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AN EFFECTIVE ERGONOMIC PROGRAMME TO IMPROVE PERFORMANCE IN THE PACKAGING INDUSTRY

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ABSTRACT

The packaging industry in South Africa is devoid of effective ergonomic programmes due to poor implementation thereby leading to failure to yield realisable benefits for the implementing firms. The study aims to develop an effective SEP that focuses on improving the firm's overall performance through synchronisation of the ergonomic programmes with the firm's business strategy. A quantitative research methodology with a questionnaire as the research instrument was adopted for this study. A quantitative research methodology was adopted to elicit information from the employees at a liquid packaging company in South Africa. A sample of 70 employees from engineering and production departments was used. The research findings demonstrated that several factors hindered the effective implementation of ergonomics in the packaging industry, and these include awareness in the subject of ergonomics, job task design, human-computer interaction, disconnection between organisational strategies and employees, as well as poor implementation of physiological and anthropometric factors. An effective ergonomic programme that incorporated systems engineering risk assessment methodology, was developed, embracing a probability of occurrence matrix, ratings of criticality and rating of consequences. It was recommended that the organisation should train the employees on ergonomics best practices to create an effective programme that will eliminate operational gaps and lead to enhanced organisational performance.

Keywords: Scientific ergonomic programme; Ergonomic Factors; Risk Assessment.

INTRODUCTION

Organisations have attempted for many years to improve their overall performance by focusing on tangible assets such as equipment and financial resources rather than the employees who are the key contributors to an organisation's growth (Chareonsuk & Chansa-ngavej, 2008). The ignorance of this subject can lead to high disengagement levels, poor performance, and an escalation in work-related ailments such as repetitive strain injuries (Bordia, Restubog, Jimmieson, & Irmer, 2011). Ergonomics is defined as the scientific discipline that explores the interaction of humans with the equipment and tools that are used to performing tasks and other activities (Reiman, Kaivo-oja,

Parviainen, Takala, & Lauraeus, 2021). It has been found that ergonomics in industrially developing countries is not well accepted in practice and is thus not comprehended as an integral part of worker wellbeing or organisational success (Roopnarain, Dewa, & Ramdass, 2019). The packaging industry in South Africa is characterised by companies that fail to implement ergonomic programmes and are unaware of the benefits ergonomics. This paper focuses on determining the gaps in implementations of scientific ergonomic programme (SEP), and thereafter develop an effective SEP that focuses on improving the firm's overall performance through synchronisation of the ergonomic programmes with the firm's business strategy. The implementation of an effective scientific ergonomic programme in the packaging industry would assist in improving the employees' overall performance and create a productive working environment that would ensure organisational effectiveness. Two packaging sites based in Cape Town and Durban in South Africa have been used for the study.

LITERATURE REVIEW

In a dynamic economy where organisations strive to perform at their optimum to remain ahead of their competitors, managers seek methods and tools to improve the performance of their organisation's most valuable assets, its people (Kamel, 2019). Ergonomics plays a key role in ensuring that the work environment is designed in a way that is conducive for employees to excel at their performance. It studies staff psychology and physiology of the working conditions, which is a complex system amongst humans, machines and the environment (Górny, 2017).

The goal of implementing ergonomic interventions and the exploitation of ergonomic science is to achieve a suitable and logical relationship between work and employees, where employees can attain maximum productivity and desirable production (Brito, Ramos, Carneiro, & Gonçalves, 2019). Ergonomics is considered as a crucial component or driver of how an organisation can attain its strategic goals. In order for a company to realise the full benefits of ergonomics, it will have to deliberately integrate ergonomics into all strategic goals and at all levels of the organisation (Sun, Houssin, Renaud, & Gardoni, 2019).

Programmes that would empower the employees in terms of decision-making at work are proven to directly lessen psychosocial strain and its undesirable health ramifications (Chung, 2018). These programmes create favourable conditions for the improvement of work processes, and thus ensuring acceptable ergonomic working conditions for effective human labour (Brunoro, Bolis, Sigahi, Kawasaki, & Sznelwar, 2020).

Employees can improve work methods or carry out impressive low-cost ergonomic improvements on equipment, if a culture that nurtures ergonomics is created in an organisation (Abarghouei & Nasab, 2012). According to Dul and Neumann (2009), both physical and psychological human aspects are considered in ergonomics; and the essence is to seek solutions in both technical and organisational spheres. The performance aspects could include lead-time, output volume, production flexibility, operating cost and quality levels.

