

SCIENTIFIC FOUNDATIONS OF THE HARMONISATION OF ERGONOMICS, PRODUCTION, AND HUMAN HEALTH

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Abstract:

This article examines the relationship between ergonomics, production efficiency, and human health from both scientific and practical perspectives. The study rests on a straightforward premise: many workplace problems cannot be attributed solely to equipment failure or employee inattentiveness. In the majority of cases, the root cause lies elsewhere — in a workplace not adapted to the human being, a work pace that disregards physiological limits, an information flow that overwhelms the employee, and management that fails to identify hazards in time.

The novelty of the study lies in treating ergonomics not as a narrow subject concerned with desk or chair specifications, but as an integral part of occupational safety, productivity, the prevention of occupational diseases, and safety culture. The analysis draws on the following documents of the Republic of Uzbekistan: Law No. URQ-410 "On Occupational Safety"; the Labour Code approved by Law No. URQ-798; Resolution No. CMR-819 on occupational safety regulations; Resolution No. CMR-263 on workplace attestation; and ILO Convention No. 155 ratified by Law No. URQ-969. The analysis is further supported by international ergonomic standards, Resolution No. CMR-454 on occupational hygiene norms, and established findings from Russian and international ergonomics research.

Keywords: ergonomics; production; human health; occupational safety; hazard factors; workplace; fatigue; occupational risk assessment; labour productivity; prevention of occupational diseases.

1. Introduction

Ergonomics is widely — but mistakenly — reduced to desk heights and chair comfort. In reality, it is a broad, interdisciplinary science that investigates the balance among human beings, work tools, the production environment, and management decisions. It synthesises anthropometry, labour physiology, labour psychology, biomechanics, occupational hygiene, and human–machine interface principles into a coherent system [1], [2], [3].

Accordingly, ergonomic problems extend well beyond awkward postures or heavy loads. They are inextricably linked to the information environment in which decisions are made,

movement repetition, work pace, rest scheduling, microclimate, noise, lighting, psychological pressure, and the economic demands of production [4], [5]. For this reason, ergonomics cannot be separated from the occupational safety system: it constitutes the preventive core of that system.

The Law of the Republic of Uzbekistan "On Occupational Safety" regulates relations in the field of occupational safety and provides the legal foundation for ergonomics, since safe working conditions encompass more than protection from accidents and injuries. The long-term health of the employee, the preservation of working capacity, and the adaptation of the process to the human being are all elements of the same system [6].

The Labour Code defines labour relations, working and rest hours, employee rights, and employer obligations. This is where ergonomics acquires legal substance: an employer who demands results is equally obliged to account for the impact of working conditions on employee health — the central intersection of labour law and ergonomics [7].

Today, enterprise technologies are updated at a rapid pace. Automation, digital control, lifting-and-handling equipment, and computerised monitoring systems appear, at first glance, to lighten the burden of work. Yet they simultaneously generate new ergonomic hazards: prolonged static sitting, sustained screen exposure, pressure for rapid decision-making, monotonous movements, information overload, and the weight of heightened responsibility [8]. Technological progress, therefore, does not eliminate ergonomic hazards — it transforms their form.

This leads to the central research question: how can technical and organisational decisions aimed at increasing production efficiency be reconciled with human health, and what scientific basis does ergonomics provide for this reconciliation? A superficial answer is insufficient. Measures intended to raise productivity may yield short-term gains while causing substantial long-term damage through chronic fatigue, accumulating errors, occupational diseases, and staff turnover [9].

The aim of the study is to reveal the scientific foundations of the relationship among ergonomics, the production process, and human health, and to propose simple, practical criteria for assessing this harmony. The specific objectives are: to define the theoretical content of the ergonomic approach; to systematise the factors affecting employee health in the production environment; to demonstrate the link between current legislation and ergonomic requirements; to provide practical formulae and a matrix for risk assessment; to analyse ergonomic measures in relation to efficiency and occupational safety; and to identify openly the issues that remain unresolved [10].

