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### Ergonomics and Quality Management—Humans in Interaction With Technology, Work Environment, and Organization

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# **Ergonomics and Quality Management—Humans in Interaction With Technology, Work Environment, and Organization**

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In many studies, ergonomics has been shown to influence human performance. The aim of this paper was to demonstrate important ergonomics influences on quality in industrial production, from the perspective of interactions between humans, technology, organization, and work environment. A second aim was to elaborate on the implications of these findings for the development of quality management strategies. This paper shows that ergonomics problems in terms of adverse work environmental conditions, inappropriate design of technology, and an unsuitable organization are important causes of quality deficiencies. Problem solving aimed at improving ergonomics, quality, and productivity simultaneously is likely to obtain support from most of the interest parties of the company, and may also enhance participation. Ergonomics has the potential of becoming a driving force for the development of new quality management strategies.

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ergonomics quality productivity improvement strategy

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## **1. INTRODUCTION**

Industrial activities are complex and cannot, therefore, be understood from only one perspective. Models of companies and production systems may reflect a few aspects, but do not provide a holistic view. From one point of view, three strong interest groups of a company can be

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identified, namely, the employers, the employees, and the customers. These groups have a strong interest in efficiency, working conditions, and quality respectively.

Today, quality is regarded as a management strategy. In particular, Total Quality Management (TQM) has been defined as a management strategy with the purpose of satisfying the interest groups mentioned in the previous paragraph, and this is also expressed in the following definition of quality: "The quality of a product or service is its ability to satisfy the needs and expectations of the customers." The employees are here seen as internal customers (Bergman & Klefsjö, 1994, p. 16).

The Nordic Ergonomics Society defines ergonomics as "Interdisciplinary field of science and application considering integrated knowledge of human requirements and needs in the interaction human-technology-environment in the design of technical components and work systems" (Ruth & Odenrick, 1994, pp. 16-21). The main purposes are to promote safety, health, well-being, and efficiency. Ergonomics is a discipline that often emphasizes the design of technology and organization. Another perspective on a company is the interactions between humans, technology, organization, and work environment. In this respect, ergonomics and quality have many similarities regarding aims.

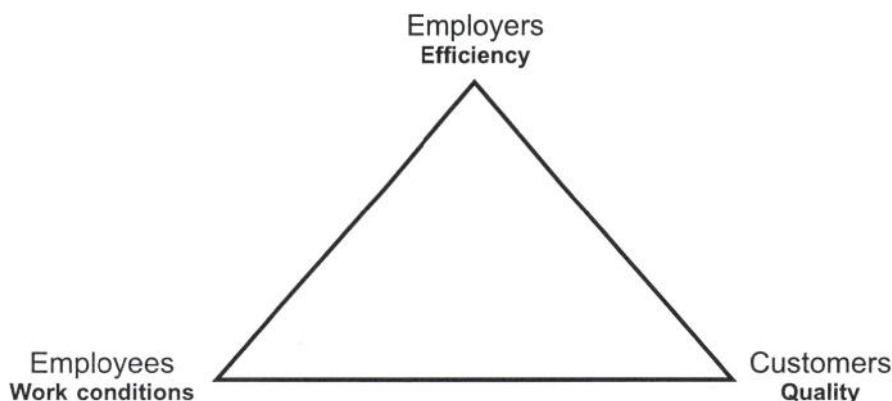


Figure 1. A model of interests of a company or an organization.

Management strategies have often focussed on one factor at a time, for example, productivity, by reducing the need for human labour through specialisation, through automation, or through employee motivation. Experience, however, shows that such approaches are often not as

successful as more holistic approaches (Shiba, Graham, & Walden, 1993). One reason for this is that full consideration has often not been given to the interactions between the factors just mentioned. In the field of ergonomics, there is abundant evidence of how insufficient interaction between humans and technology or between humans and adverse work environmental conditions can lead to losses of efficiency and productivity, not to mention the consequences for the people involved. Ergonomists have often tried to justify ergonomics improvements with gains in productivity or reduced personnel costs (Liukkonen, 1992; Oxenburgh, 1991). There have, however, been few attempts to evaluate the impact of ergonomics on quality, from a TQM perspective.

