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EVIDENCE-BASED PREVENTION OF WORK-RELATED MUSCULOSKELETAL INJURIES IN CONSTRUCTION INDUSTRY

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Abstract. Many construction work tasks are physically very strenuous and the incidence of work-related musculoskeletal disorders (WMSDs) among construction workers is considerably higher than those in most other occupations. The aim of the study presented in this paper was to contribute to understanding a healthy construction site brought about by the best practices implemented by large construction sites to prevent WMSDs. A triangulation method made of interviews, site observations and studies on company's documents was used to identify the best practices in 13 several construction projects. A range of the best practices both in the pre-construction and construction phases of the projects were identified in six different areas of the balance of the construction workplace system; however, there seems to be a significant need for good practices in the management of a systematic work environment. It is now established that Swedish construction industry has several best practices to protect work-related musculoskeletal health. However, inadequate worker participation and the neglect of health and safety issues by designers in the planning process as well as the implications of some remuneration methods on the production schedule were perceived as detrimental to the musculoskeletal health of construction workers.

Keywords: construction management, injuries, occupational health, working conditions, work-related musculoskeletal disorders, extreme working postures.

1. Introduction

Swedish construction work environment is regarded as the safest in the world (Flanagan *et al.* 2001) as far as working conditions and musculoskeletal health are concerned. Nevertheless, there are still work environment related health problems to be tackled. A public recent debate has focused increasingly on the issues of work environment. Although this alone cannot account for a large number of long-term sick leaves, it is surely one of several factors involved. A multi-aspect improvement in the workplace is seen to be the most important single measure for reducing the incidence of occupational health injuries such as work-related musculoskeletal disorders (WMSDs), thus decreasing the number of sick leaves they cause.

According to Swedish Social Insurance Agency (2004) administering various types of insurance and benefits that make up social insurance in Sweden, musculoskeletal disorders are among the most compensated illnesses among male workers, for example back pain accounts for 17 percent of all sickness compensations. The average of the total back pain illness compensation per case for men (focusing on the men who constitute 92% of workforce in construction industry) is about 5,727 US dollars; this cost denotes 56 US dollars per sick leave day. In Sweden, Samuelsson and Lundholm (2006) report that out of all 1582 cases of the sick leaves caused by occupational injuries reported in 2004 in construction industry, 1342 cases of the sick leaves were caused by ergonomic risk factors.

WMSDs are described as a whole range of injuries and illnesses which are not typically the result of an acute or instantaneous event but the result of chronic development. Various risk factors, including personal characteristics (for example physical limitations) as well as societal factors, may contribute to the development of these disorders (Armstrong *et al.* 1993; Idoro 2008). These injuries affect a wide variety of construction occupations and are not specific to any type of a job or work activity. Different construction trades are exposed to various kinds of physical workload, involving different parts of the body (Holmström *et al*. 1995) and the incidence of WMSDs is considerably higher than in most other occupations

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(Schneider 2001; Kaminskas 2007). Risk factors that can cause or may have the association with WMSDs include repetitive, forceful or prolonged exertions of hands, frequent or heavy lifting, pushing, pulling or carrying heavy objects and prolonged awkward postures. Similar high physical work demands are considered the primary risk factor for work-related musculoskeletal complaints (Marras *et al.* 2000; Hoozemans *et al*. 2002; Lotters *et al*. 2003; Fung *et al*. 2008). According to Djupsjöbacka *et al*. (2004), physical risk factors encompass work postures, heavy dynamic work, light repetitive work, static work, vibrations, temperature, lighting and noise, whereas psychological factors include work demands (time pressure, difficult work tasks), influence on social support for workplace decisions, salary and rewards, work times and role allocation/ambiguity. Many types of musculoskeletal disorders have considerable work-related component (Hagberg *et al*. 1995; NIOSH 1997; Punnett and Bergqvist 1997). This is particularly true where there is a high exposure level and where there are combinations of difficult conditions, for instance lifting loads with outstretched arms at a high frequency is stressful for shoulder region. There is also strong evidence that low back disorders are associated with lifting, high exertion and awkward back postures (Punnett *et al*. 1991; Marras *et al.* 1993).