In the past, managers did associate ergonomics with health issues and no relation to organisational effectiveness was perceived (Oakman, Macdonald, & Kinsman, 2019). This impeded the success and growth opportunities that SEPs entailed. Economic goals and human well-being come together, and ergonomics training is the best preliminary approach for educating computer users about office ergonomics in office working environments (Berlin & Adams, 2017). According to Dominguez-Alfaro et al. (2021), ergonomic programmes have benefits for the state and a mean saving of all social benefits. They positively influence the employees as well as the organisation. It was found that the monitoring of the company benefits is important in the evaluation of ergonomic programmes.

Research Design and Framework

A research design is a blueprint or overall strategy for the assemblage, measurement, and analysis of data that is chosen to integrate the different elements of a study in a logical and coherent manner (Suter, 2012). This study adopted a descriptive research design that sought to describe the assess employees' perception of the current ergonomics scenario of the packaging industry and determine the current ergonomics gaps. The research design focused on providing systematic information about the current ergonomics scenario of the packaging industry. Since the nature of the research is addressed in an industry where there are high levels of uncertainty and ignorance in the topic of scientific ergonomic programmes, the exploratory method would be regarded as the most appropriate.

Two packaging organisations in South Africa based in Cape Town and Durban were approached and invited to participate in the survey. A sample of 70 participants from the production and engineering departments was used. It was vital to understand and identify the current gaps of the packaging companies. Figure 1 shows a research framework applied in developing an ergonomic scientific programme. A bottom-up framework that commences with eliciting information on human factor engineering from knowledge bases and literature on ergonomics is initial developed. The relevant ergonomic elements anthropometry, physiological factors, work posture, task and information design, human interaction, illumination and noise and vibration identified from the findings of the literature review was selected and indicated in the questionnaires developed.

Once the questionnaire feedback was collected and analysis was conducted, systems engineering tools were reviewed from the findings of the literature to identify an effective ergonomic intervention. Data analysis was thereafter conducted to establish the current state of ergonomic programmes and determine ergonomic programmes that would integrate tools and techniques from systems engineering. An effective SEP is ultimately developed to improve organisational performance.

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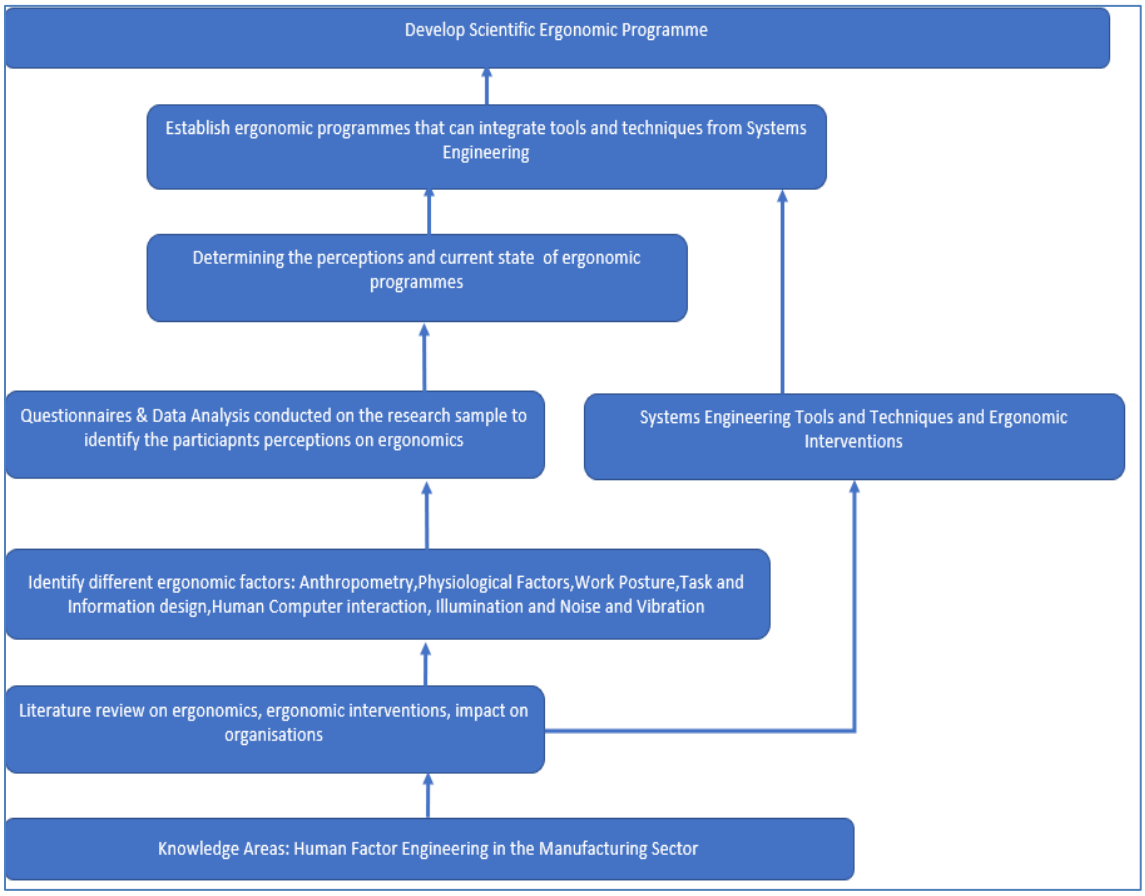

