Application of Strain Index to Assess Job Risks in Small and Micro Community Enterprises

Butree Kaden*, Sasiwimon Seeta[1] and Anun Youngcharoen[2]

***Abstract*—** This research aimed to study ergonomics load differences between Male and Female Workers in 5 Small and Micro Community Enterprises (SMCEs) in Hang Dong of Chiang Mai province by studying Strain Index. 13 male workers and 27 female workers are involved in this research. From Strain Index analysis, researchers found that average Strain Index score of female workers are 3.07(±4.65) in the left side of body and 3.41(±4.43) in the right side of body. In male workers, average Strain Index score are 2.19(±2.00) in the left side of body and 1.46(±0.88) in the right side of body. The average Strain Index score of female workers are higher than in male workers in both left and right side of body because female workers are involved directly in production, so several factors are in higher score than in male workers. Most jobs of male working are for production facilities and hardworking, so male workers have higher injuries suffering rating than in female workers. Moreover, researchers had improved a high Strain Index score working by developing a new equipment and found that workers felt more satisfied with the equipment and Strain Index was reduced when using the new equipment.

***Index Terms*—** Ergonomics, Community Enterprises, Strain Index, Small and Micro Community Enterprises

I. INTRODUCTION

After the Thai economic crisis for several years ago, Small and Medium Enterprises (SMEs) and Small and Micro Community Enterprises (SMCEs) were the transition of Thailand economic growth Thai rural economic development has generated income for centuries that could related to a better economy. The most practical problem in the SMCEs were problems about managements in organization, production, finance, distribution channel, research and development and innovation levels. Moreover low productivity level of labors in SMCEs also affect to their efficiency including; limited capabilities in technology management and knowledge acquisition, low productivity and quality output, shortage of skilled personnel, lack of information and limited access to finance [1].

Ergonomics is the process of designing workplaces, products and systems that fit to people. It is a branch of science that purposes to learn human abilities and limitations and improve people's interaction with products, systems and environments. Ergonomics aims to improve workplaces and environments to minimise risk of injury or accidents. Accordingly, researchers intended to apply Strain Index approach to evaluate job risks and improve production capability of SMCEs in Hang Dong, Chiang Mai, Thailand.

Five community enterprises are involved in this research participated with Ban Guan pottery community enterprise, Dao Dum drinking water community enterprise, Buag Krog bag sawing community enterprise, Tong Kai Nuaer cottony garment community enterprise and Muang Kung pottery community enterprise.

Researchers began this research by studying literature review and found that several researchers studied extensively about application Strain Index for ergonomic study. The Strain Index (SI) is one method to evaluate job risk to identify work-related distal upper extremity disorders [2], it has been extensively used by several researchers and industrial workers. From surveying among certified professional ergonomists showed that almost 40% of them used Strain Index as a tool to evaluate work-related distal upper extremity disorders [3]. As in [4], researcher had applied Strain Index method to evaluate the risk of distal upper limb disorder in cleaners and found that vacuuming, walls cleaning, scrapping floor, dusting offices and dusting horizontal surfaces were the most critical cleaning activities. The study [5] researchers had applied 2 methods the Strain Index and NIOSH Composite Lifting Index (CLI) to assess the ergonomic risk of multi-task jobs in 28 automotive jobs. Researchers found that the Strain Index could be useful to determinate the risk of distal upper extremity injury participatory with a multi-task job. From the study [6], physical exposure data of 21 cyclic job tasks were collected in a cheese factory in Italy, the Strain Index and Occupational Repetitive Actions (OCRA) Checklist were used to assess workers' posture risk. Results showed both the Strain Index and OCRA Checklist methods consequence adequate purposes reliability for occupational health research and practice.

II. OBJECTIVES

This study aimed to study ergonomic job risks in small community enterprises (SMCEs) operations. Five SMCEs in Hang Dong of Chiang Mai province were participated in this research. Researchers aimed find out ergonomic problem of working and create solution with a purpose that results of this study will be useful and can be implemented as an improvement for SMCEs' production. Researchers hopefully to be a beginning point of gravely concerning about working ergonomics and workers' life quality of SMCEs in Thailand.

