

Ergonomics Intervention in an Iranian Tire Manufacturing Industry

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The aim of an ergonomics intervention conducted in the tire manufacturing industry was to improve working conditions. Before the start, a senior manager supported the intervention. Participants were divided into teams and trained. After observing the overall performance of the teams, over 100 improvements were successfully implemented. After the improvements, there were statistically significant differences in annual and weekly prevalence of, and annual disability reported for, the upper back, the lower back, knees and wrists between before and after intervention. The annual prevalence of upper back, lower back, knee and wrist complaints decreased from, respectively, 60.3%, 50.2%, 28.9%, 25.8% before the intervention to 31.3%, 35.9%, 17.1%, 20.7% after the intervention. Significant factors were training and supportive environment based on full commitment of the top management.

participatory ergonomics musculoskeletal disorders team work tire industry

1. INTRODUCTION

An ergonomics intervention using a participatory approach is useful in reducing work-related musculoskeletal disorders (WMSDs) [1, 2]. Wilson and Haines defined participatory ergonomics (PE) as “the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals” (p. 490) [3]. Kuorinka defined PE as “practical ergonomics with participation of the necessary actors in problem solving” (p. 268) [4]. Forming a team or a committee is the main feature of most PE interventions. Forming intervention teams is essential to conduct an ergonomics intervention. Teams typically involve workers or their representatives, managers, ergonomists, and health and safety personnel. Teams usually receive training from an ergonomist to become familiar with ergonomics principles [5]. They use their newly developed knowledge to improve their workplace [6, 7, 8].

The development and implementation of an ergonomics intervention program requires a team effort. Employers’ and employees’ benefits from the program are reduced number and severity of WMSDs, reduced employee turnover, increased productivity, increased product quality, and increased employee morale. The benefits, e.g., decreased absenteeism, reduced disability, and reduced compensations for workers, reduce costs [9, 10, 11, 12, 13, 14, 15].

The General Accounting Office [16] and Cohen, Gjessing, Fine, et al. [17] list six critical elements necessary for a successful PE program in a workplace: management commitment [18], employee involvement [19], risk assessment of individual and job [20], analysis of data and development of controls [21], training and education [22], and health care management [23].

PE uses total employees’ potential to conduct ergonomics improvements in a workplace. PE is an element of macroergonomics; it ensures adequate consideration of organizational design and management issues [24]. PE is an increasingly

The author expresses his sincere gratitude to all those who helped make this work possible, especially all the workers, the supervisors and the managers who participated in this study.

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growing field of ergonomics, organizational design and management [19]. PE is a principal methodology used to optimize organization, and work system design [25]. While adopting PE, it is essential that the top management is committed and supportive [26].

Many organizations use team working structures to become more responsive to market conditions and more effective in operations. Team working is a very popular way to achieve greater organizational flexibility and other benefits, e.g., reduced costs of supervision, faster lead times, innovation, effective decision making, better customer service, and enhanced employee morale. The use of team-based work in organizations increased over the past few decades. In ergonomics, team-based work functions effectively and improves working conditions, increases productivity, and improves quality. A successful PE program requires corporate involvement. Creating ergonomics team-based work involving representatives from various organizational units is a major breakthrough. Ergonomics team-based work can involve employees in a corporate-wide effort to improve working conditions by tapping into the employee's knowledge about job demands and desire to have a voice in workplace decisions.

According to Driessen, Groenewoud, Proper, et al., "PE can be used for both the development and implementation of new ergonomic measures as well as to improve implementation of already planned ergonomic measures. Furthermore, the working group composition was important for implementation, meaning that a manager who is entitled to make decisions at the department level and the working group members who can play a leading role during the implementation process should be included. Stakeholder involvement can considerably facilitate implementation; therefore, it is recommended that they are involved in the working group or consulted during the implementation process" (p. 8) [27].

In their other study, Driessen, Proper, Anema, et al. pointed out that PE can be "a successful and feasible strategy to develop an implementation plan with prioritised risk factors for LBP [lower back pain] and NP [neck pain] and prioritised ergonomic measures to prevent LBP and NP" (p. 8) [28].

PE has been used in several recent studies to reduce physical work demands and to prevent musculoskeletal disorders (MSDs) [29, 30, 31]. In PE, shopfloor workers play an active role in analyzing work and planning improvements [32]. PE benefits were the use of workers' experience and knowledge, information on participants and their commitment, and better acceptance of changes [33].

