ERGONOMIC EVALUATION OF PACKAGING WORKERS' POSTURE IN A FOOD MANUFACTURING COMPANY

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Abstract: This study conducted an ergonomic evaluation of the working posture of workers engaged in various processes in the packaging section of a food manufacturing company. Workers in the packaging section of the food manufacturing company were divided into operating, folding, packing, carton wrapping and palletizing. Forty of the workers in the packaging section were placed under observation through video recording of their daily activities for a period of three months to obtain their working postures. Rapid Upper Limb Assessment (RULA) was used to analyze the working postures in order to obtain their ergonomic risk levels. Computer codes for RULA were written for quick and easy evaluation of upper arm, lower arm, wrist, wrist twist, neck, trunk and leg postures. The results from RULA indicated that 25% of the workers in the operating and folding units were exposed to medium ergonomic risk level; 30% of the workers in the packing unit and 10% of the workers in the carton wrapping unit were exposed to high ergonomic risk level while 10% of the workers in the palletizing unit were exposed to a very high ergonomic risk level. The study concluded that workers in the packaging section of the food manufacturing company were exposed to between medium and very high ergonomic risk levels of working posture necessitating the need to change the conditions of their workstations.

Keywords: RULA, ergonomics, posture, assessment

1. INTRODUCTION

There is strong evidence of an association among musculoskeletal disorders (MSDs), workplace physical factors, and non-work related characteristics [1]. Roman-Liu [2] noted that high workload is a major risk factor in the development of MSD. Workload has been defined as a function of working posture, exerted force and time sequences [3]. Considering the enumerated factors, the main factors influencing workload are working posture and exerted force [2, 4]. Work-related musculoskeletal disorders lead to substantial economic losses to individuals and the community. However, in the industry, it results in reduced worker's productivity, poor work quality, higher absenteeism and detrimental effects on worker's physical and mental well-being [5]. In most of

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the food factories, more than five employees go on sick leave every month at a rate higher than two working days [6].

Jafryet al. [7] stated that high rate of MSDs is as a result of poor working conditions and absence of an effective work injury program in industrially developing countries. There are currently many methods of assessing the working postures and workload; these include: Ovako Working Posture Analyzing System (OWAS), developed by the Finish steel industry [8, 9], the Rapid Upper Limb Assessment (RULA) [10], the Rapid Entire Body Assessment (REBA) [11] and the Postural Loading on the Upper Body Assessment (LUBA) [12].

RULA is an effective method for assessing the risk level of job which consists of moving the upper limbs, like the hands, arms, shoulders, neck, and back [10]. It evaluates the ergonomic risk factors by observing the posture of employee's while they are working at their workstation directly and does not require special equipment or pre-existing skills [10]. RULA was developed to detect work postures or risk factors that deserve further attention [13].

The results of a survey conducted by Dempsey et al. [14] showed that RULA method is the most widely used by the international ergonomic experts dueto its appropriate procedure and easeof use. It has been used for ergonomic risk assessment for prevalence of musculoskeletal disorders of packaging workers in a pharmaceutical industry [15]; dentists [16]; smartphoneusers [17]; rubber tappers [18] and apple harvesters [19]. The use of RULA method found some postures that apparently needs to be changed immediately to prevent musculoskeletal injury.

This study conducted an ergonomic evaluation of the working posture of workers engaged in various processes in the packaging section of a food manufacturing company using RULA.

2. MATERIALS AND METHODS

This study was carried out in the packaging section, food drinks department of a production company in Ikeja, Lagos, Nigeria. The packaging section is made up of different processing operations which are:
-Supply of products from buffer-hopper to all the individual flow cell-hoppers where the product will be metered or dosed to the required quantities or sizes.
- Filling of products into flexible wrappers or jars in different sizes such as: 20 g, 50 g, 500 g Refill, and 500g/900g all fill.
- Printing of date codes and other useful information on the flexible wrappers/jars.
- Screening of products with the help of x-ray or metal detector machines.
- Packing of the packaged products into the cartons.
- Carton sealing/taping.
- Palletization of cartons of products.
- Moving the pallets of finished goods to warehouse for storage.

