ORIGINAL ARTICLE

Application of the Strain Index (SI) Method for the Evaluation of Risk Factors Featuring Distal Upper Extremity (DUE) Musculoskeletal Disorders in a Textile Factory

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ABSTRACT

The upper limb musuloskeletal disorders are a significant problem with respect to ill health and associated costs within the workplace; therefore, in order to protect workers from such disorders, there is a need to evaluate work situations and use the strain index method for the assessment of risk factors presented in different industries. For this, the strain index (SI) method and Nordic Musuloskeletal Questionnaire (NMQ) were used. The research has been carried out in a major textile factory located in Qaemshahre, Mazandaran. All 320 male workers occupying in 8 various jobs (137 different tasks) were surveyed. The Results showed that the highest percents of inducing elbow, forearm, wrist, and hand disorders were allocated to the weaving job that were obtained 7.19%, 8.75%, 10.31%, and 11.56% correspondingly. On the other hand, there was a significant relationship between eight corresponding jobs and incidence rate of the upper limb disorders ($\chi^2=4.39, P=0.002$). Also means of strain indices between eight various jobs include: administrative (1.09), engineering room (1.26), primary of spinning (7.52), spinning (6.03) primary of weaving (8.18), weaving (8.18), weaving designing (3.74), and cloth meter (4.25) showed a significant different ($F=7.33, P=0.005$). Thereby administrative and engineering room jobs were located in safe level, weaving designing and cloth meter jobs were lain in uncertain level, spinning and primary of weaving of weaving jobs were posed in some risk level, weaving and primary of spinning jobs were lain in hazardous level. So SI can be used as an useful and applicable method for a textile factory.

Key words: Strain index, DUE, NMQ, Risk

INTRODUCTION

Upper extremity musculoskeletal disorders (UEMSD$_S$) that are considered to be´work- related (WMSD$_S$) are generally multi-factorial in character[1]. Disorders of the upper limbs are common problems in the general population as well as among industrial workers[2]. In the general working population in Sweden, as many as one- third of woman and one-quarter of men repotted pain in the arm and shoulder that was present every day or every other day[2] Knowledge about the epidemiological of upper limb disorders is important for different types of prevention as well as for handling medical legal issues. In primary prevention we need to know the risk factors for upper limb disorders to design workplaces and work systems that promote health for the worker. In secondary prevention involves early workplace rehabilitation where knowledge of prognosis of different upper limb disorders is important[1]. Today, 30 percent of all workers report that they suffer from back pain and 17 from the upper limbs according to the Second European Survey on Working Conditions in 1996; 45 percent report that they are working in tiring or awkward positions[3]. Also the costs for work-related musculoskeletal disorders in the US have been estimated at $20 billion per year and the indirect costs at around $ 60 billion per year[3]. There is a lack of standardized assessment criteria, which makes comparisons between the Nordic countries and The Nether lands difficult[4]. For this, there is a need to identify the risk factors at workplace of textile factory by the strain Index (SI) method. With regard to the above cases, the textile factory that it is as an industry with high occurrence of UEMSD$_S$ among industries was surveyed. There fore, the strain index is a method for evaluation of exposure to musculoskeletal stressors of distal upper extremities (DUE) for hand activities (for four parts of upper limbs include: hand, wrist, forearm, and elbow) in repetitive tasks[5].

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AIMS:

1. Introduction of the strain Index (SI) method (5);
2. Evaluation of risk factors related to upper extremity disorders in hand, wrist, forearm, and elbow (5);

3. Assessment incidence rate of $UEMSD_S$ in hand, wrist, forearm, and elbow (5);
4. Surveying risk factors related to unergonomic jobs (5);
5. Proposing ergonomic designing solution for correcting unergonomic jobs (5);
6. Classification of presented jobs on the basis of mean of strain indices (5);

MATERIAL AND METHOD

In the research, in order to evaluate risk factors featuring upper extremity musculoskeletal disorders, survery work situations, and classify occupational scenarios, a combined procedure from four data gathering methods include: observational method (for analyzing jobs and tasks featuring repetitive movements), interview method (for asking about incidence rate of $UEMSD_S$), the Strain Index (SI) method, and Nordic musculoskeletal Questionnaire (NMQ) method were used (5). All 320 male workers occupying in the various parts of Qaemshahre textile factory were surveyed and all of them completed the Nordic Questionnaire and the SI method was carried out on them. There fore, all workers presenting in 8 various jobs (totally 137 tasks) were studied and the obtained results and data from Nordic Questionnaires and setting up the SI method were analyzed by using SPSS/9 software and applying Excell package.