Haims and Carayon implemented a PE program in their study, which involved a 12-member team of ergonomics co-ordinators. External ergonomics experts trained internal ergonomics experts along the project period using behavioral cybernetics principles [34]. Allard, Bellemare, Montreuil, et al. established ergonomics teams to identify and prevent MSDs. Each team made interventions at workstations which can pose a risk and implemented corrective actions [35]. Rosecrance and Cook conducted a study on preventing MSDs with PE in the newspaper industry. The results showed that PE could contribute to the development and implementation of ergonomics solutions reducing risk factors of WMSDs [36]. Vink and Kompier designed an ergonomics program to improve working conditions in an office. A steering committee and an ergonomics team were formed. The results showed successful performance and improvement in the design, and redesign of a workplace [37].

In the present study, the ergonomics intervention with PE was conducted in an Iranian tire manufacturing industry to improve the workplace and working conditions, and to reduce WMSDs among the workers.

2. METHODS

2.1. Participants and Procedure

The study took place in a tire plant in eastern Iran in 2006–2008. The plant employed 800 shop floor workers. On the basis of previous experience [9], a PE model was applied in this intervention program called an ergonomics process. According to this model, the ergonomics process has two distinctive approaches: reactive and proactive. The ergonomics process starts with a reactive cycle with identifying the risks, evaluating

the priorities, proposing the solutions, implementing and evaluating a prototype, to adopting solutions. The proactive cycle uses the feedback from previous improvements and ensures that ergonomic principles are used in purchasing and designing new equipment (Figure 1).

2.2. Team-Based Structure of PE

A steering committee (members of the management) was formed to facilitate the implementation of the ergonomics process, maintain a vision, communicate a vision, and support the teams in their activities. The steering committee consisted of plant manager, managing director’s representative, engineering department manager, quality department manager, maintenance department manager, production department manager, factory physician, health and safety manager, and ergonomics consultant.

Management appointed some of its workers to participate in the ergonomics process. The ergonomics team members were workers’ representatives, supervisors, and health and safety department personnel. Maintenance, engineering, and production managers led the ergonomics teams, and the health and safety manager co-ordinated the steering committee and the ergonomics teams. The participants were divided into three teams and were responsible for improving working conditions at different workstations. The ergonomics

teams were responsible for assessing workstation problems, developing an improvement plan and implementing the plan after the steering committee approved it. The ergonomics teams regularly evaluated the progress according to the goals and objectives, and documented the results. Figure 2 presents the team-based structure for implementing the ergonomics process. With this ergonomics training program, team members learned how to analyze and evaluate the working environment. Checklists and measurements were used in practical examples. Suggestions for improvement were developed and presented at the team level.

2.3. Training Program

The ergonomics training program was implemented in 2006. The ergonomics professionals prepared a workshop training program for the tire plant. The training combined theoretical knowledge and practical examples. Team members attended monthly or bimonthly workshop sessions (56 h in the first year of the project). The topics of the workshops were

- elements of PE program [17, 38];
- introduction to Persian version of ILO ergonomics checkpoints [39];
- principles of team work,
- introduction to Persian version of NIOSH ergonomics checklists [17];

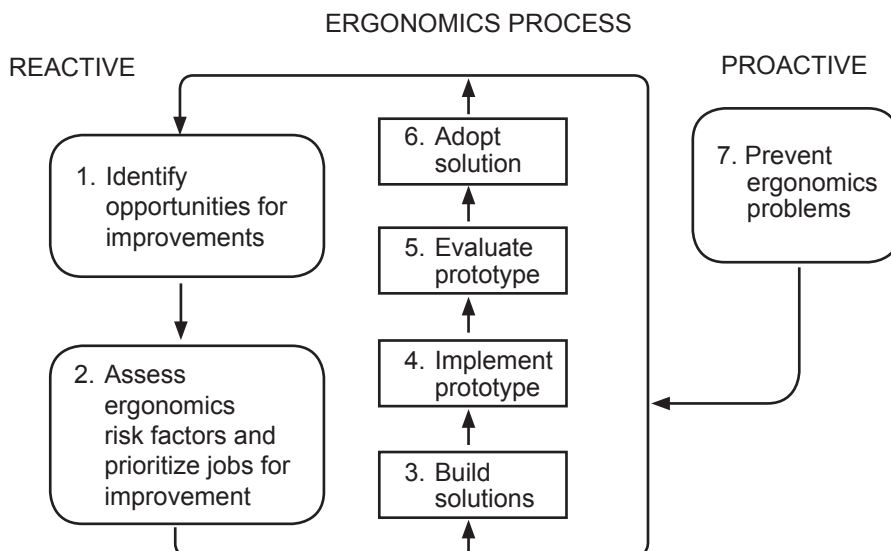


Figure 1. The ergonomics process.