Figure 1. Framework for developing an ergonomic scientific programme

RESULTS AND DISCUSSION

Ergonomic Factors

Anthropometric and Physiological Factors

The respondents were asked to express their perceptions concerning the statement "The work stations are designed in a way that allows you to work effectively".

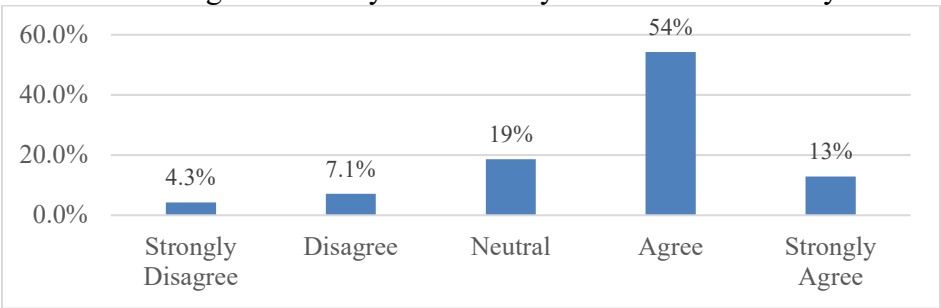

Figure 2. Workstations designed to allow effectiveness

The statistics in Figure 2 revealed that 54% agreed and 13% strongly agreed. The mean statistic was 3.66; skewness of -1.061, while kurtosis was 1.173. The skewness value was negative, an

indication that the distribution lies more to the right of the median, revealing that the respondents were inclined to be more satisfied with their workstation design.

The respondents were also asked to express their perceptions concerning the statement "There are sudden movements and force exertion present in my daily task activities". The statistics showed that 48.6% agreed and 12.9% strongly agreed. About 1.4% of the respondents strongly disagreed, 21.4% disagreed, while 14.3% were neutral. The item mean statistic was 3.51; skewness value was -0.49, while kurtosis was -0.73. The respondents also expressed their perceptions concerning whether there is a variation in worker postures and movements. The statistics showed that 60% agreed and 24.3% strongly agreed.

Factors related to work posture

The respondents were asked to express their perceptions concerning the statement "The height of the worktable is adjustable". The results in Figure 3 show that 54.3% agreed and 10% strongly agreed.

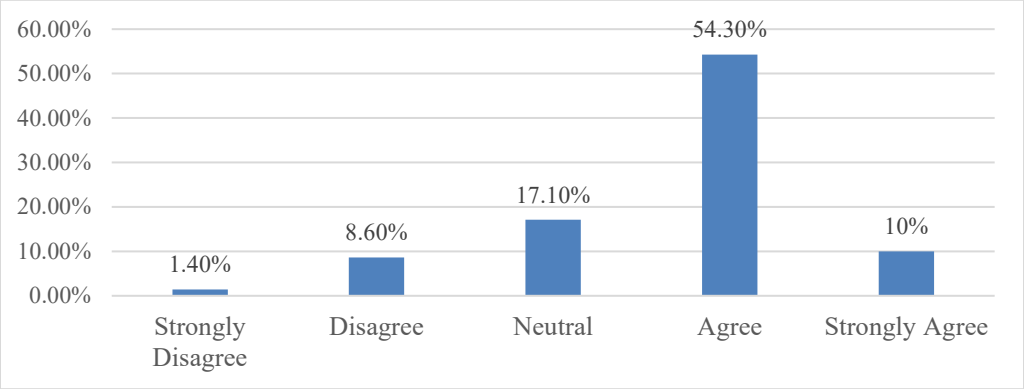

Figure 3. The height of the worktable is adjustable

About 1.4% of the respondents strongly disagreed, 8.6% disagreed, while 17.1% were neutral. The item mean statistic was 3.69; skewness of -0.9, while kurtosis was 0.9. The results on whether sitting/standing is often alternated with standing/sitting and walking showed that 30% agreed and 7.1% strongly agreed. About 5.7% of the respondents strongly disagreed, 44.3% disagreed, while 12.9% were neutral. Concerning the statement "The current seating design prevents me from working effectively" the results showed that 28.6% agreed and 5.7% strongly agreed, about 2.9% of the respondents strongly disagreed, 47.1% disagreed, while 12.9 % were neutral.