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*,1,2Department of Industrial Engineering, Faculty of Engineering, North-Chiang Mai University, Chiang Mai, Thailand. e-mail: budtree@northcm.ac.th

III. Method

A. Subjects and tasks

Five community enterprises are involved in this research including thirteen male workers and twenty-seven female workers. Forty-eight job tasks of male and female workers' posture were equally studied.

B. Data Collection

Videos of each job were monitored during working and each job was separated into work element. Left and right side of workers' side video were recorded. The work element were adjoining activities with similar movements and intensity of exertions that could be removed from the job and transferred to another workstation. In each video file included several cycles of a single job tasks that could be defined and rated strictly using the Strain Index methods for assessing that particular task variable.

C. Strain Index computations

There are four steps to calculate the Strain Index score including; collecting data, ratings values assignment, multipliers determination and Strain Index score calculation [7].

Six variables needed to be collected in each job task and a multiplier rating are assigned. The multipliers abbreviations using for calculating Strain Index are include:

1. **Intensity of Exertion (IEM);** a qualitative measurement of the percent maximum voluntary contraction that a task needs to use one cycle.
2. . **Duration of Effort (DEM);** a determination of the duration of the exertion and it is a measurement of the physiological and biomechanical stress that are related to how long an exertion is occurred.
3. **Efforts per Minute (EMM);** a frequency of exertions per minute.
4. **Hand/wrist posture (HPM);** a bodily structure, posture of the hand.
5. . **Speed of Work (SWM);** an estimation of the detected pace of the task and the additional stresses accounts that associated with dynamic work.
6. **Duration of Task (DDM);** a measuring per day of how much of the workday performing that task.

Six multipliers ratings are summarized in Table I and II.

$$SI = IEM \times DEM \times EMM \times HPM \times SWM \times DDM \quad (1)$$

Researcher [8] recommended to use 5.0 as the criterion Strain Index score to classify hazardous jobs generally been confirmed, but in manufacturing the criterion score might be higher (~9.0).

TABLE I:
STRAIN INDEX (SI) RATINGS

Rating Values	Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration per Day (hrs)
1	Light	<10	<4	Very good	Very slow	0–1
2	Somewhat hard	10–29	4–8	Good	Slow	1–2
3	Hard	30–49	9–14	Fair	Fair	2–4
4	Very hard	50–79	15–19	Bad	Fast	4–8
5	Near maximal	≥80	≥20	Very bad	Very fast	>8

TABLE II:
STRAIN INDEX (SI) MULTIPLIERS

Rating Values	Intensity of Exertion Multiplier (IEM)	Duration of Exertion Multiplier (DEM)	Efforts per Minute Multiplier (EMM)	Hand/Wrist Posture Multiplier (HPM)	Speed of Work Multiplier (SWM)	Duration of Task (DDM)
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.50
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.00
5	13	3.0	3.0	3.0	2.0	1.50

IV. Results And Discussions

A. Results from Strain Index computations

Either Twenty-four job tasks of male and female workers' posture were equally studied and results are shown in Fig.1-4 and average SI score is shown in Table III.

TABLE III:
THE ARRANGEMENT OF CHANNELS

	Left		Right	
Gender	SI Score	S.D.	SI Score	S.D.
Female	3.07	4.65	3.41	4.43
Male	2.19	2.00	1.46	0.88

Fig. 1. Average SI score of female workers' postures (left side).

Fig. 2. Average SI score of female workers' postures (right side).

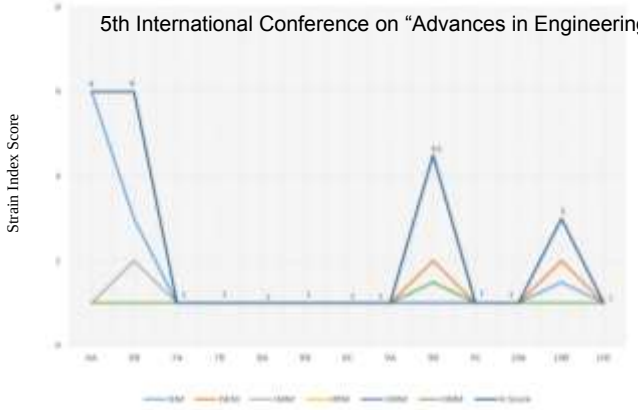

Fig. 3. Average SI score of male workers’ postures (left side).