Construction constitutes a substantial part of the economy of most countries employing large numbers of workers. In Sweden, there are 234 869 construction workers (SCB 2006). Large numbers of construction workers are still leaving the industry before the retirement age due to WMSDs (Samuelsson and Andersson 2001). Fatigue and slipping were likely contributing factors both in terms of initiating the fall as well as in workers' reduced ability (reactions/reflexes) to avoid fatal injuries (Juozulynas and Kaminskas 2004). Fung *et al.* (2008) found that the musculoskeletal symptom was common among most construction workers in Hong Kong, practically in their upper extremities and lower back. Construction workers are exposed to physical workload such as heavy burdens and extreme working postures like stooping, kneeling, work with hands above shoulder level and vibration. With respect to physical exposure, it varies between occupational groups, and therefore it seems that significantly increased prevalence of WMSDs within trade often corresponds to its physical exposure (Holmström *et al*. 1995).

There is however an emerging hope in the workplace of this industry as was recently reported (Byggnads… 2006) emphasizing that the number of WMSDs in the construction sector continued to drop for a third year in a row. Between 2003 and 2005, the number of reported work-related diseases for the majority of which WMSDs was accountable decreased by 30 percent. Bengtsson *et al.* (2002) attribute this improvement partly to the emerging construction workplace culture of health promotion which focuses on a number of the surrounding and individual-related factors. Menckel and Österblom (2004) explained that health promotion focuses more on creating supportive environments and conditions for better health for everyone at the workplace.

To sum up, it is observed through the review of literature that physical work demands which form the main cause for musculoskeletal injuries are high for construction workers. The findings of scientific studies have identified physical, organisational and individual occupational risk factors for the development of work-related musculoskeletal disorders. The risk assessment of construction products (Zavadskas *et al*. 2010a, b) indicates that occupational health also should be taken in consideration. Thus, the response appealed to for this multi-factorial problem of WMSDs should be a multi-aspect improvement (Morray 2000) of the construction workplace in the effort to prevent these construction injuries.

2. Study objectives

There were two general objectives underlying this research study. In the absence of enough information about good industry practices promoting musculoskeletal health, the first objective consisted of identifying and describing strategies and activities (i.e. best practices) which have proven to be successful in the fight against the development of work-related musculoskeletal injuries in construction industry. The second objective was to formulate recommendations significant to WMSDs prevention and specific to the construction work environment in order to bring about immediate actions or to guide further research studies on the identified issues.

3. Study boundaries

The research study focused on the issue of WMSDs in construction industry because these injuries still constitute a large portion of approximately 73 percent of all work-related diseases reported among construction workers (Samuelsson and Lundholm 2002). Other than developers, professional designers, site managers and contractors, the focal point of this study was on eight construction trades (Table 2). In Sweden, these trades have mostly been affected by musculoskeletal injuries and with a higher average of sick leave days due to WMSDs (Samuelsson and Lundholm 2002, 2003). This study was further limited to housing construction projects.

4. Research methodology and data source

The methodology for data collection has used a triangulation method (Yin 1994) which is three complementary sources of information in an effort to increase accuracy, reliability and representativeness of data: the detailed site observations of construction processes, interviews and studies on company documents.

Semi-structured interviews were conducted with a sample of 94 respondents from eight construction trades (crew leaders were selected due to their long work experience), contractors, sub-contractors, designers and developers working with specific construction projects selected for the study. The respondents came from the varying sizes of construction firms with 48.9% of the sample working with large organisations with over 2000 employees and with an annual turnover that exceeds 1 billion dollars. The rest of the respondents were from the companies that employed less than 100 people. With the help of an interview guide with 39 questions within the framework of six different aspects influencing musculoskeletal health (see Fig. 1), the interviews were conversational and open-ended, typically varying between 45 and 90 minutes in duration. All interviews were conducted by the same interviewer who was a civil engineer. Altogether, three investigative tool interviews, site observations and study on companies' documents were performed with the objective of identifying the best practices that were conducive to the musculoskeletal health of construction workers.

Thirteen large construction sites in different regions of Sweden were chosen. Construction workplaces were selected on a convenience basis from Swedish construction industry and were invited via telephone or e-mail to participate in the study.

