Innovative: International Multi-disciplinary Journal of Applied Technology
(ISSN 2995-486X) VOLUME 03 ISSUE 12, 2025

THE IMPACT OF ERGONOMIC APPROACHES ON EFFICIENCY IN THE OCCUPATIONAL SAFETY SYSTEM

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Abstract:
The paper analyzes inventive approaches of ergonomics in improving occupational safety and labor productivity in the system of providing occupational safety. The impact of ergonomic working conditions on occupational risk of injury and illness, work fatigue, and performance measures are evaluated using theoretical as well as applied research. Features of assessment of ergonomic conditions are offered and the statistical processing of results of realization of the offers is carried out. The results revealed that the inclusion of ergonomics in the occupational safety system can contribute to a considerable increase in labor safety and work productivity.
Keywords: ergonomics, occupational safety, human factor, labor productivity, occupational risks.

Introduction

Occupational safety system is one of the key factors of sustainable socio-economic development in modern production and service practice. Despite numerous technological advances, unprecedented processes of automation and digitalization of workplaces, issues of human health and safety at labor for decades continue to remain in the spotlight. Every year, millions of workers are unable to work, or die from occupational diseases and industrial accidents [1].

Current occupational safety systems, on the other hand, are often only effective for the technical safety of production processes at best. However, scientific data indicate that the majority of risks associated with labor process development factor of human nature, and occur in development there will not be possible to take into account special aspects physiological, psychophysiological and psychological capabilities of a man [2]. Therefore, a holistic approach which driven by human capabilities and embedded in the workplace safety system has become indispensable.

From this perspective, ergonomics, the science of human interaction with technology and the work environment, has a seat at the table as one of the foundational elements in the development of OHS

systems. Not only does this attitude to ergonomics ensure labor safety, but it also ensures increasing of labor productivity, health preservation of the workers and production efficiency.

At the level of the Republic in 2023, the assessment of the assessment of the labor situation, the Law of the Republic of Uzbekistan 2023 "On Labor protection" and other regulatory legal acts were adopted [3]. In addition, Uzbekistan is also able to join to a number of international labor standards in the area of ILO conventions and recommendations [4]. Nevertheless, implementation of such ergonomic requirements is very sporadic in practice, and the ergonomics effectiveness for labor productivity have not been evaluated scientifically.

As it is obvious from this analysis of the scientific literature, it is one of ergonomic environment use absence that leads to fast fatigue of employees, low attention and high error probability in work process [5]. As a result, there will be an increase in occupational risks, an increase in occupational injuries and a decrease in productivity. So, whole-scientific research in the system of occupational safety to research the impact of ergonomic methods on performance is an urgent scientific task.

Research methodology

This study is large-scale scientific research the influences of ergonomics solutions in athlete and work workforce in the system of safety in occupation society. The research design developed in line with the research was of a corresponding mixed methods design in which single methods (theoretical analysis; empirical similar analysis methods) and data sources (questionnaires; based on statistical analysis methods) together [6].

A mixed approach is selected primarily because neither qualitative nor quantitative indicators alone can sufficiently measure the effectiveness of the ergonomic environment in the context of health and work. This was how subjective perceptions of employees came into play in the study along with technical and ergonomic conditions of workplaces.

Some experimental in nature, the research was experimental in the before and after comparison model. This practice is frequently used in Europe and serves as a standard when judging real-life ergonomic interventions [7].

The basis of the research comprised work situations of industrial companies and workers in them. The study involved 120 workers and specialists. Here are the components that comprised the sample:

• production operators;
• maintenance personnel;
• engineering and technical specialists.

Chose the demographic characteristics such as age, sex, years of work experience, and character of participants. A stratification method was used to ensure sample representativeness. This method enabled to asses most of the ergonomic parameters of workplaces [8].

