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Modified sitting grinder reduces complaints of musculoskeletal disorders, workload, and increases work productivity of blacksmiths in Tabanan Regency, Bali-Indonesia

by Ida Ayu Made Sri Arjani

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Modified sitting grinder reduces complaints of musculoskeletal disorders, workload, and increases work productivity of blacksmiths in Tabanan Regency, Bali-Indonesia

Ida Ayu Made Sri Arjani^{1*}, Cok Dewi Widhya Hana Sundari¹, Nyomam Mastra¹, I Made Bulda Mahayana⁴, I Gusti Ayu Made Aryasih¹, Ni Made Marwati¹, I Gusti Agung Ayu Putu Swastini¹

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ABSTRACT

Background: Blacksmith is one of the small industries that is developing in Gubug Village, Tabanan Regency. One of the processes in manufacturing household utensils in the form of small knives, large knives, sickles, and machetes will be faced with a grinder. In this process, the worker holds a vibrating grinder weighing more than 1.5 kg. Working with heavy loads and being exposed to vibration for a long time is an additional burden that will cause musculoskeletal complaints, as well as diseases such as Raynaud's Syndrome, Tenosynovitis, and Carpal Tunnel Syndrome in workers. This study aimed to determine the effect of Sitting Grinding Modification on Reducing Complaints of Musculoskeletal Disorders (MSDs), Workload, and Increasing Work Productivity of Blacksmiths in Gubug Tabanan Village.

Methods: This research is an experimental study with treatment by subject design. The population is 40 people from 10 industries. Sample selection by simple random sampling with a table of random numbers. The minimum number of samples was calculated using the Colton formula to determine the sample size to be 16 people. Data processing and analysis: Descriptive test for subject condition data includes age, weight, height, and body mass index. Normality test was performed on the data; a) physical environment includes air temperature, humidity, and noise), b). musculoskeletal complaints; c) workload; and d) work productivity. Difference test for data on musculoskeletal complaints, workload, and work productivity using parametric statistical tests (different test paired samples t-test at significance level = 0.05) in treatment I and treatment II on data that is normally distributed, and if it is not normal, non-parametric statistical tests were performed (Wilcoxon's difference test at significance level = 0.05).

Results: The mean age of the subjects was 39.00 ± 8.52 years, body weight was 65.31 ± 6.757 kg, height was 164.69 ± 4.40 cm and the body mass index was 23.94 ± 2.05 kg/m². There is no difference in air temperature and humidity, there is a decrease in noise of 0.81%. There was a decrease in musculoskeletal complaints by 0.15%, a decrease in workload by 0.19%, an increase in productivity by 1.06%.

Conclusion: There is a significant decrease between musculoskeletal complaints, workload and noise before and after the use of the seated grinder ($p < 0.05$), and there is a significant increase between work productivity before and after using modified sitting grinder.

Keywords: sitting grinder, musculoskeletal complaints, workload, and work productivity.

INTRODUCTION

The use of uncontrolled muscle power, continuous activity and a static body position for a long time can cause complaints in the skeletal muscles.¹ Complaint of musculoskeletal disorders (MSDs) are complaints that are felt in the parts of the skeletal muscles, because of forcing movement and receiving heavy loads for a long period of time.² The World Health Organization (WHO) states that occupational risks cause the top ten causes of death and illness worldwide. In the Global Estimates of Occupational Accidents and Work-related Illnesses 2017 published by the Workplace Safety and Health Institute, the number of workers who died from occupational diseases in 2015 was 2.4 million. In 2016-2017, there were around 507,000 workers in the United Kingdom who suffered from illness due to disorders of the musculoskeletal system caused by their work.³

The prevalence rate of diagnosed musculoskeletal disease is 24.7% where one of the factors that influence the incidence of musculoskeletal complaints is work attitude.⁴ There is a relationship between workload and musculoskeletal complaints in workers in the Candi Industrial Area of Semarang City with a p-value of $0.003 > 0.05$ and the test results are stated to be significant.⁵ Based on data from the International Labor Organization, one worker in the world dies every 15 seconds due to work accidents and 160 workers experience work-related illnesses. The International Labor Organization (ILO) records the number of deaths from accidents and occupational diseases as many as 2 million cases yearly.⁶ This incident resulted in the world experiencing losses equivalent to 1.25 trillion dollars or 4% of world Global National Product (GNP).⁷

