RESEARCH ARTICLE

• Arch Hyg Sci 2017;6(3):259-267
• Journal Homepage: http://jhygiene.muq.ac.ir

Assessing Exposure to Risk Factors for Work-related Musculoskeletal Disorders Using ART method in a Manufacturing Company

Mohammad Khandan[a], Saeedeh Mosaferchi[b], Alireza Koohpaei[c*]

[a]Ergonomics Department, Health School, Qom University of Medical Sciences, Qom, Iran.
[b]Ergonomics Department, Health School, Tehran University of Medical Sciences, Tehran, Iran.
[c]Occupational Health Department, Health School, Work Health Research Centre, Qom University of Medical Sciences, Qom, Iran.

***Correspondence** should be addressed to Dr. Alireza Koohpaei, **Email:** koohpaei19@yahoo.com

A-R-T-I-C-L-EI-N-F-O

Article Notes:
Received: Feb. 19, 2017
Received in revised form: Apr. 1, 2017
Accepted: Jun. 20, 2017
Available Online: Jun. 28, 2017

Keywords:
Musculoskeletal disorders
Repetitive motion
ART method
Manufacturing factory
Iran.

A-B-S-T-R-A-C-T

Background & Aims of the Study: Musculoskeletal disorder (MSD) is one of the most serious consequences of improper posture or work-related strain with Symptoms of pain in one or more regions of the body. Repeated long-term work-related load can be considered as the main cause of ULWMSDs. This study was aimed to do ergonomic assessment in a manufacturing company in Kashan city using ART as a new method (this method was established in 2007) in 2014-2015.

Materials and Methods: In a cross-sectional study, total workers of a manufacturing factory (240), by the randomized sampling procedure were selected. Demographic and work related data were collected into the check list. Data about musculoskeletal disorders were provided from body map questionnaire (BM) and ART method worksheets. Statistical analyses were used to data analysis by SPSS V20.

Results: Data analysis from BM illustrated that %85.8 of workers claimed work related pain in one of their body limbs at least. There was a significant relation between pain position numbers and gender of workers ($p<0.05$). The total exposure score based on the ART method equals to 30.07±12.43. Art scores revealed that 74.6% of tasks were in the high level of risk.

Conclusion: Despite participants had low mean of age and work history, the prevalence of musculoskeletal disorders was high and the relationship between the ART score and the prevalence rates of disorders showed that the risk of these disorders was higher in people with musculoskeletal disorders than people without these disorders. The findings from this study suggest that management needs to identify, assess and control the most relevant WMSD risk factors for a particular job, accurately.

Please cite this article as: Khandan M, Mosaferchi S, Koohpaei A. Assessing Exposure to Risk Factors for Work-related Musculoskeletal Disorders Using ART method in a Manufacturing Company. Arch Hyg Sci 2017;6(3):259-267.

Background

Upper limb work related musculoskeletal disorders (ULWMSDs) are one of the leading causes of occupational injuries and disabilities in industrialized and developing countries (1-3). If work is carrying out repeatedly, in the non-ergonomic workstations and with awkward body positions (postures) in long-term, risk of musculoskeletal disorders in users will increase significantly.

In the United States of America, lack of attention to ergonomic principles and factors that cause musculoskeletal disorders led to $ 15-20 billion cost per year and had a 34% working days lost, also, the average time to return to work after the hospitalization and treatment of these disorders was 28 days (4). According to Health and Safety Executive

(HSE) in a one-year period between 2004 and 2005, it was estimated that 28.4 million working days were lost due to neck, shoulder and back occupational disorders. Each worker was away from work for an average of 23 days and 7.5 billion pounds has been spent for damages (5). In addition, it was the most common cause of employee absenteeism (6). The researchers (7) stated that the cost of musculoskeletal disorders in Iran was 7.6% of the country's budget in 2000. It should not be forgotten that the indirect costs of accidents, such as loss of productivity and loss of customer satisfaction, is four times more than the direct costs (8). Due to the effects of fatigue, burnout and early analysis and more economically, the loss of time and increase in normal production costs, optimization of the interaction and balance between employee and workplace is one of the concerns of experts. Economic losses resulting from this disease impacts not only on individuals, but also organizations and society and reduces the productivity of employees (9,2).

