Improvement of environment and work posture through ergonomic approach to increase productivity of balinese kepeng coin workers in Kamasan village Klungkung Bali

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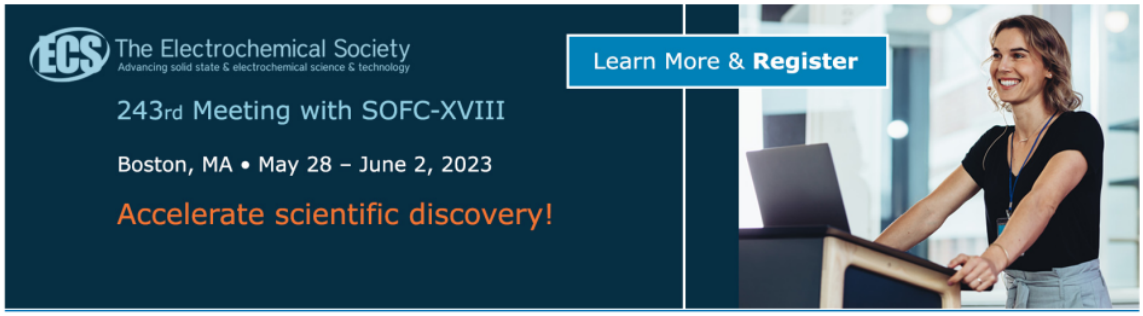

Improvement of environment and work posture through ergonomic approach to increase productivity of balinese kepeng coin workers in Kamasan village Klungkung Bali

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Abstract. Balinese coins (*Pis Bolong*) have become part of Balinese life as *yadnya* material or religious ceremony. To meet a variety of purposes, *balinese coint* today many produced by the community Kamasan village of Bali, in addition to religious purposes are also used as souvenirs. *Pis bolong* (*kepeng* coin) manufactured by molding techniques and molding metal in a simple manner of raw materials in a furnace smelting subsequently printed and refining process. *Kepeng* coins (*Balinese coins*) to production reached 20,000 in a day with more than 50 artisans. Use of a furnace with open flame and work posture and ways of working are not naturally able to increase the workload, subjective disorders of artisans, and decrease productivity. To overcome these problems, the improvement of environment and work posture by ergonomic approach. This research used by design "pre and post test group design" to 8 crafters of the melting process. Productivity calculated from the number of kepeng coin produced per work pulse of workers. The results showed that there were significant difference in productivity between treatment 1 (using old way) with treatment 2 (using improvement of environment and work posture) in kepeng coin workers. Work productivity increase by 33.9%. It can be concluded that the improvement of environment and work posture through ergonomic approach increase productivity of kepeng coin workers.

1. Introduction

Kamasan Village is one of the tourist destinations located in Klungkung Regency consisting of three areas namely Glegel, Tojan and Kamasan which incorporated into one traditional village. This tourist village is famous for its cultural art beauty in making silver handicrafts, bullet shell carvings, gold, balinese coins and traditional wayang paintings. They are famous for very smooth, detailed and have their own charm and distinctive features that are not found elsewhere. One of the handicrafts product of Kamasan Village is handicraft of balinese coins (Balinese: *Pis Bolong*). Balinese coins (*pis bolong*) has been a part of Balinese society ever since. It functions as a means of payment and materials for *yadnya* or religious ceremonies. It is used to be called the chinese *kepeng* money used in Bali, but because these coins are increasingly scarce, it is now preserved and protected. Governor Decree No.

68 year 2003, on the Establisment of Bali Heritage Trust, an institution in charge of preserving Balinese culture, is produced, and of them preserved is the balinese coins. The many essential usage of balinese coins as a means of ceremony are like the *plangkiran, daksina, ider-ider, cilli, tamiyang, sampian, or lamak, lumbung arta, gedong arta, bale gading,* and *pabuan*.

