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Human Factors and Ergonomics Society Policy Statement on Occupational Ergonomics for Industry 4.0

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HFES Policy Statement
Occupational Human Factors & Ergonomics for Industry 4.0

Ergonomics initiatives should be prioritized in Industry 4.0 innovation funding in order to optimize productivity, worker health and industry prosperity

Summary

Human Factors & Ergonomic workplace analysis and design are well proven methods for reducing occupational injuries and illnesses in the workplace, [3,9] and provide substantial benefits for reducing costs and improving operational efficiencies and productivity [8,18,21]. Balancing the cognitive and physical demands of work with the capacity of the worker optimizes productivity, quality of work and worker wellbeing, all of which contribute to healthy organizations and economies. Emerging Industry 4.0 technologies provide a substantial opportunity for improving the quality and effectiveness of ergonomics efforts, creating both improved worker safety and industry cost savings.

Background

The International Labor Organization identifies the need to account for individual differences and work contingencies in the design of work through the foundational principle of Ergonomic Work Design. Workplace analyses utilizing Ergonomic risk assessment tools offer unique insights and are complementarity to other work design tools such as Lean Manufacturing and Six Sigma. They can lead to significant reductions in worker injuries and productivity losses.

Figure 1. The International Labor Organization emphasizes the foundational principles of Human Factors and Ergonomics Design for the Management of Work Systems

Foundational Principles for Ergonomic Design and Management of Work Systems				
Principle 1	**Principle 2**	**Principle 3**	**Principle 4**	**Principle 5**
Ensure worker safety, health, and wellbeing in the optimization of work systems as a top priority;	Design and manage work systems to ensure organizational and worker alignment, continuous evaluation and learning, and sustainability;	Create a safe, healthy, and sustainable work environment from a holistic perspective, understanding and providing for human needs;	Account for individual differences and organizational contingencies in the design of work systems;	Utilize collective, trans-disciplinary knowledge and full participation of workers for designing systems, detecting problems, and creating solutions for HF/E in work systems.

Occupational Injuries are Common and Costly

Worker Injuries Cost Time and Money	
30%	Of Occupational Injuries Involve Musculoskeletal Disorders
12	Days of Lost Work/Injury
$40,050	Average Cost of Workers Compensation Claim
$14 Billion	Costs per year of Materials Handling Injuries

According to the most recent data available from the Bureau of Labor Statistics, there were 900,380 cases of occupational injuries and illnesses which resulted in missed work in 2018. [23] Of these, 272,780 lost time cases were associated with Musculoskeletal Disorders (MSDs) such as carpal tunnel syndrome and tendonitis, about 30% of all lost-time injury and illness cases in private industry. [23,24] The median number of days away from work associated with MSDs was 12 days, 50% greater than the median of 8 days off work for all injuries and illnesses. [24] Further, back injuries caused by over-exertion (primarily associated with lifting, lowering, carrying, pushing and pulling materials of different types) has been identified by the insurance industry in the Liberty Mutual Workplace Safety Index as the number one cause of disabling workers compensation claims for the past 20 years, resulting in some $14 Billion in costs per year. [31]

The National Safety Council estimates that preventable injuries cost employers about $1,100 per employee in 2018, [16] and that the average cost of a Workers' Compensation case was $40,050. [16] Occupational injuries and illnesses impact both workers' lives and companies' bottom-line.

Preventing Occupational Injuries Provides Significant Return on Investment

Ergonomic interventions provide significant savings and avoided costs due to reductions in workers compensation. [8,18,21] Many studies also show a positive return on investment (ROI) resulting from ergonomic work design. [1,4,5,7,10-15,17,20,22,25,26] Table 1 summarizes the findings of these studies. Ergonomic interventions provided productivity gains of between 1.6 and 140%, with payback periods between 0.5 and 59 weeks.

Table 1. Summary of case reports showing benefits of occupational ergonomic interventions.

Reference	Setting	Payback period in weeks
Burri and Helander	Electronics manufacturing	0.5
Stanton and Baber	4 reports from various manufacturing settings	1-18
Tompa et al	Textile manufacturing	9.6
Amick et al	Office Work	2
Larson	14 projects in manufacturing settings world-wide	0.7 to 59 (range) 16.4 (average)
Reference	Setting	Annual percent gain in productivity
DeLooze et al	Valve and furniture manufacturing	15-20 %
Garrett et al	Call center	45 %
Loo and Yeow	Air handling unit mfg.	140%
Yeow	Order picking in warehouse	8.4 %
De Macedo Galmarãs et al	Furniture manufacturing	46 %
Dhande and Patil	Various manufacturers	1.6 %
Reference	Setting	Operational Efficiency
Motamedzade et al	Hospital and Medical Manufacturing	3-5 % decrease in waste, 8 % decrease in re-work

Ergonomic Workplace Analysis & Design are Highly Effective for Reducing Injuries

Ergonomic workplace design has been shown to be effective in reducing the number or severity of MSDs by balancing task demand with worker capacity. [8,18,21] Improvements in the design of work are guided by quantitative ergonomics analyses that calculate physical exposure to activities, which can then be used to guide interventions that target specific risks where work demand exceeds worker capacities. Tools used to support ergonomics analyses today typically include both active (checklists or observational assessments) and passive (injury logs, errors, quality control reports) surveillance efforts.