musculoskeletal disorders Risk factors, including occupational activity like manual handling heavy loads, repetitive motions, poor work posture (10-12) and also psychological, organizational and individual (12). In general, ergonomic risk factor in the workplace which employees faced with such as force exertion, repetitive work, and contact stress. Exposure with these types of risk factors in the workplace leads to a series of disorders such as elongation and tear muscle, strain or tendonitis and joint pain, back pain, herniated disc, spinal cord injury and other musculoskeletal problems. These conditions may gradually or suddenly created by activities such as lifting a heavy load, leading to pain, disability or loss of jobs. Studies have shown that the best way to prevent WMSDs, intervention to reduce exposure to risk factors such as repetitive motion, excessive force, awkward postures, vibration exposure and static activities. On this basis, risk factors for WMSDs should be considered and evaluated at the workstations (13).

Therefore, a method that is able to pay attention to series of risk factors (physical, mechanical, organizational, psychological and social, individual and personal) (14) and provide the level of risk, can improve decision-making and is very effective. Sometimes easier assessment methods are more efficient than complex ones. In the scientific literature, direct measurement of musculoskeletal damages (with methods such as EMG) (15) as well as methods based on biomarkers of musculoskeletal disorders (16) or internal load evaluation methods such as body temperature, heart rate and blood pressure (14), besides observational methods (external evaluation) (17), are methods to evaluate ergonomic risk factors and musculoskeletal injuries.

Although some researchers have criticized the widespread use observational tools but used many epidemiological risk factors with high stability by these methods and using self-report and observational or pen -paper methods have been evaluated sufficient for epidemiological purposes (18). In addition, cost of these methods is estimated as one-tenth of direct methods and it is possible to choose more samples with a similar budget (15).

Upper limb disorders are very common, and 20-30 percent of working population has experienced it [18]. ULWMSDs are observed in occupations with high amount of manual tasks (18). ART method as an indicator for measuring the external load on upper limbs is one of the new tools that as well as Stress Index (SI) (19), Upper Limb Risk Assessment (ULRA) (20), Occupational Repetitive Action Index (OCRA) (21), can be used to assess load on upper limbs with parameters of posture, force and time sequence (14,22). Some studies (23) demonstrated application of ART method practically and proposed it as a usable, easy and convenient method for purposes of evaluation and ergonomic interventions in the repetitive work task. Karimi and colleagues also said that

ART is a valid method to assess ergonomic risk factors in repetitive tasks and its results was confirmed by the results of the Nordic questionnaire (24).

Aims of the study:

This study aimed to evaluate tasks ergonomically and provide associated risk factors studied in an Arc Opal dishes manufacture company in Kashan using Assessment of Repetitive Tasks (ART) tool as a new method and was conducted in 2014-2015.

Materials & Methods

The study was cross-sectional and descriptive and analytical. A total of 240 personnel working in seven production halls, who had run a total of 13 types of tasks were studied by randomized sapling method.

It is noteworthy that tasks were identified through the documentation in the process department of the company and statuses of tasks in different halls were analyzed. Exclusion criteria including joint problems such as arthritis, herniated disc, disc infection, fracture in spine, other musculoskeletal problems and pain in different parts the body and were identified through interviews and self-report. To gather data on demographics, researchers-developed questionnaire including age, gender, work experience and training courses related to ergonomics and work was applied. Body map questionnaire was used to study musculoskeletal disorders (25). This questionnaire seeks the issue that musculoskeletal disorders have focused on which parts of the body. Furthermore, ergonomics risk factors have been assessed by ART method. T test, chi-square test and analysis of variance were utilized for statistical analysis of obtained data through SPSS V.20.

ART tool was introduced by Health and Safety Laboratory (HSL) in collaboration with Health and Safety Executive (HSE) in 2007. This tool is a appropriate method to study the upper limbs in repetitive tasks (26). The applicability of this tool has been approved by users and experts (26). Assessment through this method consists of four parts (27).

Frequency and repetition, force, awkward postures and additional factors and qualitative and quantitative assessment is carried out for each step. Any privilege mode takes specific score in quantitative evaluation and three levels of low, medium, and high risk would be defined in qualitative evaluation (27). Its final score (0-72) form t three levels: 0-11: low, 12-21: moderate and more than 22 are high risk level (27).