Blacksmith is one of the small industries that is growing in the village of Gubug, Tabanan Regency. These blacksmith craftsmen have been in the job for quite a long time and are hereditary from their ancestors. They accept the inheritance as it is and engage in this work as the responsibility of their ancestors. One of the processes in the manufacture of household utensils in the form of small knives, large knives, sickles, and machetes they are faced with a tool in the form of a grinder to smooth and sharpen the knife. In this process, the worker holds a vibrating grinder, weighing more than 1.5 kg with one hand and the other holding the knife to be grinded. Working with hands exposed to vibration for a long time is a burden that will cause musculoskeletal

complaints and diseases for workers such as hand-arm vibration syndrome, Raynaud's syndrome, tenosynovitis, and carpal tunnel syndrome.⁸

In high-risk work on the wrist, the prevalence of carpal tunnel syndrome is between 5.6% and 15%. Musculoskeletal complaints found include tingling and pain in the fingers, reduced grip strength, difficulty holding small objects. There are disorders of blood vessels, disorders of the nerves caused by compression of the median nerve that passes through the carpal tunnel, these nerve disorders related to work that has repeated exposure to vibration in the long term.^{3,10}

After conducting limited interviews with seven workers, all workers felt pain, tingling and stiffness in the hands, wrist pain, pain in the right arm, elbow, waist, back and neck. Working with heavy grinding tools and being exposed to vibrations for more than an hour has an impact on workers' health. Based on this, the researchers raised the above problems by using a modified sitting grinder to reduce complaints of musculoskeletal disorders (MSDs), workload and increase work productivity of blacksmiths in Gubug Tabanan Village.

MATERIALS AND METHODS

This research is an experimental research with *treatment by subject* design.¹² The total population is 40 people from 10 industries. Sample selection by simple random sampling with a table of random numbers. The minimum number of samples was calculated using the Colton formula to determine the sample size to be 16 people. The sample inclusion criteria included: blacksmith workers living in the village of Gubug Tabanan aged 20-60 years, physically healthy with a doctor's examination, at least one year of work experience, and willing to be research subjects. While the exclusion criteria were not present during the study, suffering from illness during the study, for certain reasons withdrew from the sample. Data processing and analysis: Descriptive test for subject condition data includes age, weight, height, and body mass index. A normality test was performed on the data; a) physical environmental conditions including air temperature, humidity and noise, b) musculoskeletal complaints; c) workload data; and d) work productivity data. Difference test for data on musculoskeletal complaints, workload, and work productivity using parametric statistical tests (different test paired samples t-test at significance level = 0.05) in treatment I and treatment II on data that is normally distributed, and if not normal, non-parametric statistical tests were performed (Wilcoxon's difference test at significance level = 0.05).

RESULTS

Study participant

The research subjects were 16 blacksmith workers who lived in the village of Gubug Tabanan. The conditions of the subjects recorded in this study were age, weight, height, and body mass index (BMI). A descriptive analysis of the condition of the subject is presented in Table 1.

Table 1. Descriptive characteristics of study participant

Characteristics	Rerata±SB	Min	Max
Age (years)	39.00±8.52	28	55
Height (cm)	164.69±4.40	160	170
Weight (kg)	65.31±7.57	55	80
Body mass index (kg/m ²)	23.94±2.048	21	28

Physical Environment

In this study, the environmental conditions measured were air temperature, humidity, and noise. Descriptive analysis and normality test of environmental condition data are presented in Table 2. There was no significant difference in environmental conditions before and after intervention

Table 2. Physical environment data difference test results in pre-treatment and post-treatment

Environment	Pre-intervention	Post-intervention	t	p
Room temperature (°C)	26.00±1.10	25.50±0.95	0.333	0.795
Humidity (%)	83.50±2.21	81.50±2.06	0.667	0.626
Noise level (dB)	63.50±0.70	51.50±0.55	1.091	0.472

Musculoskeletal complaints

Musculoskeletal complaints data were obtained using a Nordic Body Map questionnaire with direct interviews with workers. Table 4 shows the analysis of the paired sample-t-test difference test on pre-treatment and post-treatment before work, there is a significant difference $p < 0.001$, indicating that the initial conditions in the pre-treatment and post-treatment are different. analysis of pre-treatment and post-treatment after work there is a significant difference where the $p < 0.001$.

