Physical and Cognitive Ergonomics in the Workplace:

A Comprehensive Review of Research-Based Approaches

Abstract:

The modern workplace is evolving quickly as trends towards employee wellbeing and productivity are prioritized [1]. Assessing workers' health, comfort, and performance requires investigating the physical and cognitive ergonomics shaping their work environments.

This manuscript explores the diverse applications of physical and cognitive ergonomics by reviewing extensive research. The primary goal is to provide a holistic understanding of how physical and cognitive ergonomics impact the workplace. Evidence-based recommendations are discussed to improve both fields of ergonomics, developing workplace environments that promote employee wellbeing, efficiency, and innovation.

Introduction:

Society's modern workplace is brimming with unprecedented transformations, technological advancements, alternative work arrangements, and diverse job roles. A thorough assessment of physical and cognitive ergonomics is necessary to prioritize the wellbeing and productivity of employees in these ever-changing environments.

Defining Physical and Cognitive Ergonomics:

Physical ergonomics is concerned with the physical design of workspaces, focusing on accommodating the physiological needs and skills of individuals. Physical ergonomics pertains to

the ways in which the human body interacts with tools and tasks. Healthy physical ergonomics include measures to prevent injuries, support posture, streamline manual tasks, reduce human error, and reduce harmful repetitive movements. Overall, physical ergonomics aims to increase productivity with tools, machinery, room design, and workers' wellbeing and satisfaction [2].

In contrast, cognitive ergonomics seeks to optimize mental processes, striving to nurture a workplace that engages cognitive functions and minimizes mental fatigue. Cognitive Ergonomics focuses on how brain function impacts the quality of worker performance as well as the mind's ability to process information and data. Relevant cognitive ergonomic markers include accidents and errors, decision making, interaction between humans and tools or machinery, mental workload, emotional distress, satisfaction, efficiency of design, and worker training.

Physical and Cognitive Ergonomics within the workplace have a significant impact on worker's wellbeing and quality of productivity [3]. Physical and cognitive ergonomics do not operate independent of each other, as the mind affects the body, and the body affects the mind [4]. Though deeply interconnected, these topics can still be discussed individually.

Purpose:

The goal of this manuscript is to highlight the complexities of physical and cognitive ergonomics in work environments and offer solutions for improvement. Individual and interconnected influences are examined to determine how they impact employee wellbeing and performance. This manuscript surveys peer-reviewed studies in existing research to provide evidence-based suggestions for workplace renovation. The connections outlined in this review

serve as a helpful resource to employers, workplace designers, and policymakers who desire to nourish and improve the holistic health of workforces.

Unique Workplace, Unique Needs:

Each workplace and their workers have special ergonomic needs. Every workspace requires different design and consideration, depending on the function of the business and the tasks of the workers. The scope of this manuscript will focus mainly on office, assembly line, and healthcare workspaces.

In 2019 alone, employers nation-wide spent an average of $3.6 million on workplace wellness programs [5]. Research also revealed that “employees who are satisfied with their work environments are 16% more productive, 18% more likely to stay, and 30% more attracted to their company over competitors” [6].

No matter what field of work is being studied, a better environment equals better quality of work and satisfaction of workers. It is therefore understandable why employers are increasingly willing to invest in achieving optimal ergonomic designs for their businesses.

Physical Ergonomics and Workspace Design:

Evaluation of workspace design is critical for the foundations of physical ergonomics in the workplace. It considers employee privacy, the arrangement of limited open spaces, worker autonomy to personalize their own workspace, designated rest and break areas, and more.

Worker’s wellbeing is significantly affected by the layout and design of their environments. Research confirms that specialized office furniture, such as adjustable-height

desks and proper lighting, can improve comfort while decreasing the chances of developing musculoskeletal disorders [7].

Seating Ergonomics:

Comfortable, posture-minded seating is a necessary element within physical ergonomics. The natural curvature of the spine benefits from the support of ergonomic chairs, which promote healthy posture and can reduce or prevent back pain [8].

Adjustable Standing Desks:

Prolonged sitting is associated with musculoskeletal pain disorders. Adjustable standing desks are a popular choice for office environments, as they have been shown to minimize sedentary consequences while increasing the physical activity of employees. One study observed that call center employees who received a standing desk showed increased productivity than the seated control group [3].

Lighting Considerations:

Office lighting has a powerful effect on the wellbeing of workers. Natural light is directly linked to improved mood and increased alertness. Poor lighting conditions have been linked to visual discomfort, dry eyes, blurry vision, and headaches. In one study, workers were provided with adjustable LED task lights. They reported significantly less discomfort, eye fatigue, and poor posture. They also had a more positive perception of job content [9].