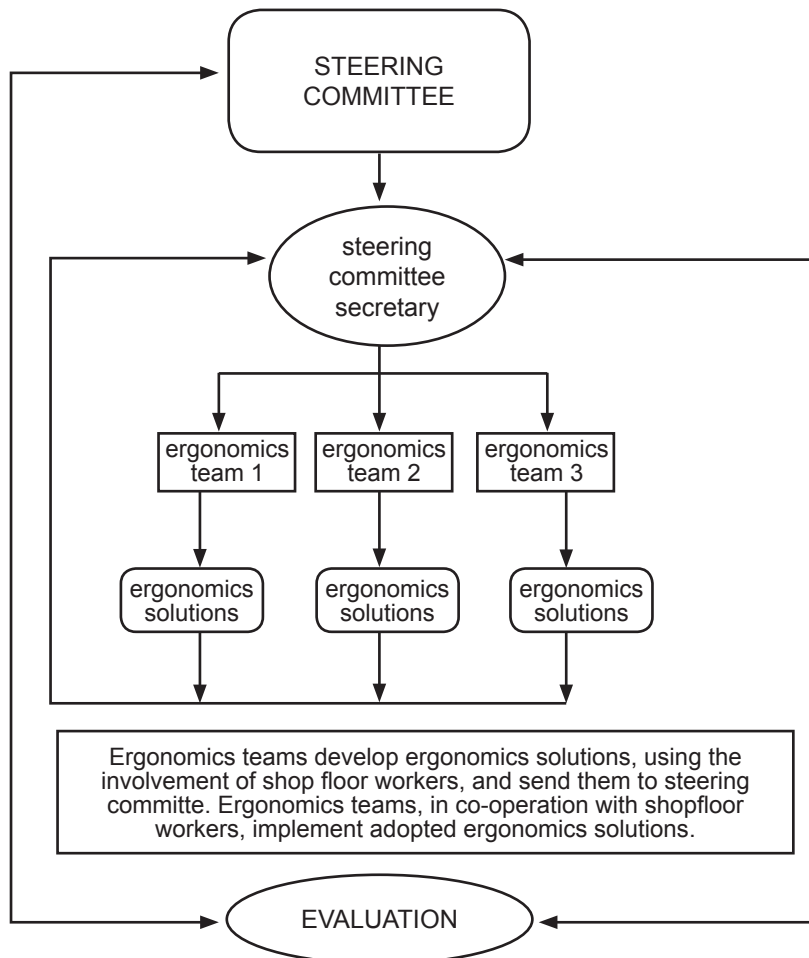


Figure 2. A team-based structure for implementing an ergonomics process.

- introduction to Persian version of “Easy ergonomics” [40];
- MSDs and their risk factors;
- observational methods for assessing risk of developing MSDs, including OWAS [41], RULA [42], REBA [43] and QEC [44];
- body discomfort assessment with body map [45];
- manual material handling assessment including the NIOSH lifting equation [46], and Snook and Ciriello’s tables [47];
- control of MSDs (engineering and administrative controls);
- ergonomics and design;
- applied anthropometry;
- workstation design;
- ergonomics hand tool design;
- physiology of work.

The Nordic musculoskeletal questionnaire evaluates body discomfort and the effectiveness of the ergonomics intervention. It was applied in the second and the third year of the project (before and after intervention) as part of the factory annual periodic examinations [45]. The adapted Nordic musculoskeletal questionnaire determined annual and weekly prevalence, and the annual disability rates for musculoskeletal complaints. SPSS version 13 was used for data analysis. Nonparametric χ^2 test compared proportions.

3. RESULTS

3.1. Ergonomics Solutions

The overall performance of the teams, when improving the ergonomics conditions, was considerable. With the support of the steering committee,

the teams designed and implemented low or no cost ergonomics solutions using local resources. During the second and the third year of the project over 100 low or no cost improvements were successfully implemented in the factory. Some of the most important were

- designing
 - a pneumatic lifting mechanism for tires,
 - portable/fixed foot rests,
 - a loading station in warehouse,
 - ergonomic chairs,
 - a handle for easy pulling/pushing pallets and carts,
 - ergonomic worktables,
 - rotary tables in trim shops,
 - accessible shelves,
 - new carts for material handling,
- improving carrying tire compound from batch section to feeding section;
- designing/redesigning hand tools;
- improving lifting raw material bags;
- installing rubber mats on the floor.

Defining new solutions improving working conditions became the team’s routine activity. Poor ergonomics conditions would continue to improve.

3.2. Reduced Musculoskeletal Complaints

Table 1 shows the prevalence of MSD symptoms during the 12 months before intervention. The highest annual prevalence of musculoskeletal

complaints was for the lower back (60.3%), followed by the upper back (50.2%). About 15% of workers reported MSD symptoms in the elbows and ankles. Accordingly, the lower back and annual disability complaints had the highest weekly prevalence of complaints in the past week with 59.5% and 30%, respectively.

The result showed that a large number of workers reported lower back symptoms. Moreover, proportionally fewer workers reported that their MSD symptoms had prevented them from performing their job. The workers who complained of upper extremity disorders in past 12 months did not report disability.

