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Ergonomic-Based Redesign of Broomsticks Reduces the Physiological Burdens of Street Sweepers in Denpasar City, Indonesia

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Abstract

The equipment, such as broomsticks used by street sweepers are not appropriate based on anthropometric aspects, with a potency to induce inconvenience among them. Working with equipment that is not ergonomics, in addition to non-physiological work posture can cause fatigue, musculoskeletal disorders, and increased workload. This study aims to determine whether redesign an ergonomic-based broomstick may reduce the physiological burden of street sweepers in Denpasar city, Indonesia. This research is a pure experiment using a cross-design (two-period crossover design). The sample was 16 female street sweepers, divided into two groups: 8 as the control group and 8 treatment groups. Data analysis were performed using a paired t-test with significance level of 5%. The results showed significant difference ($p<0.05$) on the variables of workload, musculoskeletal complaints, and fatigue. In the first period, the mean of the street sweeper working heart rate was 118.96 ±2.26 beats per minutes (bpm), the mean musculoskeletal complaint score was 91.63 ±2.70 and the average fatigue was 77.69 ±2.96. In Period II, the mean heart rate was 98.49 ±2.22 bpm, the mean musculoskeletal complaint score was 63.56 ±2.73 and the average fatigue was 57.56 ±2.94. Redesigned stem brooms turned out to reduce workload, musculoskeletal complaints, and fatigue by 17.21%, 30.6%, and 25.91%, respectively. It can be concluded that the redesign of an ergonomic-based broomstick can reduce workload, musculoskeletal complaints, and fatigue.

Keywords: broomstick, ergonomics, redesign, street sweeper

Redesain Sapu Lidi Berbasis Ergonomi Mengurangi Beban Fisiologis Pada Penyapu Jalan Di Kota Denpasar

Abstrak

Alat atau sarana yang digunakan oleh para pekerja penyapu jalan belum mengacu pada aspek antropometri sehingga dapat menimbulkan ketidaknyamanan dalam melakukan pekerjaan. Sapu lidi yang digunakan pekerja masih terdapat beberapa kekurangan yang menjadikan pekerjaan menjadi kurang efektif dikarenakan ketidaknyamanan dari peralatan kerja. Bekerja dengan peralatan yang tidak sesuai dengan kaidah ergonomi serta sikap kerja yang tidak fisiologis dapat menyebabkan kelelahan, gangguan otot muskuloskeletal dan beban kerja meningkat. Penelitian ini bertujuan untuk mengetahui apakah dengan redesain sapu lidi berbasis ergonomi mengurangi beban fisiologis penyapu jalan di Kota Denpasar. Metode Penelitian adalah eksperimen murni dengan menggunakan rancangan silang (two-period cross over design). Sampel yang dilibatkan dalam penelitian ini adalah penyapu jalan wanita yang berjumlah 16 orang, selanjutnya dibagi menjadi dua kelompok yaitu 8 orang sebagai

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kelompok kontrol dan 8 orang kelompok perlakuan. Analisa data menggunakan uji t-paired dengan taraf signifikasi 5%. Hasil penelitian menunjukkan adanya perbedaan bermakna (p<0.05) terhadap variabel beban kerja, keluhan muskuloskeletal dan kelelahan. Pada periode I rerata denyut nadi kerja penyapu jalan adalah 118.96±2.26 dpm, rerata skor keluhan muskuloskeletal adalah 91.63±2.70 dan rerata kelelahan adalah 77.69±2.96. Sedangkan pada Periode II rerata rerata denyut nadi kerja penyapu jalan adalah 98.49±2.22 dpm, rerata skor keluhan muskuloskeletal adalah 63.56±2.73 dan rerata kelelahan adalah 57.56±2.94. Redesain sapu lidi jenis bertangkai ternyata menurunkan beban kerja sebesar 17.21 %, keluhan muskuloskeletal sebesar 30.63% dan kelelahan sebesar 25.91 %. dapat disimpulkan bahwa redesain sapu lidi berbasis ergonomi dapat menurunkan beban kerja, keluhan muskuloskeletal dan kelelahan.