Integrating windows, skylights, and adjustable artificial lighting has a positive effect on circadian rhythms, reduces eye strain, and contributes to overall wellbeing of workers.

Temperature and Ventilation:

Optimal temperatures and ventilation systems are essential for employee comfort and productivity in the workplace. Research reveals that temperatures between 68-75.2 degrees Fahrenheit, combined with appropriate ventilation, contribute to a more comfortable and focused work environment [10].

Movement and Breaks:

Essential to healthy physical ergonomics is regular movement and breaks throughout the workday [11]. Providing break rooms with comfortable seating, encouraging short breaks, walking, and stretching all help balance sedentary behavior, improving wellbeing.

One study led a group of healthcare workers through a whole body stretching (WBS) routine, 3 times a week for 6 weeks. Compared to the control group, who only received education, the Whole-Body Stretching group reported significantly less musculoskeletal pain and fatigue and were able to do a variety of physical tasks with less effort [12].

Other Tools for Physical Ergonomics in the Workplace:

There are many other physical ergonomic tools that can be introduced into the office workplace: specialized computer keyboards and mouses, comfortable headphones, blue light

blocking computer glasses, adjustable laptop stands, curved monitor screens, seat cushions, document holders, anti-fatigue mats, and footrests, and more.

Cognitive Ergonomics Defined:

The International Ergonomics Association defines cognitive ergonomics as "mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system" [13].

Cognitive ergonomics can also be defined as "the mental effort and resources required to perform a specific task or activity. It is a measure of how demanding a particular cognitive task is on a person's brain" [14]. Cognitive ergonomics impact the mind, which in turn impacts the quality of work and goals of workers.

The vast field of cognitive ergonomics considers human reliability, mental workload, decision-making, skill performance, human-computer interaction, training, physical pain and demands, work stress, attention, memory, and learning.

Workspace Design for Cognitive Ergonomics:

Designing workspaces for optimal cognitive ergonomic impact includes decreasing cognitive strain, disruptions, interruptions, and information overload. It is also important to provide clearly organized information and instructions to minimize cognitive load. Other helpful tactics are to assign a variety of tasks, minimize multi-tasking, encourage autonomy, offer advanced training, and create opportunities for teamwork [3].

Reducing Cognitive Load:

Understanding cognitive workload is essential for enhancing employee productivity and performance. Excessive cognitive workloads can result in fatigue, stress, and decreased productivity [15] [16]. A balanced workload can be achieved by assigning tasks with reasonable complexity, providing sufficient resources, and offering training programs.

Examples of cognitive workload support include implementing quiet hours, in which phone calls, visitors, and emails are temporarily suspended at times during the workday [3].

Reducing information overload, disruptions and interruptions allow workers to concentrate and stay on task. One study showed that limiting email checking to just 3 times a day increased the productivity of employees. In addition, it was shown that asking multiple questions at one time, as opposed to interrupting throughout the day, reduced information overload and stress [3].

Technology Integration and Challenges:

Friendly interfaces in technology are pivotal to cognitive ergonomics. Providing employees with efficient software and ergonomic hardware can increase workflow and alleviate cognitive strain. However, even reliable technology and machinery experience breakdowns, which impacts worker wellbeing.

It is vital that workers have a sense of autonomy in their work environments. Machine and technology breakdowns are stressful, given that these tools are necessary to complete tasks. Workers report frustration and irritation following system or component failures. The consequences of these system failures create time delays, requiring overtime, and exertion of additional physical and mental effort, leading to exhaustion [18].

Cultivating a strong sense of autonomy is challenging when employees experience breakdowns that are inherently out of human control. To mitigate machine mishaps, companies can limit overtime, increase overtime wages, hire more staff to shoulder the workload, and have expert repair services on-site to minimize downtime due to malfunctions.

Group Dynamics and Cognitive Diversity:

Creating positive group dynamics and pleasant fellowship improves group communication and increases motivation to work. Positive social contribution increases work performance and worker commitment to their company [19].

Conversely, emotionally toxic workplace environments drive employees away and reduce wellbeing and productivity. Dissatisfied workers are also likely to spread their discontent to other employees, draining the morale of a toxic culture even lower. This creates a cascade of unhappy, quitting workers and a high turn-over rate [20].

Research has shown that teams high in diversity produce more innovative solutions and better problem-solving skills [21]. Building a cognitively diverse population of employees helps to ensure a rich reward for both employer and employee. Diverse perspectives are indispensable to workplaces, contributing to a supportive, intellectually stimulating environment.