Table 1. Scientific interpretation of key concepts

Concept	Definition	Role in the Study
Ergonomics	Studies the compatibility between human beings, work tools, and the production environment	Criterion for adapting the workplace to the human being
Production	An integrated set of technological, organisational, and economic processes	The unity of efficiency and safety
Human health	Stability of physical, mental, and occupational condition (WHO definition)	The ultimate social outcome of the system
Occupational	A system for ensuring safe	Regulatory and

safety	and healthy working conditions	managerial foundation
Occupational hazard	A factor that creates a probability of harm to an employee's health	Object of ergonomic assessment

2. Materials and Methods

The "Materials" component reviews applicable documents of the Republic of Uzbekistan, ratified international instruments — including ILO Convention No. 161 on Occupational Health Services and ILO Convention No. 187 on a Promotional Framework for Occupational Safety and Health — ergonomic standards including ISO 9241-210 on human-centred design, scholarly perspectives on occupational safety, and the criteria of production ergonomics. The "Methods" component employs systems analysis, normative-legal analysis, cause-and-effect analysis, point-based risk assessment, and comparative methods.

Only documents confirmed to be in force were included in the normative analysis. Foreign standards whose applicability within Uzbekistan's national legal system could not be verified were excluded from the normative framework. This caution is significant because ergonomics literature frequently cites ISO, EN, or GOST standards in general terms; when their status within the national legal system is unclear, the reliability of the analysis is compromised.

The attestation procedure prescribed by Resolution No. CMR-263 served as the methodological basis for assessing working conditions and workplaces. It legally consolidates the evaluation of injury hazard levels in working conditions and equipment. Resolution No. CMR-454 on sanitary norms and occupational hygiene rules supplemented this foundation by establishing permissible exposure limits for physical, chemical, and biological hazard factors directly relevant to ergonomic assessment. Ergonomic analysis deepens these assessments by revealing not only whether a hazard is present but also how it arises, the likelihood of recurrence, and the severity of consequences.

The regulations approved by Resolution No. CMR-819 establish the procedures for briefing, training, knowledge testing, and organising occupational safety activities within organisations. Ergonomic hazards are not solely a design issue — they are directly linked to employee knowledge, skill, and behavioural culture. Particular emphasis was therefore placed on the 'briefing → skill → supervision → reassessment' chain; when this chain breaks, even the most effective ergonomic solution produces no benefit.

The principal methods used, together with their advantages and limitations, are presented in Table 2. Their combined application allows the weaknesses of any single method to be offset by the strengths of another, thereby strengthening the reliability of the conclusions.

Table 2. Methods employed in the study

Method	Description	Advantage	Limitation
Systems analysis	Treats the human being, equipment, environment, and management as a single system	Reveals complex causal chains	Yields generalities without concrete data
Regulatory analysis	Links findings to applicable laws and resolutions	Provides legal credibility	May not cover subtle ergonomic

			nuances
Risk matrix	Assesses risk according to probability and severity of consequences	Clear and quick to apply	Prone to subjective assessment errors
Comparative analysis	Contrasts the existing and proposed states	Demonstrates the effectiveness of measures	Requires reliable empirical data

3. Results and Discussion

In-depth analysis of the normative-legal framework

Uzbekistan has no single dedicated code on ergonomics. Rather than weakening the subject, this situation requires ergonomics to be examined in conjunction with occupational safety, labour relations, production safety, and workplace assessment. Ergonomic requirements appear in legal texts — sometimes directly, sometimes indirectly — through concepts such as 'safe working conditions', 'assessment of working conditions', 'briefing', 'training', and 'prophylaxis'.

The value of Law No. URQ-410 from an ergonomic standpoint is that it frames the employer's responsibility for occupational safety not as a mere declaration but as a practical organisational obligation. This implies that the workplace is not simply a space where work is performed; it is an environment in which the employee's health must be actively preserved.

The Labour Code is the second essential pillar. Ergonomic hazards frequently arise from an improper allocation of working and rest time, an excessively prolonged shift, tasks assigned beyond the employee's competence, or inadequately assessed working conditions. While the Code governs labour relations in legal terms, ergonomics provides a scientific analysis of their biological, physiological, and technological consequences.

Resolution No. CMR-454 on sanitary norms and occupational hygiene is particularly relevant here. It sets permissible levels for noise, vibration, chemical substances, microclimate parameters, and other physical factors that constitute the environmental dimension of ergonomic risk. Without these normative thresholds, any ergonomic assessment of environmental hazards lacks a legally defensible reference point.