Results

The conducted analysis revealed that 124 (51.67%) of participants (240) was female and the rest are men. The mean age was 28.02±5.53 and in the range of 57-18 years.

Work experience of employees was 4.54 years on average with a standard deviation of 3.72 years. In addition, participants had tool part on average 0.64 (±0.71) on ergonomics or work training. 225 participated employees (93.8%) were right hand and others were left hand. Information on studied halls and conditions of responders in terms of education level is shown in table 1.

Variable		Frequency	%
Hall	Pars pack	47	19.6
	Pars Naghsh	26	10.8
	Packaging	3	1.2
	Leher	28	11.7
	Tempering	19	7.9
	Gradation	33	13.8
	Decoration	84	35
Education level	Up to diploma	58	24.2
	Diploma	137	57.1
	Associate's degree	21	8.7
	Bachelor and higher	24	10

206 (85.8%) workers have experienced of work-related musculoskeletal pain at least in

one part of the body during the past year. Among the different body parts that were examined in this study, lower back with 126 (52.5%), neck (35 percent) and right hand shoulder with about 33% were the most common problems in the musculoskeletal system. On the opposite side, right and left hips respectively with 3.6 and 1.7 percent had the least problems. Table 2 provides the complete information in this regard. Significant differences in musculoskeletal disorders among different groups regard to demographic variables were not demonstrated ($p>0.05$). Except for gender groups, the difference was statistically significant ($p<0.05$) in the sense that the number of parts with pain in females were more than in males (0.98 against 0.72, on average).

In addition, differences between musculoskeletal problems in different areas of the body between men and women were tested with chi-square and analysis results are depicted in table 3.

Average of final score of ART method on all samples was 30.07 (±43.12) (in the range of 39-6). Among the 240 examined cases, 179 ones (6.74%) were in the high risk area, 33 (8.13%) at moderate risk, and 11.7 percent (28 cases) have located at low levels of risk.

Among the studied manufacturing facilities, in degradation hall risk level as medium and Pars Naghsh was low; other sectors have been achieved high risk level. Table 4 shows the descriptive information of various factors and total score of ART in different salons and total assessed employees.

Arm movements and repetition factors had undesirable conditions in various halls in term of the large numbers of maximum score (ie, 6). Detailed assessment results of factors involved in ART method can be seen in table 4. The differences in the ART's score, using t-test, it was found that the differences between men and women is significant ($p<0.05$) it means women had higher scores (36.43 against 23.25 on average). The final score of the seven studied sectors in terms of ART score are significantly different ($p<0.05$). However, final score difference analysis between workers with musculoskeletal disorders and without it using t-test, indicated it was not significant ($p>0.05$). On further investigation it was determined that final score of ART differences between people with problems and pain in neck, lower back, hands, shoulder and forearm and it is statistically significant ($p<0.05$) (table 2) and responders who have problems in these areas had higher ART's final score.

Table 2) Musculoskeletal disorders description and P-values of ART's scores differences (n=240)

Body part		Frequency	%	P-value	Body part		Frequency	%	P-value
Back	Upper	32	13.3	0.651	Hand	R.	39	16.2	0.004
	Lower	126	52.5	0.009		L.	34	14.2	0.019
Shoulder	R.*	79	32.9	0.010	Tight	R.	42	17.5	0.406
	L.*	66	27.5	0.139		L.	41	17.1	0.104
Arm	R.	32	13.3	0.640	Knee	R.	68	28.3	0.135
	L.	23	9.6	0.280		L.	65	27.1	0.033
Elbow	R.	54	22.5	0.009	Bottom	R.	17	7.1	0.164
	L.	38	15.8	0.058		L.	15	6.3	0.239
Neck		84	35	0.001					

*Note: R: Right, L: Left

Table 3) Musculoskeletal disorders differences between males and females using Chi-squared test

Body part		P_{-value}	Body part		P_{-value}
Back	Upper	0.561	Hand	R.	0.000
	Lower	0.025		L.	0.001
Shoulder	R.*	0.000	Tight	R.	0.417
	L.*	0.001		L.	0.757
Arm	R.	0.013	Knee	R.	0.010
	L.	0.068		L.	0.002
Elbow	R.	0.000	Bottom	R.	0.257
	L.	0.000		L.	0.224
	Neck	0.000			

