoint, occlusion, clothing and task conditions a system remains accurate, especially for the axes and segments that drive risk (Brunner et al., 2022; Scataglini et al., 2025).

The Core Gap: AI Often Measures Motion, But Risk Requires Loading

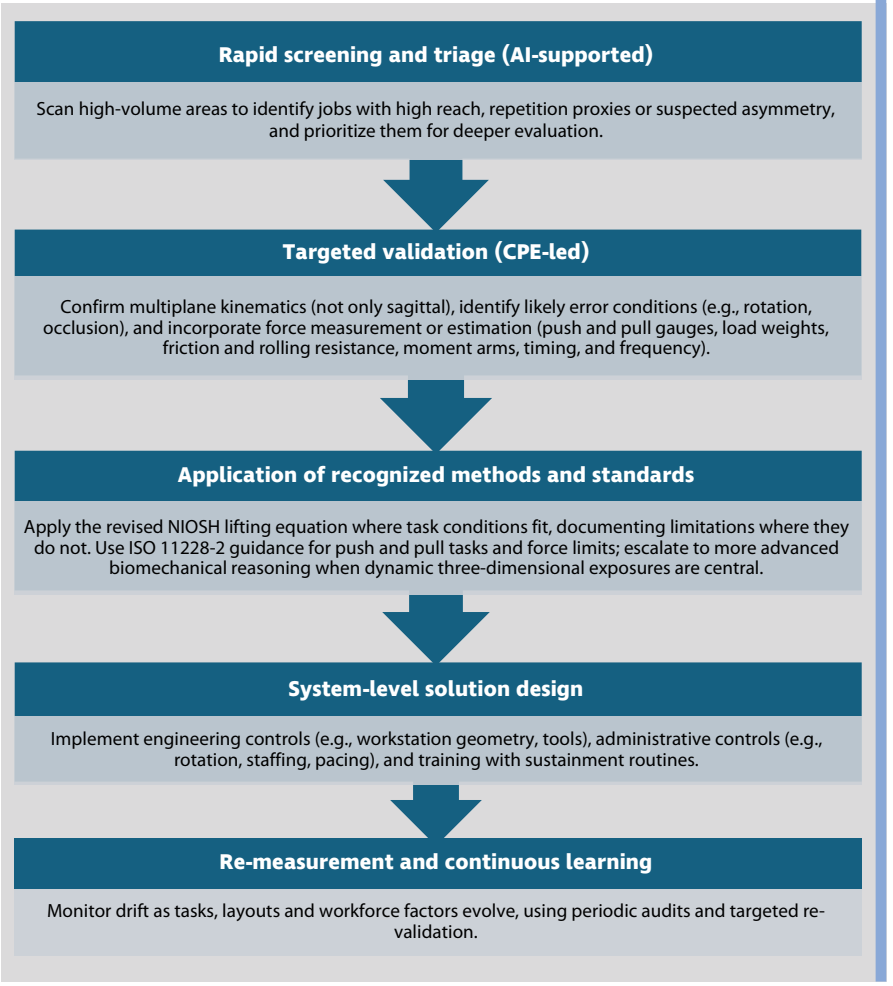
The central biomechanics argument is straightforward: Risk validation requires the physics of loading (e.g., forces, moments, multi-axis movement (Faber et al., 2018; Marras & Sommerich, 1991). Posture alone is insufficient, and kinematics alone is incomplete without force (ISO, 2007; Waters et al., 1993).

Consider common examples:

- A 40° trunk bend holding 5 lb is not the same as a 40° trunk bend holding 50 lb (Waters et al., 1993).
- A shoulder at 70° flexion with no load is not the same as a shoulder at 70° flexion holding a vibrating tool (Scataglini et al., 2025).
- A push with the force of 120 N sustained is not the same as a force of 120 N peak to initiate motion (ISO, 2007).
- Twisting slowly is not the same as twisting rapidly under load (Marras, Lavender et al., 1993).

This is why ISO standards treat force as central and why NIOSH-based guidance incorporates load, geometry, frequency, and asymmetry (ISO, 2007; Waters et al., 1993). When an AI app provides a posture score without validating external forces and multi-axis dynamics, it is not truly validating biomechanical risk, rather it is flagging potential concerns (Faber et al., 2018; Scataglini et al., 2025).