The regulations contained in Resolution No. CMR-819 play a decisive role in shaping ergonomic culture. Any technical solution that employees do not understand and that managers do not supervise will remain on paper. Briefing, training, and knowledge-testing processes must explicitly cover ergonomic hazards: improper working postures, safe manual-handling techniques, screen-work protocols, signal recognition, and safe movement must be demonstrated and practised hands-on.

Resolution No. CMR-263 is significant for ergonomics because it establishes the procedure for attesting workplaces with respect to working conditions and injury hazard levels. Attestation must not, however, become a formal exercise. It should function as a diagnostic instrument that reflects the actual state of the workplace, the physiological load placed on the employee, and the degree to which equipment has been adapted to the human being.

ILO Convention No. 155, ratified by Law No. URQ-969, aligns the national system with an international preventive approach. ILO Convention No. 161 on Occupational Health Services reinforces this by requiring the establishment of multidisciplinary occupational health services capable of addressing ergonomic hazards as part of routine health surveillance. ILO Convention

No. 187 on a Promotional Framework for Occupational Safety and Health further calls for a national preventive culture in which ergonomics is embedded within the overall management of occupational risks.

At the international technical standard level, ISO 9241-210 on human-centred design provides the methodological framework for designing work systems and interfaces that meet human capabilities and limitations. This standard directly underpins the ergonomic design of workplaces, control panels, and digital work environments — a dimension increasingly relevant in Uzbekistan's modernising industrial sector.

The overarching conclusion drawn from these sources is that high-quality ergonomics research must integrate three elements — a national legal foundation, interdisciplinary theoretical knowledge, and empirical observation at a specific production facility. When this triad is broken, the study devolves into either normative commentary, generality, or mere description, and loses its practical value.

Ergonomic assessment criteria

Three questions are central to ergonomic assessment: what movements does the employee perform; under what conditions are those movements repeated; and what effect do they have on the organism? These questions transform the observation of a work process from a simple inspection into a scientific diagnosis. The study proposes the following formula for quantitative ergonomic risk assessment:

$$R = P \times S \times E \quad (1)$$

where:

R — level of ergonomic risk;

P — probability of the hazard occurring;

S — severity coefficient of the consequences;

E — duration of the employee's exposure to the hazard (exposure coefficient).

The formula does not capture the full complexity of physiological processes, but it provides a practical criterion for rapidly screening workplace hazards and informing management decisions. Adding the exposure coefficient to the classical 'probability × severity' model accounts for the cumulative — that is, gradually accumulating — nature of ergonomic risk, a feature well-documented in the occupational health literature.

Results

The analysis confirms that ergonomics is directly related to production efficiency, yet this relationship is not mechanical. Making a workplace ergonomically more comfortable does not always raise productivity immediately, and initially demands additional time, resources, and training. Over the long term, however, a systematic economic and social benefit emerges through reduced chronic fatigue, fewer errors, a lower risk of injury, and greater employee accountability [11], [12].

The most significant finding is that ergonomic hazards are often hidden and imperceptible. Excessive noise, poor lighting, or an awkward working posture may not cause a serious incident within a single day. Over weeks and months, however, they progressively erode the employee's attentional stability, musculoskeletal integrity, visual function, and mental resilience [13], [14]. Ergonomic analysis must therefore encompass not only accident statistics but also occupational disease incidence, chronic fatigue syndrome, and employee complaint records.

Ergonomic deficiencies in the production environment are conveniently classified into four principal groups: physical load, environmental factors, cognitive load, and organisational load. Physical load arises from improper working postures, heavy manual handling, repetitive movements, and static strain. Environmental factors include noise, vibration, lighting,

microclimate, dust, and aerosols — all regulated by Resolution No. CMR-454. Cognitive load is associated with information overload, ambiguous signals and indicators, and the need for rapid decision-making. Organisational load results from an improper work schedule, excessive shift duration, inadequate rest intervals, and poorly structured supervision [15].

The normative-legal analysis yielded equally important findings. The legislation of the Republic of Uzbekistan, complemented by the international instruments analysed above, establishes an adequate legal and technical framework for the ergonomic approach. Ergonomic requirements in the applicable documents, however, are frequently expressed not through the word 'ergonomics' but through related concepts. The researcher's task is therefore to identify this latent legal-ergonomic connection and translate it into practice.