Table 4. Results of different tests of musculoskeletal complaints data on pre-treatment and post-treatment before and after work

Musculoskeletal complain	Pre Intervention	Post- Intervention	t	p
Before work	2.83±1.87	1.23±1.74	58.014	<0.001
After work	1.26±2.09	1.13±1.34	6.325	<0.001

Workload

The workload was assessed by measuring the pulse before and after working on the pre and post-treatment. Paired sample T-test analysis of workload data on Pre and Post-treatment before work, there is no significant difference because the $p=0.860$. This shows that there is no difference in the initial conditions in the pre-treatment and post-treatment or it can be interpreted that the initial conditions of the two periods are the same or comparable. Analysis on Pre-treatment and post-treatment after work found a significant difference because the $p<0.001$ (Table 5).

Table 5. Workload Data Difference Test Results on Pre I, II and Post I, II Treatment Before and After Work

Workload	Pre Intervention	Post Intervention	t	p
Before work	79.69±1.70	99.81±1.40	0.180	0.860
After work	79.63 ±3.70	86.94±2.15	10.853	0.000

The average plate produced in the pre and post-treatments increased by 1.1%, namely $3.50±1.25$ to $3.87±1.29$ and after calculating the productivity in Treatment I and Treatment II also increased by 1.06 % from $0.045±0.12$ to $0.048±0.14$. There was a significant difference in work productivity regarding plate production before and after intervention (Table 6).

Table 6. Productivity data difference test results on pre and post treatments

Workload	Pre intervention	Post Intervention	t	p
Plate production in one hour	-7.18±1.25	-5.87±1.29	-3	<0.001
Productivity in one hour	-0.375±0.12	-0.037±0.14	-3	<0.009

DISCUSSION

Complaints of Musculoskeletal Disorders

A Nordic Body Map questionnaire containing 28 question items measured the subject's musculoskeletal complaints. The study found a decrease in complaints after an improvement of 0.15%. The analysis of the difference test on Pre-Treatment and Post Treatment after work ¹³ found that there was a significant difference ($p < 0.05$). Thus, the improvement by modifying the sitting wheel influences complaints.^{13,14}

Musculoskeletal complain complaints or disturbances ⁹ felt by a person ranging from mild complaints to feeling very sick in the skeletal muscles which include the joints, nerves, muscles, and spine due to unnatural work. If the muscles are disturbed, the activities of doing daily work can be disrupted, because muscle strength is one of the most important parts of the body's organs to be able to move. In this study, it was found that there was a decrease in complaints among workers who used a seated grinder by 13.23%. This study's results align with other studies that state that improving ergonomics-based work systems can reduce worker complaints. Research that explains that work is in a static posture on the lower body and experiences repetitive movements in the hands¹⁵. When in a static position, the body will experience a blockage of blood flow, resulting in a lack of oxygen and glucose from the blood in that section. In addition, the body will produce lactic acid which can cause pain. Muscles cannot work naturally if a person works with an unnatural posture, this causes the muscles to require more strength to carry out their duties, thus triggering fatigue and tension in the muscles and tendons. Improvements in work attitudes reduce musculoskeletal complaints by 34.6%, research in the form of improving the work system and work environment reduces worker fatigue by 22.09%, research in the form of improving ergonomics-based SKKB workstations reduces worker fatigue by 18.84%¹⁹, and research in the form of improving ergonomics-based work aids reduces worker fatigue by 30.31%.¹⁸⁻²¹ The higher the assessment of work attitudes, the higher the perceived musculoskeletal complaints.

In grinding, workers are faced with repetitive movements of the hands by carrying a hammer that is quite heavy, so that the load on the right hand is more dominant. When the grinding wheel rotates and hits the steel plate, vibrations arise and propagate from the tool to the hand or wrist even though the vibration is not felt directly by the worker.²² The vibrations that are felt continuously while working will accumulate and can have an impact on causing hand-arm vibration syndrome, which is a disease caused by exposure to vibrations in the hands. Exposure to

hand-arm vibrations, prolonged work with flexed wrists, and high repetition are also associated with CTS.

Workload

The workload is an important factor in assessing a job's lightness or severity, including grinding work. The workload given to workers must be adjusted to their physical and psychological abilities so that they do not affect the health conditions of the workers.²² To reduce workers' workload, it can be done by planning and/or designing a tool that can minimize complaints due to an inappropriate workload.²³ The workload can be predicted from the frequency of the worker's pulse because the pulse is one of the indicators that can be used to determine a person's workload level. The study found a decrease in workload after an improvement of 0.19%. Different test analyses on Pre-Treatment and Post Treatment after work found a significant difference ($p < 0.05$).