SI method: The strain Index (SI) method is one of the methods that can be used for assessing exposure to musculoskeletal stressors or risk factors of distal upper extremity (DUE) in repetitive tasks[5,6,7]. This method proposed and submitted by Moore & Garg in United States in the year of 1995 and it was instituted on the basis of physiological, biomechanical, and epidemiological principles[6,7,8]. The method describes hand activities based on six task variables include: intensity of exertion, duration of exertion, effort per minute, hand_wrist posture, speed of work, and duration per day[6,7,8]. On the other hand, the strain index (SI) method proposed for calculating an exposure index deriving from the description of six risk factors (include: force, frequency, posture, recovery times in the cycle, movement speed and duration)[7,8]. The model must be separately calculated for every hand (6). The aim of the method is to assess and analyze risk of developing DUE disorders in different works and classify various jobs on the basis of SI rating[5,6,7]. The SI model is a semi-quantified job analysis method that it was centralized to an numerical score that the corresponding score has high correlation with risk of inducing distal upper extremity (DUE) disorders[5,6,7,8]. Also the SI model is one of the approaches that tend to highlight only the presence, versus the absence, of significant exposure[6,7,8]. Every of six mentioned variables is classified to five levels and finally, the total strain index calculated by multiplying the mentioned variables together, is classified by the following rating[5,7]:

- Level 1: The SI score of<3 indicates that the situation is safe.
- Level 2: The SI score of 3 to 5 indicates that the situation is uncertain.
- Level 3: The SI score of 5 to 7 indicates that there is some risk.
- Level 4: The SI score of>7 indicate that the situation is hazardous.

Nordic musculoskeletal Questionnaire (NMQ) method Since 1987 Nordic Musculoskeletal Questionnaire (NMQ) was established by Kuorinka and his colleagues in occupational Health institutes of Scandinavian countries aiming to the determination of the incidence rate of musculoskeletal disorders resulted from the work[9]. It's one of the most commonly used standardized symptom questionnaires that suits surveillance purposes well, but further development of good standardized methods to ascertain symptom- based musculoskeletal symptoms are needed[9].

RESULTS

Results obtained from Nordic Questionnaire are shown in table 1.

It was considered that in the control group, there were two jobs include: administrative and engineering jobs, and the highest percents of inducing elbow, forearm, wrist, and hand disorders were allocated to engineering job that were obtained 2.50%, 2. 81%, 3.13%, and 4.09% corresponding. Also in the case group, there were six jobs include: primary of spinning, spinning, primary of weaving, weaving, weaving designing, and cloth meter. The highest percents of inducing elbow, forearm, wrist, and hand disorders were related to the weaving job that were gained 7.19%, 8.75%, 10.31%, and 11.56% respectively. The least percents of inducing elbow, forearm, wrist, and hand disorders were referred to the weaving designing job with 5.31%, 5.94%, 7.19%, and 8.75% correspondingly. Finally, in the corresponding textile factory, the total incidence percents of elbow, forearm, wrist, and hand disorders were obtained 40.31%, 49.06% 55.31%, and63.75% respectively, and the individual percents without disorders of every of four mentioned parts (percents of healthful persons) were separately gained 59.69%, 50.94%, 44.69%, and 36.25% corresponding. Also there was a significant statistical relationship between eight mentioned jobs and incidence rates of distal

upper extremity disorders by using Fisher's Exact Test ($\chi 2= 4.39, df= 21, P=0.002$).

Results from performing the strain index method are illustrated in table 2.

It is observed that two jobs presented in the control group were lain in level 1(safe level) and mean of strain indices of administrative and engineering room were obtained 1.09 and 1.26 respectively. Also, in the case group, the cloth meter and weaving designing jobs were located in level 2 (uncertain level) with mean of strain indices of 3.47 and 4.25 correspondingly. Two jobs with the names of spinning (6.03) and primary of weaving (5.91) were lain in level3 (some risk level). Also the weaving and primary of spinning jobs were located in level4 (hazardous level) with the mean of strain indices of 7.52 and 8.18 correspondingly. It was observed that one-sided analysis of variance test appears a significant statistical difference between means of strain indices of eight mentioned job group ($F=7.33$, df=24, $P=0.005$). *Then*, Schaffer method was used for characterizing and comparing means of strain indices from each other.