Data collection methods. The study has used Just a few of data collection methods. To evaluate workplace ergonomic conditions, an ergonomic audit and direct observation using a developed checklist based on ISO 6385 and ISO 45001 international standards were performed. Parameters imposed by occupational geometry, ergonomics at the workplace, illumination and sound conditions, microclimatic parameters and interaction between operator and machine were evaluated in the audit. Workers were also evaluated through questionnaires on their fatigue, job satisfaction, attention and stress level on a five-point scale [9]. The physical volume of works, labour operations, and a coefficient of a time use of the working time according to production reports were observed for labour productivity (LP).

Calculation of the ergonomic condition index (ECI). To evaluate the overall ergonomic status of workstations, a new integral ergonomic condition index was developed. The index was computed with the following formula:

$$EHI = \Sigma(x_i \times w_i)$$

Where:

• EHI is the ergonomic condition index,

• x_i represents individual ergonomic indicators such as lighting, posture, and noise,

• w_i denotes the weight coefficient reflecting the importance of each indicator.

The coefficients were established by means of an expert evaluation technique, which is commonly used in European countries in ergonomic research [10].

Ergonomic interventions. In the second stage of the study, ergonomic measures were taken such as: application of anthropometric standards to workplace height and sitting surface; formulating work movements, standardization of light and noise level, and reorganization of working and rest regime. Since detecting postures of acceptance of ergonomics takes time, we believe the three-month intervention time used here was long enough [11].

Statistical analysis methods. Data were analysed using descriptive statistics (mean and standard deviation), comparative (Student t, df) and correlation analysis. The formula used to calculate the correlation coefficient is:

$$r = \Sigma[(x - \bar{x})(y - \bar{y})] / \sqrt{[\Sigma(x - \bar{x})^2 \times \Sigma(y - \bar{y})^2]}$$

Here, r value inbetween ergonomic condition and productivity of labour indicates the strength relation [12]. Statistical significance level was set at $p < 0.05$.

This methodology enabled comprehensive and scientific assessment of the effectiveness of ergonomic approaches integrated into the occupational safety system. Therefore, merging theoretical grounds with practical insights enhanced the scientific and practical significance of the research result.

Results and Discussion

Workplace ergonomic assessment. The first phase in this applied study was to perform a workplace study of their current ergonomics conditions. At the conclusion of their initial analysis, they suggested that most workplaces were failing to meet even basic ergonomic needs. Particularly, the largest gaps were detected in working posture and microclimate indicators of workplace geometry.

Applying the Ergonomic Audit Methodology, 62% of the evaluated workplaces did not comply with anthropometric requirements for worktables and chairs. This mismatch caused workers more physical strain and faster exhaustion [13]. Additionally, 48% of worksites did not reach regulatory-standard-lighting among the worksites. Past studies have established that low-light conditions can negatively impact visual comfort and task performance, which can heighten operational risks.

The psychophysiological test results indicated that 55 percent of workers showed increased signs of severe fatigue and decreased attention at the end of the work day. It significantly raised the likelihood of making work-related mistakes and impaired performance in general. The latter is consistent with contemporary research on the extent to which inadequate ergonomic condition relates to safety and or productivity and efficiency.

The ECI was originally very low in ergonomics conditions. Then, the ECI value determined as 0.46 on a scale from 0 to 1, reflected that the studied workplaces had an inappropriate ergonomic condition.

Results of ergonomic interventions. Post implementation of ergonomic measures, ECI was again re-calculated. That enhanced ergonomic quality saw the average rise to 0.71 There are positive changes like Less physical work means almost 60% less physical workload of the work environment, Greater convenience and clean and hygienic environment to work, Carbon Fiber is highly stable to be work on, The health and satisfaction of the contractor, Improved work postures. And perhaps not surprisingly, shift work and rest were key factors in reducing fatigue. According to their report, 68 percent of workers who responded to a survey said that reduced fatigue by the end of the workday was a measurable benefit of their intervention [14].