A criterion for participation was that construction projects/organisations had distinguished themselves in one or more areas, namely, planning, work organisation, technical aspects, work tasks and physical environment. Another selection criterion was the size of the construction workplace because the research study was limited to construction sites with at least fifty construction workers.

The data collected for this study was analysed by sorting the obtained material into different best practices relating them to various aspects affecting the musculoskeletal health of the construction worker, as depicted in the model for the balance of the construction workplace system (see Fig. 1). Belle (2000) asserted that to improve performance, benchmarking should single out those practices that have proved to be the best in a given area.

According to the model in Fig. 1, every construction workplace can be characterised by the carried out planning, the organisation performed, the technology used, the work tasks performed, physical work environment as well as by those individuals that carry out different work tasks. If these various aspects or components are not balanced, then problems in various forms emerge, for example low productivity, injuries and other ill health among the personnel. However, through a good balance of these components, a corresponding positive result could be attained (Rwamamara 2005). The model above takes into account of external influence exerted on individual musculoskeletal health through various interacting aspects. All interaction relationships between various aspects of the balance of the construction workplace system are not shown in the above presented simplified model and these relationships vary in strength and direction depending on which workplace is being studied.

The model considers the planning aspect which is important to the health of the construction workplace because planning is very much linked to production tasks to be performed. Hendrickson and Au (2000) stated that construction planning was fundamental and challenging activity in the management and execution of construction projects.

In addition to the planning component, the model takes into consideration four more aspects, namely work tasks, production technology, physical work environment and work organisation that affect the individual musculoskeletal health of a construction worker. Karasek and Theorell (1996) and a number of other authors have outlined principles for designing healthy work tasks for human-machine systems. The ability to accomplish tasks and the load on the individual accomplishing of those tasks are often determined by the technology being used by the worker. Carriere *et al.* (1998) examined the relationship between the introduction of new technologies and a health and safety system and found that health minded and effective companies faster adopted new technologies. Work environment refers to work conditions that may affect individual workers in the workplace. Typically, this includes cold weather, vibration emissions, and mechanical environments (Smith and Sainfort 1989). Manuelle (1997) noted that a culture of work organisation determines the level of safety attained and management commitment or non-commitment to safety is an outward sign of that culture. All individual workers enter the construction work environment with a variety of strengths and weaknesses. These include age, gender,

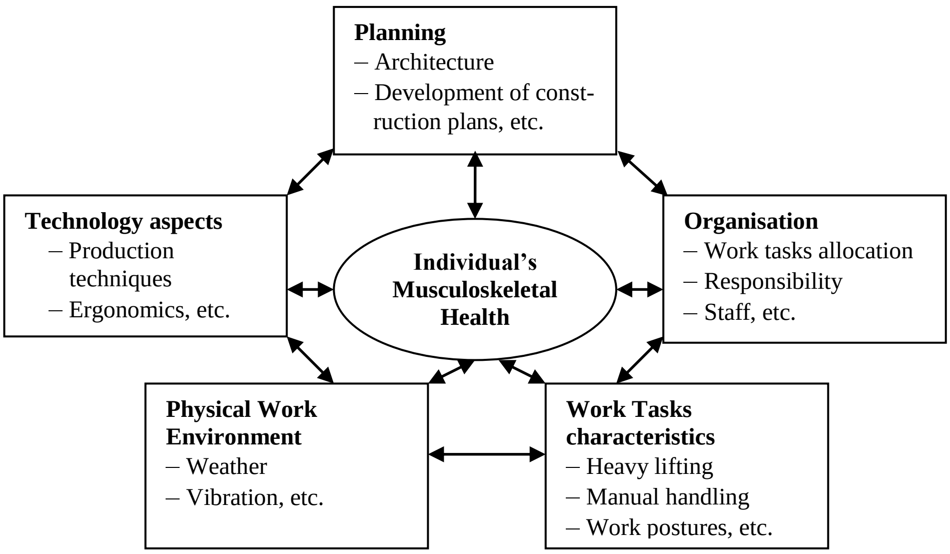

Fig. 1. Six aspects affecting work-related musculoskeletal health of the construction worker (Rwamamara 2005)

Table 1. A description of the construction projects and characteristics of the sites and workers involved