Table 1: Distribution of indices rate of the upper extremity musculoskeletal disorders.

Job type	Elbow	Forearm	Wrist	Hand
Control Group				
Administrative	6(1.88%)	8(2.50%)	9(2.18%)	12(3.75%)
Engineering room	8(2.50%)	9(2.81%)	10(3.13%)	13(4.09%)
Total	14(4.83%)	17(5.31%)	19(5.94%)	25(7.81%)
Control Group				
Primary of spinning	20(6.25)	29(9.06%)	33(10.31%)	35(10.94%)
Spinning	19(5.94%)	20(6.25%)	21(6.56%)	24(7.50%)
Primary of weaving	18(5.63%)	22(6.88%)	25(7.81%)	29(9.06%)
Weaving	23(7.19%)	28(8.75%)	33(10.31%)	37(11.56%)
Weaving designing	17(5.31%)	19(5.94%)	23(7.19%)	28(8.75%)
Cloth meter	18(5.63%)	22(6.88%)	23(7.19%)	26(8.13%)
Total	115(35.94%)	140(43.75%)	158(49.38%)	179(55.94%)
Healthy group				
	191(59.69%)	163(50.94%)	143(44.69%)	116(36.25%)
Total	320(100%)	320(100%)	320(100%)	320(100%)

Table 2: Determining mean of strain indices of various jobs presented in the textile factory.

Job Type	Mean of strain indices	Range of strain indices	Standard deviation of strain indices	Risk level	Risk type
Control group					
Administrative	1.09	0.96-1.16	0.13	Level 1 SI≤3	Safe
Engineering room	1.26	1.08-1.44	0.18	Level 1 SI≤3	Safe
Case group					
Primary spinning	7.52	7.23-7.81	0.29	Level 4 SI>7	Hazardous
Spinning	6.03	5.84-6.22	0.19	Level 4 5<SI ≤7	Some risk
Primary of weaving	5.91	5.68-6.14	0.23	Level 3 5<SI ≤7	Some risk
Weaving	8.18	7.80-8.56	0.38	Level 4 SI>7	Hazardous
Weaving designing	3.47	3.30-3.64	0.17	Level 2 3<SI ≤5	Uncertain
Cloth meter	4.25	4.10-4.40	0.15	Level 2 3<SI ≤5	Uncertain

DISCUSSION

As it was considered, incidence rate of hand disorder is more than disorders of other parts of distal upper extremity and the highest mean of strain indices was allocated to the weaving and primary of spinning jobs. Therefore, etiologic epidemiological aims at identifying the risk factors (task variables) of diseases and provides the basis for the action to prevent the

disease by reducing or eliminating exposure to the risk factors[10]. Also prognostic (intervention or experimental) epidemiological studies the effectiveness of interventions (change of exposure, interventions to alter the course of a disease)[1,3]. The following recommendations are suggested:

- By eliminating or controlling or diminishing a set physical load factors generally agreed upon as risk factors for upper extremity disorders, such as repetitive use of hand, use of hand force, pinch grip, non-neutral wrist posture, elevation of upper arm and local mechanical pressure, use of vibrating tools, cold exhaust air and factors hindering gripping, can prevent or avoid from inducing distal upper extremity disorders[10,11].
- By designing the chair, the work table, the proportion of the work type to its height, and the ergonomic intervention in some jobs embarking on transportation by hand, will considerably be reduced the incidence rate of musculoskeletal disorders[12].
- By rotating the workers or the jobs in clockwise, workers who are doing the repetitive works in a static positions have an enough opportunity in doing movements and preventing accumulation of lactic acid too much in muscles and tiredness and fatigues could be prevented[13].
- As most jobs in this factory have been allocated based on the physical capability of the young individuals (i.e. in most work situations in weaving and primary of spinning jobs, the young individuals have been engaged), the role of anthropometrical_principles in designing hand tools and work stations is completely characterized[2,13].
- By using the work-shift program and a proper ergonomic designing system according to the human physiology system (in a weekly work-shift, i.e. morning, evening, and night shift respectively) at the factory, will effectively be deducted in mental and physiological stresses resulted from the works[3,12].
- A periodic educational program as well aw daily body practice can play a main role in reducing the musculoskeletal disorders resulted from the work position and postures[10,14].

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