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SYMPOSIUM INTRODUCTION: CORPORATE STRATEGY, PRODUCTION SYSTEM DESIGN, AND MUSCULOSKELETAL HEALTH

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Musculoskeletal disorders (MSDs) are unintended consequences of many modern manufacturing systems. While many MSD risk factors have been identified, the sources of these risk factors lie in a series of events beginning with strategic business decisions through production system design and emerging finally in the implementation and operation of the production system itself. Thus we can see a chain of events and critical decisions which are displaced from the 'shop floor' in both time and space but can have dramatic impacts on operators' exposure to WMSD risk factors. Intervening to jointly optimise both worker health and productivity aspects requires a combined understanding of ergonomics, production engineering, and corporate strategy. There is a critical need in today's hyper-competitive business environment to learn how to design productive systems that are also ergonomically sustainable – without the need for expensive 'ergonomic' retrofitting. This symposium aims to explore how corporate strategies can influence employee musculoskeletal health in order to set the stage for developing innovative strategies that are both profitable and sustainable.

SYMPOSIUM INTRODUCTION

Setting the Stage

This paper introduces a special seminar examining the current trends in manufacturing practice and the consequences these trends can have for musculoskeletal health. We see the ongoing problem of musculoskeletal disorders (MSDs) in the manufacturing sector as an unintended side effect of production systems. In Sweden we have seen a disturbing and rapid increase in long-term sick-leave and associated costs. Europe wide surveys have noted long term trends in increasing work intensity and its coupling to MSDs (Paoli & Merrilé 2000). The term "globalisation" appears both in popular and scientific literature daily and implies increasingly intense competition between companies. Increases in electronic commerce (stock trading) have also intensified pressure in the time domain for companies to maximise short-term profits. Rassmussen (1997) has explained how the forces of competition *systematically* drives complex systems towards unsafe operating conditions as stakeholders attempt to optimise their operational domains independently and thus, unknowingly, drive the whole system towards unsafe states. Operating in a competitive context, senior managers may choose production strategies that, while profitable in the short term, are not sustainable from the human perspective and thus are not profitable over the long term. Better models and methods are needed to assist decision makers in choosing manufacturing approaches that are both profitable and ergonomically sustainable.