Construction work (Building firm)	Construction period (month/year)	Contract value	Procurement	Site visit period	Number of subcontractors in the construction project	Number of salaried employees/ trade workers in the project
Office and Residential building Turning Torso/ Malmö (NCC)	02/00–05/05	180,832,000 US$	Shared contract	Spring 2004	45	100/500
Office buildings/ Malmö (PEAB)	09/02–05/04	17,404,000 US$	Design-build contract	Autumn 2003	18	5/100
Refuse Incinerator Plant/ Linköping (NCC)	10/02–02/05	21,486,000 US$	Design-build contract	Autumn 2003	50	15/200
Office building/Staffanstorp (NCC)	03/02–11/03	6,446,000 US$	Design-build contract	Autumn 2002	20 (40 indiv.)	4/60
Apartments buildings/ Bromma-Stockholm (SKANSKA)	04/03–10/05	20,995,000 US$	Performance-based contract	Summer 2004	45	6/22
Senior citizen homes/ Vindeln-Umeå (PEAB)	06/03–08/04	6,546,000 US$	Design-build contract	Spring 2004	5	2/15
Office building renovation/ Lidingö (JM)	01/03–03/05	9,633,000 US$	General contract	Summer 2004	20 (60 indiv.)	4/16
Multiple apartments building Diamanten/Lund (NCC)	12/03–03/05	Confidential	General contract and Shared contract	Winter 2003	24	6/60
Apartments building/ Örebro (PEAB)	10/02–01/04	5,586,000 US$	Divided contractor	Summer 2004	12	4/50
Apartments building/ Filmstaden-Stockholm (SKANSKA)	05/04–12/05	15,912,000 US$	Design-build contract	Spring 2004	15	13/30
House building/Luleå (PEAB)	10/03–02/04	683,000 US$	General contract	Autumn 2003	8	4/10
Swimming pool building renovation/Gammalstad-Luleå (PEAB)	04/03–01/04	2,704,000 US$	General contract	Winter 2003	10	3/10
University offices and facilities /Luleå (NCC)	03/03–12/05	4,114,000 US$	General contract	Summer 2004	30	2/25

general health status, motivation, skill level, notions about how to perform the work required expectations and ways of interacting with co-workers, supervisors and management. A healthy work environment builds on those strengths and motivations to develop a continuous learning and sharing work environment that rewards creativity, problem-solving initiative, responsibility and teamwork. Open communication and participation are integral to a supportive work environment (Jaffe 1995).

5. Results: empirical findings

A three year investigation of large 13 construction projects (see Table 1) scattered across Swedish map has yielded the results presented in this paper and are the product of the analysis of site observations, document study and as well as interviews involving 94 participants 70 of whom have at least 15 years of work experience in construction industry and the rest had worked at least 3 years in the industry (see Table 2). The best practices were identified from other practices through the analysis that matched those practices simultaneously recurring over and over in the results of our observations, interviews (Table 3) and document study.

6. Identified best practices

6.1. Planning

At every construction workplace, a compulsory Work Environment Plan (WEP) (AFS 1999:3) consisting of three important things, including the regulations to be applied on the construction site, a description of how the work environment work is to be organised and a description of how certain work environment recommendations are to be implemented during the construction phase is laid down by the developer although the implementation of WEP is delegated to the principal contractor.

A long term planning of health issues starts with the preliminary hazard analysis of construction activities. This risk analysis makes it easier to schedule and select appropriate mechanical aids such as cranes and personnel and material hoists. A high level master schedule maintained throughout the project is coordinated with short-term/look-ahead schedules to manage detailed flow. A common requirement during planning and scheduling is to match the product, the process, work methods and the promotion of health issues at the workplace.