The production of balinese coins per day reaches 20,000 pieces which is done by about 50 craftsmen. The condition of the working environment in the smelting process is hot due to the use of open flame, causing the workload increases and fatigue to workers. As the result, most of the craftsmen is only able to work about 6.5 hours a day that is starting at 07:00 to 15:00 pm, with a break time at 11:00 to 12:30 pm. This smelting and moulding job requires considerable energy with high burning furnace heat exposure. The use of traditional equipment requires patience and thoroughness and requires considerable energy and a lot of calorie intake to keep up with the amount of calories and energy that comes out while doing the job. Due to the high temperature environment the body temperature will increase. Subjective disorders commonly felt by all respondents are feeling thirsty, skin feeling hot, and sweating a lot, while a few complained cramps on the muscles of the hands and feet. There is an increase in body temperature that occurred, although it did not exceed the normal body temperature limit of 38° C [1].

In the preliminary study, the result of heavy workload accompanied by exposure to hot temperature, increased the average fatigue complaint score of 20.44 where the average fatigue score before work was 31.05 ± 4.67 to 51.49 ± 3.66 after work. The mean musculoskeletal score before work of 27.42 ± 4.54 increased to 56.93 ± 3.93 after work (increased 28.97). This causes the work productivity of the craftsmen to decrease along with the length of work due to increased average working rate or average working duration to complete one unit of product compared with the previous. Efforts to prevent the existence of failed or defective products with quality control is by an approach of production process. The production process will take place optimally if the demands of the task, organization and work environment in accordance with the abilities, permissibility and limitations of workers [2,3].

Based on the above, it is indispensable to thoroughly improve the working conditions of crafters through a total ergonomic approach including improving working environment conditions, improving work methods, and improving work organization. If the above problems are not dealt with immediately, it will result in decreased work productivity, increase of defective products and the income of crafters will be reduced. In addition, the risk of health problems will increase and eventually the productive age will decrease. Through ergonomic intervention in small-scale industries using ergonomic work equipment is proposed to reduce workload and subjective disorders [4].

There are several alternative ways of solving problems done with the ergonomic approach that is: (1) improve the work tool by improving the smelting tools and moulding of balinese coins ergonomically; (2) improving the working environment by adding cross ventilation to lower the ambient temperature; (3) improving the organization of work by applying work rotation system and (4) providing drinking water in the workplace, so as to maintain worker health, reduce physical burden and psychological burden which can improve the quality of balinese coins and productivity.

With the improvement of conditions and working environment, of course the work organization that includes work system, working time - rest, and rotation between the artisans especially the craftsmen melting parts will experience a better change. Similarly, an important work environment improvement is done to prevent exposure to hot and dust temperatures to the environment that can expose the crafters, so that dehydration and health problems from exposure to heat and dust can be prevented. Improvements in working conditions and environments should take into account all aspects of ergonomics, such as the utilization of appropriate technology, the improvement of the whole production process with a systematic, comprehensive approach, involving various discipline and active participation both physically and psychologically in all components involved in the production process. The application of the concept of appropriate technology and the overall improvement of the production process of the SHIP (Systemic Holistic Interdisciplinary Participatory) approach should be done in a consistent and sustainable manner [2]. And the various factors that need to be considered in

relation to the production process such as work tools and work stations include the size, dimension, way of work, work attitude to match the abilities, permissibility and limitations of workers [2,3].

Based on the above description it is deemed necessary to research the improvement of working conditions and environment with the application of the appropriate technology and SHIP approach. These efforts are expected to reduce the workload and subjective disorders that will ultimately increase work productivity.

2. Reseach Methods

This research is an experimental research with design Treatment by Subject. The number of samples is 10 people craftsmen in the process of smelting. The sample is given two treatments, which is working to make kepeng coin using the old way (Period 1) and work to make kepeng coin using new way with environmental improvement and work posture (Period 2). Workload is calculated based on the working pulse perminute. The work productivity of the subjects is recorded based on the ratio of output (output) to the input (input) at a certain time unit. Output generated is the amount of printed kepeng money produced by artisans during working hours, while the input is the crafters work pulse. Data before and after intervention were analyzed using parametric statistic t-paired test at significance level of $\alpha = 0,05$.

3. Result and Discussion

3.1 Subject Characteristics

The subjects of this study are the 10 artisan who are all male. The results of characteristic analysis of research subjects are as follows.