Factors related to design of tasks and jobs

The respondents were asked to express their perceptions concerning the statement "The job consists of more than one task". The results in Figure 4 results show that 47.10% agreed and 30% strongly agreed. The mean statistic of 3.93; skewness is -0.1, while kurtosis is 0.27.

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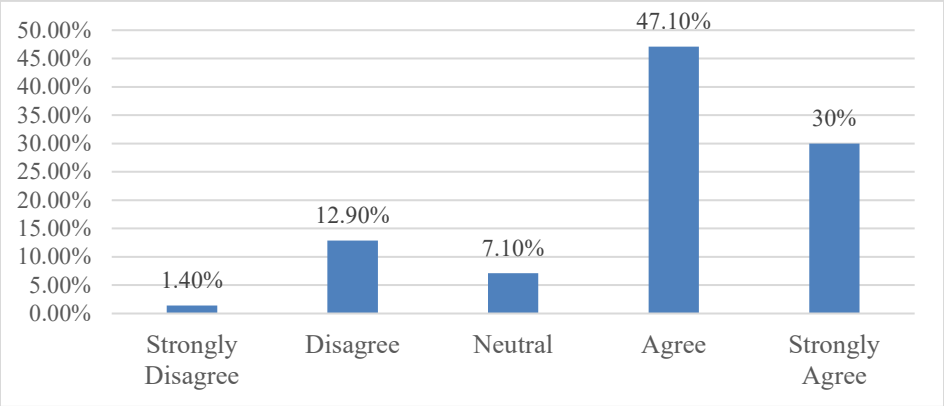

Figure 4. The job consists of more than one task

Elton, Johnson, Nicolle, and Clift (2013) suggested that management should use job rotation as an organisational practise and adequate training should be provided to the workers in various tasks, taking into consideration, the ergonomic aspects of each task. Job rotation can be a significant intervention when ergonomic principles are deployed, and would thus, help to minimise workplace hazards (Padula, Comper, Sparer, & Dennerlein, 2017).

Concerning whether the tasks performed contributed to problem-solving, the results showed that 55.7% of the respondents agreed on the notion that the tasks performed to contribute to problem-solving and 20% strongly agreed. The mean statistic of 3.79; skewness is -1, while kurtosis is 0.7. Concerning whether workers can decide independently on how the tasks are carried out, the results showed that 30% agreed and 10% strongly agreed, about 8.60% of the respondents strongly disagreed, 27.10% disagreed, while 22.90 % were neutral.

Factors related to Information Tasks

The respondents were asked to express their perceptions concerning the statement "The information presented is as simple as possible and easily understood Figure 5 results show that 65.7% agreed and 5.7% strongly agreed. About 2.9% of the respondents strongly disagreed, 12.9% disagreed, while 12.9% were neutral. The item mean statistic was 3.59; skewness of -1.2, while kurtosis is 1.

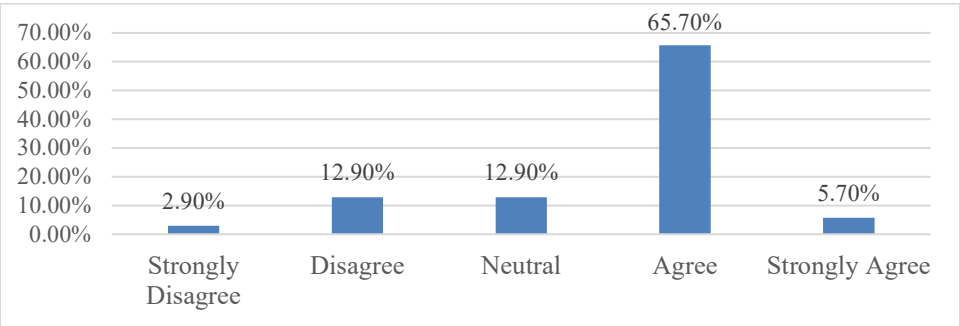

Figure 5. Information presented is simple and easily understood

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The information presented was perceived as simple as possible and easily understood since results showed that 60% of the respondents agreed on that notion and 8.6% strongly agreed. The item mean statistic was 3.67; skewness value of -1, while kurtosis is 1.2. The respondents also expressed that the method of displaying information selected was appropriate given that results showed that 60% agreed and 2.9% strongly agreed on that notion.