Table 2. Details provided by the respondents

Occupational group	Number of interviewees (N = 94)	Gender		Average of occupational experience (years)	Occupational experience (in years)	
		Male	Female		Minimum	Maximum
Developers	5	5	0	22	15	25
Designers (architects + Structural engineers)	9	8	1	18	3	27
Site managers/ supervisors	19	19	0	15	6	25
Concrete workers	11	11	0	21	12	26
Carpenters	12	12	0	25	15	35
Sub-contractor managers	3	3	0	12	9	15
Electricians	7	7	0	15	6	25
Plumbers/HAC	6	6	0	12	5	20
Scaffolding workers	6	6	0	15	10	20
Roofers	5	5	0	20	10	25
Floor layers	6	6	0	10	7	13
Machine operators	5	5	0	12	5	16

Table 3. Percentages of respondents that have identified the best practices as highly effective to reduce WMSDs

Best practices / Respondents	Planning, %	Work organisation, %	Production technology, %	Physical work environment, %	Work tasks characteristics, %	Individual factors, %
Developers	60	100	80	100	80	60
Designers (architects + Structural engineers)	89	55.5	89	100	22	22
Site managers/ supervisors	63	63	95	100	79	53
Concrete workers	100	89	91	82	82	73
Carpenters	100	58	83	75	75	58
Sub-contractor managers	100	100	100	100	100	67
Electricians	100	100	57	100	57	43
Plumbers/HAC	100	67	83	67	100	50
Scaffolding workers	100	83	100	83	83	67
Roofers	100	80	100	100	100	60
Floor layers	100	100	83	100	100	50
Machine operators	60	80	100	100	100	80

In planning industrialised construction, which is more often the case in large Swedish construction workplaces, more attention is paid to building components design and the ease of installation, thus prefabrication is preferred to traditional construction which entails heavy lifting, awkward postures and repetitive tasks. Although professional designers, especially architects admitted their little knowledge about health and safety issues affecting construction workers, thus little consideration for these issues in their design is taken into account; they expressed that there is a growing dialogue between designers and contractors on designing workers' health.

During the pre-production planning stage of preventive measures, worker's views and risks from the previous projects are taken into account through health and safety management documents compiled with the help of workers representatives and health and safety officers.

6.2. Work and workplace organization

Depending on how large the construction workplace is, management is made up of the site manager and supervisors. The organisation is a flat hierarchy and site managers are responsible not only for production matters but also for economic and work environment issues. Construction workplaces currently have a more streamlined organisation with a system of cooperation based on negotiation.

Healthy organisations included regular meetings between various groups, e.g. the main contractor and subcontractors and a good flow of information on different health and safety issues between, for example, work supervisors and construction workers. This was made easier by the flat organisational system. For more effectiveness in dealing with WMSDs issues, worker representatives and work team leaders are offered regular training through health and safety courses which provide updated knowledge about health promotion and WMSDs prevention measures. It was practiced at the worksites where the consultation of construction workers was of a paramount importance as a number of site managers asserted that workers were resourceful and well worth listening to when dealing with health issues pertaining to workers' musculoskeletal health.

6.3. Production technology

Special production techniques were discussed in the interviews and observed on construction sites; some of these techniques are not commonly available in all construction workplaces. During discussions with both the management and construction workers, production halls, Automatic Climbing System (ACS) scaffoldings (Fig. 2) and the off-site pre-assembly of bathrooms and ventilation modules (Fig. 3) were identified as special production techniques that contributed to the reduction of WMSDs risk factors.

At construction sites where ACS scaffolding systems were used along with multiple cranes that could serve every corner of the building site, the traditional scaffolding system was replaced effectively, thus eliminating the risk of WMSDs due to heavy lifting and repetitive tasks often related to scaffolding assembly tasks, in addition to avoiding workers the risk of slip and fall injuries.

The scaffolding installation of an automatic climbing system (ACS) allows concreting the core ring wall at any level to simultaneously proceed with tightening the internal elevator walls on the floor below.

The use of these innovative production techniques such as producing steel reinforcement, bathroom and ventilation modules in a controlled work environment such as a factory or production hall minimise the risks of heavy manual material handling, repetitive tasks, awkward work postures and slips and falls, thus eliminating the exposure to some of the WMSDs risk factors. Other aids include remote-controlled concrete pumps (Fig. 4) and traverses (used in production halls) (see Fig. 5), personnel and material hoists and carrying aids such as automatic scissor lifts (Fig. 6). Other than mechanical aids, large Swedish construction workplaces have invested a lot in ergonomically-designed and light hand tools in order to reduce vibration and awkward postures.