Table 1. Subject Characteristics

Variables	n	Minimum	Maximum	Mean	Std. Deviation
Age (year)	10	28.00	53.00	44.60	8.41
Body Height (cm)	10	162.20	177.00	167.90	6.12
Body Weight (kg)	10	55.40	73.60	62.14	6.98
BMI (kg/m2)	10	20.80	23.49	21.96	0.92
Working Experience (year)	10	5.00	8.00	6.60	1.35

All subjects followed the study in accordance with the provisions of the study protocol so that no subject declared drop out. Mean age of subject is 44,60 ± 8,41 year and age range 28 - 53 years old. This age range still includes the working age group. The age range still includes a productive workforce with the age limit of the labor force applicable in Indonesia that is aged 15 to 64 years. The mean age of this study subjects when viewed from muscle strength has decreased since the optimum muscle strength for recommended work is between 20 to 30 years [4]. The mean body mass index (BMI) in this study was 21.96 ± 0.92 kg / m2. Increased weight causes an improper Body Mass Index can cause musculoskeletal muscle disorders and work-psychosocial stress. The purpose of this study was to investigate the effect of BMI on musculoskeletal discomfort on work and worker pressures of computer in ergonomic setup developed [5]. Age conditions affect the ability of physical work or muscle strength of a person. Maximum physical ability of a person is achieved at the age between 25 - 35 years and will continue to decline with age [3]. Organ systems such as the cardiovascular, respiratory, and muscular systems may decrease by 2% per year after the age of 30 years [6]. The

average of subject experience in this research is 8.70 ± 2.75 years. The meaning of the average value of this experience is that the subject has been skilled and able to adapt to his work.

3.2 Working Environment Condition

Table 2 shows that there are significant differences (p <0.05) in the working environment components ie at wet temperature, dry temperature, relative humidity, light intensity, wind velocity and air dust content, between group period 1 and period 2. at the noise is not significantly different. Judging from the average it can be stated that the working environment condition in period 2 is better than period 1. There is a decrease of working environment temperature and decreasing of dust level. Wind speed increases due to cross ventilation, thus lowering the room temperature and expediting the flow of wind.

Table 2. Working Environment Condition

No.	Uraian	Period 1		Period 2		t	p
		Mean	SD	Mean	SD		
1.	Wet Air Temp (0C)	28.71	0.41	26.41	0.55	-2.197	0.000
2.	Dry Air Temp (0C)	35.99	0.38	31.86	0.39	-3.097	0.000
4.	Relative Humidity (%)	61.53	1.04	69.34	0.81	4.862	0.000
6.	Light Intensity (Lux)	325.57	3.20	385.90	3.40	22.416	0.042
7.	Sound Intensity (dB)	85.81	1.50	84.97	1.82	-0.473	0.116
8.	Wind Speed (m/det)	0.72	0.17	0.89	0.18	0.817	0.002
9	Dust Particles (µg/m3)	48.38	1.43	28.97	0.97	-12.724	0.000

SD: Standard Deviation

The intensity of lighting 300 - 400 lux is in the safe category as Minister of Health decree. No. 405 of 2002 on the requirements and procedures for the organization of industrial working environment health, where for rough work requires minimal light intensity of 100 lux. Inadequate or below required thresholds will cause work fatigue. Workplace noise is still within normal limits when below 85 dBA [3].

Air movement indoors no more than 0.2 m / s so that air movement does not cause adverse impact on workers, whereas for the exposed work environment heat required higher wind speed [2]. The value of dust levels decreased, but still above the threshold. Based on the Circular Letter of the Minister of Manpower No.01 / SE / IVIEN / 1997, Permenakertras No. 13 / MEN / X / 2011, and SNI 19-0232-2005. The maximum amount of metal dust threshold (NAB) determined in Indonesia is 10 mg / m3. Air quality affects the effectiveness of work and comfort and occupational health to support the creation of work productivity.