The aim of this paper was to demonstrate important ergonomics influences on quality, from the perspective of the interaction between humans, technology, organization, and work environment. A second aim was to elaborate on the implications of the findings regarding quality management strategies.

## 2. LITERATURE REVIEW

This review focuses on ergonomics from the perspective of the interactions between humans, technology, organization, and work environment, and the influence of these interactions on quality.

Starting with the interaction between humans and work environment, there are a large number of studies showing clear relationships between effects on human (quality) performance and environmental factors such as lighting, noise, vibration, chemicals, and climatic conditions (Sanders & McCormick, 1993; Smith & Jones, 1992).

Many studies have identified increased rates of misjudgements due to insufficient lighting, such as light levels, colour rendering, luminance, and reflections (Grandjean, 1988). This has been observed in proof-reading of texts with poor visibility (Dillon, 1992; Wilkinson & Robinshaw, 1987). In production industries, increased illumination levels have resulted in up to 40% reductions in rejection rates or wastage (Grandjean, 1988).

Noise may increase the error rate through distraction and lapses of attention or due to masking of essential information. One example from Lovén and Axelsson (1993) showed that in the assembly of components with a snap-on function, the snap sound signalled "passed" to the

worker. Extraneous noise obscured the snap sound and led to a higher number of quality deficiencies.

Vibrations of the eye or the viewed object make it difficult to see particularly fine objects. One such effect of vibration observed is that the error frequency in reading tasks has been shown to increase. Vibrations may cause unwanted movement of the controls in manual control tasks. Vibrations may also interfere with the neuromuscular processes, including finger sensitivity, and thereby cause errors (Griffin, 1992).

Low temperatures that cool the hands decrease the sensitivity and precision of hand and finger movements. Adverse climatic conditions in combination with cognitive and mental tasks, decrease performance measured as frequency of errors or as accuracy (Hygge, 1992; Sanders & McCormick, 1993). The use of gloves as protection against low temperatures or chemical compounds decreases precision (Cushman & Rosenberg, 1991), and the tactile feedback, sometimes necessary in order to judge the quality of the work result, may be lost if gloves are used (Lovén & Axelsson, 1993).

The precision of body movements varies depending on the directions of movement and depending on which muscles are used. Ergonomic design that considers this facilitates greater accuracy of performance. Existing bodily discomfort and pain tend to be aggravated by heavy and strenuous work tasks, which is a situation that is accompanied by avoidance and deteriorating performance (Corlett & Bishop, 1976; Grandjean, 1988).

The studies just quoted may be generalised by the statement that adverse environmental and physical conditions causing discomfort to humans are related to quality errors or deficiencies. One explanation may be that discomfort can cause distraction and lapses in attention or lead to compensatory activities that compete with the main task. Other mechanisms may be impaired perception or masking. Another possibility is that adverse working conditions act as a drain on motivation.

Not so much research has been put into the interactions between humans and technology with respect to possible influences on quality. Self-paced work in relation to machine-paced work has been shown to improve quality (Eklund, 1996; McFarling & Heimstra, 1975). The use of production lines with short work cycle assembly in which the worker was not able to control his distribution of time between different work objects led to increased rates of quality deficiencies. One reason was the

variability in the time needed for each operation, leading to unfinished operations when a slight problem occurred (Eklund, 1995). Repetitive jobs give rise to symptoms of boredom or fatigue, which cause an increased error rate (Grandjean, 1988). This interaction between humans and technology has been discussed with relation to product design. Technology for presenting information to operators may facilitate substantial improvements in the quality of decisions, and the design of controls may improve the accuracy of the operator in controlling the technology (Sanders & McCormick, 1993).