Training, Development, and Information Organization:

Training and development are integral to cognitive ergonomics. Clear instructions and thorough, continuous training make tasks feel more manageable. This helps to reduce mistakes, improve reaction speeds, and shorten learning curves [22]. Companies should invest in frequent training and development programs to keep their staff engaged and up to date on best practices. Employees then have more opportunities to sharpen their skillset and become an in-demand worker. Continual learning improves job satisfaction while also shaping adaptable and resilient workers [23].

Cognitive ergonomics relies heavily on optimal information organization. Providing clear and intuitive information systems, reducing distractions, and offering sufficient storage solutions help a work environment remain focused and organized [24].

Biophilic Office Design for Cognitive Ergonomics:

Research shows that incorporating live plants in workplaces creates a positive biophilic (nature-connected) environment. Natural environments capture a person's involuntary attention, subconsciously supporting the recovery of mental fatigue, attention span, and cognitive capacities. Natural environments also have positive impacts on blood pressure regulation, heart rate, cortisol levels, and mood states. Biophilic design in offices is associated with the perception of more pleasant work environments as well as improvements in workers' health, wellbeing, productivity, and performance [25].

Physical Design and Cognitive Ergonomics:

Physical design of workspaces impacts cognitive ergonomics of workers. One study asserts that employee satisfaction is linked to office design, considering aspects such as interior decor, level of openness in floor plan, subdivision of space, seclusive space, number and diversity of workspaces, and accessibility of the building [26].

Some office design negatively impacts worker satisfaction. Research shows that an open-space concept was criticized by workers, who expressed that “stations” created polarization between different employee groups. This fostered a sense of exclusion, as groups reflected territorial behaviors in popular work zones. An open-concept floor plan contributes to a sense of lack of belonging or being “lost in space”. Personal corners were highly coveted for the privacy they offered [27].

Integrating Physical and Cognitive Ergonomics in the Workplace:

The nature of physical and cognitive ergonomics is holistic and interconnected. Balanced implementation of proven strategies is essential for creating an optimized work environment. The relationship between physical and mental wellbeing requires an integrated approach to achieve holistic workplace design, policies, and practices that support the health, wellbeing, and performance of employees [28].

Conclusion:

In conclusion, the modern workplace is undergoing powerful changes as society implements healthy elements of physical and cognitive ergonomics. A well-designed, physical

and cognitive ergonomic-focused environment benefits employee's wellbeing. At the same time, it also contributes to increased productivity, innovation, and job satisfaction.

Strategies to improve physical ergonomics in the workplace include provision of posture-supportive seating, adjustable standing desks, natural lighting, personal LED lighting, proper temperature and ventilation, incorporation of breaks, movement and stretching, and providing various hardware tools like ergonomic computer keyboards, blue-light blocking glasses, and curved monitor screens.

To implement strategies that improve cognitive ergonomics in the workplace, employers should reduce cognitive load, minimize disruptions and interruptions, provide organized information and instructions, assign a variety of tasks, decrease multi-tasking, optimize technology interfaces, minimize technology breakdown, encourage worker autonomy, offer frequent training, and create opportunities for enjoyable teamwork and fellowship. Physical design considerations for cognitive ergonomics include incorporating live plants and biophilic elements, choosing pleasant interior décor, carefully considering design that promotes worker privacy, and avoiding certain open-concept layouts that promote feelings of exclusion and isolation amongst workers.

By approaching these evidence-based recommendations with a holistic mindset, organizations can cultivate work environments that are adaptable while safeguarding the health of their most valuable asset: their workforce.

References:

1. Stringer, H. Worker well-being is in demand as organizational culture shifts. *American Psychological Association*. 2023;**54**(1):58.

2. The Difference between Physical Ergonomics, Cognitive Ergonomics, and Macroergonomics. *Berkely Center for Occupational and Environmental Health*. 2020.

3. Kalakoski, V, Selinheimo, S. Effects of a cognitive ergonomics workplace intervention (CogErg) on cognitive strain and well-being: a cluster-randomized controlled trial. A study protocol. *BMC Psychology*. 2020; **8**(1). doi: 10.1186/s40359-019-0349-1.

4. Mehta, R, Parasuraman, R. Neuroergonomics: a review of applications to physical and cognitive work. *Frontiers in Human Neuroscience*. 2013;**7**. doi: 10.3389/fnhum.2013.00889

5. Meister, J. Survey: What Employees Want Most from Their Workspaces. *Harvard Business Review*. 2019.

6. Aagarwal, A, Rozwell, C. Gartner research: Trusted insight for executives and their teams. *Gartner Research*. 2018.

7. Ma, J, Ma, D. Effects of a Workplace Sit-Stand Desk Intervention on Health and Productivity. *Int J Environ Res Public Health*. 2021; **18**(21):11604. doi: 10.3390/ijerph182111604.