*Note: R: Right, L: Left

Table 4) ART's score in terms of its criteria and in studied halls (n=240)

Criteria	Halls (n)	arm movements	repetition	force	neck/head posture	back posture	Arm posture	Wrist posture	hand/finger grip	breaks	work pace	other factors such as vibration	duration	Total
Pars pack (19)		6	6	5	2	2	0	2	0	8	2	2	1	3
Pars Naghsh (28)		0	3	0	1	1	0	1	0	4	1	1	0.5	6
Packaging (47)		6	6	8	2	1	2	2	1	8	2	1	1	39
Leher (3)		3	6	0	2	2	4	2	2	0	1	0	1	22
Tempering (26)		6	6	5	2	2	4	2	0	0	1	2	1	30
Gradation (33)		3	3	0	2	0	0	2	0	0	1	2	1	13
Decoration (84)		6	6	8	2	0	2	2	1	8	2	2	1	39
Total	**Mean**	4.85	5.24	5.3	1.88	0.71	1.58	1.88	0.57	5.47	1.62	1.66	0.94	30.07
	SD	2.06	1.31	3.4	0.32	0.78	1.28	0.32	0.52	3.47	0.48	0.5	0.16	12.43
	Min	0	3	0	1	0	0	1	0	0	1	0	0.5	6
	Max	6	6	8	2	2	4	2	2	8	2	2	1	39

Discussion

The comparison between men and women has been shown in Table 3. According to the results, women are more affected by work condition. Our results were similar to previous studies (28). A study that was implemented on 852 office workers showed that 58% of participants had neck problems as well as 57% shoulder problems and 51% low back pain have been reported. According to the results of the neck and shoulder pain, between men and women a significant difference was reported. Older women are also more likely to show symptoms (5). Some researchers were reported more upper limb disorders in women than men that this trend is increasing with ageing phenomena (29). Physiological differences between men and women such as body size, muscle capacity, hormonal conditions and work-life balance is enumerated the reasons for this difference. Other authors believe that exposure to different physical and psychosocial conditions can leads to this difference (5).

Besides the aging phenomena it seems that exercise as one of the important factors can reduces the risk of MSD. In a previous study, the implementation of an exercise program for women workers was lead to the pain control in the shoulder region (30). As well as physical inactivity in the leisure-times increases the risk of MSDs (31). Previous education course numbers about how to properly do the work was other question. Based on our results, some of the workers had not passed any courses (0.64 (±0.71)). In connection with educational issues it should be noted that if ergonomic equipment or standard work stations is not considered, implementation of training courses were not led to improve working conditions and changing postures and tasks for workers (32). Using experienced and interested workers to train other workers besides repeating the course content using posters, audio, video and recall, have been a huge impact on modifying non ergonomic behaviors (33). On this basis, and considering that 81.3% of workers with lower secondary education level, design and implementation of an applied multimedia training courses related to manufacturing industry along with replication and using the version of repetition aided by experienced workers can help to reduce the amount and level of the ergonomic disorders in the plant (34).

Results of body map showed that the 85.8% of workers had musculoskeletal pain in one region of their bodies at least in over the past year. Our data was similar to the results of Collins (5). Another study showed that the at least for 66.7% of workers in manufacturing industries has been reported the pain in their upper limbs. Morbidity of pain in upper limbs among public population was recorded equals to 20.6% (35). According to the expected, pain in the lower back, neck and shoulders were observed. Neck and back pain is one of the most common occupational disorders that 70 percent of employees have been experienced on the part of their lives (15,36). In a study on the Slaughterhouse workers prevalence of pain in the neck and shoulder pain were reported 48% and 60% respectively. The analysis showed that repetitive work force, lack of proper rest, the need for accuracy in work and poor postures, including the risk factors for neck pain and upper organs (37).