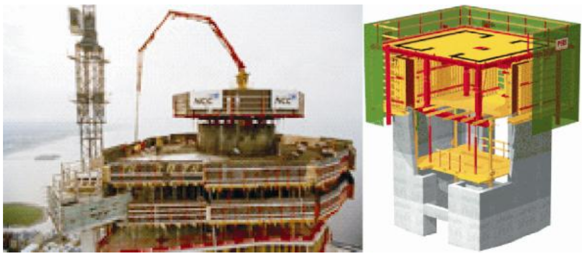

Fig. 2. Automatic climbing system (ACS) scaffolding (Courtesy of HSB and PERI)

Fig. 3. Prefabricated bathroom and ventilation room modules lifted into a building site

The newly developed building products, for instance, self-compacting concrete (SCC) (Fig. 7) has huge musculoskeletal health benefits for concrete workers. SCC is a type of concrete to which no additional inner or

Fig. 4. Concrete cast with a remote-controlled pump

Fig. 5. Off-site steel reinforcement in the production hall with a traverse for lifting heavy structures

Fig. 6. Personnel, material hoist and a scissor lift

Fig. 7. Self-Compacting Concrete Casting (photo on the left) with no need to use a compacting vibrator (as seen on photo on the right)

outer vibration is necessary for compaction. SCC compacts itself alone due to its self-weight and is de-aerated almost completely while flowing in the formwork.

Traditional or conventional concrete casting produces high noise levels, and thus vibrating tools used for the compaction of concrete often lead to unhealthy and repetitive working postures. When SCC is used, concrete workers don't need to compact concrete; therefore, those work tasks related to lifting and using a vibrator disappear and the likelihood of workers suffering from vibration white finger will not occur.

Furthermore, the use of prefabricated building concrete components such as slabs, walls and stairs has reduced the number of work tasks which were traditionally performed on the site, thus minimising the occurrence of awkward work postures.

6.4. Work tasks

When it comes to improving work tasks by eliminating WMDSs risk factors, including the use of mechanical aids, personal protective equipment (PPE), work rotation within a work group, team work and working with an upright work posture are the common preventive measures. Among the eight trades investigated, only plumbers, electricians and carpenters were found to have several work tasks done above shoulder level; however, management often solves this problem by minimising the risk exposure level through, for instance, using prefabricated components on the site and off-site assembly of building materials, hence reducing the number of risky tasks performed on the site.

6.5. Physical work environment

During interviews, many construction workplace managers and construction workers have affirmed that good lighting, good housekeeping and having enough work space contribute to reduction in work-related injuries. The use of new or improved building materials and hand tools has considerably reduced vibration emissions at the construction workplace.

To accommodate different working heights, the use of lifts and access ramps is very common on construction sites, thus making it easier for workers to perform their tasks and transport materials without undue strain.

Fig. 8. A weather independent production hall with safe lifting with a traverse

Performing production tasks in the production hall (Fig. 8) where buildings up to five-story can be built or in a large tent and working under the weather cover sheets are considerably changing construction activities into weather independent ones and consequently cutting down WMSDs related to cold, windy or snowy weather.

6.6. Individual factors

Although Swedish construction workforce is an aging one, construction workers indicated that their health was generally good and that they liked their occupations despite the risk factors involved in their jobs. The workers understand the importance of using PPE applying adequate work methods as well as having good physical fitness in order to minimise risk for WMDS. Besides regular physical fitness, pre-work stretching sessions on sites which focus on loosening up ligaments, tendons and muscles are considered to contribute to reduction in WMSDs, especially during winter time where workers need to warm up before lifting and carrying building materials between 20 and 30 kilograms. A typical pre-work stretching session emphasises stretching the body from the neck down to the ankles. The stretches in the ten-minute session include chin tucks, shoulder shrugs, wrist flexion, hamstring stretch, calf stretch and even a seated back stretch.

Through massage and physiotherapy sessions, the number of those who stayed at home because of muscular pain has reduced. During interviews, the management expressed its satisfaction with the worker's foot anthropometry profile system that takes into account the characteristics of individual workers and has been used to equip their workers with custom-made safety footwear, thus reducing some of their workers' musculoskeletal problems in the lower limb and the back.

7. Recommendations and conclusions

The recommendations in this paper constitute a proposal on the areas where good practices need to be developed in consideration of work-related musculoskeletal health issues.