Human-Computer Interaction

The respondents were asked to express their perceptions concerning the statement Touch screens are used to facilitate operation by inexperienced users". The results in Figure 6 show that 20% agreed, 10% disagreed and 2.9% were neutral. About 67.10% found the question not applicable to their job role. The item mean statistic is 3.3; skewness is -0.7 while kurtosis is -1.5.

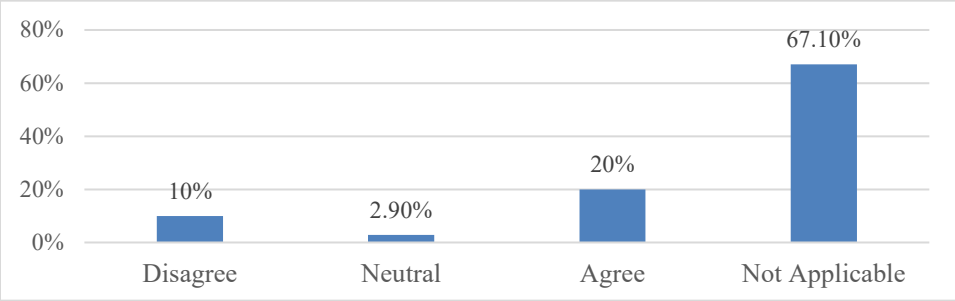

Figure 6. Touch screens used to facilitate operation by inexperienced users

Concerning whether the numerical keypad layout is logical, about 68.60% found the question not applicable to their job role. The respondents were also asked their perception on whether there are concerns relating to computer interaction that affects their job. Since this question did not apply to many of the research participants, a small response was obtained.

Illumination

The respondents were asked if the light intensity for normal activities is in the range of 200–800 lux. Figure 7 results show that 42.9% agreed, 11.4% strongly agreed, 21.4% disagreed. 4.3% strongly disagreed and 15.7% were neutral. The item mean statistic of 3.37; skewness is -0.44 while kurtosis is -0.76.

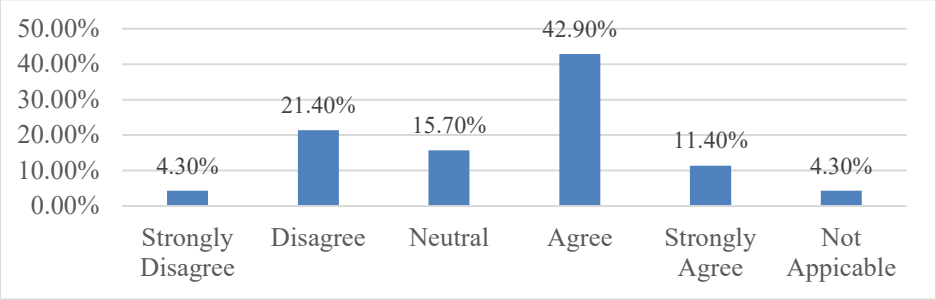

Figure 7. Light intensity for normal activities is in range of 200–800 lux

The respondents were also asked if the information on the training material and standard operating procedures at site was documented and displayed in a format that can be easily deciphered and a majority of the respondents agreed on that notion. In visual ergonomics, the level of ambient illumination is regarded as a critical factor when performing visual tasks. According to a study

conducted by Elton et al. (2013), ambient illumination should be regarded as a critical factor, which can affect the perception of materials, equipment setting, and operation of equipment for the packaging firm.

The respondents also expressed that the light reflections, shadows, or flickers from the fluorescent tubes can be prevented at the site. They also expressed that the lighting at the site had a negative impact on their eyesight since the mean statistic was 2.59; skewness was 0.73 while kurtosis is -0.39. The respondents also expressed that their vision had deteriorated since the start of their employment. The mean statistic was found to be 2.49; skewness is 0.84 while kurtosis is -0.28.

Noise and Vibration

The respondents were asked to express their perception of whether there is adequate separation between the workers and the source of the noise.