Figure 1 shows the flow chart of the packaging activities of food drinks department of Cadbury Nigeria Plc., Ikeja, Lagos, Nigeria.

Table 1 shows the list of packaging machines and the number of people in each flow cell. A flow cell is a single production line or multiple production lines, organized in a straight or U- formation to have one piece flow without generating any waste.

Selections of subjects were conducted from each assessed flow cell for this study, after the subjects showed their willingness to participate in this study. As subjects were performing their task, a list of the practices involved in a task was compiled and photographed/video recorded. All the body movements and postures of the subjects during each task were observed.

In order to complete the RULA assessment process, the researcher performed the following actions:
1. Observed the entire task to become familiar with the work practices and procedures.
2. Assessed and appropriately record body posture involved in performing the task in each flow cell.
3. Identified specific process that included assessment of the body postures.

4. Determined the score of each posture for individual body parts for both section A & B of the RULA worksheet.
5. Entered scores in the appropriate table based on the instructions on the assessment score sheet.
6. Add muscle rise and exerted force to calculate individual score of section A & B.
7. Combined section A and B scores to produce a Final RULA score.
8. Evaluate risk level of each process based on the Final RULA score, ranging from low to high.
9. Determine interventions, action levels or required controls based on the identified risk levels.

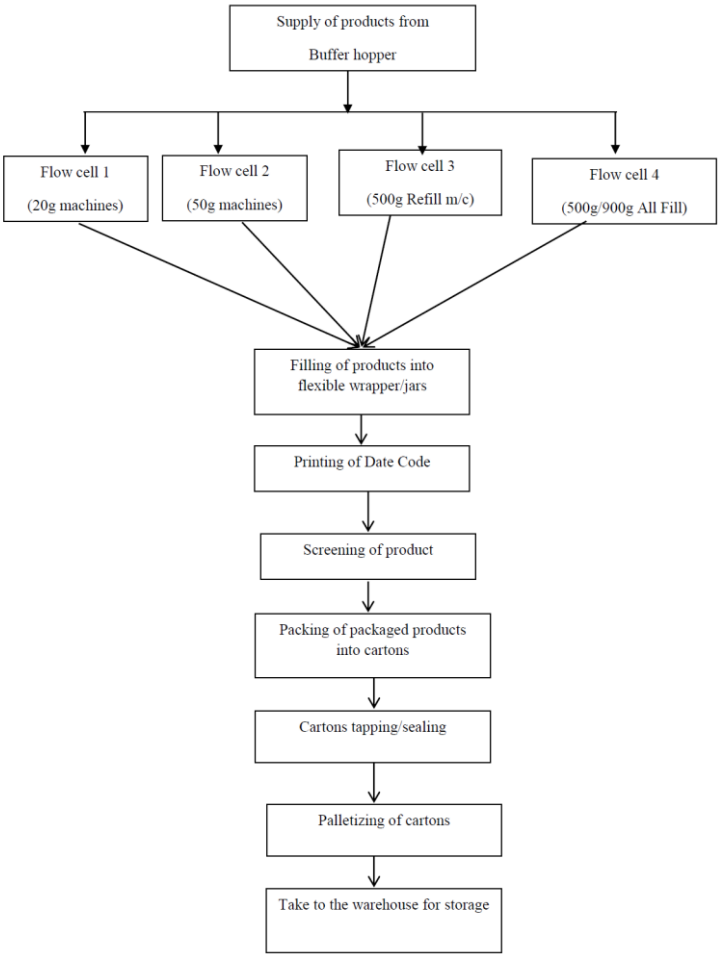

Fig. 1. Flow chart for packaging activities.

The final scores that were obtained from the RULA assessment worksheets were compared with the RULA standard i.e.

Table 1. Number of packaging machines and workers in each flow cell.

Flow cell	No of equipment	Packaging machine	No of folders	No of packers	No of carton wrapper	No of Palletizers	No of operators
1	4	20g	4	4	1	1	5
2	3	50g	3	3	1	1	3
3	1	500g Refill	1	2	1	1	3
4	1	500g All fill	2	4	1	1	3
Total			**10**	**13**	**4**	**4**	**14**

Final Score: 1 or 2-Acceptable; 3 or 4-Investigate further; 5 or 6 - Investigate further and change soon; 7-Investigate and change immediately.