FIGURE 2
AI + CPE WORKFLOW



The CPE Remains Indispensable

The CPE fits exactly at the moment where data becomes decisions (BCPE, n.d., IEA, n.d.). BCPE (n.d.) describes board-certified human factors and ergonomics professionals as combining education and experience with knowledge of human capabilities, needs and limitations to optimize design, performance, safety and comfort. In an environment where software can be purchased by anyone, certification helps distinguish professionals with verified competency and a code-governed practice standard (BCPE, n.d.; IEA, n.d.).

In practice, the value of a CPE shows up in five critical ways.

- **A CPE validates meaning, not just measurements.** AI may report joint angles. A CPE asks whether the worker was rushing due to a line disruption, whether the posture is a rare jam-clear or a frequent exposure, whether equipment wear is causing compensation, whether the actual load is asymmetric in practice, and whether friction or maintenance issues elevate push and pull forces (ISO, 2007; Waters et al., 1993).
- **A CPE knows when observational tools are appropriate and when they are not.** Postural tools can help screen and communicate, but biomechanics evidence indicates that dynamic three-dimensional trunk motion can be central to low back disorder risk (Marras, Lavender et al., 1993). A CPE can identify when more rigorous analysis or direct

force measurement is warranted (Faber et al., 2018; Waters et al., 1993).

•A CPE integrates standards and defensibility. Certified professionals can align interventions with established guidance such as ISO manual handling standards and NIOSH lifting analysis while documenting where task conditions fall beyond a method's design scope (ISO, 2007; Waters et al., 1994).

•A CPE leads cultural adoption. Ergonomics is not only engineering, but behavior, training, maintenance, supervision and continuous improvement (BCPE, n.d.). Software cannot build trust or negotiate operational constraints. A CPE can (BCPE, n.d.; IEA, n.d.).

•A CPE protects organizations from automation bias. Dashboards look authoritative, but research shows that markerless systems can be inaccurate for trunk rotation and can degrade with occlusion (Brunner et al., 2022; Steinebach et al., 2020). A CPE provides the disciplined skepticism needed to prevent misprioritization and missed hazards (Brunner et al., 2022; Scataglini et al., 2025).

The AI + CPE Workflow

The best programs will not choose between technology and expertise. They will build governance where each is used for its strength (BCPE, n.d.; Scataglini et al., 2025).

The AI + CPE workflow (Figure 2) combines the speed of AI-enabled screening with the rigor of CPE validation and established biomechanical methods. AI is used up front to rapidly triage high-volume work and identify where risk is most likely, after which targeted human expertise confirms exposures, applies appropriate standards and guides solution design. The process is that iterative solutions are validated, and tasks are periodically re-evaluated to ensure sustained risk reduction as conditions evolve.

The Future Is Faster Data, Not Faster Certainty

AI-based ergonomic apps will continue to improve, and they should be part of many modern ergonomics programs (Scataglini et al., 2025). They are excellent accelerators for screening, basic consistency and program management (Scataglini et al., 2025). But the closer you get to risk validation, the more you must respect the physics and the evidence (Faber et al., 2018; Marras, Lavender et al., 1993).

Biomechanics shows that low back and musculoskeletal disorder risk is influenced by dynamic, multi-axis motion and workplace factors; that three-dimensional spine loading involves compression, shear and torsion; that markerless systems can struggle with rotation and occlusion; and that even gold-standard kinematics face soft tissue artifact (Brunner et al., 2022; Leardini et al., 2005; Marras, Knapik et al., 2009; Marras, Lavender et al., 1993). Standards and models such as ISO manual handling guidance and the revised NIOSH lifting equation exist precisely because force, geometry, frequency and asymmetry drive risk (ISO, 2007; Waters et al., 1993).