8. van Niekerk SM, Louw QA. The effectiveness of a chair intervention in the workplace to reduce musculoskeletal symptoms. A systematic review. *BMC Musculoskelet Disord*. 2012; **13**(145) doi: 10.1186/1471-2474-13-145.

9. Joines S, James T. Adjustable task lighting: Field study assesses the benefits in an office environment. *Work*. 2015; **51**(3):471-81. doi: 10.3233/WOR-141879.

10. Seppanen, Olli Fisk, William J. Control of temperature for health and productivity in offices. *Lawrence Berkeley National Laboratory*. 2004.

11. Albulescu P, Macsinga I. “Give me a break!" A systematic review and meta-analysis on the efficacy of micro-breaks for increasing well-being and performance. *PLoS One*. 2022;**17**(8):e0272460. doi: 10.1371/journal.pone.0272460.

12. Alqhtani RS, Ahmed H. Effects of Whole-Body Stretching Exercise during Lunch Break for Reducing Musculoskeletal Pain and Physical Exertion among Healthcare Professionals. *Medicina (Kaunas)*. 2023;**59**(5):910. doi: 10.3390/medicina59050910.

13. Wikipedia contributors. Cognitive ergonomics. *Wikipedia, The Free Encyclopedia*. 2024.

14. Pedersen, M. Understanding Cognitive Workload: What Is It and How Does It Affect Us? *IMOTIONS*. 2023.

15. Mehta, R. Integrating Physical and Cognitive Ergonomics, *IIE Transactions on Occupational Ergonomics and Human Factors*. 2016; **4**:2-3, 83-87, doi: 10.1080/21577323.2016.1207475

16. Karr-Wisniewski, P, Lu, Y. When more is too much: Operationalizing technology overload and exploring its impact on knowledge worker productivity. *Computers in Human Behavior*. 2010.

18. Wollter Bergman M, Berlin C. Cognitive Ergonomics of Assembly Work from a Job Demands-Resources Perspective: Three Qualitative Case Studies. *Int J Environ Res Public Health*. 2021; **18**(23):12282. doi: 10.3390/ijerph182312282.

19. Zhenjing G, Chupradit S. Impact of Employees' Workplace Environment on Employees' Performance: A Multi-Mediation Model. *Front Public Health*. 2022; **10**:890400. doi: 10.3389/fpubh.2022.890400.

20. Rasool SF, Wang M. How Toxic Workplace Environment Effects the Employee Engagement: The Mediating Role of Organizational Support and Employee Wellbeing. *Int J Environ Res Public Health*. 2021;**18**(5):2294. doi: 10.3390/ijerph18052294.

21. Loseby, D. Cognitive Diversity. *JOUR*. 2021.

22. Koirala, R, Maharjan, K. Cognitive Ergonomics on Employee Wellbeing: A Literature Review. The Journal of Economic Concerns. 2023; 13(93). doi: 10.3126/tjec.v13i1.57064

23. Shin MG, Kim YK. Relationship Between Job Training and Subjective Well-being In Accordance With Work Creativity, Task Variety, and Occupation. *Saf Health Work*. 2020;(**4**):466-478. doi: 10.1016/j.shaw.2020.08.006.

24. Watson, D, Tregaskis, O. Well-being through learning: a systematic review of learning interventions in the workplace and their impact on well-being. *European Journal of Work and Organizational Psychology*. 2018; **27**:2, 247-268. doi: 10.1080/1359432X.2018.1435529

25. Gonçalves G, Sousa C. Restorative Effects of Biophilic Workplace and Nature Exposure during Working Time: A Systematic Review. *Int J Environ Res Public Health*. 2023; **20**(21):6986. doi: 10.3390/ijerph20216986. **26

26. Forooraghi M, Miedema E. How Does Office Design Support Employees' Health? A Case Study on the Relationships among Employees' Perceptions of the Office Environment, Their Sense of Coherence and Office Design. *Int J Environ Res Public Health*. 2021;**18**(23):12779. doi: 10.3390/ijerph182312779.

27. Bodin Danielsson C, Hoy S. Health-Supportive Office Design—It Is Chafing Somewhere: Where and Why? *Sustainability*. 2022; **14**(19):12504. https://doi.org/10.3390/su141912504

28. Mehta, R. Integrating Physical and Cognitive Ergonomics, *IIE Transactions on Occupational Ergonomics and Human Factors*. 2016;(**4**):2-3, 83-87. doi: 10.1080/21577323.2016.1207475