It is commonly recognised that the design of products has a decisive influence on manufacturing time, quality output, and ease of manufacturing (Helander & Nagamachi, 1995; Willkrans, 1995). There are numerous studies in ergonomics literature that show how ergonomically designed products may improve performance (Corlett & Bishop, 1976; Grandjean, 1988; Kilbom, Makarainen, Sperling, Kadefors, & Liedberg, 1993). Some examples from electric connector assembly are

- Visibility,
- Position,
- Layout,
- Sequence,
- Size,
- Shape,
- Weight,
- Colour,
- Texture,
- Friction,
- Fragility,
- Heat conductivity,
- Hardness,
- Fittings,
- Force,
- Displacement.

The design aspects mentioned have been identified as potential causes of quality deficiencies, and constitute examples of how insufficient interaction between technology and humans may be the origin of such quality deficiencies (see Eklund, 1997).

The interaction between humans and organization has been given some attention in terms of quality influences. Kronlund, Gries, Gille,

and Mattson (1978) observed that increased work content appeared to improve product quality. Drury and Prabhu (1994) came to the results that job enrichment improves inspection performance, and Eklund (1996) obtained data indicating improved assembly quality when self-inspection was included in the assembly tasks compared to using separate quality inspectors. Operators with broader assembly competence were found to perform 33% better quality than those with less competence, and the lack of operator feedback was found to be one important reason for poor ability in assessing quality (Lovén & Helander, 1997). Also, status differences and tensions between categories of workers in a hierarchical work organisation were shown to be related to quality deficiencies (Eklund, 1995). Furthermore, production philosophy, work organisation, and personnel policy, as well as wage form, have been shown to correlate with quality (Deming, 1986; Sundström-Frisk & Werner, 1978; Womack, Jones, & Roos, 1990). A frequently used argument is that motivation leads to improved product quality and that the best incentives are continuous levels of interest in the work, maintained by challenges and achievements being recognised, involvement through ownership, and improved communication (Lammermeyr, 1990).

Systematic quality work, for example, in quality circles, not only improve quality but can also solve working environment problems (Lewis, Imada, & Robertson, 1988). One third of the problems addressed in quality circles are related to shortcomings in the working environment (Axelsson, 1995; Noro, 1991).

In summary, the literature contains many examples of how the interactions between humans on the one hand and technology, organization, and work environment on the other are related to quality. In section 3, four case studies are presented in order to give a more complete picture of how the aforementioned interactions influence product quality.

### 3. CASE STUDIES

These case studies have been taken from mechanical and electrical manufacturing. A detailed description of the case studies can be found in Eklund (1994, 1995), Sandström and Svensson (1996), Hallberg (1995), and Axelsson (1995).

### 3.1. Study 1

The study was conducted at a Swedish car assembly line. Painted car bodies were being fully assembled. The cycle time was about 5 min. In the last department, all the cars were given a final inspection, and final adjustments were carried out. The plant operated almost along the lines of a "Fordistic" production philosophy. The division of labour was very pronounced, and the jobs were regarded as low status ones. Assembly workers, replacement personnel, quality inspectors, adjusters, instructors, lift truck drivers, and material handlers were organised under the leadership of foremen. The foremen applied virtually direct control, and there was hardly any delegation of responsibility and authority to the assembly workers. The training level of the workers was very low. Both absenteeism and personnel turnover in the plant were higher compared to industry in general. The purpose of this particular study was to evaluate and identify relationships between a number of ergonomic conditions and product quality in car assembly.

Ergonomically demanding tasks were assessed through interviews with experienced workers. Three categories of ergonomic problems were assessed, that is, (a) problems of physically demanding tasks, (b) designs that made assembly difficult, and (c) psychologically demanding tasks. Thereafter the quality statistics from the plant were analysed.

In the assessment of ergonomically demanding tasks from the eight departments, a total of 58 tasks were identified on the basis of the three-criteria set. For 43 of the tasks, problems in the form of physically demanding tasks were found, in 25 of the tasks the designs were difficult to assemble, and 10 of the tasks were psychologically demanding. Eight of the tasks were thus classified concerning two criteria and six of the tasks had problems covering all three criteria.