2.1. Hardware requirements

The hardware requirements for the codes are as follows:

- Processor: Pentium (IV), 2.6 GHz or above;
- Hard Disk Drive: 4 GB or above;
- Monitor: LCD or CRT as softcopy display;
- Keyboard: standard keyboard (PS/2);
- Mouse: Better optical;
- RAM: 1 GB and above recommended.

2.2. Software requirements

The software requirements for the codes are as follows:
- Microsoft Access 2007 and above;
- Operating System: Window XP, 2000, Window vista etc.;
- System type: 32 and 64 bits.

2.3. Development of visual basic codes for RULA

These codes were developed to aid and fast track the whole data assessment processes and comparing the individual final score of each subject with the RULA Standard. It also presents some benefits such as:
- Improvement on the workers postural evaluation.
- It speeds up the whole process of evaluation with accurate and precise final score.
- It is efficient and effective process.
- It is stress free because it removes the stress of relating final wrist/ arm score with final neck/trunk score in order to get the final score.

2.3.1. Choice of programming language

The programming language that is used for this project is Microsoft Visual Basic 6.0 and the database used for storing the information is Access 2007 and above version.

2.3.2. System testing

System testing was carried out in stages, namely codes testing, procedure testing, hardware testing and acceptance testing.

2.3.3. Codes testing

This involves the testing of individual code module to ensure that it conforms to the system analyst's specifications. The system analyst prepares a set of input data (i.e. both correct and erroneous) together with the corresponding output and test the code in all possible situations to identify and eliminate execution errors.

The main aspect of code testing includes: Feasibility and validity checks on the input data, correct interpretation of symbols, etc.

2.3.4. Procedure testing

This involved the testing of two or more code modules that depends on one another. The main aspects of this procedure include interfacing of routine within a procedure, compilation and continuity of control totals, error-correction procedures, user requests for amendment and output, and output preparation and distribution.

2.3.5. Hardware testing

This was carried out to ensure that the various parts of the system's configuration work together to produce the required outputs.

2.3.6. Acceptance testing

This involved the testing of the whole system's hardware and software by the group of all user, departments, system department, and management to ensure that the new system operate as specified.

2.3.7. Input design

This software consists of the following input:
- *Upper Arm Input***:** To determine the range of movement of the upper arm whether it is in extension or in flexion and at what degree. It also determines if the upper arm is elevated and/or if the upper arm is abducted or if the worker is leaning.

- *Lower Arm Input:* To determine the range of movement of the lower arm whether it is in extension or in flexion and at what degree. It also determines if the lower arm is working across the midline of the body or out to the side.
- *Wrist Input*: To determine the range of movement of the wrist whether it is in extension or in flexion and at what degree. It determines if the wrist is ulnar or radial deviated and it also determines if the wrist is twisted or not.
- *Neck Input*: To determine the range of movement of the neck whether it is in extension or in flexion and at what degree. It determines if the neck is twisted or not and determines if the neck is side-bended.
- *Trunk Input:* To determine the range of movement of the trunk whether it is in extension or in flexion and at what degree. It determines if the truck is twisted or not and determines if the trunk is side-bended.
- *Leg Input:* To determine the posture of the leg, whether the legs and feet are well supported when seated with weight evenly balanced or if the worker is standing with the body weight evenly distributed over both feet, with room for changes of position or the legs and feet are not supported or the weight is unevenly distributed.
- *Muscle Use Input*: To determine if the posture is mainly static or not.
- *Force or Load Input*: To determine the specific type of force that is being applied and the quantity of that is carried at a particular point in time, and it also determines whether the action is repeated or intermittent.

2.3.8. Output Design

There is only one output design which include the Grand score (which range from 1 – 7) and the action level that can falls between one to four (1 – 4) which will determine whether the position needs to be changed immediately or needs further investigation.