The decrease in workload in the Pre and Post-treatment is predicted due to the decrease in external stress in the work environment. One of the effects of external stress conditions is an increase in pulse rate. In this study, after external stress can be overcome by making improvements in the form of a seated grinding.²⁴ There is an efficiency of energy use so that it can reduce the workload as measured by the work pulse. Some similar research results also found a decrease in workload of 18.3 in the redesign of the work stove, a decrease in workload of 21.43% in the modification of Tri Hita Karana-based ergonomics for rice mill workers, a decrease in workload of 15.3% in dodol industry workers in Bali, and a decrease in workload of 3.41% for steamed bread industry workers in Denpasar.²⁵⁻²⁸ The results of this study are in accordance with the theory which states that an increase will also follow an increase in workload in musculoskeletal complaints.

Work Productivity

The final impact of improving working conditions is increased productivity and income for crafters and entrepreneurs. The increase in productivity in this study was seen from the increasing number of metal plates that workers successfully forged in one working hour by 30.85%, namely 3.50 ± 1.25 to 3.87 ± 1.29 . By calculating output divided by input per unit of time, worker productivity also increased by 1.06%, from 0.045 ± 0.01 to 0.048 ± 0.01 . The analysis of the different tests in the Pre and Post-treatment found a significant difference ($p < 0.05$).

Increased productivity through the number of plates produced will have an impact on increasing the number of knives produced by workers so that it will increase their income. In addition to an increase in income, this improvement will reduce the risk of workers contracting occupational diseases.¹⁵

Several similar research results also found that improvements with an ergonomic approach can increase productivity. The increase in productivity obtained was due to an improvement in physiological response, faster processing time, and increased production. The increase in productivity was obtained by 36.96% in the improvement of the work system, in the ergonomic application of the total pottery industry workers in Bantul by 30, the intervention by stretching and giving sweet tea to the tailor was also reported to increase worker productivity by 66.67%, an increase in productivity of 54.95% using a solar dryer with a Techno-Ergonomic approach in making traditional cake (dodol) in Singaraja, Bali, Indonesia, and an increase in productivity of 1.06% by using a sitting grinder in Tabanan Regency.²⁹⁻³¹ Understanding how musculoskeletal function and its symptoms impact workload and productivity, and by regularly assessing functional and activity limitations, recommending ergonomic adjustments in this study by providing sitting grinders to blacksmith workers is a strategy to maximize the functional ability and quality of life of workers.

CONCLUSIONS

The conclusion in this study is that there is a significant decrease between musculoskeletal complaints, workload, and noise before and after the use of a seated grinder ($p < 0.05$), and there is a significant increase in work productivity before and after modifying a sitting grinder.

Conflict of interest

All author declares there is no conflict of interest regarding publication of current study.

Funding

None.

Author contribution

All author had contributed to manuscript writing and agreed for final version of the manuscript for publication.