The assembly time for these 58 tasks with ergonomic problems constituted 25% of the total assembly time according to the company's time records. The numeric proportion of these tasks was clearly less than 25%.

From Table 1, it can be seen that there was a noticeable over-representation of quality deficiencies from final adjustment statistics for the ergonomically demanding tasks. The difference was statistically significant ( $p < .05$ ). The relative risk for quality deficiencies among the ergonomically demanding tasks was three times greater than for the other tasks. Another way of expressing this is that 33% of all quality deficiencies were due to ergonomic problems.



**TABLE 1. Assembly Time Data and Quality Deficiencies for Tasks with Ergonomic Problems and Other Tasks, Including Quality Statistics From Final Adjustment**

Investigated Factors	Tasks with Ergonomic		
	Problems (58)	Other Tasks	All Tasks
Assembly time proportion	25%	75%	100%
Quality deficiencies from final adjustment	4088*	4154*	8242*
• Proportion	50%	50%	
• Relative risk for quality deficiencies	2.95	(1.0)	

*Notes.* Relative risk—the likelihood of getting quality deficiencies for ergonomically problematic tasks compared to other tasks, based on assembly time; \*—the differences are significant at the 5% level.

During the interviews, many causes of the quality deficiencies were identified. Nearly all workers wanted to perform well, but they faced different hindrances. Examples of such were conflicts, if a supervisor was uninterested or authoritarian, uncommitted fellow workers, and high levels of absenteeism. Furthermore, the workers perceived that the company seldom showed any appreciation of good work. There was a lack of materials and poor levels of information due to organizational deficiencies, and all these factors created lower motivation for quality.

Poorly designed assembly components, straining work postures, and troublesome machines could cause fatigue and pains in various parts of the body. This resulted in less effort being put into performing the task correctly. Workers contented themselves with slightly defective results to spare their bodies more discomfort.

The assembly line was designed so that if one person was delayed, the rest of the group was also delayed. Therefore, the workers took chances on borderline quality levels or deliberately passed on unfinished work to the adjusters when problems occurred, to avoid delaying their colleagues. Another reason for workers deliberately passing on uncompleted work to the adjusters was a sense of "fair play." The assemblers had lower status and lower wages than the adjusters. When the assemblers saw that the adjusters had little or nothing to do, they reacted to this situation. They could only do something about this by passing on more work to the adjusters.

Certain faults with fittings had occurred for several years despite repeated requests for corrective measures. When no reaction or information regarding these problems was received, the assemblers experienced this as a drain on their motivation. The result was that they stopped

trying to compensate for the faults caused by "well-paid engineers," and they also lost the desire to make efforts in other areas. Some assemblers felt that they were treated as second class people as they were not worth even 5 minutes' information time about what had happened with their complaint. Further details can be found in Eklund (1994, 1995).

### 3.2. Study 2

Study 2 was conducted at a different Swedish car assembly line, manufacturing a newer model. The cycle time was about 3 min. The division of labour was quite pronounced. For several years intense work had been put into improving the organization and productivity along the lines of lean production. The company management also emphasized quality as a major strategy. Increasing efforts had been placed on suggestion schemes with an increase in delegation of responsibility and authority to the assembly workers. A new car model had recently been developed with a strong emphasis on design for shorter assembly time. The training level of the workers had been somewhat improved. Absenteeism (6%) and personnel turnover (8%) in the plant were not abnormal for that type of production. The purpose of this study was to identify possible physical contributors to difficulties with assembly-ability and ergonomics.

All the assembly workers were given a questionnaire about the most common problems they perceived with components, production equipment, and packing. The problems were estimated according to frequency and classified as shortages in supply, assembly problems, function problems, ergonomics problems, and work environment problems. Assembly times, component waste frequency, quality deficiencies, and work injury rates were collected from the statistics being kept at the company.

