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Improvement of work posture to decrease musculoskeletal disorder and increase work productivity jewelry worker in bali

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Abstract. *Finishing process of workmanship on jewel stone at small scale industry of jewelry crafting in Bali was polishing. This process was done manually by working posture were cross-legged sitting on the floor. This awkward working posture (cross-legged sitting) caused more musculoskeletal disorder (MSD) special on the arm, waist, and low back pain. The MSD problem can decrease production. To solve these problems and increase productivity, the improvement of work posture should done by ergonomics approach. The research was conducted on 12 jewel craftsmen by "treatment by subject design". Work load was measured by using work heart rate which was count using ten pulses methods. Musculoskeletal disorders were assessed by Nordic Body Map questionnaire. And work productivity was assessed by amount of product per pulse rate. The data were analysed by using t-pair test at significant level 5%. Results of this reserach showed that there was significant different ($p < 0.05$) of work load, MSD, and work productivity betwen before improvement and after improvement. Work load decrease11,8%, MSD decrease 30,4%, and work productivity increase 38,7%. Its can be concluded that inprovement of work posture decreased of work load and musculoskeletal disorders and increased of productivity of jewel workers. That is why, it was recommended the improvement of work posture should be used by workmanship the jewel stone and ergonomics work station.*

1. INTRODUCTION

Gemstone jewerlry handicrafts is small industry or home industry that produce jewelry such as rings, eye necklaces, jewelry on the handle of kris or spear, and so forth. It has become an alternative business to earn income in facing the current monetary crisis. This business can be found in several districts in Bali and generally they only have a tool in the form of grinding wheels for the workmanship. Types of stone used include turquoise, agate, amethyst, mirah stone and the like. The final process of making this gemstone is the process of smoothing. In some places in Bali generally, this process is done by sitting cross-legged position on the floor.

The finishing process of smoothing a gemstone is still done by sitting cross-legged on the floor for few hours. This position of work is unnatural, and can cause few problems. Unnatural working position can be the cause of various disorders of the musculoskeletal muscle system [1-2]. It leads to disruption to the musculoskeletal system and there is considerable pressure on the intervertebral discs that can lead

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to lower back pain. In the long run this working position can cause the body to become bent [3]. Working position by sitting cross-legged on the floor causes complaints from the workers especially pain and sore in skeletal muscles in certain body parts. As the result it adds weight to the workload of the workers and affects their productivity.

This problem of working posture and muscle complaints should be resolved soon, as it may cause serious health problems for the workers [4-5]. Steps that can be taken to reduce their workload, complaints on muscle pain and sore, as well as to increase the productivity of the artisans is to improve the work station of where all their activities take place. This improvement is done by considering the aspects of ergonomics and participatory approaches. A change of working position from stting on the floor to stiing on a chair is proposed in this research. Grinding wheels are placed on the workbench, so the jeweler can work more comfortably. The size of the chair and work table is adjusted to the anthropometry of the crafters' body. In addition, the organization of working hours and breaks in between them is to be looked upon. Improvements suggested in the organization of the work and break is a 5 minutes rest time for every hour of work. We predicted, that with these steps are to be taken, it will reduce workload, skeletal muscle complaints, and increase labor productivity.

2. METHODOLOGY

This research was conducted experimentally using treatment by subject. This experiment took place in Subagan Village, Karangasem, Bali. The number of samples was calculated based on the Colton formula [6], to obtain a sample of 12 gemstone craftsmen. Subjects were divided into two group where P0 group are the untreated who are doing the usual work done by previous craftsmen and the P1 group would be treated with an improvement of work posture and work station with participatory approach. Workload is measured by the pulse of crafters, musculoskeletal complaints measured by Nordic Body Map questionnaire, and labour productivity is measured from the amount of production divided by workload and working time. Data were analyzed descriptively and inferentially. In order to tell the difference of treatment, workload data, musculoskeletal complaints, and labour productivity were analyzed using t-pair test at 5% significance level.

3. RESULT FINDINGS

3.1 Research Subject Condition

The result of the analysis in the subject of this research is shown in the table below which is summarized in a table from the 12 samples.

Table 1. Reseacrh Subjects Characteristic Summary

No	Variable	Ave.	SD	Range
1	Age (year)	35.07	3.41	28 – 41
2	Body Weight (kg)	62.17	4.72	57.3 – 69.8
3	Body Height (cm)	163.21	3.14	160 – 172
4	Working Experience (year)	5.32	3.21	3 – 10
5	Body Mass Index	22.71	1.08	20.92 – 23.17

From the characteristic of the subject it is seen that the research samples are under normal conditions and the subjects, when the study is done, are healthy and fit. The average age of the subjects was 35.27 years. This shows the subject is in the productive age to work. The average work experience is 5.32 years indicating that the subject has experience in terms of gemstone workmanship. The mean body mass index was 22.71 with range 20.92 - 23.17 in normal condition (not lean and not fat). The subject's condition is still in an optimal physical state to do the job because it is in productive age and in good physical condition. Age conditions affect the ability of physical work or muscle strength of a person.

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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 [7].

3.2. Microclimate Condition

Microclimate conditions are the working environment conditions where the artisans work. These conditions include temperature, relative humidity, light intensity, and sound intensity. This environmental condition data was tested for normality by using Shapiro-Wilk test and obtained normal working environment data results (p> 0,05) both in group P1 (before improvement) and P2 (after repair). The result of different test of working environment condition on P1 and P2 is presented in Table 2 below.