3. RESULTS AND DISCUSSION

The study was conducted for the ergonomic evaluation of packing workers in a food manufacturing company while performing their routine work. It was observed generally that the workers spend an average of eight hours per day and forty hours to forty-eight hours per week at work and observed two days off.

The workers performed the following activities depending on the category of workers:

- *Operators:* Operators were in charge of monitoring which included:
    - Checking the weight of the products with the help of electronic scale.
    - Ensuring that date codes are appropriately printed in the right place.
    - The products are properly sealed to prevent leakages.
    - Adjustment of machines to ensure the products meet quality standard.
    - Managing both edible and inedible wastes generated within the operational hours.

All these job activities involved bending, squatting, standing, etc., which have ergonomic risk factors to the operators of the packaging machines.

- *Folders*: As the products are conveyed from the machines with high speed, the folders pick the products, fold and split them into appropriate numbers i.e. (10 sachets of products per row, 5 rows of sachet products in 10 revolutions and the production rate is 60 revolutions per minute, making a total of 300 sachets of products in a minute). Placing the products on another conveyor for products screening against extraneous matters. They also check for leakages of products and that date codes printing are in the right place. All these activities involve twisting and bending of the wrist, arm working across midline of the body, shoulder being raised, upper arm being abducted, neck side bending, and trunk twisted.
- *Packers*: As the products pass through the x-ray/metal detector machines for screening, the ones with extraneous matters are rejected while the others get through to the packers. The packers perform the following activities:
    - They fan - fold the cartons manually into boxes.
    - They also check for any form of quality variation before filling the cartons with products.
    - They count the appropriate number of products into the cartons.

- *Carton sealers/tapers*: The products in cartons were checked for weight compliance with online check weighing machine/electronic scale, if it falls within the range is accepted but if otherwise is rejected. The compliant cartons of products are sealed/taped manually using a hand held taping machine. During this process

the subjects were observed experiencing ulnar deviation of approximately twelve degree on the wrist and a forward flexion of fifteen degrees on the neck and spine. All these activities involve twisting and bending of the wrist, arm working across midline, flexing of the spine etc.

- *Palletizers*: Cartons of products are picked up from roller conveyor and arranged on pallets layer by layer to the required quantities (between 72 & 84 cartons per pallet). These activities involve lifting, bending, flexing of spine, overstretching of the arm, twisting and bending of wrist.

The assessment of the workers are represented in Table 2, showed upper arm position analysis, lower arm position analysis, wrist position analysis, wrist twist position analysis, final wrist/arm scores, neck position analysis, trunk position analysis, leg position analysis, final necks/trunk/leg scores and corresponding final result of RULA score.

Figure 2 presents the RULA score with assessed body parts and final score while Figure 5 presents the number of subjects in percentage and risk level of workers at the packaging section in a food manufacturing company. The workers were exposed to various degrees of ergonomic risk level depending on the section. Workers at the Palletizing section that constitute 10.0% of the workforce experienced very high ergonomic risk level (grand score of 7) and thus were required to be investigated with request for immediate change in their work condition. Twenty five percent of the workforce were engaged with folding activities and experienced medium ergonomic risk level (grand score of 4) that required them to be placed only under investigation.

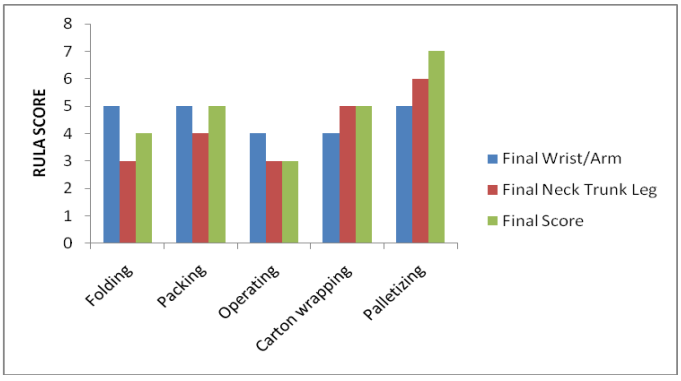

Fig. 2. RULA score with assessed body parts and final score.

Table 2. Percentage description of ergonomic risk level.