Industry 4.0 Advanced Sensing & AI Can Predict When Occupational Injuries Are Likely

The next phase of the industrial revolution, Industry 4.0, is the application of advanced sensing and artificial intelligence. Today's Industry 4.0 emphasizes the automation of traditional manufacturing processes using improved integrated sensors and smart technologies such as AI computer vision, smartphones apps, and machine learning. Industry 4.0 provides a unique opportunity to improve injury exposure assessment due to increased precision and reliability of imbedded sensors in the workplace. While current methods rely on observations, surveys or injury records, new wearable devices (such as inertial measuring units and video tracking) can provide valuable information on the magnitude, duration and patterns of injury exposure. For example, inertial measuring units can provide the percent time spent in awkward postures as well as key inputs for established risk assessment tools. In combination with machine learning approaches, this data can be used to more accurately quantify the physical demands of a job such as the percent time spent kneeling, crawling, reaching or lifting, providing a more accurate physical demand assessment used for job placements and return to work purposes.

Improved injury exposure assessment allows improvements in work design, as well as individualized approaches for proactively identifying accident inducing fatigue and avoiding injury. For example, it provides an improved means of personalized monitoring of worker activities in jobs with past injuries. It also supports the CDC National Occupational Research Agenda for Musculoskeletal Health research objectives.[30] The application of these new Industry 4.0 technologies to occupational Ergonomics is just emerging, and more research is needed to support their development, usability and validation.

Recommendation: Support Research on Industry 4.0 Tools & Methods to Reduce Occupational Injuries

Currently, there is little emphasis on the development and utilization of these new technologies to optimize task demand to fit worker capacity. Further, there are a number of socio-technical issues associated with the introduction of Industry 4.0, including its acceptability to workers. Issues of comfort, trust, data security, privacy, comfort, and changes to social interactions on the job are all highly relevant to its success. Research is needed to determine evidence of Industry 4.0's ability to support injury prevention, validated risk models, and accuracy of measurements captured by these technologies, and to determine effective methods for integrating them in a manner that is acceptable to workers.

Industry 4.0 provides an excellent opportunity to address reliability issues that limit the widespread implementation of Ergonomic work space design across industries. Including and prioritizing Ergonomics initiatives in future funding of Industry 4.0 innovation will catalyze the integration of technology, machine learning and core Ergonomics risk assessment approaches, leading to a watershed moment that optimizes productivity, worker health and company prosperity, if developed and applied appropriately. Good Ergonomics is not only beneficial for the health and well-being of workers, avoiding unnecessary injuries, it is also good economics.

References

1. Amick III, B. C., Robertson, M. M., DeRango, K., Bazzani, L., Moore, A., Rooney, T., & Harris, R. (2003). Effect of office ergonomics intervention on reducing musculoskeletal symptoms. *Spine*, *28*(24), 2706-2711.
2. Andersson, G. (2008). *The burden of musculoskeletal diseases in the United States: prevalence, societal and economic cost*. Amer Academy of Orthopaedics.
3. Anema, J. R., Cuelenaere, B., Van Der Beek, A. J., Knol, D. L., De Vet, H. C. W., & Van Mechelen, W. (2004). The effectiveness of ergonomic interventions on return-to-work after low back pain; a prospective two year cohort study in six countries on low back pain patients sicklisted for 3–4 months. *Occupational and environmental medicine*, *61*(4), 289-294.
4. Burri Jr, G. J., & Helander, M. G. (1991). A field study of productivity improvements in the manufacturing of circuit boards. *International Journal of Industrial Ergonomics*, *7*(3), 207-215.
5. De Looze, M. P., Van Rhijn, J. W., Van Deursen, J., Tuinzaad, G. H., & Reijneveld, C. N. (2003). A participatory and integrative approach to improve productivity and ergonomics in assembly. *Production Planning & Control*, *14*(2), 174-181.
6. Descatha, A., Roquelaure, Y., Chastang, J. F., Evanoff, B., Melchior, M., Mariot, C., ... & Leclerc, A. (2007). Validity of Nordic-style questionnaires in the surveillance of upper-limb work-related musculoskeletal disorders. *Scandinavian journal of work, environment & health*, *33*(1), 58.
7. Dhande, K. K., & Patil, D. Y. (2013). Practical approach towards issue on ergonomic training with respect to productivity improvement. *Journal of Ergonomics*, *3*(2), 1-7.
8. Fujishiro, K., Weaver, J. L., Heaney, C. A., Hamrick, C. A., & Marras, W. S. (2005). The effect of ergonomic interventions in healthcare facilities on musculoskeletal disorders. *American journal of industrial medicine*, *48*(5), 338-347.
9. Gallagher, S., Sesek, R. F., Schall Jr, M. C., & Huangfu, R. (2017). Development and validation of an easy-to-use risk assessment tool for cumulative low back loading: The Lifting Fatigue Failure Tool (LiFFT). *Applied ergonomics*, *63*, 142-150.
10. Garrett, G., Benden, M., Mehta, R., Pickens, A., Peres, S. C., & Zhao, H. (2016). Call center productivity over 6 months following a standing desk intervention. *IIE Transactions on Occupational Ergonomics and Human Factors*, *4*(2-3), 188-195.
11. Hemphälä, H., Hansson, G. Å., Dahlqvist, C., & Eklund, J. (2012). Visual ergonomics interventions in mail sorting facilities. *Work*, *41*(Supplement 1), 3433-3437.
12. Larson, N. L. (2014). Business advantages of ergonomics in industry. Doctoral dissertation, TU Delft, Delft, The Netherlands
13. Loo, H. S., & Yeow, P. H. (2015). Effects of two ergonomic improvements in brazing coils of air-handler units. *Applied ergonomics*, *51*, 383-391.
14. de Macedo Guimarães, L. B., Anzanello, M. J., Ribeiro, J. L. D., & Saurin, T. A. (2015). Participatory ergonomics intervention for improving human and production outcomes of a Brazilian furniture company. *International Journal of Industrial Ergonomics*, *49*, 97-107.
15. Motamedzade, M., Shahnavaz, H., Kazemnejad, A., Azar, A., & Karimi, H. (2003). The impact of participatory ergonomics on working conditions, quality, and productivity. *International Journal of Occupational Safety and Ergonomics*, *9*(2), 135-147.