Kata kunci: ergonomi, penyapu jalan, redesain, sapu lidi

INTRODUCTION

One of the problems faced by big cities is garbage. Garbage is a classic problem in big cities, including Denpasar. In maintaining a clean and healthy environment, the city government carries out environmental care movement under the Hygiene and Gardening Service. All activities related to the maintenance of the city environment are under the supervision of the Sanitation and Gardening Department. This agency consists of several divisions, including the road cleaning department. The job of sweeping the streets has been performed using a broomstick that has been modified by adding a wooden stalk. The equipment used by the street sweepers have not yet referred to the anthropometric aspects, so that some of the workers perform their work in a lordotic posture. These workers, working from morning and evening if it is done continuously and for long hours can cause discomfort. The broomsticks used by workers still have shortcomings that make work less effective due to the inconvenience of the work equipment provided.

Based on field observations, the diameter of the broomstick stalk is too small about 2.23 cm and is made of hard material so that the workers developed blisters and calluses. The average length of the broomsticks is 42 cm with a weight of approximately 519.06 grams. The broomstick has a length of about 53 cm. By interviewing several workers, we found that they felt physical pain and complaints after work, namely, pain in the neck to the back, sore and hot palms, even often accompanied by cramps and numbness, as well as and thirst. These workers sweep in a bent posture toward. Sideways and the head lowered, which made fatigue develops quickly. If it happens over a long period of time, it will affect the skeletal muscles of the body which are more at risk if neglected.

Working with equipment that is not in accordance with ergonomic principles and non-physiological work attitudes can cause fatigue, musculoskeletal disorders and increased workload. Work that is not done with an ergonomic work posture for a long duration of time without stretching will cause excessive muscle contraction due to the load on several parts of the body such as neck muscles, shoulder muscles, arm muscles, hand muscles, finger muscles, back muscles, muscles waist and lower muscles (Tarwaka, 2015).

Palilingan (2017) showed that the high value of musculoskeletal complaints in *bendi* coachmen was due to the fact that the chairs did not match the workers' anthropometry. When the load rests on the spine, spasms will occur in the muscles around the back and waist which spontaneously force the posture of the worker to bend, then the back muscles will be stressed and tense to compensate for the body, resulting in lower back pain (Sengadji, 2015). According to Guyton and Hall (2014), strong and prolonged muscle contractions result in muscle fatigue. Muscle fatigue is caused by the inability of the contraction and impaired metabolism of the muscle fibers to continue the same work.

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Types of work tools and facilities that are less comfortable often cause ergonomic problems for workers, and if this work is carried out continuously, negative impact on health will develop, which triggers occupational diseases (Cris, 2012). Manuaba states in Palilingan (2017) that when the work tool is not designed properly, various problems will arise in workers, such as fatigue, musculoskeletal complaints, high workloads, which ultimately results in poor productivity and worker health. This is also in line with the results of observations on street sweepers. Various symptoms are complained because the design of the work tool is not ergonomic, thus caused discomfort in working.

Ergonomic aspects and technological accuracy must be considered in creating a work tool. There are six criteria that must be met to create a work tool in accordance with an appropriate technological approach. These criteria are that these work tools must be considered from a technical, economic, ergonomic, accountability, as well as, not wasting of energy and environmentally friendly (Manuaba 2004).

METHOD

This is a pure experimental research that utilizes the same subject method but is developed in a cross method. In this study, it took a time span *(washing out)* for each team to provide a pause so that the effect of the first treatment given by the researcher disappeared and only then was given the next treatment. The population is street sweeping cleaners in the Niti Mandala Renon area, Denpasar City, Bali.

The number of samples was determined by using *Pocock* method with total sample size was 16 people. This type of research was a cross-design, the 16 samples were divided into control and treatment groups (n=8 for each group). The measuring instruments in this research are; 10 pulse technique, *Nordic Body* questionnaire and subjective fatigue questionnaire. These instruments aim to measure the workload as well as the, subjective and musculoskeletal fatigue of street sweeping cleaners in Denpasar City. Data were processed with SPSS version 20 (IBM, USA). To determine the statistical significance, a paired t-test was carried out with the significance level is set at 0.05.