For office workers the prevalence of neck pain (58%), shoulder (57%) and the back equals to 51% have been reported (5). 43 percent of Construction workers were suffered from low back pain as well as 31% were complained from pain in the shoulder region (32). Gholami et al. in a ceramic factory for neck disorders 45% (compared with 35% of our research), the back 77% (compared with 52.5% of our research), and 49% for the shoulders (compared with 32.9% of our research) have been reported (38). Lower amount of pain in this study can be resulted from lower the age of workers as well as changing the method of assessment (Rula). Studies have shown that using of different methods can leads to up to 20 percent difference in risk exposure calculations (35). In this study as a novelty, the new ART method was used in the dishes production industry to assess ergonomic risk factors for upper extremity. However This method have been used successfully for computer users (39), the combination of cytotoxic agents (40), the production of chocolate (41), an assembly line of electrical industry (23) and handicraft workers (24). The results of ART method revealed that the given with an average score of 30.7 and a standard deviation equal to 12.43, workplace condition had a high risk level. Our findings were consistent with other researches that have been done using this method, (23,24,39-41). According to the ART data, complaints prevalence particularly in the upper limbs and lower back is justified ($p>0.05$). in under study company, according to the available information and analyses carried out based on the results of Table 4, long-standing work (more than 50% of working time), poor postures especially in order to quality control of

products, the lack of proper regulations and systematic work-rest, manual handling on work demand and non-standards, repetitive movements with the force for gripe the products and equipment, exposure to vibration and poor lighting were identified as physical risk factors in the workplace that was showed similarity with other studies in many variables (1,15,28,37,42-43).

Results in Table 4 shows that the highest score of the studied factors resulted from ART method were belonged to repetition and force. Evaluation of these two factors in a cohort study that was conducted on manufacturing and service sector workers (n=2474) showed that the maximum hand force, the repetitions with the force and the percentage of time related to activities with forces have been associated with disorders (44).

A study in 2010 showed that with using direct methods diagnosis would be 10% higher. Accordingly, it can be concluded that the workplace conditions is more harmful than evaluation based on the observational methods (15). Another study in 2015 also showed that compliance with NIOSH lifting equation can leads to apply too much pressure on the spine (45). In another study it was found that lean methods of production such as JIT, Six Sigma and TQM itself due to increased activity and reduced workers' rest (press time) causes MSD and other mental and somatic disorders (46). On this basis, the need for intervention strategies and more attention in the evaluation of the amount and range of risk factors is more essential than ever before. After the execution of each ergonomics management program, implementing Proactive ergonomics is recommended. The program focuses on prevention and identifies risks at source and can leads to reduce the absenteeism from work, increase efficiency, productivity and quality improvement, reduce fatigue, improve ethical issues, reduce errors, and improve the working interactions and control of ergonomic disorders (47).

Conclusion

The researchers found that the pain index cannot very well reflect the reality of pain and musculoskeletal injuries. So it can be said that the results assessment actually represents the minimum disorders. Current strategies to reduce WMSD were focused on biomechanical loads reduction. Studies have shown that the current strategies of risk management in occupational musculoskeletal disorders must change. It has been proved that focusing only on physical exercise, is not an optimal method for ergonomic risk reduction, but also pay attention to all risks and hazards especially psychosocial factors is vital. In addition Air pollution, lighting, atmospheric conditions, vibration, organizational, cognitive, psychological and personal factors are risk factors that must be considered in any assessment of occupational ergonomic conditions.

In summary results showed that the evaluation using art method is well able to assess repetitive tasks lead to musculoskeletal disorders of the upper limb in the manufacturing industry. However more researches in different industries as well as psychosocial evaluation and its relationship with physical disorders are recommended.

Footnotes

Acknowledgement:
The authors would like to express their thanks to all honorable managers and staff in the studied company for their kind cooperation.

Conflict of Interest:
The authors declared no conflict of interest.

References

1. Rossi D, Bertoloni E, Fenaroli M, Marciano F, Alberti M. A multi-criteria ergonomic and performance methodology forevaluating alternatives in “manuable” material handling. Int J Ind Ergon 2013;43(4):314-327.