Table 3. Ergonomic Problems and Scientific Diagnosis

Ergonomic Problem	Observable Sign	Hidden Consequence	Scientific Diagnosis
Awkward working posture	Employee frequently bends or reaches	Chronic musculoskeletal strain	Workplace does not conform to anthropometric parameters
Repetitive movements	The same operation is repeated many times	Fatigue and occupational strain (RSI syndrome)	Job rotation is insufficient
Noise	Employee raises their voice to communicate	Reduced attention; elevated hearing threshold	Acoustic environment control is inadequate
Inadequate lighting	Employee squints to see	Visual fatigue and increased error rate	Visual ergonomics requirements are violated
Information overload	Operator monitors multiple indicators simultaneously	Decision quality deteriorates	Cognitive load is unmanaged

The relationship between economic and health indicators

Treating ergonomic measures purely as costs is a misleading framing. Adjusting desk height, installing a lifting-and-handling device, improving lighting, or revising the work schedule initially requires investment. However, these costs are recouped through reductions in work stoppages, errors, rework, injuries, sick leave, and staff turnover. International research consistently demonstrates positive returns on ergonomic investment over a three-to-five-year horizon. A straightforward model for calculating ergonomic measure effectiveness:

$$S = Y_0 - Y_1 \quad (2)$$

where:

S — economic benefit resulting from the measure;

Y_0 — annual losses without the measure;

Y_1 — annual losses after implementation of the measure.

Though simple, the formula clearly illustrates the comparison principle: the calculation is

not a mere tallying of costs but a consistent before-and-after comparison. The payback period for an ergonomic investment is determined as follows:

$$T = X / S_y \quad (3)$$

where:

T — payback period;

X — cost of implementing the measure;

S_y — net economic benefit obtained over the year.

If T proves excessive, the measure is re-examined or introduced in phases. Using these two formulae together allows a manager to justify an ergonomic investment on sound economic grounds.

Discussion

The dual nature of ergonomics must first be acknowledged. On one hand, it protects employees, preserves health, and reduces hazards. On the other, it serves the goal of increasing production efficiency. These two objectives do not always coincide automatically. Enterprises may, in pursuit of short-term targets, raise the work pace, shorten rest intervals, or assign multiple concurrent tasks to a single employee — all of which carry adverse ergonomic consequences.

The strength of the ergonomic approach is its refusal to accept "the employee made a mistake" as a sufficient explanation. Human error typically has deeper causes: a poorly designed interface, an inconvenient working height, an insufficiently lit area, confusing signals, a rushed schedule, or excessive psychological pressure. Scientific analysis must therefore examine the system — the workplace design, process layout, and management decisions — before attributing fault to the individual. This approach is fully consistent with the "Just Culture" and "Human Factors" principles of contemporary occupational safety, as articulated in seminal works by Rasmussen and Reason.

It is equally important, however, not to absolutise ergonomics. Eliminating every source of discomfort is impracticable. In construction, manufacturing, transport, and energy, certain operations inevitably entail a degree of physical or psychological load. The issue is not the load's existence but its remaining uncontrolled, unmeasured, and without prophylaxis. The objective of ergonomic safety is not to reduce the load to zero but to maintain it within limits that the employee can tolerate and recover from, as defined by ISO 9241 series standards.

When an enterprise genuinely values employee health, ergonomic decisions are visible in the workplace itself rather than on paper alone. Workers retrieve tools without excessive reaching; operators quickly identify required signals; heavy loads are moved by mechanised devices rather than manually; and managers treat a hazardous work pace not as 'diligence' but as a management failure. At this point, ergonomics becomes a tangible criterion of production culture.

ILO Convention No. 155 addresses occupational safety, hygiene, and the working environment at the level of state policy. ILO Convention No. 187 further reinforces this by requiring governments and employers to build a preventive safety culture as a systemic national priority. Uzbekistan's ratification and alignment with these instruments provides an important foundation for directing the national occupational safety system towards a more systematic and preventive approach. Ergonomics corresponds precisely to this preventive philosophy.

Table 5. Comparative Analysis of Ergonomic Approaches

Approach	Core Idea	Strength	Weakness
Technical approach	The problem	Precise	Excludes the

	resides in equipment and layout	measurement and redesign are feasible	employee's psychological state
Medical approach	The problem resides in employee health and occupational diseases	Essential for prevention	Identifies production causes too late
Managerial approach	The problem resides in the work schedule and supervision	Delivers a systemic solution	May overlook technical details
Integrated approach	Human being, equipment, environment, and management are assessed as a single system	The most comprehensive approach	Demands high expertise and a solid data base

The most consequential error in implementing ergonomic measures is merely listing them. Each measure must specify which hazard it addresses, who is responsible, by which indicator success will be assessed, and when the measure will be reviewed. Without this clarity, measures remain on paper and never reach practice.