7.1. Planning

The study showed that developers had very little involvement in the implementation of the Work Environment Plan. Constant cooperation between developers and general contractors is necessary not only for designing the work environment plan but also for implementing it.

A broader participation of workers in pre-production planning should be desired for an optimal input about potential risks and controls. Furthermore, general contractors should encourage sub-contractors to take part of pre-production planning to present the identified health risks. Moreover, due to ignorance expressed by designers in regard to health and safety issues and their consideration in design, educational courses on health and safety design in construction should be recommended for civil engineering programmes in architecture as suggested by Gambatese *et al*. (2004).

7.2. Work organisation

An effective solution to reduce WMSDs among construction workers should not ignore the issues of leadership, remuneration system, employment types and worker involvement.

Training workers in health and safety issues provides a basis for consistent awareness, identification, analysis, targeting and control of WMSDs. Therefore, construction companies should consider providing training to workers, supervisors and site managers through participating in the program of musculoskeletal disorders control.

Both the management and workers need more training to improve their knowledge in Systematic Work Environment management (SWEM) (see Fig. 9). The features that distinguish SWEM are similar to those of the EU-directive 89/391 (EU 1989) which requires a policy, risk analysis, information, the division of work tasks regarding the work environment, the registration of work-related accidents etc. Swedish regulation however, is more far-reaching than the EU-directive 89/391/EEC (EU 1989).

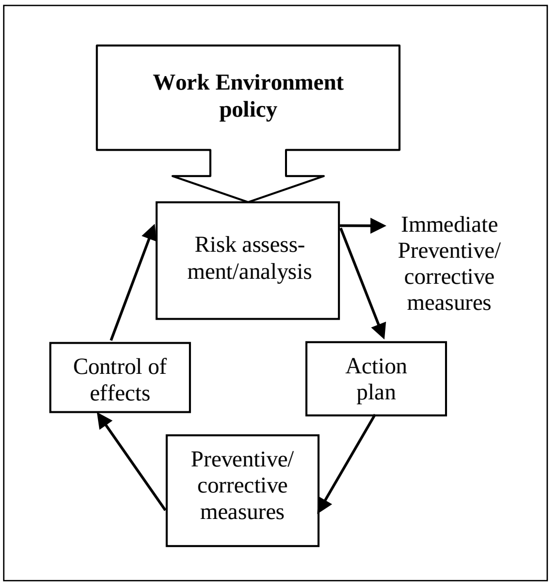

Fig. 9. Schematic description of SWEM

7.3. Technical aspects

A greater level of industrialised production and the use of assembling techniques for prefabricated modules are recommended to construction companies in their endeavour to prevent WMSDs. Furthermore, the availability of mechanical aids on the site should depend on the nature of the work tasks to be performed. Construction employers should do an evaluation of the cost-effectiveness of the positive effects generated by the accessibility of mechanical aids.

7.4. Work tasks

To reduce production pressures, the principal contractor and his subcontractors should consider providing enough manual labour. By estimating reduced costs for sick leaves due to reduced workload, the employer should be able to support his staffing strategy.

Employers and workers in partnership should continue addressing these risk factors by both administrative (e.g., management systems) and engineering (e.g., mechanical aids and ergonomic tools) controls. In addition to this, the feedback mechanism 'workers – designers/managers/engineers' as well as a common language to facilitate communication on health and safety issues are needed.

Further, the study has showed there is a need for efficient planning that will make mechanical aids and necessary work tools promptly and readily available to workers to help them perform their work tasks.

7.5. Physical work environment

Findings indicated that poor and inadequate planning was the first contributor to a bad physical work environment. A dynamic and thorough site layout should be considered in order to accommodate a constantly changing construction workplace. This point is supported by Anumba and Bishop (1997) who state that site layout and organisation are essential management functions which should, ideally, be given full consideration early at the construction planning stage of the construction process. The study indicated there is a lack of the coordination of housekeeping the responsibilities of which should be spelt out in contracts and tender documents that should define responsibilities while contractors should discuss details.

In line with the study findings, it would be reasonable to suggest that the more construction activities are performed in a production hall, the less WMSDs risk factors workers will be exposed to, especially during winter. This suggestion is also supported by Rundgren and Östlund (2002) in the study on how to make the production hall more efficient.