Table 2. Indicators before and after ergonomic intervention

Indicator	Before (M ± σ)	After (M ± σ)
Fatigue level	4.3 ± 0.6	2.7 ± 0.5
Number of work errors	6.2 ± 1.1	3.5 ± 0.9
Job satisfaction level	3.4 ± 0.7	4.5 ± 0.6
Ergonomic condition index	0.46 ± 0.08	0.71 ± 0.06

The table below illustrates the positive tendencies of all the primary key indicators.

The labor productivity was evaluated according to work performance and the coefficient of utilization of working time. For the pre intervention period, labor productivity was provisionally anchored at 100 percent. This index, after the implementation of ergonomic measures, rose to 118 to 120% of pre-implementation levels. This is around 15 to 20 percent increase that proves that a good ergonomic atmosphere does have a direct impact on the efficiency of performance.

Labor productivity was calculated using the following formula:

$$LP = Q / T$$

Where:

- LP denotes labor productivity,
- Q represents the volume of completed work,
- T indicates the time spent on work.

The results of the ECI and labor productivity correlation analysis demonstrated a strong positive correlation ($r = 0.68$, $p < 0.05$). This is highly significant and indicates that growth in ECI increases the level of labor productivity [15].

A series of actionable recommendations were then created deriving from research findings. On the one hand, it is imperative to first set up mandatory ergonomic regulations, which shape design and restructuring of workplaces transcending anthropometric, physiological and psychophysiological benchmarks. Secondly the ergonomic audit system reference checklist of ISO 45001, and ISO 6385 must be continuously followed and undergo periodically systematically assessment of workstations and other workplace ergonomic conditions in need for improvements. Integration of ergonomic

factors into occupational risk assessment is two-fold: these factors should appear as a distinct risk category (although referred to as description elements) in the context of the existing measures and the recommendations for preventive measures should be verified; the latter could mean either more precise recommendations for preventive measures or more targeted recommendations in terms of how to prevent the related hazards. However, at ergonomics perspective, review of work and rest schedules, functional break, and optimum work cycle introduction to accommodate lesser fatigue and so to maintain staff availability; Secondly, an ergonomic culture has to be established which is possible through integrating specific ergonomics modules into the occupational safety trainings and continuing education. Finally, it should be a fundamental change in regulatory and legal documents on occupational safety through development and improvement of requirements with an ergonomic approach.

Conclusion

The objective evidence of the performed empirical study, coupled with the scientific certainty that the establishment of ergonomics may contribute to the institution of the system for the occupational safety applied by more places. A simple means of improving the ergonomic condition had a statistically proven impact on health preservation of workers, lowering occupational risks and offering sustainable raise of labor productivity.

The data thus collected were processed using statistical analysis methods allowing safe assessment of implications of ergonomic approaches on occupational safety and efficiency. Thus, data was reasonably close to normal distribution ($p > 0.05$) according to Kolmogorov Smirnov test ($p > 0.05$) so parametric statistics was justified.

Differences between measurements of the indicators administered pre- and post-intervention were considered statistically significant according to the Student test. In particular, [on a level of worker fatigue $\tau = 6.12$ ($p < 0{,}001$) the number of work-related errorsϵ $\tau = 4.87$ ($p < 0{,}01$) labour productivity was higher from 15 to 20 percent on averageϵ $\tau = 5.34$ ($p < 0{,}001$).] Moreover, the Pearson correlation coefficient was $r = 0.68$ ($p < 0.05$) and so this finding validated strong positive relationship between ergonomics condition index (ECI) and labor productivity.

Musculoskeletal complaints were also reduced by 30 percent with ergonomic interventions. Using chi square test, this change was statistically significant ($\chi^2 = 9.41$, $p < 0.01$).

The results are consistent with PK study done in European countries, confirming that ergonomic approaches might be implemented successfully under conditions of Uzbekistan. In the meantime, future research needs to test the effects of ergonomic interventions over the long-term, along with larger studies across several industries.

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