In total, 348 problems were listed, and the workers perceived that 143 or 41% of these were related to the ergonomics situation. The causes of these 143 ergonomics problems were assigned to the design of the component (85), work postures (30), packing (22), and production equipment (6). Of these, 121 could be related to specific components and also estimated in assembly time. These components were consequently problematical from both an ergonomics point of view and from an assembly-ability point of view.

**TABLE 2. Assembly Time Data and Quality Deficiencies for Components with Assembly Problems and Other Components**

Investigated Factors	Components with Assembly Problems (121)	Other Components	All Components (approximately 1000)
Assembly time proportion	11%	89%	100%
Quality deficiencies, averages	4.85*	13.45*	18.3*
• Proportion	27%	73%	100%
• Relative risk for quality deficiencies	2.9	(1.0)	

Notes. Relative risk—the likelihood of getting quality deficiencies, based on assembly time; \*—the differences are significant at the 5% level.

As can be seen in Table 2, the components with ergonomics and assembly-ability problems were causing quality deficiencies significantly more often compared to the other components ( $p < .05$ ). The risk of getting quality deficiencies was 2.9 times higher. Another way of expressing this is that 17% of all the quality deficiencies were due to ergonomic deficiencies that included assembly-ability problems. The results also showed that components with longer assembly times were significantly more likely to give rise to quality deficiencies and to work injuries. There was also a tendency that the components with the highest waste frequency seemed to be over-represented with components that had assembly-ability problems and long assembly time. One reason for the finding that components with longer assembly times had more quality deficiencies and assembly-ability problems, was that additional time had been allocated to the assembly of these components. This study also highlighted the fact that the design of a component seems to be the most common cause of ergonomics and assembly-ability problems. Further details can be found in Sandström and Svensson (1996).

### 3.3. Study 3

Study 3 was conducted at two Swedish engine plants, where car engines were fully assembled. The engines were assembled in fixed work stations where automatically guided vehicles (AGVs) were used for transport. This gave opportunities for increased cycle times and increased freedom for the assembly workers to vary their work pace. Cycle times and the degree of work division, however, differed between and within the plants. There was an emphasis on improvements of the organization,

which included increased work content and group organization. Increasing emphasis and effort had been put on worker participation and increasing delegation of responsibility and authority. The training level of the workers had been improved. Absenteeism and personnel turnover in the plants were considered normal for that type of production. The purpose of this study was to identify relationships where ergonomics problems contributed to quality deficiencies, and to investigate to what extent ergonomics improvements resulted in quality improvements.

Quality deficiency statistics were collected for both plants. In plant A, there was a conditional restriction that quality problems that were caused by the design should not be dealt with. The five most frequent quality problems that could be influenced in-house were selected. In plant B, the focus was on electric connectors, and the five most common quality problems were selected. One system group was set up for each plant, according to Andersson (1988). The members were typically one representative for production engineering, a supervisor, a few assembly workers, a representative from the quality department, and a working environment and safety and health representative. The sessions in the system groups were to deal with problem identification, idea generation, idea selection, and idea development.

The problem identification in plant A was partly based on video films, and in total 41 causes of the five quality problems were identified. Based on a session around a demonstration engine, 59 causes of quality problems were identified in plant B. In the idea generation session, there were 50 solutions proposed in plant A and 82 in plant B. Twenty-eight of the 50 solutions proposed in plant A were selected to be included in the action plan. Fifteen of the 50 solutions proposed were related to ergonomics; not only physical but also psychosocial work conditions. Out of the 82 solutions proposed in plant B, 25 were selected to be included in the action plan. Forty-nine of the 82 proposed solutions in plant B were related to ergonomics. This means that approximately 50% (30 and 60% respectively) of the solutions proposed in both plants were related to ergonomics. The ideas were distributed among different types of actions according to Table 3.