2. Choobineh AR, Tabatabaee S, Behzadi M. Musculoskeletal problems among workers of an Iranian sugar- producing factory. Int J Occup Saf Ergon 2009;15(4):419–27.
3. Choobineh A, Hosseini M, Lahmi M, Khani Jazani R, Shahnavaz H. Musculoskeletal problems in Iranian hand–woven carpet industry: Guidelines for workstation design. Appl Ergon 2007;38(5):617–24.
4. State University of New York. Ergonomics For health in your home and office. USA; 2003.
5. Collins JD, O'Sullivan LW. Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions. Int J Ind Ergon 2015;46:85-97.
6. Choobineh A, Tabatabaee SH, Tozihian M, Ghadami F. Musculoskeletal problems among workers of an Iranian communication company. Indian J Occup Environ Med 2007;11(1):32–36.
7. Nouri J, Azadeh A, Mohammad Fam I. The evaluation of safety behaviors in a gas treatment company in Iran. J Loss Prev Process Ind 2008;21(3):319–325.
8. Mohammadfam I. Quantitative safety assessment. Hamedan: Fanavaran Publisher; 2006. (Full Text in Persian)
9. Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of work ability, the quality of work and retirement. Occup Med (Lond) 2001;51(5):318-24.
10. Choobineh A. Posture assessment methods in occupational ergonomics. 2nd ed. Hamedan: Fanavaran, 2008. (Persian)
11. Delleman NJ, Haslegrave CM, Chaffin DB. Working Postures and Movement: Tools for Evaluation and Engineering. USA: CRC Press; 2004. p.4, 109.
12. Carayon P, Smith MJ, Haims MC. Work Organization, Job Stress, and Work-Related Musculoskeletal Disorders. Hum Factors 1999;41(4):644-663.
13. Mohammadian Mastanabad M, Motamedzade M, Fardmal J. Correlation between OCRA Index, Strain Index and ACGIH HAL methods to ULMSD risk assessment. J Ergon 2013;1(2):63-71. (Full Text in Persian)
14. Roman-Liu D. Comparison of concepts in easy-to-use methods for MSD risk assessment. Appl Ergon 2014;45(3):420-427.
15. Trask C, Teschke K, Morrison J, Village J, Johnson P, Koehoorn M. Using observation and self-report to predict mean, 90th percentile, and cumulative low back muscle activity in heavy industry workers. Ann Occup Hyg 2010;54(5):595–606.
16. Barbe MF, Gallagher S, Popoff SN. Serum biomarkers as predictors of stage of work-related musculoskeletal disorders. J Am Acad Orthop Surg 2013;21(10):644-646.
17. David GC. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. Occup Med 2005;55:190–199.
18. Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. J Electromyogr Kinesiol 2004;14(1):13–23.
19. Moore JS, Garg A. The strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders. Am Ind Hyg Assoc J 1995;56(5):443-458.
20. Roman-Liu D. Repetitive task indicator as a tool for assessment of upper limb musculoskeletal load induced by repetitive tasks. Ergonomics 2007;50(11):1740-1760.
21. Occhipinti E, Colombini D. Updating reference values and predictive models of the OCRA method in the risk assessment of work-related musculoskeletal disorders of the upper limbs. Ergonomics 2007;50(11):1727-1739.
22. Ferreira J, Gray M, Hunter L, Birtles M, Riley D. Development of an assessment tool for repetitive tasks of the upper limbs (ART). Health and Safety Executive. RR707 Research Report. Norwich: HSE Books; 2009.
23. Abbaszadeh M, Zokaei M, Zakerian S, Hassani H. Using Assessment Repetitive Task (ART) tool in an assembly industry. Iran Occup Health J 2013;10(6):1-15. (Full Text in Persian)
24. Jafari Rodbandi A, Karimi A, Mardi H, Nadri F, Nadri H. The Prevalence of Musculoskelet al Disorders and Posture Assessment by ART method in Mosaic art in Kerman city. J Neyshabur Univ Med Sci 2014;2(2):38-42
25. Hoe VC, Urquhart DM, Kelsall HL, Sim MR. Ergonomic design and training for preventing work-related musculoskeletal disorders of the upper limb and neck in adults. Cochrane Database Syst Rev 2012 Aug 15;(8):CD008570.
26. Bust PD. Contemporary Ergonomics 2008. Taylor & Francis; 2008. P. 453-458.
27. Assessment of Repetitive Tasks of the upper limbs (the ART tool): Guidance for health and safety practitioners, consultants, ergonomists and large organizations. Health and safety executive. Avaiable from: www.hse.gov.uk/pubns/indg438.pdf. (September 21st 2016)
28. Lugay CIP, Matias AC. Predictive models of work-related musculoskeletal disorders (WMSDs) among sewing machine operators in the garments industry. Asia Pacific J Multidiscip Res 2015;3(1):56-64.
29. Onishi T, Kurimoto S, Suzuki M, Imaeda T, Hirata H. Work-related musculoskeletal disorders in the upper extremity among the staff of a Japanese university hospital. Int Arch Occup Environ Health 2014;87(5):547-555.