Tabel 2. Microclimate Condition

No	Variable	P1 Group		P2 Group		t	p
		Ave	SD	Ave	SD		
1	Temperature (°c)	26.13	3.22	26.59	2.62	3.193	0.214
2	Relative Humidity (%)	72.55	4.15	73.04	3.19	2.691	0.192
3	Light Intensity (lux)	421.55	29.71	433.29	30.81	9.107	0.088
4	Sound Intensity (dBA)	69.13	3.07	69.87	2.94	0.936	0.309

SD = Standard Deviation

From the results of microclimate condition analysis, it showed that the working environment microclimatic conditions of the craftsmen of the gems both in group P1 and group P2 were still within comfortable working condition for the workers. Temperature variables, relative humidity, light intensity, and noise (sound intensity) did not have a significant difference between the groups P1 and P2 (p> 0.05). This means that the working environment between P1 and P2 can be considered the same and consistent.

The microclimate condition is still within normal limits and feels comfortable for working. The threshold value of air temperatures for workers is 33°C and the relative humidity for Indonesian workers is between 70% - 80% [1]. It is suggested as well that headgear is worn by the workers to prevent excess heat to the face and head [8], and other body armor so that workers can work comfortably. The highest sound intensity threshold that is tolerable by human being for working time of not more than 8 hours a day is 85 dBA [9].

3.3 Workloads

Workload is measured by the pulse of the crafters of the gems both at rest (resting pulse) and at work (working pulse). This workload data is tested in normality by using Shapiro-Wilk test. From the test it is found that the resting pulse and the work pulse in both groups (P1 and P2) are normally distributed (P> 0.05). Prior to analysis of the effect of treatment, first comparability of resting pulse. This is done to see the initial conditions of the craftsmen whether the difference is signficant or not. It is necessary to see if the workload change is purely due to the effects of research intervention or any external factors contributing to the change in the workload. The comparability of the resting pulse on this gem crafter is done by using t-pair test. The result of the analysis shows that there is no difference between P1 and P2 in the istirahanya pulse (p> 0,05) as shown in Table 3. It means that the initial condition of craftsmen workload can be considered the same. Treatment effects were also analyzed using a t-pair test with the results shown in Table 3.

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Table 3 Workloads Analysis on Workers

Variable	Group P1		Group P2		t	p
	Ave	SD	Ave	SD		
Resting Pulse (beats/minute)	68.17	2.68	69.27	2.19	0.109	0.305
Working Pulse (beats/minute)	119.32	3.12	105.21	4.07	-19.163	0.000

SD = Standard Deviation

From Table 3 above it can be seen that there are significant differences between group P1 and group P2 ($p < 0,05$) in the workload (working pulse rate). Judging from the average there is a decrease in working pulse from 119.32 beats per minute to 105.21 beats per minute, or decreased by 11.8%. It is in line with research conducted by Tirtayasa [10], that ergonomic intervention could reduce the workload of the heart and the pulse of work to workers in small industries.

3.4 Muscluloskeletal Complaints

Musculoskeletal complaints were predicted using a Nordic Body Map questionnaire with 5 Likert scales. These muscle complaints were measured both before and after work on P1 and P2 groups. The results of the analysis are presented in Table 4 below.

Table 4 Musculoskeletal Complaints Analysis

Variabel	Group P1		Group P2		t	p
	Ave	SD	Ave	SD		
Before	32.08	1.56	31.83	1.74	-2.814	0.164
After	69.48	3.62	48.31	3.26	12.571	0.000

SD = Standard Deviation

Table 4 shows that the before activity muscle complaints condition between the two groups was not significantly different or could be considered the same ($p > 0.05$). While conditions after work there are significant differences between P1 and P2. Judging from the average of skeletal muscle complaints there was a significant decrease between group P1 and group P2 by 30,4%. In line with research conducted by Curwin [11], it was mentioned that ergonomic intervention in workers could decrease skeletal muscle complaints, about 10% decrease in prevalence of musculoskeletal disorders for 12 months, ranging from 4% for hip/thigh problems to 12% for lower back problems and upper back.

3.5 Labour Productivity Analysis

Labour productivity of jewelry crafter is obtained from the division between the production of gems with the working pulse and then multiplied the required working time. While production is the results obtained from the number of gems produced by each craftsman for every working hour. Prior to the significance test between each treatment, production data and work productivity is tested normality by using Shapiro-Wilk test. From normality test results obtained that the data of production and work productivity is normally distributed ($p > 0.05$).

In order to know the effect of treatment, the mean difference test between each group (group P1 and P2) is tested using pair t-test. The analysis results are shown in Table 4 below.

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Table 4 Production and Labour Productivity Comparison Analysis

Variable	Group P1		Group P2		t	p
	Ave	SD	Ave	SD		
Production (pieces/day)	10.31	0.19	12.67	0.41	34.157	0.000
Labour Productivity	0.0863	0.0021	0.1198	0.0042	37.165	0.000

SD = Standard Deviation

From Table 4 above, it can be seen that the production and productivity of the work of jewelry craftsmen has a significant difference between each group ($p<0.05$). Judging from the average of work productivity there was an increase of 38.7%.

The use of desks and chairs and the use of appropriate technology in the form of a gemstone machine will increase the productivity of the crafters, in accordance with the concept of total ergonomics which requires that the technology to be applied in the industry should be reviewed and discussed through the SHIP approach (Systemic, Holistic, Interdicipliner, and Participatory) so as to increase worker productivity [1]. Performing ergonomic interventions in the industrial world will increase the production and productivity of workers [12].

4. CONCLUSION

From the results and discussion above can be concluded the following things, 1) improved working position and posture reduced musculoskeletal complaints of gemstone craftsmen in Bali, 2) improvement of work posture increased labour productivity of gemstone crafters in Bali. It is suggested to small industry managers including gem industry to pay attention to employee working posture and position problem so employees can work in healthier and more productive working enviroment.

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