Although this analysis illuminates the relationship among ergonomics, production, and human health comprehensively, several limitations must be acknowledged.

First, ergonomic assessment in many cases requires actual instrumental measurements: illuminance levels, noise indicators, microclimate parameters, load weights, movement repetition rates, anthropometric data, and health indicators — all of which are regulated under Resolution No. CMR-454 but require trained personnel and calibrated instruments to measure in practice.

Second, ergonomic benefits are not always immediately apparent. Following a workplace redesign, the employee undergoes an adaptation period. Productivity may temporarily decline — a signal not that the solution is flawed, but that the implementation stage must be carefully managed.

Third, the relationship between labour productivity and human health cannot be captured in a single formula. Equations such as $R = P \times S \times E$ and $T = X / S_y$ simplify decisions but cannot encompass the full complexity of biological, psychophysiological, and social factors. They must be regarded as instruments for rationalising management decisions rather than as absolute truths.

Fourth, ergonomics research in Uzbekistan is frequently conducted within the broader frameworks of occupational safety or life safety. For ergonomics to mature as an independent scientific discipline, more empirical observations, surveys, physiological measurements, and economic comparisons need to be conducted at real production facilities.

4. Conclusion

The harmonisation of ergonomics, production, and human health is one of the central questions in contemporary occupational safety science. The study demonstrates that ergonomics is not a narrow concept of workplace comfort but a management philosophy that unifies safety,

efficiency, and health. It places the human factor at the centre of the system and advances the principle of adapting the system to the human being.

When the production process is not adapted to human capacities, even the most advanced enterprise cannot function as a safe and efficient system. Awkward working postures, excessive repetitive movements, noise, inadequate lighting, information overload, and an improper work schedule initially appear as imperceptible problems, then manifest as fatigue, errors, injuries, occupational diseases, and significant economic losses.

The applicable normative-legal documents of the Republic of Uzbekistan provide an adequate legal framework for the ergonomic approach. Law No. URQ-410, the Labour Code approved by Law No. URQ-798, Resolution No. CMR-819, Resolution No. CMR-263, Resolution No. CMR-454, and ILO Convention No. 155 ratified by Law No. URQ-969, together with ILO Conventions No. 161 and No. 187 and ISO 9241-210, collectively consolidate the necessity of managing working conditions in a safe, healthy, and systematic manner. Connecting these instruments to real-world ergonomic analysis at every workplace remains the direct responsibility of researchers and practitioners.

The primary recommendation is this: at every production facility, ergonomic risk assessment must become a mandatory practical element of the occupational safety system, comprehensively addressing workplace dimensions, employee movements, repetitive operations, microclimate, noise, lighting, information load, and the work schedule. Only under this condition will ergonomics cease to be a standalone recommendation and become a genuine criterion of production quality.

Promising directions for future research include: establishing systematic ergonomic monitoring at real production facilities; deploying digital sensors to automatically analyse working posture and early indicators of fatigue; conducting long-term monitoring of the economic effectiveness of ergonomic interventions; and developing sector-specific ergonomic hazard maps for construction, manufacturing, and transport.

Practical Recommendations

1. Incorporate ergonomic observation into planned supervisory rounds. The occupational safety officer must monitor not only technical safety compliance but also working posture, range of movement, load duration, field of vision, and the rest schedule — systematically and in writing, in accordance with CMR-819 and CMR-454.

2. Treat employee feedback as a source of scientific data. Complaints of back pain, eye strain, or limb numbness should be viewed not as signs of personal weakness but as ergonomic signals about the workplace requiring investigation.

3. Align ergonomic measures with the financial plan. Quantifying a measure's impact — reduction in errors, fewer stoppages, less rework, lower sick-leave costs — integrates ergonomics into enterprise strategy and facilitates budget approval.

4. Pilot digital monitoring tools in a phased manner. Video surveillance, motion sensors, electronic checklists, and mobile surveys can substantially improve the accuracy of ergonomic analysis. These tools must be introduced transparently and with employee participation, in line with human-centred design principles [9].

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