Activities	Final Score	No of Subjects	%	Remark	Ergonomic Risk Level	Activities
Operating	3	10	25%	Investigate further	Medium	Operating
Folding	4	10	25%	Investigate further	Medium	Folding
Packing	5	12	30%	Investigate further & Change soon	High	Packing
Carton wrapping	5	4	10%	Investigate further & Change soon	High	Carton wrapping
Palletizing	7	4	10%	Investigate and change immediately	Very high	Palletizing
Total		**40**	**100%**			

Four subjects that were involved in carton wrapping activities which constitute 10% of the work force under review experienced high ergonomic risk level (grand score of 5) and thus were required to be investigated with request for change soon in the work condition because this process subjected the workers to ulnar deviation of approximately twelve degrees on the wrist and a forward flexion of fifteen degrees on the neck and spine. Figures 2 ÷ 11 present the screen shot of using the codes developed for RULA.

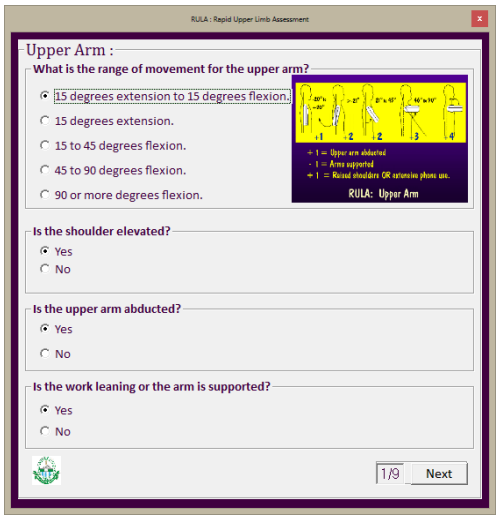

Fig. 3. Screen shot for upper arm assessment.

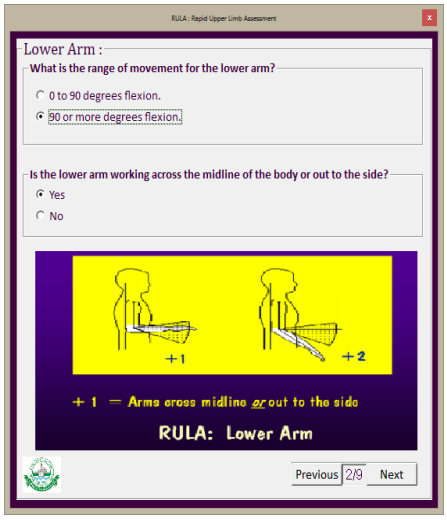

Fig. 4. Screen shot for lower arm assessment.

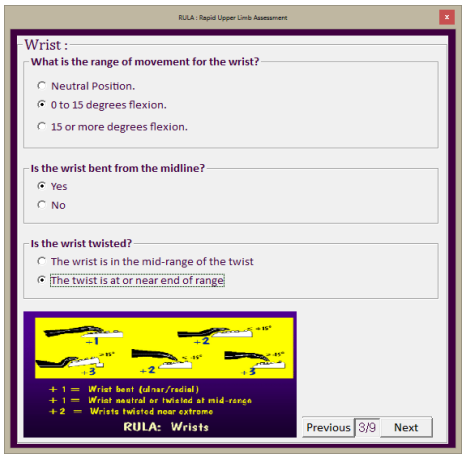

Fig. 5. Screen shot for wrist assessment.

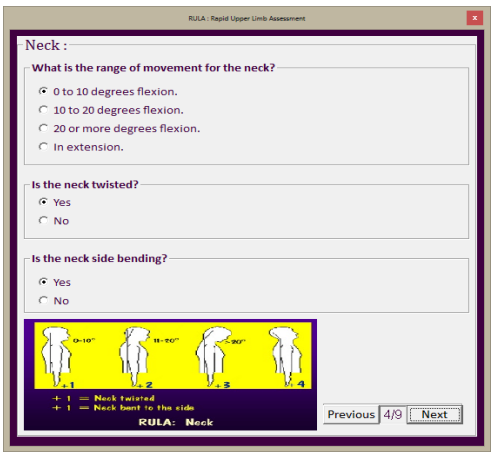

Fig. 6. Screen shot for neck assessment.

