Risk factors for musculoskeletal disorders in industry - a changing pattern?

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Abstract

Risk factors for musculoskeletal disorders are well known from a series of international reviews. Briefly, these were documented as forceful exertions, awkward postures, static postures, repetition, vibration, and cold. We argue that the goals of improving mechanical exposures through the manipulation of extreme postures and forces can be pursued using a range of evaluation and design tools, and further that the goals and actions of engineering and ergonomics can be harmonized around these exposures. Where time is concerned however, the design and evaluation tools are less good and there may not be agreement between the goals and actions of engineers and ergonomists. Thus, we emphasise the need for engineers and ergonomists to harmonise goals, actions and tools related to time aspects of work, in order to design sustainable production systems of high productivity and high ergonomic quality.

Keywords

Mechanical Exposure, Time Variation Pattern, Risk Factors, Ergonomists, Engineers

1 INTRODUCTION

The paper by Winkel et al. in the present Proceedings presented the challenge of designing work for musculoskeletal health in the face of work intensification and globalisation. It was also suggested that changes in rationalisation strategies lead to changed patterns of risk factors for musculoskeletal disorders. These risk factors for musculoskeletal disorders are well known from a series of international reviews. Briefly, these were documented as forceful exertions, awkward postures, static postures, repetition, vibration, and cold. Some of these factors include time aspects of work, and in the ergonomic literature, time, and especially the time variation pattern of exposure appears in concepts and descriptors such as repetitive work, monotonous work, static posture, postural fixity, movement frequency, short and long cycle time, duty cycle or work/rest ratio, fatigue and recovery. We conceptualize mechanical exposure as being defined by three dimensions; its level or amplitude, its time variation pattern and by its duration.

Most of the ergonomic interventions reported in the literature have focussed upon reaches/postures and forces.This paper asks the question whether this focus is appropriate today. In the face of modern trends in industry, we believe that time aspects of work will be of increased importance in the future. We expect musculoskeletal disorders caused by time-related risk factors to increase, both in absolute terms and as compared to disorders due to extreme postures and forces. The paper briefly reviews findings regarding time variation patterns, and suggests areas for improved understanding.

2 ERGONOMIC INTERVENTIONS ADDRESSING THE AMPLITUDE OF MECHANICAL EXPOSURE

Winkel and Westgaard (1997) reecently reviewed reported ergonomic interventions. Most addressed force and posture. Of the twenty studies addressing mechanical exposure only about one third addressed explicitly the time variation pattern of exposure and only about one quarter evaluated the effect of the intervention on exposure. Studies addressing production system interventions/rationalization strategies almost all addressed the time variation pattern indirectly by for example, team building, job enlargement or rotation. Again, less than half evaluated the effect of the intervention on exposure.

Because of the constant manipulation of the production system by engineers and management an ergonmic intervention focussed upon the amplitude of mechanical exposures is likely to have simultaneous or subsequent co-interventions by engineering or management. The "Ergonomic Pitfall" described by Winkel and Westgaard (1996) is a classic example of this. Briefly, changes to the amplitude of Swedish dentists' mechanical exposure (postures, reaches etc) were counteracted by task reorganisation which affected the time variation pattern of their exposure for the worse. The focus of this paper is on musculoskeletal disorders and thus the aim is to eliminate or reduce mechanical risk factors both through magnitude reduction where necessary but also through a focus on time variation patterns.

In general succesful ergonomic interventions reducing peak forces through improved postures and reduced reaches would be seen as improvements by engineering also. Improving the amplitude of forces and postures constitute an area of agreement for workplace change between workers, ergonomists and engineers but the time variation pattern is typically an area of contention or outright opposition.

2 KNOWLEDGE OF TIME VARIATION PATTERN AS A RISK FACTOR FOR MUSCULOSKELETAL DISORDERS

Time is a core aspect of ergonomics, and appears throughout the literature in such concepts and parameters as repetitive work, monotonous work, static posture, postural fixity, frequency, short and long cycle time, duty cycle or work/rest ratios, fatigue and recovery. The scale of time variations under consideration ranges from very short term events such as EMG gaps (0.2 sec) to those found in seasonal or contingent or seasonal work (months). Unfortunately, the quantification and conceptualization of time in ergonomics has not

advanced as rapidly as those associated with postural and force levels. Time, or rather the time variation pattern of risk factors, has not been as well studied as the presence or absence of the risk factors nor of the magnitude/intensity of these factors.

Table 1 Examples of Time Variation Pattern of Mechanical Exposure and its Relationship to Musculoskeletal Disorders (WMSD).