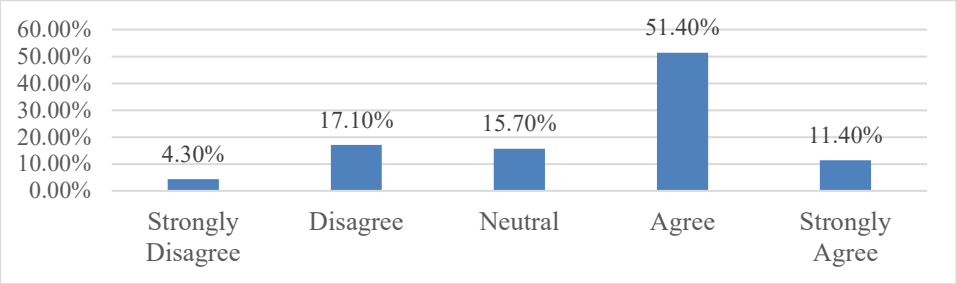

Figure 8. Adequate separation between workers and source of noise

Figure 8 results show that 11.4% strongly agreed, 51.4% agreed, 15.7% were neutral, 17.1% disagreed and 4.3% strongly disagreed. The mean statistic of 3.49; skewness is -0.7 while kurtosis is -0.25.

Concerning the statement "The sources of uncomfortable and damaging body vibrations are recognised" the results showed that 4.3% of the respondents strongly agreed on that notion, 44.3% agreed, 18.6% were neutral, 17.1% disagreed, 4.3% strongly disagreed and 11.4% found the statement to be not applicable. The mean statistic was 3.31; skewness is -0.66 while kurtosis is -0.42. The respondents were also asked to respond concerning the statement "The Noise has a negative impact on my performance". The results showed that 1.4% of the respondents strongly agreed, 14.3% agreed, 15.7% were neutral, 55.7% disagreed and 12.9% strongly disagreed. The mean statistic was 2.36; skewness is 0.76 while kurtosis is 0.01.

Correlation Analysis of Ergonomic Factors

Appendix K shows the results for tests of normality using the Shapiro–Wilk test. The Kolmogorov–Smirnov test is used for n ≥50 while the Shapiro–Wilk test is proper for small sample sizes (<50 samples) (Kim, 2013). The sigma values for the Shapiro–Wilk test for the variables were generally less than 0.05, at 95% confidence interval, and thus non-parametric tests were run for all the variables. Spearman's rank correlation coefficient for non-parametric measure of statistical dependence between variables was used to examine the relationships between the ergonomic factors since the data were non-normal. Table 1 shows the 2-tailed Spearman's rho correlations at the 0.01 level.

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Table 1. Spearman's rho correlations for ergonomic factors

		APF	FP	FDTJ	FIT	HCI	I	NV
APF	Correlation Coefficient	1	.652**	.782**	.628**	.546**	.284*	.356*
	Sig. (2-tailed)		0.01	0.02	0.009	0.04	0.03	0.02
FP	Correlation Coefficient	.652**	1	.672**	.588**	.126**	.344**	.462*
	Sig. (2-tailed)	0.01		0.02	0.04	0.005	0.03	0.01
FDTJ	Correlation Coefficient	.782**	.672**	1	.274*	.111**	.254**	.372*
	Sig. (2-tailed)	0.02	0.02		0.03	0.01	0.005	0.02
FIT	Correlation Coefficient	.628**	.588**	.274**	1	.345**	.678**	.189*
	Sig. (2-tailed)	0.009	0.04	0.03		0.02	0.03	0.043
HCI	Correlation Coefficient	.546**	.126**	.111**	.345**	1	.799**	.328*
	Sig. (2-tailed)	0.04	0.005	0.01	0.02		0.02	0.009
I	Correlation Coefficient	.284**	.344**	.254**	.678**	.799**	1	.175*
	Sig. (2-tailed)	0.03	0.03	0.005	0.03	0.02		0.044
NV	Correlation Coefficient	.356**	.462**	.372**	.189**	.328*	.175*	1
	Sig. (2-tailed)	0.02	0.01	0.02	0.043	0.009	0.044	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The variables were abbreviated as shown below:

- Anthropometric & Physiological Factors (APF)
- Factors related to Posture (FP)
- Factors Related to Design of Tasks and Jobs (FDTJ)
- Factors Related to Information Tasks (Whitley, Mathias, & Fitzhorn)
- Human–Computer Interaction (HCI)
- Illumination (I)
- Noise and Vibration (NV)