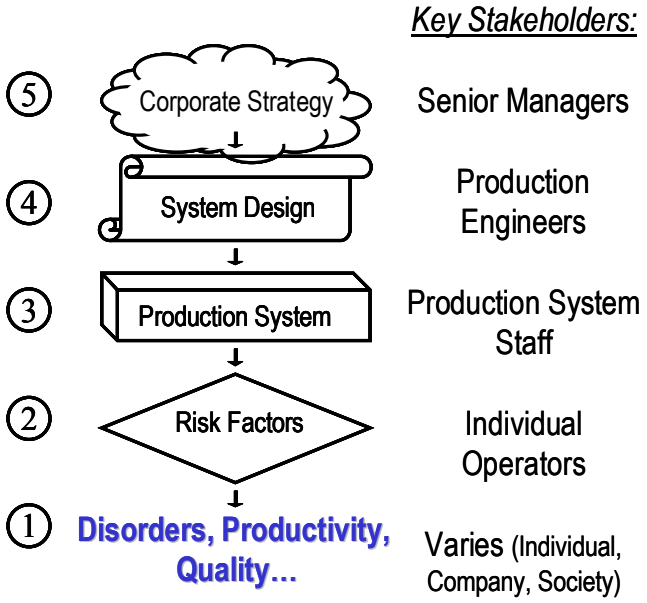

Figure 1: Simplified model of MSD causal chain

A Model of MSD Sources

While many psychosocial and physical risk factors for MSDs have been identified (e.g. Bernard 1997), and mechanistic model have been proposed (NRC 2001) the sources of these risk factor lie deeper in the system development process. Figure 1 illustrates a deliberately simplified system model to assist in understanding MSDs emergence in production systems (adapted from Neumann et al. 2002). In this model MSDs, as well as production outputs and quality levels, result from the interaction of operators with the Production system (level 1). These disorders are related to a variety of both physical and psychosocial risk factors (Level 2). These risk factors are determined by the physical and operational features of the production system itself (Level 3). This production system, however, is the result of a design process in which decisions are made regarding layout, technology, cycle times and all other system features (Level 4). This design process in turn is directed by senior managers who make strategic decisions on production models and design process to be used by the design team (Level 5). It is this highest level in which initial decisions with ergonomic impact are being made. It is at this point that we believe the greatest latitude exists to integrate ergonomics into production systems. Intervention at higher levels in the model may also address multiple outcomes simultaneously – creating potential for the joint optimisation of human and technical factors in the system. Can we integrate ergonomics considerations to decision making at these higher levels in work system design?

Production Strategy as Ergonomic Determinant

Adam Smith was promoting the economic benefits of division of labour already in the 18th century (Smith 1776). Three quarters of a century earlier Bernadarno Ramazzini (1700 as cited by Kadefors & Läubli 2002) was already describing occupational diseases related to intense and unvarying workload. By the 20th century entrepreneurs like Henry Ford (Ford 1926) had begun to implement Taylor's "scientific" principles of management, which virtually destroyed craft style production and set the stage for today's 'Lean manufacturing' and 'Continuous Improvement' rubrics. This trend, we argue has been taken further in recent years as a huge array of "new" strategies are proposed for increasing competitiveness in the increasingly globalised market environment. This historical view echoes the work intensification trends observed today (eg Docherty et al 2002) across Europe. Biomechanically, this could occur as individuals' work has been reduced to increasingly narrow scope with less physical variability, increased repetitiveness, and ever increasing demands for productivity. Clearly this change has influenced both the psychosocial and physical conditions for individuals operating these systems.

The negative health consequences of overwork have been much discussed since Razzamini & Smith starting in the 18th century. In the modern manufacturing context, Björkman (1996) has presented a helpful discussion of the relations between manufacturing strategy and ergonomics. Vahtera et al. (1997) have found 'corporate downsizing' to increase MSD risk by 5.7 times. Landbergis et al. (1999) in their review of available literature noted increased negative health outcomes with the adoption of Lean manufacturing approaches. Karltun et al. (1998) found signs of increased physical loading with the implementation of ISO 9000 standards. Looking at more specific system design elements Coury et al. (2000) have demonstrated increased physical risk with partial automation strategies which couple workers more tightly to the production system. An increasing number of studies are finding risk increases with the adoption line-based production approaches (Neumann et al. 2002, Fredriksson et al. 2001, Ólofsdóttir & Rafnsson 1986). On the positive side, Kadefors et al. (1996) found that ergonomics improved in the application of parallelized assembly flows without sacrificing productivity. This small but growing body of research demonstrates how higher level strategic decisions can result in increased, or decreased, MSD risk for employees.

Intensification of Work

Ergonomic efforts focussed on reducing load amplitude can often be implemented successfully. Efforts to reduce the time duration of exposure, such as number of repetitions, can be more problematic as these tend to reduce productivity - the primary concern of industrial engineering teams who wish to maximise productive working. These two forces operating simultaneously can lead to a workplace with very low exposure amplitudes but, because of high system efficiencies, very high exposure durations and thus high time-density of working. The resulting high risk situation has been described as the 'ergonomic pitfall' since an 'ergonomically designed' workplace retains high MSD risk, albeit with different risk factors (Winkel & Westgaard 1996). How can we control exposure durations in the face of

continually intensifying work systems?

Ergonomics and productivity elements are intimately entwined. Overcoming the ergonomic pitfall therefore will require engaging the hearts and minds of industrial engineers and others to integrate ergonomics into the design process (Jensen 2002). Thus there is a growing call for 'joint optimisation' of productivity and ergonomics in the design of new workplaces (Neumann 2001, Burns & Vicente 2000). Can the negative consequences of increasing intensity be avoided by working smarter instead of just harder?