Ethical consideration

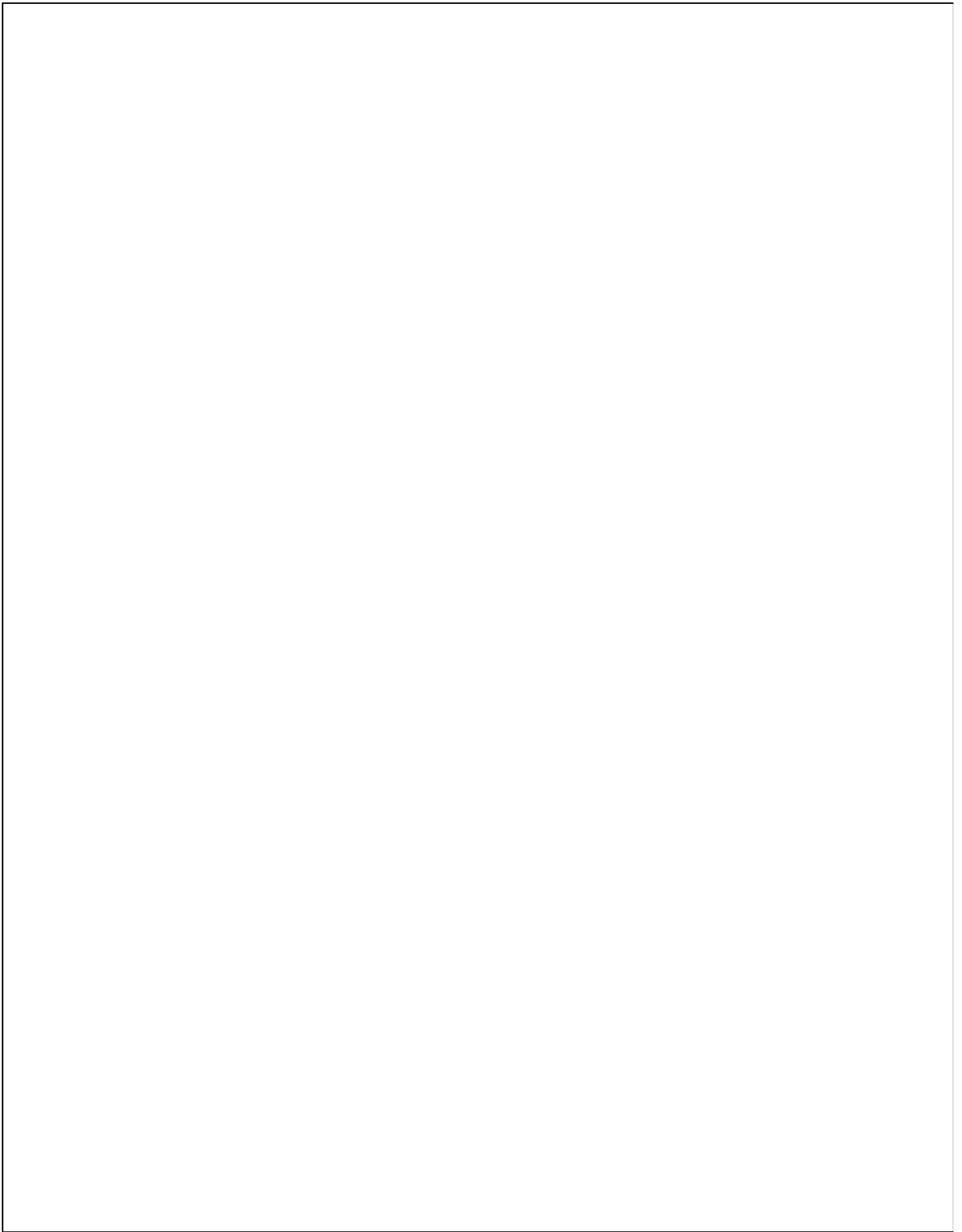
This study has been approved by Ethical Committee Health Polytechnics with Ethical Clearance reference number LB.02.03/EA/KEPK/0596/2022.

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To: To: <sri_arjani62@yahoo.com>

Mon, Nov 21, 2022 at 11.06 AM

Dear Author
We had received your full revision

Best and regards
Managing Editor Indonesia Journal of Biomedical Science
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Editor IJBS Udayana <editorijbsudayana@gmail.com>
To: <sri_arjani62@yahoo.com>

Wed, Nov 23, 2022 at 11.02 AM

Dear author: please find the attached acceptance letter and invoice billing for your manuscript

Letter of Acceptance
23 November 2022

**Dear: Ida Ayu Made Sri Arjani^{1*}, Cok Dewi Widhya Hana Sundari¹,
Nyomam Mastra¹, I Made Bulda Mahayana⁴, I Gusti Ayu Made Aryasih¹,
Ni Made Marwati¹, I Gusti Agung Ayu Putu Swastini¹**

¹Polytechnic of Health Denpasar, Bali, Indonesia

*Corresponding author: sri_arjani62@yahoo.com

I am very excited to accept your paper entitled:

“Modified sitting grinder reduces complaints of musculoskeletal disorders, workload, and increases work productivity of blacksmiths in Tabanan Regency-Bali.”

Your paper will be published in the issue Vol. 16 Number 2 (July - December 2022) <http://dx.doi.org/10.15562/ijbs.v16i2.425>

([Online Link: https://ijbs-udayana.org/index.php/ijbs/article/view/425](https://ijbs-udayana.org/index.php/ijbs/article/view/425)).

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Please do not hesitate to contact me if you need anything. It has been a pleasure for us to proofread and edit your work and we are looking forward to your colleagues and your other papers in the near future.

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Editor IJBS Udayana <editorijbsudayana@gmail.com>
To: <sri_arjani62@yahoo.com>

Wed, Nov 23, 2022 at 11.02 AM

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Wed, Nov 23, 2022 at 11.02 AM

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Sri Anjani <sri_arjani62@yahoo.com>
To: Editor IJBS Udayana <editorijbsudayana@gmail.com>

Fry, Nov 25, 2022 at 2.32 PM

Dear Editorial Board Member of **Indonesia Journal of Biomedical Science**
Thank you for the acceptance letter, its an honor to be published in
your journal
Please find the attached payment proof for my manuscript

Warm regards
Ida Ayu Made Sri Arjani
[Quoted text hidden]



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