At 0.01 level (2-tailed), a strong positive correlation was noted between HCI and I, which was statistically significant, $r_s = 0.799$, $p = 0.02$. Another strong positive correlation was noted between FDGI and APF, which was statistically significant, $r_s = 0.782$, $p = 0.02$. Similarly, there was strong positive correlation that was noted between FP and APF, which was statistically significant, $r_s = 0.652$, $p = 0.01$. At 0.05 level (2-tailed), a mild positive correlation was also noted between HCI and APF, which was statistically significant, $r_s = 0.546$, $p = 0.004$. At 0.05 level (2-tailed), weak positive correlations were noted between NV and I, and between HCI and FDTJ, which were statistically significant, $r_s = 0.175$, $p = 0.044$ and $r_s = 0.111$, $p = 0.01$ respectively. Similarly, there was a weak positive correlation that was noted between HCI and FP, which was statistically significant, $r_s = 0.126$, $p = 0.005$. These results highlighted the interdependence of key factors that should be taken into consideration when designing SEPs to improve organisational performance. Any Kaizen improvements on factors related to design of tasks and jobs may also positively influence anthropometric and physiological factors indirectly.

DISCUSSION OF RESULTS

The overall results displayed a positive response to the current ergonomic conditions at the site. Anthropometric data captured per sample size can be extremely useful when designing work station and operator task layouts. It is advisable that industrial and ergonomic engineering techniques should be used to design safe and productive workstation designs meet the needs of most users (Ahmadi, Zakerian, & Salmanzadeh, 2017). It was noted from the study that highly repetitive tasks performed without the provision of sufficient rest-breaks is a concern as the residual strain would compound the muscular strain experienced. The results also demonstrated that when human activities are performed indoors, hence, it is essential to have good illumination to provide a satisfactory environment for the user. It is vital to ascertain the effect of lighting condition, a key determinant of cognitive ergonomics, to ensure the working efficiency of a visual display terminal.

The presence of occupational noise in various workplaces can have serious consequences on the health of the workers in such an atmosphere and the major concern of long exposure to occupational noise is noise-induced hearing loss. Continuous, periodic and intermittent noise can lead to more errors by the workers since noise has a varied effect on tasks and performance (Fernandes, Hurtado, & Batiz, 2015). The results also demonstrated that vibration is another factor that affects human performance, spanning from simple tasks such as reading and writing, to workers' manual control and vision.

The major gap identified links to the use of technology, where interaction between the respondents and computers seldom occurs. While this could be due to the nature of the environment and job specifications, management should consider options of increasing the use of computers by upskilling the staff members and encouraging job rotation since it aids to expand work experience, job knowledge and social support through interaction with other co-employees (Jackson, Fleming, & Rowe, 2019; Sakthi Nagaraj & Jeyapaul, 2020). It was also found from this study that there is a huge knowledge gap concerning the employees' understanding of basic fundamentals and principles of ergonomics. Most employees were found to understood their job expectations, however, they could not comprehend how factors such as operational performance, safety procedures, and employee best practices fitted into the bigger organisation picture of firm performance.

Departments were also found to be working functional silos, which was a major barrier to effective implementation of SEPs and organisational effectiveness. It was also found that older employees, those over thirty-six years, had little knowledge of ergonomic interventions and the use of computers was restricted to a few employees. The correlation analysis of ergonomic factors highlighted the interdependence of key factors that should be taken into consideration when designing SEPs to improve organisational performance. Kaizen improvements on factors related to design of tasks and jobs may also positively influence anthropometric and physiological factors indirectly.

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RECOMMENDATIONS

It was imperative to develop and integrate an effective ergonomic programme with the current working processes that would contribute to organisational improvement. The implementation of the risk assessment is a vital process that characterised the technical planning process of systems engineering. The approach of integrating risk assessment with ergonomic programmes addresses the existing gaps that were identified in the results and aids to build a sustainable programme that is aligned with the needs of the organisation. To develop an effective ergonomic programme that is incorporated with the systems engineering risk assessment methodology, several steps were followed and these include a probability of occurrence matrix, ratings of criticality and rating of consequences. The results of these activities assisted in determining the criticality of the ergonomic factors.

