

ORIGINAL ARTICLE

ERGONOMIC RISK ANALYSIS AND MENTAL WORKLOAD STUDY AMONG OPERATORS IN SYRINGE ASSEMBLY LINES

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ABSTRACT

Inappropriate sitting working position among operators in syringe assembly inspection possibly contribute to the issue of several syringes passed the quality inspection and delivered to the clients even they contaminated with over amount of silicon lubricant. This inappropriate sitting posture in the inspection workstation could result the stress, fatigue, musculoskeletal disorder and mental workload issue among operators which influence the operators' performance. This paper presents an investigation to identify the ergonomics and mental workload issues among the operators in the syringe assembly lines. A series of interview and observations were conducted using ergonomic risk analysis (ERA) checklist to investigate the ergonomics issues. NASA-Task Load Index (TLX) method also had been used as mental workload assessment tool. The results from this study show that there are issues in awkward postures, static and sustained work posture, repetition, lighting and noise. Besides, three out of four operators experience more than 50% score of workload during inspections with the high percentage of five index elements except one operator shows the different result. This study contributes to the study field by verifying the ergonomics and mental workload as significant factor to maintain the product quality and productivity. In future, advanced analysis will be conducted to investigate the identified issues in details and next propose the workstation design improvements.

Keywords: ERA, NASA-TLX, postural analysis, sitting position, syringe assembly

INTRODUCTION

Medical devices industry such as syringes constantly receiving positive market demands due to the extensive and daily use of the product (Sung *et al.*, 2011). The capability of a production floor to produce high volumes of syringes is depend on the quality inspection output. The inspection process is conducted by the operators according to the quality standard in the assembly line. The syringe is passing the quality inspection if it clears from the defects such as broken barrel, broken plunger, and tilted rubber gasket as well as over amount of silicon lubricant.

However, it was claimed by customer service department that several syringes with over amount of silicon lubricant were found by customers during the quality screening. One of the factors that contribute to this problem is possibly related to the operators' performance during conducting the inspection activities. The operators conduct the inspections in sitting working posture by using physical visual to inspect the excessive silicon lubricant in the syringe as shown in Figure 1. These daily routines consume energy and mental workload to focus on the tasks. In addition, static sitting posture combined with repetitive body movements contributes to the stress, fatigue, musculoskeletal pain and mental issue among

operators (Bridger, 2009). Therefore, human error could occur during the inspection process.



Figure 1 Sitting working posture during syringe inspection

Providing a good working condition is the most important factors of ergonomics to increase the level of comfort at a workplace. It has been proven that awkward factors, task demands and repetition significantly influencing individual performance (Chiasson, M.-È., Imbeau, D., Aubry, K., & Delisle, 2012). Bad posture and repetitive movements during performing the task could contribute to work-related musculoskeletal disorders (WMSDs) in numerous working sectors such as manufacturing (Balasubramanian, V., Adalarasu, K., & Regulapati, 2009), construction (Chiasson, M.-È., Imbeau, D., Aubry, K., & Delisle, 2012) and healthcare (Ngomo, S., Messing, K., Perrault, H., & Comtois, 2008). Two million labourers have been identified suffering musculoskeletal

disorder and the number of suffering is increasing in the developing countries (Abduljabbar, 2005). The WMSDs is identified as a factor that contribute to the low productivity, increased the cost of compensation, medical costs and increased human errors (Chung MK, Lee I, 2005; DOSH Malaysia, 2017).

Relationship between awkward postures, task factors, and both physical and mental demands assessment is rarely investigated (Kittusamy, N. K., & Buchholz, 2004) since many research has been focused on the poor posture conditions separately to physical and mental demands (Vieira, E. R., & Kumar, 2004). However, Putz-Anderson *et al.*, (1997) noted that there is a significant correlation between musculoskeletal problems and awkward postures. (Hongwei Hsiao; W. Monroe Keyserling, 1990; Vieira, E. R., & Kumar, 2004; A. N. Aisyah; N.Y. Guan & M.T. Shamsul, 2017) also agreed that there are various factors affect the working postures in a workplace, such as the layout of workplace, the design of workstation, and individual anthropometric.