The best message to industry is not, "Do not use AI." It is, "Use AI to go faster, then use a BCPE-certified professional to go correctly" (BCPE, n.d.; IEA, n.d.). In ergonomics, the costliest errors are not slow assessments. They are confident, unvalidated decisions (Faber et al., 2018; Scataglini et al., 2025). **PSJ**

References

Balogh, D., Cui, X., Mayer, M., Koehncke, N., Dueck, R. & Lang, A.E. (2025). Reliability and agreement during the Rapid Entire Body Assessment: Comparing rater expertise and artificial intelligence. *PLOS ONE 20*(5): e0323262. https://doi.org/10.1371/journal.pone.0323262

Board of Certification in Professional Ergonomics (BCPE). (n.d.). https://bcpe.org

Brunner, O., Mertens, A., Nitsch, V. & Brandl, C. (2022). Accuracy of a markerless motion capture system for postural ergonomic risk assessment in occupational practice. *International Journal of Occupational Safety and Ergonomics, 28*(3), 1865-1873. https://doi.org/10.1080/10803548.2021.1954791

Camomilla, V., Dumas, R. & Cappozzo, A. (2017). Human movement analysis: The soft tissue artefact issue. *Journal of Biomechanics, 62*, 1-4. https://doi.org/10.1016/j.jbiomech.2017.09.001

Faber, H., van Soest, A.J. & Kistemaker, D.A. (2018). Inverse dynamics of mechanical multibody systems: An improved algorithm that ensures consistency between kinematics and external forces. *PLOS ONE, 13*(9), e0204575. https://doi.org/10.1371/journal.pone.0204575

International Ergonomics and Human Factors Association (IEA). (n.d.). Certification systems for professional ergonomists. https://iea.cc/leadership/education-certification/iea-recognized-and-endorsed-certification-systems-for-professional-ergonomists

International Organization for Standardization (ISO). (2007). Ergonomics—Manual handling part 2: Pushing and pulling (ISO 11228-2:2007). www.iso.org/standard/26521.html

Leardini, A., Chiari, L., Croce, U.D. & Cappozzo, A. (2005). Human movement analysis using stereophotogrammetry: Part 3: Soft tissue artifact assessment and compensation. *Gait and Posture, 21*(2), 212-225. https://doi.org/10.1016/j.gaitpost.2004.05.002

Marras, W.S., Knapik, G.G. & Ferguson, S. (2009). Loading along the lumbar spine as influenced by speed, control, load magnitude, and handle height during pushing. *Clinical Biomechanics, 24*(2), 155-163. http://doi.org/10.1016/j.clinbiomech.2008.10.007

Marras, W.S., Lavender, S.A., Leurgans, S.E., Rajulu, S.L., Allread, W.G., Fathallah, F.A. & Ferguson, S.A. (1993). The role of dynamic three-dimensional trunk motion in occupationally-related low back disorders. *Spine, 18*(5), 617-628. https://doi.org/10.1097/00007632-199304000-00015

Marras, W.S. & Sommerich, C.M. (1991). A three-dimensional motion model of loads on the lumbar spine: I. model structure. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 33*(2), 123-137. https://doi.org/10.1177/001872089103300201

Scataglini, S., Fontinovo, E., Khafaga, N., Khan, M.U., Khan, M.F. & Truijen, S. (2025). A systematic review of accuracy, validity, and reliability of markerless versus marker camera-based 3D motion capture for industrial ergonomic risk analysis. *Sensors, 25*(17), 5513. https://doi.org/10.3390/s25175513

Steinebach, T., Grosse, E.H., Glock, C.H., Wakula, J. & Lunin, A. (2020). Accuracy evaluation of two markerless motion capture systems for measurement of upper extremities: Kinect V2 and Captiv. *Human Factors and Ergonomics in Manufacturing and Service Industries, 30*(4), 291-302. https://doi.org/10.1002/hfm.20840

Waters, T.R., Putz-Anderson, V. & Garg, A. (1994). Applications manual for the revised NIOSH lifting equation. NIOSH. www.burgess-limerick.com/site/Resources_files/94-110.pdf

Waters, T.R., Putz-Anderson, V., Garg, A. & Fine, L.J. (1993). Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics, 36*(7), 749-776. https://doi.org/10.1080/00140139308967940

Brock Anderson, M.S., CPE, LSSBB, is the founder of Ergo-ology, Inc., where he leads strategic alignment of consulting services, manages a team of professional ergonomists, and supports technical projects to enhance human performance and productivity in industry. He previously served as global ergonomics program manager for Coca-Cola, an ergonomist advisor for NASA, and a corporate ergonomist at Gulfstream Aerospace. Anderson holds master's degrees in biomechanics and physiology from Auburn University.

Cite this article

Anderson, B. (2026, Nov.). AI-based ergonomics apps: Why biomechanics demands a certified professional ergonomist. *Professional Safety, 71*(11), 20-23.