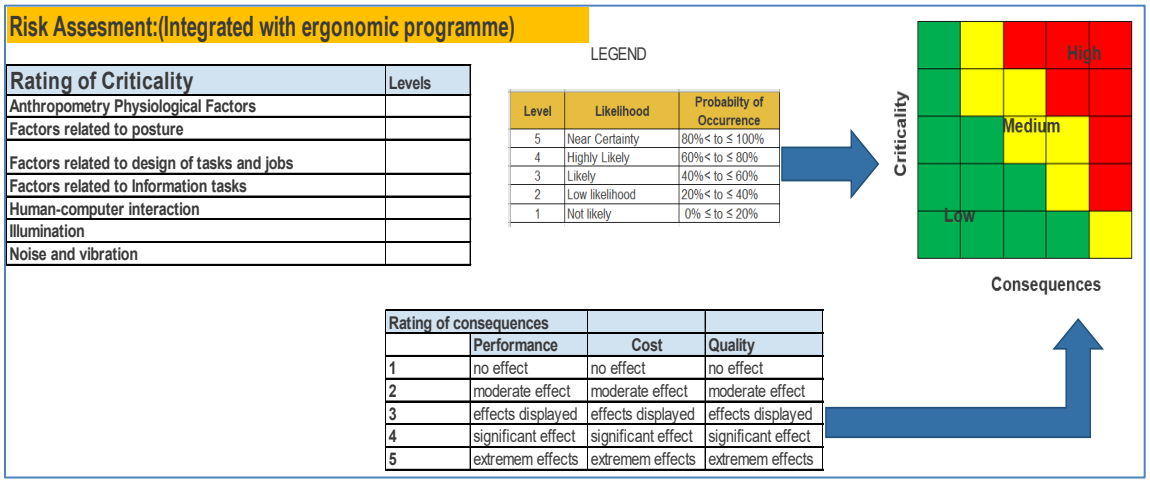

Figure 9. Risk Assessment integrated with ergonomic programme

Figure 9 displays a risk assessment consequence rating table. Level 1 is not likely to occur and falls in the probability of occurrence range between 1% and 20%, and Level 2 indicates a low likelihood and falls in the probability of occurrence range between 20% and 40%. Level 3 is likely to occur and falls in the probability of occurrence range between 40% and 60%, Level 4 is highly likely to occur and falls in the probability of occurrence range between 60% and 80% and Level 5 has a high probability of occurring and falls in the probability of occurrence range of 80% to 100%. Figure 9 illustrates how both processes can be integrated as an intervention to identify current gaps that impede performance and growth opportunities. Risk assessment tools highlight ways of working preventively and improve the work environment (Nilsson & Vänje, 2018; Nord Nilsson & Vänje, 2018). The procedure of the programme would entail a criticality analysis related to ergonomic factors. The levels of criticality would be scored by a matrix and the 'rating of consequences' table. The result of the assessment would then be used to identify the priority of the ergonomic factors. Based on the priority scale (low, medium, high), action plans were developed to resolve the current issues that impeded organisational performance. The problem factors identified in the adopted ergonomic programme in Figure 9 were resolved using effective problem-solving techniques in order to prevent consequential events. Some mitigation options for problem areas identified in the ergonomic programme included ignoring the issue of accepting the consequences without further action if deduced as a low severity on the risk management criteria.

Results were categorised using ergonomic checkpoints adapted from (Association, 1996). These templates were selected for the study as they displayed practical and low-cost solutions to ergonomic problems and addressed all relevant factors in the packaging plant. The ergonomic manual checkpoints were developed to address materials storage and handling, hand tools, workstation design, participatory training, workplace safety and premises.

CONCLUSION

An effective ergonomic programme can improve organisational performance. The light reflections, shadows, or flicker from the fluorescent tubes could be prevented and the current lighting conditions of the case study organisations needed to be addressed to prevent any risk of injury or poor performance related to lighting and illumination. The findings also demonstrated that there was a need for an improvement plan concerning noise and vibration. There was a huge knowledge gap concerning the employees' understanding of basic fundamentals and principles of ergonomics. A majority of the employees were found to understood their job expectations, however, they could not comprehend how factors such as operational performance, safety procedures, and employee best practices fitted into the bigger organisation picture of firm performance. An effective ergonomic programme that incorporated systems engineering risk assessment methodology, was developed, embracing a probability of occurrence matrix, ratings of criticality and rating of consequences. Holistically, there is room for improvement in the field of ergonomics in the packaging sector; it is thus important that organisations foster a culture that aligns their operational processes with ergonomic best practices.

Practical implications

This study significantly adds value to the limited knowledge about ergonomics in the packaging manufacturing sector. The outcomes of the study would help organisations to adopt a proactive approach in addressing organisational gaps through the synergy derived from integrating risk assessment with ergonomic programmes. Additionally, the positive practical implications of the study is better appreciation of the relationship between ergonomics and overall organisational improvement by workers in implementing firms.

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