30. Rasotto C, Bergamin M, Sieverdes JC, Gobbo S, Alberton CL, Neunhaeuserer D, et al. A Tailored workplace exercise program for women at risk for neck and upper limb musculoskeletal disorders: A randomized controlled trial. J Occup Environ Med 2015;57(2):178-183.
31. Rasotto C, Bergamin M, Simonetti A, Maso S, Bartolucci GB, Ermolao A, et al. Tailored exercise program reduces symptoms of upper limb work-related musculoskeletal disorders in a group of metalworkers: A randomized controlled trial. Man Ther 2015;20(1):56-62.
32. Boschman JS, Frings-Dresen MHW, van der Molen HF. Use of Ergonomic Measures Related to Musculoskeletal Complaints among Construction Workers: A 2-year Follow-up Study. Saf Health Work 2015 Jun;6(2):90-62014.12.003.
33. Ouellet S, Vézina N. Work training and MSDs prevention: Contribution of ergonomics. Int J Ind Ergon 2014;44(1):24-31.
34. Roman GA, Vincent S. Workstation ergonomics improves posture and reduces musculoskeletal pain in video interpreters. J Interpret 2015;24(1):1-19.
35. Jones T, Kumar S. Comparison of ergonomic risk assessment output in four sawmills jobs. Int J Occup Saf Ergon 2010;16(1):105-11.
36. Shinde V, Patel S, Naik R, Desousa A. Neck pain amongst dentists in Mumbai: An exploratory study. J Res Adv Dent 2015;4(1):43-46.
37. Sundstrup E, Jakobsen MD, Jay K, Brandt M, Andersen LL. High intensity physical exercise and pain in the neck and upper limb among slaughterhouse workers: cross-sectional study. Biomed Res Int 2014; 2014:218546.
38. Gholami A, Soltanzadeh A, Abedini R, Sahranavard M. Ergonomic assessment of musculoskeletal disorders risk by rapid upper limb assessment (RULA) technique in a porcelain manufacturing factory. J Res Health 2014; 4(1):608-612.
39. Tint P, Traumann A, Pille V, Tuulik-Leisi VR, Tuulik V. Computer users' health risks caused by the simultaneous influence of inadequate indoor climate and monotonous work. Ergon Res Biosystem Eng 2012;1:261-268.
40. McLeod M, Zochowska A, Leonard D, Crow M, Jacklin A, Franklin BD. Comparing the upper limb disorder risks associated with manual and automated cytotoxic compounding: a pilot study. Eur J Hosp Pharm 2012;19(3):293-298.
41. Sahu S, Moitra S, Maity SG. Evaluation of the musculoskeletal problems related to Occupational health of sweet makers of West Bengal. Al Ameen J Med Sci 2013;6(2):150-157.
42. Latko WA, Armstrong TJ, Franzblau A, Ulin SS, Werner RA, Albers JW. Cross-sectional study of the relationship between repetitive work and the prevalence of upper limb musculoskeletal disorders. Am J Ind Med 1999;36(2):248-259.
43. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. Appl Ergon 2002;33(3):207–217.
44. Harris-Adamson C, Eisen EA, Kapellusch J, Garg A, Hegmann KT, Thiese MS, et al. Biomechanical risk factors for carpal tunnel syndrome: a pooled study of 2474 workers. Occup Environ Med 2014;72:33–41.
45. Arjmand N, Amini M, Shirazi-Adl A, Plamondon A, Parnianpour M. Revised NIOSH lifting equation may generate spine loads exceeding recommended limits. Int J Ind Ergon 2015;47:1-8.
46. Koukoulaki T. The impact of lean production on musculoskeletal and psychosocial risks: An examination of sociotechnical trends over 20 years. Appl Ergon 2014;45(2):198-212.
47. Rwamamara RA, Smallwood JJ. Ergonomics in construction, Specifically. In: Ergonomics in developing regions: Needs and Applications (Ergonomics Design and Management: Theory and Applications). Scott PA, Editor. Boca Raton: CRC Press, Taylor & Francis Group; 2009. p. 307-322.