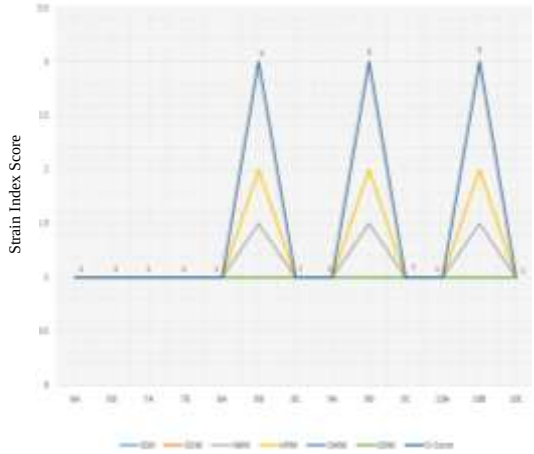

Fig. 4. Average SI score of male workers’ postures (right side).

From SI score calculations, the average SI scores of female workers are higher than male workers in both left and right body side. Since female workers are mainly in production operations but male workers are in facilities area and hardworking tasks. SI is a method that consider factors that affect to job risks not only the heavy of the task but have to consider the overview factor that can affect job risks including; task intensity, task duration, task frequency, hand/wrist posture, task speed and duration of task. Several indexes that involved in SI score calculation of female workers are almost all higher than in male workers so the assessment results are higher than in male workers’.

The task with the highest average SI score at 20.25 is a female workers’ job in Ban Guan pottery community enterprise the task is clay pot knuckling as shown in Fig.5.

The clay pot knuckling working is a task that operators have no handle equipment, workers have to put workpieces on their thigh and have to contract their muscles to support during work. Moreover, operators have to work by using a hand tool made by stone weighted approximately 1 kg., the task is repetitively that is harmful for workers if they work for a long time period. Furthermore, working repetitively can be a cause of repetitive strain injury (RSI) that is a pain felt in muscles, nerves and tendons caused by repetitive movement and overuse. The condition mostly affects parts of the upper body such as forearms and elbows, wrists and hands neck and shoulders [9]. The longer or more frequently static loading occurs, the greater the risk of injury due to overuse of muscles, joints and other tissues.

Fig. 5. Clay pot knuckling task

B. Working Improvement.

Researchers developed 4 hand tool prototype to help workers handle the clay pot and can easily knuckle the pot. The tools are shown in Fig.6. All new designed tools are made from wood with a reason of low weight and can be formed to different shapes easily. After producing new equipments, researchers applied them into working and assessed the users’ satisfaction by using questionnaires. Results showed that workers preferred the first tool most, it got the highest satisfaction score from users at 4.62 from 5.00 full score and the third type got the lowest score at 3.92. The first type’s design is similar to the former stone shape, that may be a reason for highest satisfaction score of it

Fig. 6. Four new designed hand tool prototypes.

Operators working new tool were recorded in video and the Strain Index score were calculated again and found that the average SI score is reduced to 13.5 that is lower than 20.25 in the former. Even the score is still in high risk but it is 33% decreased and researchers must find some more challenge improvement not only hand tools but some other working conditions.

V. Conclusion

After application Strain Index analysis in work improvement, researchers found most job in studied Small and Micro Community Enterprises (SMCEs) were in high risks, because of several capability limits affect to labors’ productivity level. SMCEs still need efficiency improvement in different ways not only ergonomic improvement.

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Butree Kaden is a lecturer in Department of Industrial Engineering at North-Chiang Mai University. Her researches focuses on Human Factors and Ergonomics that is known as comfort design, functional design, and systems.

Her current work is aimed at trying study ergonomic risk in small industries in northern Thailand. Another aim of her research is application ergonomics approach to improve working capability of elderly workers in Chiang Mai. She hopes to be a beginning point to improve several parameters in small industries and elderly people to rectify ergonomics work design that will be benefit to workers to persuade job attraction in workplace, safety working conditions and quality of work life.