RESULTS AND DISCUSSION

Sixteen female subjects who worked as street sweeping cleaners in Denpasar, Bali were included in the study. The 16 subjects were divided into two different groups. The first group consisted of 8 subjects using old broomsticks, and the second group consisted of 8 people using new broom stalks. Table 1 shows the age, weight and height and working period of the subjects.

Table 1
Characteristics of Subjects

No	Variable	N	Mean	SD	range
1	Age (yrs.)	16	38.56	3.58	32 - 43
2	Weight (kg)	16	60.06	6.61	45 - 72
3	Height (cm)	16	156.00	5.73	145 - 165
4	working period (yrs.)	16	9.56	1.41	8 - 13

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Normality tests on the three variables of workload, musculoskeletal fatigue and pre-post work fatigue were performed using the *Shapiro Wilk Test (n<50).* The results of the normality test obtained a p score of more than 0.05, which means that the three variables in this study were workload, musculoskeletal fatigue and fatigue before working on the control team and treatment were normally distributed. Homogeneity testing, was carried out using the *Levine's Test* which obtained a p score of more than 0.05. Based on this score, it can be concluded that the sample of this study has a homogeneous variation.

The subjects were divided into two groups: control and treatment groups. Each group consists of 8 subjects. All of the subjects were subjected to a non-dependent t test to determine the conditions for differences in each variable that might occur in each team. The results of these tests are shown in Table 2.

Table 2
Comparability Test Results on Workload, Musculoskeletal Complaints and Fatigue
Variable Group I (control-treatment) Group II (treatment-control)

Variable	Group I			Group II			t	p
	n	Mean	SD	n	Mean	SD		
Workload	8	65.25	2.12	8	66.75	3.69	-0.996	0.336
Musculoskeletal Complaints	8	45.25	2.96	8	45.63	2.50	-0.273	0.789
Fatigue	8	47.63	1.77	8	47.13	1.55	0.601	0.557

Based on the data obtained, it is revealed that the scores of the three variables are p>0.05 which means that there is no significant difference. In other words, the three variables studied in this study, workload, musculoskeletal complaints and work fatigue, both in team I (control-before broom handle repair) and team II (treatment-after broom handle repair) did not have a significant difference. It can be said that the decline score that occurred was due to the intervention provided by the researcher alone.

The score is *period effect* obtained from the sum of the mean of the variable team I (control) period one with the average results of the variable team II (treatment) in the second period. In table 3, the results of the period effect test on street sweeping cleaners will be presented on the three research variables.

Table 3
Period Effect Test Results on Workload, Musculoskeletal Complaints and Fatigue

Variable	Group I			Group II			t	p
	n	Mean	SD	n	Mean	SD		
Workload	8	21.11	3.89	8	22.21	3.92	-0.57	0.58
Musculoskeletal Complaints	8	29.00	3.78	8	25.75	4.28	1.61	0.13
Fatigue	8	19.87	5.17	8	20.25	4.20	-0.16	0.88

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As can be seen on the p score in Table 3, the p values are >0.05, it can be concluded that there is no significant difference between Team I (control-with old broom) and Team II (treatment - with a new broom). In other words, it can be interpreted that team I (control) has no influence on Team II (treatment) and vice versa. As well as workload, increased musculoskeletal complaints and fatigue were only caused by differences in the treatment given by the researchers.

The calculation for the residual effect is done by subtracting the average of the first period (control) team I (control) variables from the mean of the second period (treatment) team II variable. In table 4, the results of the residual effect test on street sweeping cleaners will be presented on the three research variables.

Table 4
Results of the Residual Effect Test on Workload, Musculoskeletal Complaints and Fatigue

Variable	Group I			Group II			T	p
	n	Mean	SD	n	Mean	SD		
Workload	8	86.34	4.90	8	87.44	6.11	-0.40	0.70
Musculoskeletal Complaints	8	26.75	6.30	8	28.00	4.04	-0.47	0.64
Fatigue	8	18.63	4.07	8	21.50	6.05	-1.12	0.28

Judging by the p score in Table 4 which shows a number >0.05, it can be concluded that no significant difference occurred. It can be interpreted that the residual treatment does not have any effect on further treatment. As well as workload, increased musculoskeletal complaints and fatigue were only caused by differences in the treatment given by the researchers.