Stress and time pressure were identified several times as a cause of deficient quality. Too short an introduction course for newly employed personnel and insufficient information about the quality demands were also observed. Difficult work postures, lack of space, and low motivation levels were other causes identified.

TABLE 3. The Distribution of Types of Proposed Solutions for the Two Plants

Plant	Design	Production Technology	Organization	Personnel	Miscellaneous
A	10	23	2	5	10
B	36	13	19	8	6

In the assembly of electrical connectors, at least five main partial tasks may be distinguished, namely, to identify the connectors, to grip them, to connect them, to check the connection, and to remake them if necessary. This last partial task sometimes involves disconnection, a task that is also very important in maintenance. The system group activities revealed a large number of difficulties that could occur; many of them avoidable with improved design. Among these were difficulties in seeing the connector, difficulties in reaching it with maintained upright body posture, and too high force requirements for connection. The list in section 2 provides an overview of possibilities or a checklist for improvements in the ergonomics situation simultaneously with assembly-ability and quality.

During the 4-month time period for this study, nearly half of the proposals in the action plan were implemented, and many of the other proposals were being planned in plant A, whereas no proposals had been implemented in plant B. Unfortunately for this study, the quality report system was changed so that it was not possible to make an accurate follow up for more than one of the quality problems, after actions had been taken. The number of quality remarks was halved (from 10 to 5 on average per week) during a 13-week period, whereas no changes could be identified for the quality problems where no changes had been introduced. This difference was statistically significant. It also shows how actions to improve the ergonomics situation also improve the quality. Further information can be found in Hallberg (1995).

### 3.4. Study 4

Study 4 was conducted at a Swedish subcontractor to the car industry. In one department the critical components were manufactured, and in the second department the final product was assembled. The products consisted of relatively few components, but the design of the products

was relatively complex and knowledge intensive. The assembly department employed mainly female workers. The assembly was performed on an assembly line, where the workers had relatively machine-paced and highly repetitive tasks. Due to the character of the product, the cycle times were short, but an extensive job rotation scheme was in place. The degree of work division was high. The company emphasised technology improvements, even though improvements of the organization were being aimed for, mainly towards group organization. No particular effort was put into worker participation, or into delegation of responsibility and authority. The training level of the workers had been improved to a certain extent. Turnover and absenteeism in the plant due to musculoskeletal problems were relatively high, but not unusually so for the type of production. The purpose of this study was to identify relationships between ergonomics problems and quality deficiencies, and to investigate to what extent ergonomics improvements resulted in quality improvements.

Assessment of work postures were made through a questionnaire and assessments using the RULA method (McAtamney & Corlett, 1993). Bodily symptoms and psychological load were assessed through the questionnaire, and assembly-ability through the questionnaire and an analysis according to Boothroyd and Dewhurst (1989). Twenty-eight workers answered the questionnaire. The quality statistics used for this study were based on wasted parts and were collected by the assembly workers. One of two assembly lines were redesigned, where the ergonomics situation was improved, which also brought with it better assembly-ability and production engineering improvements. The reference line was not changed. The improvements included improved information and education, improved work space, easier materials handling, better work postures, better lighting, improved fixtures, and less strenuous assembly by altering the product design. After the improvements a follow up questionnaire was distributed to the 10 workers at the changed and the reference lines.

The results showed significant correlations between difficult assembly on one hand (due to lacking space, fixation of parts, bad fittings, and details getting stuck) and on the other hand adverse working postures, the perception of strenuous movements and postures, and discomfort from neck, shoulders, and arms. These difficulties also correlated significantly with psychologically demanding tasks. In a further analysis of this data, the quality deficiency rate was found to be almost 10 times higher for the worst posture compared to the best posture.

After the ergonomics changes, several improvements could be identified in the improved line but not in the reference line. These included fewer musculoskeletal problems, improved work postures and movements, and better assembly-ability. Also, quality had improved in terms of waste ratios. The average improvement in relation to the reference line, measured over a 16-month period, was 39%. All these changes were statistically significant. The pay-off time for the improvements was less than 7 months. Further information can be found in Axelsson (1995).