This study performed an investigation to identify the ergonomics and mental workload issues among operators in the syringe assembly lines. The study also searches for levels of assembly task workloads on mental workload to determine whether poor sitting postures can affect operators' mental workload in actual inspection environment. The results of this study propose that ergonomics and mental workload as significant factor to maintain the product quality and productivity in specific to syringe manufacturing and medical devices as general. In addition, the results of this study also verify the importance of identifying the issues in sitting working posture among the operators during conducting the tasks in order to maintain the health, avoid injury and improve the safety in work station.

In the next section, the study methods will be described briefly, followed by results and findings before ended by conclusion.

METHODS

Participants

Individual interview was conducted among four operators in assembly lines regarding the syringe assembly activities. Two operators were males with ages between 19 to 32 with mean age 22. The operators had almost two years of working experience in assembly process by the time this study was conducted.

It is important to note that four operators were participated in mental workload assessment and only three operators in ergonomic risk

investigation due to the changes in working schedule during the study.

Instrumentations

A structured interview sheet was used to facilitate the individual interviews (Salvendy, 2012). Besides, a video camera was used to capture and record the inspection activities conducted by four operators. ERA checklist was used to identify ergonomic risk factors, to quantify them, and then made measurable improvements to the workplace, ensuring the jobs and tasks are within workers' capabilities and limitation (Salvendy, 2006). The ergonomics risk factors consist of awkward posture, forceful and sustained exertions, repetitive motion, static and sustained posture, vibrations, contact stress and environmental risk. All the factors evaluated by the main situation of workload task to be assessed. ERA assessment was conducted by referring to ERA guidelines and method framework (DOSH Malaysia, 2017). Two approaches were applied for initiating ERA assessment which is proactive and reactive. Each risk factor were identified and filled into ERA checklist. The total scores were based on each factor that had been observed and analysed. The assessments score results were summarized in initial ERA checklist table. The identified risk factors related to postural analysis were reported in details.

The NASA-TLX method (Sandra G.HartLowell E.Staveland, 1998; Bridger, 2009) were used to examine six parameters of mental workload measurement which is mental demand, physical demand, temporal demand, performance, effort, and frustration. Mental demand is a level of mental and perceptual activity whether the task easy or demanding, simple or complex, exacting or forgiving i.e. thinking, deciding, calculating, remembering, looking, searching etc. Physical demand is the physical activity in the task whether the task demanding, slow, or brisk, slack or strenuous, restful or laborious i.e. pushing, pulling, turn, control, activate etc. Temporal demand is the feeling of time pressure due to the rate or pace at the task or task elements occurred. Performance is defined as successful rate in accomplishing the task goals. Effort index is measuring the difficulties rate to accomplish the level of performance. Frustration is level of insecure, discouraged, irritated, stress and annoyed feeling versus secure, gratified, content, relax and complacent during accomplishing the task.

Twenty steps bipolar scales were used to obtained ratings for these parameters. A score from 0 to 100 (assigned to the nearest point 5) is obtained for each scale (Rubio, S., Díaz, E., Martín, J., & Puente, 2004). A weightage technique was used by combining the six rating

of each individual into a global score which requires a paired comparison task to be performed after the workload assessments. Paired comparisons required the operator to select the most relevant parameter options to the type of workload across all pairs of the six parameters. The number of times a parameter chosen as more relevant was the weighting of that parameter scale for a given task for that operator. The workload score from 0 to 100 was obtained for each rated task by multiplying the weight of individual parameters scale score, summing all across the scales, and divided by 15 (the total number of paired comparisons) (Gopher and Donchin, 1986; Sandra G.HartLowell E.Staveland, 1998; Rubio, S., Díaz, E., Martín, J., & Puente, 2004).

Data analysis

Data from ERA forms, interview and observations were analysed using task analysis (Salvendy, 2006). The data from mental workload assessment tools were analysed using NASA-TLX analysis software.