16. National Safety Council (2018) Injury Facts. Downloaded from https://injuryfacts.nsc.org March 19, 2020.
17. Neumann, W. P., Winkel, J., Medbo, L., Magneberg, R., & Mathiassen, S. E. (2006). Production system design elements influencing productivity and ergonomics. *International journal of operations & production management*.
18. Rivilis, I., Van Eerd, D., Cullen, K., Cole, D.C., Irvin, E., Tyson, J., and Mahood, Q. (2008). Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. *Applied Ergonomics*, 39(3), 342-358.
19. Silverstein, B. A., Stetson, D. S., Keyserling, W. M., & Fine, L. J. (1997). Work-related musculoskeletal disorders: Comparison of data sources for surveillance. *American journal of industrial medicine*, *31*(5), 600-608.
20. Stanton, N. A., & Baber, C. (2003). On the cost-effectiveness of ergonomics.
21. Tompa, E., Dolinschi, R., De Oliveira, C., Amick, B. C., & Irvin, E. (2010). A systematic review of workplace ergonomic interventions with economic analyses. *Journal of occupational rehabilitation*, *20*(2), 220-234.
22. Tompa, E., Dolinschi, R., & Natale, J. (2013). Economic evaluation of a participatory ergonomics intervention in a textile plant. *Applied ergonomics*, *44*(3), 480-487.
23. US Department of Labor, Bureau of Labor Statistics. (2019a) News Release. Downloaded from https://www.bls.gov/news.release/pdf/osh.pdf March 19, 2020
24. US Department of Labor, Bureau of Labor Statistics. (2019b) Survey of Occupational Injuries and Illnesses Data, Tables R1 and R71. Downloaded from https://www.bls.gov/iif/soii-data.htm#msd March 19, 2020
25. Yeow, P. H., & Goomas, D. T. (2014). Ergonomics improvement in order selection in a refrigerated environment. *Human factors and ergonomics in manufacturing & service industries*, *24*(3), 262-274.
26. Yeow, P. H., & Sen, R. N. (2006). Productivity and quality improvements, revenue increment, and rejection cost reduction in the manual component insertion lines through the application of ergonomics. *International journal of industrial ergonomics*, *36*(4), 367-377.
27. Yung, M., Kolus, A., Wells, R., & Neumann, W. P. (2020). Examining the fatigue-quality relationship in manufacturing. *Applied ergonomics*, *82*, 102919.
28. Waters, T. R., Putz-Anderson, V., & Garg, A. (1994). Applications manual for the revised NIOSH lifting equation.
29. Zare, M., Croq, M., Hossein-Arabi, F., Brunet, R., & Roquelaure, Y. (2016). Does ergonomics improve product quality and reduce costs? A review article. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *26*(2), 205-223.
30. Center for Disease Control (2018) National Occupational Research Agenda for Musculoskeletal Health. https://www.cdc.gov/nora/councils/mus/pdfs/National-Occupational-Research-Agenda-for-Musculoskeletal-Health-October-2018.pdf
31. Liberty Mutual Insurance Company (2020) 2020 Workplace Safety Index : The top 10 causes of disabling injuries. https://viewpoint.libertymutualgroup.com/article/2020-workplace-safety-index-the-top-10-causes-of-disabling-injuries/