#### 4. CONCLUDING RESULTS AND DISCUSSION

The case studies demonstrate that ergonomic problems in many cases cause quality deficiencies. The causes are directly related to the human interactions with technology, with the organization, and the work environment. A substantial part of the quality problems in production originate from this type of deficiencies in the ergonomics situation.

**TABLE 4. An Overview of the Results from the Four Case Studies of Relationships Between Quality and Ergonomics**

Case Study	Ergonomics Factors Studied	Results
1. Car assembly	<ul style="list-style-type: none"> <li>• Physical demands</li> <li>• Difficult assembly</li> <li>• Psychologically demanding tasks</li> </ul>	<ul style="list-style-type: none"> <li>• Ergonomic problems increased risk of quality deficiencies 2.95 times</li> <li>• 33% of quality deficiencies due to ergonomics problems</li> </ul>
2. Car assembly	<ul style="list-style-type: none"> <li>• Physical demands</li> <li>• Difficult assembly</li> </ul>	<ul style="list-style-type: none"> <li>• Ergonomic problems increased risk of quality deficiencies 2.9 times</li> <li>• 17% of quality deficiencies were due to ergonomics problems</li> <li>• 41% of production problems were characterised as ergonomics</li> </ul>
3. Engine assembly	<ul style="list-style-type: none"> <li>• Physical demands</li> <li>• Difficult assembly</li> </ul>	<ul style="list-style-type: none"> <li>• Quality deficiencies decreased by 50% after ergonomics improvements</li> <li>• 30–60% of quality improvement proposals were characterised as ergonomics</li> </ul>
4. Component assembly	<ul style="list-style-type: none"> <li>• Physical demands</li> <li>• Light</li> <li>• Psychosocial factors</li> <li>• Information</li> <li>• Competence</li> </ul>	<ul style="list-style-type: none"> <li>• Quality waste decreased by 39% after ergonomics improvements</li> </ul>

As can be seen in Table 4, the results point to differences between different types of production, in regards to the strength of the relationship between ergonomics and quality. However, it seems as if physical demands, including difficult assembly-ability, increase the risk for quality deficiencies threefold. Also, it is not uncommon that one third or more of the quality deficiencies are due to ergonomics problems, even if the quantitative results must be interpreted with caution. These relationships are not only supported from statistical correlations but also from assessments of chains of events, leading to quality deficiencies, as well as from assessments of causes of quality deficiencies. Furthermore, in cases where improvements of the ergonomics situation have been performed, this has resulted in improved quality, which strengthens the conclusion that ergonomics problems are direct causes of quality deficiencies.

The results clearly point to the fact that an ergonomics improvement strategy should be considered as an effective and natural part of a quality strategy. There is strong potential for enhancing quality by improving work and workplace design and by giving more consideration to human characteristics and needs.

Many problems seem to be of a composite nature, involving quality, ergonomics, and also productivity aspects at the same time. We can also identify these three aspects as central in a company, and related to three strong interest groups, namely, the customers, the employees, and the employers respectively. A quality management approach, therefore, needs to consider these aspects simultaneously. One possible management strategy is to focus on these joint problems as a starting point for improvement activities. This allows most of the interest parties on the organization to take a positive view towards this approach, as each group will see that their primary goals are being considered. Management, customers, and employees all become potential winners. This approach offers a new opportunity for improvements in the company.

A further aspect is that this approach cannot be taken successfully in the long run with an "expert strategy." Participation of the work force is needed in order to identify the subtle nuances of how ergonomics aspects interfere with quality and result in productivity losses. Problem solving activities also constitute a change towards better job content. A participation strategy in problem solving such as this can, therefore, become a driving force for further improved worker participation, which will bring along with it new improvements in working conditions, as



well as in the psychosocial field. Ergonomics has the potential to become a driving force for the development of new quality management strategies.

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