RESULTS

Postural analysis

Table 1 shows the awkward postures receives highest score for ergonomic risk among operators in the syringe assembly lines with seven, nine and eleven scores. The second important risk is repetition which all operators gave three scores for this risk, followed by two scores for noise. The risk for static and sustained work posture and lighting risk also recommended to be analysed further because the score is fulfil the minimum requirement of ERA advance.

Results from Table 1 also presents the three major body discomfort issues related to the shoulder, upper arm and lower back. These issues verified by the observations of operators' sitting posture as shown in Figure 2.

Table 1 ERA results

Risk factors	Total Score	Minimum requirement for advanced ERA	Result of Initial ERA			Need Advanced ERA? (Yes/No)			Any Pain or Discomfort due to risk factors as found in Musculoskeletal Assessment (/) which part of the body			
			Op 1	Op 2	Op 3	Op 1	Op 2	Op 3	Op 1	Op 2	Op 3	
Awkward postures	13	≥ 6	11	9	7	yes	yes	yes	Neck			
Static and sustained work posture	3	≥ 1	1	1	1	yes	yes	yes	Shoulder	/	/	/
Forceful exertion	1	1	0	0	0	no	no	no	Upper arm	/	/	/
Repetition	5	≥ 1	3	3	3	yes	yes	yes	Lower back	/	/	/
Vibration	4	≥ 1	0	0	0	no	no	no	Forearm			
Lighting	1	1	1	1	1	yes	yes	yes	Wrist	/		
Temperature	1	1	0	0	0	no	no	no	Hand			
Ventilation	1	1	0	0	0	no	no	no	Hip / buttocks			
Noise	2	≥ 1	2	2	2	yes	yes	yes	Thigh			
									Knee			
									Lower leg			
									Feet			



(a)



(b)



(c)

Figure 2 (a), (b), (c) Observations on shoulder, upper arm and lower back discomfort positions

Mental workload analysis

Figure 3 illustrates the graph of NASA-TLX elements. Three operators experience more than 50% score of workload during conducting syringe inspection activities. From six elements of task load, all operators show that they require high effort with mean value is 92%. Three operators respond to high temporal demand with mean value 87% and mean score of 86% for high mental demand. Also, two operators experience high frustration with mean score 83%.

However, the data obtained from operator four need further investigation because the result for all elements except the effort scale are outliers. The possible explanation for this data is could be the perception of the operator during the assessment such as people, events, experiences and feeling (Liu, Volcic and Gallois, 2011) influence the study results.

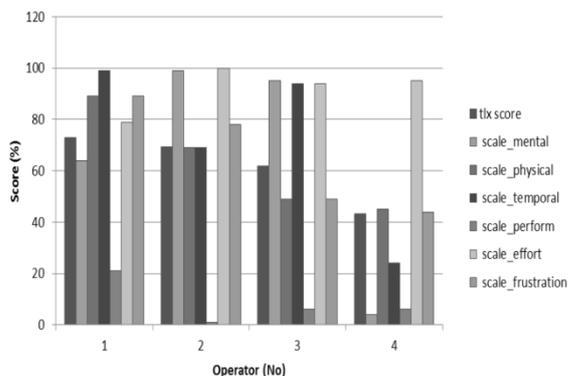


Figure 3 NASA Task Load Index (TLX) results

CONCLUSION

Inappropriate sitting working position among operators in syringe assembly inspection possibly contributes to the issue of several over silicon lubricant syringes passed the quality inspections and delivered to the clients. This study investigated and identified the ergonomics and mental workload issues among the operators that involved in syringe inspections by conducting interviews and observations using ergonomic risk analysis (ERA) checklist and NASA-Task Load Index (TLX) method. The results from this study show that there are issues in awkward postures, static and sustained work posture, repetition, lighting and noise. In addition, three major discomfort issues which is shoulder, upper arm and lower back are identified. Besides, three out of four operators experience more than 50% score of workload during inspections with the high percentage of five index elements except one operator shows the outlier result. In future, advanced analysis will be conducted to investigate the identified issues in details and propose the workstation design improvements in next process.

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COMPETING INTERESTS

There is no conflict of interest.

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