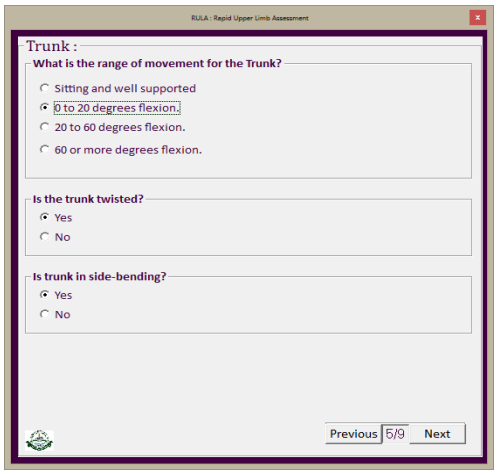

Fig. 7. Screen shot for trunk assessment.

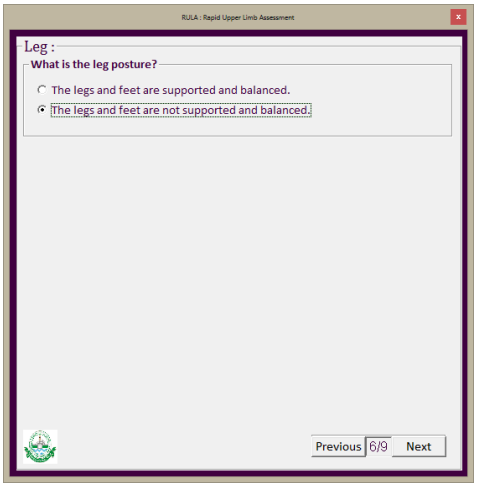

Fig. 8. Screen shot for leg assessment.

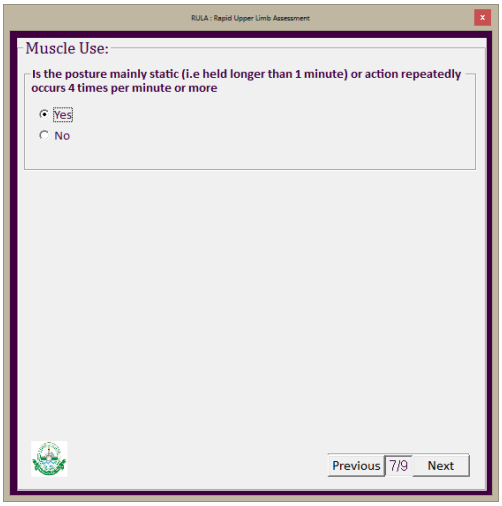

Fig. 9. Screen shot for muscle use assessment.

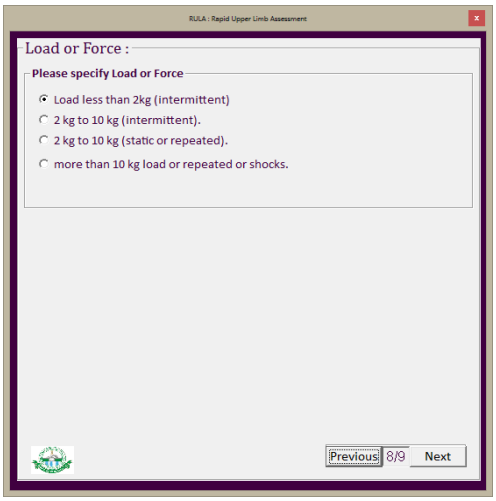

Fig. 10. Screen shot for load or force assessment.

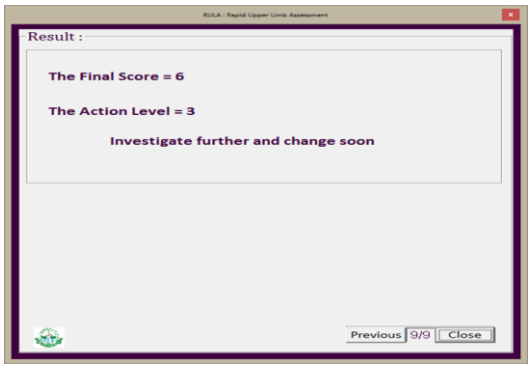

Fig. 11. Screen shot for final score and action level.