The same questionnaire was repeated 12 months later (after intervention). During the last year of the project, ergonomics improvements were in progress. Table 2 shows the results of the questionnaire after ergonomics intervention. The χ^2 test showed that there were statistically significant differences in annual and weekly prevalence, and annual disability reported for the upper back, the lower back, knees and wrists between before and after intervention ($p < .05$).

4. DISCUSSION

According to Wilson, the most important requirements for a participative approach to implementing ergonomics solutions were the motivation of the workers and their competence at the individual and team level. These prerequisites cannot be imposed; they have to be implemented through

TABLE 1. Prevalence of Musculoskeletal Complaints at the End of the 2nd Year of the Project (Before Intervention)

Body Part	Prevalence (%)		Annual Disability (%)
	Annual	Weekly	
Neck	32.9	29.9	5.5
Shoulder	44.1	40.1	9.2
Elbow	15.0	18.0	1.5
Wrist	25.8	35.1	10.5
Upper back	60.3	55.1	25.9
Lower back	50.2	59.5	30.0
Hip	19.0	17.1	1.0
Knee	28.9	30.4	10.4
Ankle	15.0	16.0	0.5

TABLE 2. Prevalence of Musculoskeletal Complaints at the End of the 3rd Year of the Project (After Intervention)

Body Part	Prevalence (%)		Annual Disability (%)
	Annual	Weekly	
Neck	29.4	26.2	3.2
Shoulder	39.1	30.7	8.0
Elbow	13.1	16.5	1.2
Wrist	20.7	19.3	6.3
Upper back	31.3	36.7	20.2
Lower back	35.9	41.9	18.7
Hip	18.0	17.2	1.0
Knee	17.1	19.8	6.6
Ankle	15.0	14.6	0.5

learning and involvement. The main requirements for full participation are information, knowledge and power; power is possible only when one has information and knowledge [48]. These were the aims of the team work structure in the present study; the results are very positive. The teams could follow an action plan, analyze the necessities of the sector, prepare the workplace for changes and implement solution, which is the beginning of an organizational change process.

According to Halpern and Dawson, an intervention program, with multidisciplinary participation (similar to the team-based structure in the present study), “is one approach by which a company can weave together its manufacturing objectives of quality, productivity, safety and cost containment to achieve effective production and injury reduction” (p. 440) [7]. According to Moore and Grag, using teams (similar to the teams in the present study) is an effective way and may contribute to ergonomics improvements [49].

In the present study, the main obstacle towards successful performance of the established teams was shortage of time because of work overload of the team members. Previous studies also discussed this constraint [49, 50].

Establishing the steering committee is an important element of adopting PE. The steering committee informs the teams about financial resources for implementing changes. It also provides access to authorized members of the company. Workers “participation creates ownership of the new ideas and helps people buy into the

process, rather than having it dictated from above” (p. 192) [51]. The most successful strategy includes forming teams and allowing them to learn about their working conditions and to decide about changing them, with optional help from an ergonomics consultant as a facilitator.

The results of this study show that implementation of ergonomics solutions decreased prevalence of musculoskeletal complaints. There are two speculative explanations for these findings. The ergonomically improved conditions influenced the condition of the back and the lower limbs. The changes reduced effectively the risk of complaints in the upper and the lower back, knees and wrists. However, reporting about musculoskeletal symptoms is much more complicated, and in the present study, it is too early to assess the impact of the ergonomics changes or to link improvements with specific body parts.

A supportive work environment is a key factor for successful realization of ergonomics solutions. Supervisory support of training has been found to be important work environment variable affecting the transfer process for over 50 years [53].

The 3-year experience shows that the employees’ readiness for ergonomics improvements in the organization is a factor for success [53, 54]. According to Choobineh, Tabatabaei and Behzadi, “any ergonomics intervention program in the workplace should focus on eliminating awkward postures and manual handling of heavy loads” and designing ergonomic workstations (p. 423) [55]. According to this experience, the

following statements are the recommendations for successful implementation of ergonomics intervention programs:

- managers, supervisors and employees need to be aware of the value of ergonomics solutions in their working environment;
- supervisors and managers need to support shopfloor workers by showing interest and personal contact;
- information and active participation solutions are important organizational resources;
- a participatory organizational culture is a necessary precondition;
- the right people should be involved, appropriate ergonomics training should be provided and clear responsibilities should be introduced.

5. CONCLUSIONS

A supportive environment based on a full commitment of the top management, comprehensive training about ergonomics, team work, endurance and diligence of the people involved in the project are the key factors to a success of PE program. Furthermore, good communication with all organization levels is also necessary for enabling implementation of ergonomics low or no cost solutions. A successful PE implementation model could be a sustainable strategy towards basic changes in working conditions in industries in developing regions, e.g., Iran.

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