7.6. Individual factors

The study showed that workers had different physical work capacities due to their age, gender and muscular strength. Therefore, it is important to consider mapping out individual workers' capacities and limitations, for example, consequently allocating less physically demanding work tasks to older workers. Other beneficial measures include the foot profile system of the worker and physical training during work hours. The benefits of physical fitness or the consequence of lacking it have been shown, for example, in the studies by Hildebrandt *et al.* (2000) and Merlino *et al.* (2003)

7.7. The final conclusion

To sum up, all these best practices formulated into practical recommendations are a part of a quest after an optimal solution is achieved. As stated by Morray (2000), a range of generic issues or aspects such task design (at the planning stage), worker/equipment interface, individual variation, training needs, work organisation and legal requirement should be considered. To create a health-yielding balance between all these aspects affecting work-related musculoskeletal health is though a challenge but can be achievable.

In regard to the occupational groups investigated in this study, the performed observations showed that these trade groups were representatives of those performing the same work tasks throughout Sweden as the study took 13 construction projects located in different regions of the country.

8. Limitations of the study

The limitations of the study were mainly due to difficulties encountered during interviews. At many occasions, interviewees found it difficult to identify and describe the examples of the best practices at hand in their construction workplaces. Furthermore, it is possible that this study could have given perhaps better results if there had been a fair participation of designers and developers of different construction projects investigated in the research study. Limited participation in the study was generally due to the fact that designers and developers felt lack of time.

The participation of subcontractors' managers in this study was also unexpectedly low. Although several telephone and e-mail contacts were made with contractors inviting them to participate in the study, these invitations were often not responded to or declined on several occasions.

Another limitation of the study was the cultural attitude of the interviewed respondents who did not often think that they had anything better than another construction workplace. This "Swedish unassuming nature" made it hard getting some best practices examples out of the interviewed participants.

9. Future research

The following areas require more attention and future research will focus on finding answers to the following issues:

- develop improved planning methods that also consider working methods, work space allocation, including dynamic site plans of the shared construction site areas and equipment with the objective to minimise the risk of WMSDs.
- investigate ways to have greater and adequate worker participation in pre-production planning.

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SU DARBU SUSIJUSIŲ RAUMENŲ IR SKELETO SISTEMOS PAŽEIDIMŲ STATYBOS PRAMONĖJE PREVENCIJA

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S a n t r a u k a

Daug statybos darbų yra fiziškai labai įtempti, o su darbu susijusių raumenų ir skeleto sistemos pažeidimų dažnis tarp statybininkų yra kur kas aukštesnis negu tarp daugelio kitų profesijų. Šio tyrimo tikslas – plėtoti supratimą apie sveikatos būklę ir jos svarbą dirbant statybų aikštelėse, įgyvendinant didelius statybos objektus, siekiant išvengti su darbu susijusių raumenų ir skeleto sistemos pažeidimų. Tyrimams buvo taikytas interviu, pagrįstas trianguliacijos metodu, darbo procesų stebėjimo statybos aikštelėse metodas, buvo nagrinėti statybos kompanijų dokumentai, siekiant identifikuoti 13 skirtingų statybos projektų. Geriausia praktika, prieš pradedant statybas ir jau statant, buvo nustatyta šešiuose skirtinguose statybų regionuose, tačiau tokia praktika yra svarbi darbo aplinkos vadyboje. Pripažinta, kad Švedijos statybos pramonėje taikomi keli būdai, kaip apsaugoti statybininkus nuo raumenų ir skeleto sistemos pažeidimų. Vis dėlto mažas darbininkų domėjimasis šia problema, sveikatos bei saugos problemų nepaisymas planavimo procese, kai kurių atsilyginimo būdų įtraukimas į gamybos veiksnių sąrašą buvo vertinti kaip faktoriai, žalingai veikiantys statybininkų raumenų ir skeleto sistemą.

Reikšminiai žodžiai: statybos vadyba, sužalojimai, profesinė sveikata, darbo sąlygos, su darbu susijęs raumenų ir skeleto sistemos sutrikimas, nepatogi darbo poza.

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