The study conducted an ergonomic evaluation of the working posture of workers engaged in various processes in the packaging section of a food manufacturing company. Awkward posture, forceful exertions and repetitive activities are most crucial for developing work related musculoskeletal discomforts and become more critical if the factors are combined. Mc Attemny and Corlett [10] noted the three components of RULA were posture, muscle use and force scores. For the posture, it was observed that 70 percent of the workers held their upper arms in forward flexed postures between 15 and 20^0 with 30 percent between 45 and 90^0. About 78 percent abducted their upper arms; about 18 percent raised their shoulder while five percent supported their upper arms. All the workers had their lower arms between 0 and 90^0 while their arms were across the midline or outside the body.

Most (90 percent) of the workers held their wrists between 0 and 15^0 in upward or downward position while 10 percent had their wrists lowered or raised above 15^0 with 45 percent bending their wrists from the midline. All the workers twisted their wrists at or near end range while working.

All workers held their neck between 10 and 20^0 with 52.5 percent of them twisted or side-bent their necks. Flexed neck at 20^0 for more than 40% (3.2 hours) of the working time will rapidly increase the risk of neck pain [20]. If the neck is forward flexed position, the compressive load on cervical discs in the neck-forward flexed will be 10 kilograms greater than that in the upright neck position [21]. The trunk flexion was between 0 and 10^0 for 12.5 percent of the workers; 10 percent had a twisted trunk and flexion of between 20 and 60^0 while 22.5 percent bent their trunks. A strong risk factor for developing back pain is working in a bent or twisted position for more than two hours a day [22].

Fifty percent of the workers had grand scores of 3 and 4 which required that their schedule of duties should be investigated further while 40% of the workers had a grand score of 5 which required that they should have their jobs investigated further and change soon. The workers in palletizing which constituted 10% had a score of 7 and required that the jobs should not only be investigated further but should be changed immediately. It is observed

that high RULA score for palletizing and carton wrapping workers were due mainly due to their posture, frequent twisting, bending and muscle use. Working at these non-neutral positions increases the overall discomfort and pain at the lower back, neck, and shoulders [23]. The job of workers in these sections could be likened to the work of welders in small scale industry as observed by Agrawal et al. [24] with a final score of 7 and thus the workstation must be investigated, and changes are needed immediately.

The RULA grand score of 5 obtained for packing workers was more than between 3 and 4 obtained for packing workers in a pharmaceutical industry by Pourmahabadian et al. [15]. Musculoskeletal disorder is a great concern in world concern among industrialized countries (ICs) and Industrially Developing Countries (IDCs) [25] with IDCs having the problems of extremely serious workplace injuries due to poor working conditions and absence of an effective work injury program resulting in high rate of MSD [7].

Musculoskeletal stress due to awkward and constrained postures on different body regions is the major factor in the development of musculoskeletal disorders [26]. In order to reduce the level of exposure to risk factors, medium to very high risk actions should be urgently addressed [23]. Working in the food industries required standing and walking in addition to repetitive activities [27] leading to discomfort and pain in the body [28]. One of the fundamentals of ergonomics is that a job that can be done while sitting or standing should be done sitting since it is less strenuous and as noted by Kroemer et al. [29], the loading on the upper limbs will be evenly distributed over the seat pan leading to reduced load on the lower limbs. However, if a job requires that it must be done in a standing posture throughout the duration of the working hours, the job should be rotated within those hours [30].

4. CONCLUSIONS

According to RULA method, the awkward postures adopted by the workers in the food manufacturing company has been categorized as having medium to very high risk level. Operating and Folding workers were at medium risk of musculoskeletal disorder, while Packing and Carton wrapping workers were at high risk of musculoskeletal disorder and Palletizing workers were at very high risk of musculoskeletal disorders. Hence, ergonomic interventions are required in this section. Proper training of workers and awareness may reduce the risk of musculoskeletal disorders.

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