Stakeholders, Decisions, and Processes

Figure 2 presents a simple model of the context in which decisions are made by individuals in the system modelled in Figure 1. More detailed models of this type are presented by Rasmussen (1997) and Moray (2000). This model does not just apply to the affected workers, but to all stakeholders in the system. Individual decisions and action are embedded in the social and cultural forces acting at the company (or other sub-group). Power relationships, for example, can be expected to play a role in decision making within these systems. Corporate culture, established routines, structures and patterns will influence individual behaviours. Neumann et al. (1999) have discussed specific stakeholders and groups in relation to achieving ergonomics objectives in the organisation. Similarly societal forces such as legislation, professional fads and fashions, and economic forces will all influence individuals who make decisions with eventual ergonomic consequences in the production system (Figure 1). Unfortunately decision makers are often distanced from these ergonomics consequences both in time and organisationally, as most system designers are not forced to deal with MSD problems arising from their decision-making processes. We believe that successful solutions will engage arrays of stakeholders who see their personal and professional goals as being best met through the joint optimisation process. Are organisational or societal changes necessary to have ergonomic objectives integrated into decisions on production system design? Do individuals have the information, competencies, and mandate needed to achieve good ergonomics in modern work systems?

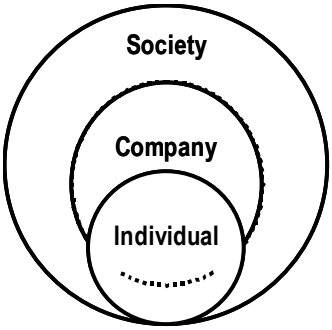

Figure 2: Simple model of stakeholder context applying to ALL system stakeholders.

Symposium Objectives

The problem area we describe is very large. In this symposium we aim to explore current trends in corporate strategy and production system design and the consequences these trends can have for the musculoskeletal health of the production workers. We attempt to foster discussion in this area with invited papers by both researchers and practitioners working in this area internationally by asking the following questions:

1) What are the current trends in corporate strategy in manufacturing?
2) How might these strategies affect ergonomic conditions for production workers?
3) What possible routes of action might be taken to improve ergonomics in the face of these new manufacturing trends?

These questions are addressed in four papers and are to be discussed in a plenary discussion. Each paper deals with a different aspect of corporate strategies in modern production environments.

Symposium Papers

The first paper in this symposium by Jensen & Broberg (2003) from the Danish Technical University presents conceptual frames for changing production system design. Here the authors explore the importance stakeholder roles and social dynamics in production system development processes. Strategy here includes recognition of the existing organisational structures and behaviour patterns while working as a political agent to integrate ergonomics into the ongoing design processes.

The second paper from Vink & de Jong present a case study from a large company considering the strategic advantages of keeping employees healthy to build experience and competence to tackle larger, more complicated jobs. The project demonstrated repeatedly that both productivity and ergonomic objectives could be furthered with careful planning. Distribution of these new methods to achieve workforce-wide impact however remains a challenge.

Stuart, Tooley, and Holtman from the Boeing Corporation

describe their approach as ergonomics practitioners operating inside a large organisation using the strategies of participatory ergonomics, downsizing, and 'lean manufacturing'; all common practices in today's industries.

Finally Neumann et al. present a case in which a parallel long-cycle time assembly system is redesigned to a more conventional serial flow system. This appears to be part of a trend in Sweden in which sociotechnically innovative production approaches, developed in the past decades, are abandoned in favour of modern variants of traditional line assembly (e.g. Ford 1926). This case presents a systems analysis of the change that reveals both advantages and disadvantages of the new system from both human and technical factors aspects.

These papers all examine different types of corporate strategies and demonstrate their effects on employee risks. As Stuart, Tooley, & Holtman point out in their paper – these strategies can have both positive and negative effects on ergonomics. Our question remains as a challenge: Can today's complex manufacturing systems be induced to embrace the long and short-term benefits of the appropriate integration of ergonomics at strategic levels?

