

Where is the Learner in Ergonomics?

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Ergonomics can be broadly defined as the understanding of interactions among people and other elements of a system in order to optimize human well being and overall system performance. The Human Factors and Ergonomics Society recognize 23 technical groups that are concerned with the ergonomic aspects of specific application areas (<http://www.hfes.org/>). Although these 23 technical groups cover a very broad range of the field, none focus on the issue of the human as an adaptive and constantly evolving part of the system. More specifically, ergonomic standards for safe work performance are largely based on the observation and performance of experienced workers. However, from the motor learning literature we know that the novice performer moves with more co-contraction, utilizes greater degrees of freedom when moving, generates more force than necessary and often moves with sub-optimal biomechanical postures when compared to skilled performers [1]. All of these factors can lead to increased injury if continued over a period of time. Therefore, in this paper we aim to highlight a growing need to consider the trainee when looking at ergonomic issues. We will mainly use examples derived from the growing field of ergonomics in healthcare, which is our research group's primary area of expertise. In this particular domain, trainees often work long hours and are required to perform under sleep-deprived conditions [2].

In general, one might not be concerned about ergonomic-related injuries in the trainee population if it is assumed that they will move quickly from being poorly skilled to becoming proficient. Although it may be true for some work places, it may not be for others. In particular, in healthcare the period between the initiation of training and achievement of skill proficiency may be very lengthy [3]. In medicine, for example, the transition from observing as a learner to performing as an autonomous and competent clinician happens during residency and fellowship. Typically residency programs require 2 to 5 years, and fellowships an additional 2 years, of focused learning and hands on practice. While there is very little record of injury amongst trainees during this time, it would be culturally inappropriate for medical trainees, for example, to complain about pain or fatigue related to activity in the workplace. Anecdotally it is not uncommon for surgical residents to experience back or neck pain related to incorrect posture or numbness in the hands from holding surgical instruments inappropriately. This situation could be exacerbated as the ergonomic layout of the operating room is aimed to suit the needs of the attending surgeon, and does not necessarily take into consideration the needs of the surgical trainee (e.g., medical student, resident or fellow). While the situations that exist for medical trainees may be extreme, it is not unreasonable to assume that similar issues may exist in other work environments.

There is abundant evidence that novices move differently when performing job related skills when compared to experienced workers. In the medical field, for example, studies have shown that junior trainees

are less effective in manipulating medical instruments, their motions are typically less efficient, and they take additional time and require more movements to complete certain tasks [4]. Trainees also do not optimize the working environment as efficiently as more experienced doctors [5]. Together, these sub-efficient movement strategies may lead to greater healthcare delivery costs and patient safety issues, as well as to an increased potential for acute (e.g., needle prick while suturing a wound) and chronic (e.g., shoulder pain from continually elevating one's shoulders while holding laparoscopic instruments) injuries to the learners [6].

These practical findings are supported by well-established principles of motor learning. For example, in one of the key models of motor learning [7], suggested that learning progresses through three distinct stages. First is the cognitive phase, where the learner identifies and develops component parts of a skill in order to form a mental representation of the skill. In this phase movements are largely disorganized and suboptimal. Second is the associative phase, where the learner links the component parts into a smooth action. The learning of physical skills requires the relevant movements to be assembled, component-by-component, using feedback to shape and polish them into a smooth action. In the third autonomous phase, the learned skills become automatic. The duration that learners spend in each of these phases varies substantially between skills. Consequently, the importance of these motor learning principles and findings to the field of ergonomics will vary. Human-environment systems that require a long learning curve, such as medical practice, may need to more carefully consider the human as a changing element. Other systems, where leaning curves are very short, may not need to be as concerned with this concept.

Overall, we need to incorporate principles of motor learning into training programs in order to emphasize safer ergonomics for trainees. In addition, we need to consider factors that influence the ergonomics of trainee's performance, such as increased fatigue or pain, and limit exposure when the potential for injury exists. The role of skill learning in optimizing the human-environment system is a topic that deserves further research to achieve optimal worker safety and performance.

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