3.3 Workloads

The workload of the subjects in the smelting process is recorded by the work pulse (DNK) and the resting pulse (DNI) before work. The resting pulse was measured by a 15 second palpation method while the work pulse was measured by a pulse method of 10 pulses. In addition to pulse measurements, the workload is also measured by calculating the percentage of cardiac workload or cardio vascular load (% CVL) and measuring the skin temperature of the worker. The results of pulse resting calculations, work rate, CVL%, and skin temperature are shown in Table 3 below.

In Table 3 it was found that the resting pulse between period 1 and period 2 did not change significantly (p> 0.05), this indicated that the initial conditions could be considered equal, so that the initial conditions did not affect the effect of ergonomic interventions given to the worker. In the variable of work pulse,% CVL and skin temperature, there is significant difference (p <0,00) between

period 1 and period 2. In view of its mean, period 2 gives a mean value smaller than period 1, on the variable workload.

Tabel 3. Workloads Results Analysis

Variable	Period 1		Period 2		t	p
	Mean	SD	Mean	SD		
Resting Pulse (beat/minutes)	73.20	3.97	74.06	2.86	0.172	0.315
Working Pulse (beat/minutes)	129.86	5.89	122.15	4.08	-4.712	0.000
%CVL	57.06	5.45	42.56	3.68	-6.168	0.000
Skin Temp (°C)	39.15	0.61	33.17	1.74	-2.814	0.000

SD = Standard Deviation

Working pulse decreased from 126.56 beats per minute (Period 1) to 122.35 beats per minute (period 2) or decreased by 5.9%. The classification of workloads in period 1 is included in the category of "heavy" workload due to the range 125-150 / min while in period 2 includes medium work load that is in the range of 100 - 125 beats per minute [3]. The decrease in workload is due to ergonomic intervention in the form of improved work environment and work posture. Ergonomic interventions with changes in work systems will lead to decreased workload and increased work productivity [7,8,9].

Average cardiovascular load (CVL%) also decreased from 57.06 to 42.56 or decreased by 25.4%. The percentage value of this cardiac workload (CVL) is included in the medium work load category that is between 30% - 60% [10]. While the mean skin surface temperature also decreased from 39.15°C to 33.17°C or decreased by 15.3%. This decline in skin surface temperature is due to an environmental improvement intervention that is the addition of cross ventilation. Ventilation improvements will lower the surface heat temperature of the worker's skin and may decrease workload [11].

3.4 Work Productivity

The work productivity of the subjects in the smelting process is recorded based on the ratio of output (output) to the input (input) at a certain time unit. Output generated is the amount of printed kepeng money produced by artisans during working hours, while the input is the crafters work pulse.

Tabel 4. Work Productivity Result Analysis

Variable	Period 1		Period 2		t	p
	Mean	SD	Mean	SD		
Work Productivity	91.08	5.19	119.87	6.24	34.789	0.000

SD: Standard Deviation

The result of the analysis showed that there was a significant difference ($p < 0.05$) on the productivity of the craftsmen craftsmen between period 1 and period 2. Viewed from the large average, Period 2 gives a mean greater than period 1. This indicates an increase in work productivity from period 1 to period 2. The increase occurred from 91.8 to 119.87 or an increase of 31.6%.

To improve work productivity there needs to be a change of work system to decrease worker fatigue level, so that work time is shorter and production can increase. Increased work productivity can be done by improving work systems based on ergonomic principles [12,13,14]. and also with the principle of ergonomics, work will be more effective and can be more efficient [15,16].

4. Conclusion

Based on the discussion that has been done then can be conveyed conclusion as follows: a) improving the environment and working attitude through ergonomic approaches reduce the workload of craftsmen kepeng kepeng in kungkasan klungkung Bali village, b) improvement of environment and work attitude through ergonomic approach improve productivity of money maker kepeng in kungkasan klungkung Bali village.

Based on the findings of the research results, it can be suggested to improve the work attitude of craftsmen in the process of smelting. Improvement work attitude can be done through the provision of foundation or field of work place of printing, so the artisans no longer bend while doing the printing task. Likewise, it is necessary to repair the furnace repair by making hot air duct remnants outside the room, so that radiation exposure can be reduced.

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