Risk Factor	Units	Body Region	Findings	Reference
Time OR Proportion of Time	% or s	Shoulder	Increased risk of shoulder disorders if arm above shoulder > 10% time	Punnet et al. (2000)
		Wrist	Increased risk of hand disorders with increased time in flexed or extended wrist postures	Hunting et al. (1981)
		Low Back	Increased risk of low back disorders if mild trunk flexion > 10% time	Punnett et al (1991)
Frequency of Performing Action OR Cycle Time	Min, s, hr OR day^{-1}, hr^{-1}, s^{-1}	Wrist	Increased risk with cycle times less than 30 seconds of with a fundamental subcycle occupying more than 50% of the time	Silverstein et al., (1986)
		Shoulder	Increased risk of shoulder disorders if arm above shoulder at least once per minute	Punnet et al. (2000)
		Low Back	Increasing risk of being in high risk group if number of lifts exceeds 120/hr	Marras et al., (1995)
Angular velocity/ accelera-tion of joint	Deg s^{-1} OR Deg s^{-2}	Low Back	Increased risk of low back pain with increasing flexion/extension and lateral bend angular velocity	Marras et al., (1993), Norman et al (1998)
		Wrist	Increased risk of hand/arm disorders with increased angular wrist acceleration (and velocity)	Marras and Schoemarklin (1995)
Hand Activity Level	-	Hand/ Arm	Greater risk of injury/discomfort with increasing Hand Activity Level[1]	Latko et al., (1999)
Muscle Rest Events	min^{-1}	Shoulder/ Neck	Increased sick leave if low number of EMG gaps	Veiersted et al (1993)
Average Load	N or % MVC	Forearm/ Hand	Increased disorders with increased Median EMG amplitude of forearm musculature.	Malchaire et al (1997)
Cumulative load	N.s	Low Back	Increased risk of low back pain with increased cumulative spinal moment compression and shear load	Norman et al (1998), Kumar (1990)

For example, NIOSH found studies of time as a risk factor for low back pain almost completely lacking in the epidemiological literature although more studies were available

for the upper limbs especially with respect to variables such as frequency and percentage of time in a give posture (Bernard, 1997). This is perhaps due to the lack of operationalizing this dimension of exposure and the difficulty of collecting it in the field; for example while people can report their tasks and activities quite well, the time and relative time estimation ability is not as good (e.g., Wiktorin er al., 1993). There exist many guidelines and standards, based partly upon epidemilogical studies, which include time related elements. A review by Westgaard and Winkel (1992) noted that because of the different metric used it was difficult to arrive at any quantitative guidelines on desirable time variation pattern. In a sense this is not surprising as time variation pattern cannot exist separated from it associated risk factor.

The general aim of rationalization is the reduction in non-value added time(i.e., losses), with an aim to increase value added time and give increased flexibility of labour Another goal of manufacturing is minimal process variance. In general this will probably lead to a reduction in periods of muscle rest and an increase in static, average, and cumulative load (Bao et al., 1997), as well as frequency of moves, peak and average velocity, and acceleration. Thus, as concerns time-related issues, the goals and actions of engineers and ergonomists may disagree.

3 HAVE THE RISK FACTORS CHANGED?

The early focus on reducing high loads and reducing poor postures created jobs that superficially appeared low risk. Further experience revealed that "light" jobs such as cashiers exhibited high local loading and musculoskeletal disorders. Other experience showed that jobs that exhibited lack of variety created more problems than varied jobs. In other words, a good workstation was not enough. An increase in knowledge of pathophysiology of WMSD and further epidemiological study reinforced the realization that the pattern of exposure (time) was also critical in designing jobs of high ergonomic quality to reduce musculoskeletal disorders. It was also realized that, in addition to mechanical exposure, time affects psychosocial risk factors including, low control, high demand, poor social environment and social support (Bongers, 1993) which in turn is critical in health in general, including musculoskeletal health.

In a setting where forces are low, the office, Punnett and Bergqvist(1997) concluded that issues of duration and pace were of critical importance. Both the technical factors (distances, forces, technical autonomy, etc.) and work organizational factors (task distribution, work pace, administrative autonomy) influence the loading (mechanical exposure such as reach, forces exerted or posture and their time distribution) and perception of the workplace (psychosocial factors). The time variation pattern is thus a common variable which spans physical and psychosocial aspects of work exposures. We argue that risk factors related to the duration of work, as well as the (lack of) variation has become increasingly more important in modern working life as compared to peak loads and extreme postures. Therefore, although the risk factors have not changed, the relative importance of the risk factors have.

The goals of improving mechanical exposures through the manipulation of extreme postures and forces can be pursued using a range of evaluation and design tools. The goals and actions of engineering and ergonomics can be harmonized around these exposures. Where time is concerned however, the design and evaluation tools are less good. Thus, we emphasise the need for information and tools addressing time and time variation patterns of mechanical exposure to enable engineers and ergonomists to design production systems of high productivity and high ergonomic quality.

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