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IEA 2003, SYMPOSIUM INTRODUCTION:

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Chapter 1: of the Division of Labour

”The greatest improvement in the productive powers of labour… seem to have been the effects of the division of labour”

-ADAM SMITH (1776)

’The Wealth of Nations’

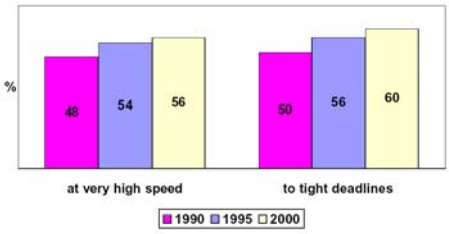
✓ The Pin Factory Example

And the race was on…

- Talyor (1911) – *Scientific management*
- FORD (1920’s)
- Demming (1950s +) – *Continuous Improvement*
- TOYOTA (1970 +)
- Womack (1994) – *The machine that changed the world*

Modern signs of work intensification

Figure 4: *Working at very high speed or to tight deadlines*



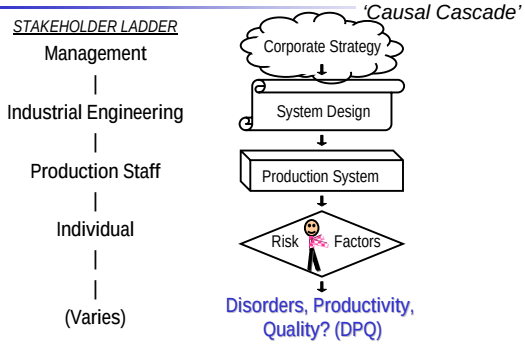
3rd Survey on Working Conditions in EU
Merllié & Paoli 2000. **n=21 500** EU workers

WMSDs - Scope of Problem

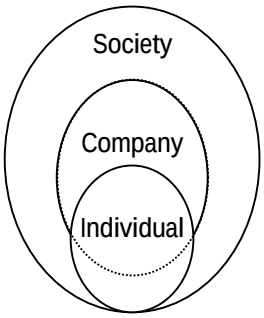
- **~5% GDP to WMSDs in industrialised countries (WHO 1995)**
- **~40% Musculoskeletal Disorders**

System Model

’Causal Cascade’

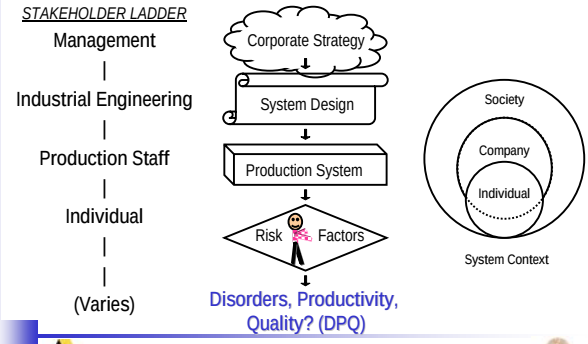


System Contexts



- **Globalization** (Netherlands 16th c.)
- **'Hyper-Competition'** (D'aveni 1994)
- **Complex Sociotechnical Systems** (Rasmussen 2000)

System Overview



Productivity - Ergonomics Relationships

Productivity \ Ergonomics	Better	No Change	Worse
Better	*Go!*	OK	Phantom Profit ?
No change	OK	↖	X
Worse	**Hidden Gains?**	X	X

Symposium Questions

1. Current trends in corporate strategy?
2. Consequences for ergonomics?
3. Opportunities for Intervention?

Symposium Papers

1. **Jensen & Broberg** (DTU) *Conceptual frames for changing production system design*
2. **Vink & de Jong** (Delft U, TNO) *Corporate strategy & workload reduction in installation work*
3. **Stuart, Tooley & Holtman** (Boeing) *Ergonomics, Lean Manufacturing, and reductions in Workforce*
4. **Neumann et al.** (ALI, LU, CTH) *Ergonomics and productivity in line-based production*
5. **Walker** (CAW) - *Response & Union Perspective*