The calculation for the treatment effect was carried out by comparing the mean of the variable team I (control) period one with the average result of the variable team II (treatment) in the second period. In Table 5, the results of the treatment effect test on street sweeper cleaners will be presented on the three research variables. Latest was also *paired t carried out* because the data had a normal spread.

Table 5
Results of the Treatment Effect Test on the Workload of the Street Sweeper

Variable	n	Control		Treatment		t	p
		Mean	SD	Mean	SD		
Resting Rate	16	64.69	3.24	65.88	3.22	-1.50	0.154
Work Rate	16	118.96	2.26	98.49	2.22	28.69	0.001
Work pulse	16	54.27	3.46	32.61	3.25	21.58	0.001

Referring to Table 5, it can be seen that the p score in the condition before work is >0.05. This score implies that there is no meaningful result or a decrease in workload that may occur simply because of differences in treatment performed by researchers. However, the p score after work shows a result <0.05, which means a change in the new broom handle has an effect on reducing the workload of the street sweeper.

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Table 6 describes the differences in musculoskeletal complaints between Team I (Control) and Team II (Treatment):

Table 6
Results of the Treatment Effect Test on Musculoskeletal Complaints on Street Sweepers

Variable	n	Control		Treatment		t	p
		Mean	SD	Mean	SD		
Musculoskeletal Complaints (before)	16	46.13	2.45	45.44	2.34	0.87	0.397
Musculoskeletal Complaints (after)	16	91.63	2.70	63.56	2.73	24.98	0.001
Ratio	16	45.50	2.92	18.13	3.79	21.36	0.001

In the conditions before work, a score of p>0.05 means that in Team I (control) and team II (treatment), there was no significant difference in terms of musculoskeletal complaints before work. Meanwhile, in the post-work condition, it can be seen that the p score is <0.05, which means that in the post-work condition, there is a significant difference in terms of musculoskeletal complaints between Team I (control) and Team II (treatment). In other words, the use of a broomstick that has been newly designed with the ergonomic method has a positive effect on reducing musculoskeletal complaints in street sweeping cleaners.

The different conditions of fatigue tested on Team I (Control) and Team II (Treatment) can be seen in Table 7.

Table 7
Results of the Test Results of the Fatigue Treatment of Street Sweepers

Variable	n	Control		Treatment		t	p
		mean	SD	Mean	SD		
Fatigue (before)	16	46.50	2.45	46.44	2.34	0.85	0.934
Fatigue (After)	16	77.69	2.96	57.56	2.94	21.95	0.001
Ratio	16	31.19	3.66	11.13	3.12	15.45	0.001

Based on the exposure in Table 7, it can be seen that the p score in the condition before work shows a number >0.05, this means that there is no significant difference in the condition of the street sweepers' fatigue before working, or in other words it can be assumed that the differences that might occur are due to the effect of differences in treatment that the researchers did. While the p score after work shows the result <0.05, which means that there is a significant difference in the fatigue condition of street sweepers after doing their job. It can also be interpreted that the use of a broom stick with a new design can reduce the fatigue of working on street sweepers.

DISCUSSION

The subjects involved in this study ranged from 32 to 37 years with an average age of 38.56 ±3.58 years, which can be categorized into the productive age range. In general, it is known that some physical capacities such as sight, hearing and reaction speed decrease after 40 years of age (Suma'mur, in Aziz 2018). Based on research from Guo et al (in Tarwaka 2011) states that in general, skeletal muscle complaints are felt between the ages of 35-65 years. The first complaint is usually felt at the age of 35 years and the level of complaints will continue to

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increase with age. This can be because at the age of over 35 years, degeneration process starts, causing reduced stability of muscles and joints. As a person ages, bone elasticity decreases and complaints will increase. In addition, this complaint will appear more quickly if it occurs in workers who do work related to muscle and joint activity with excessive workload. This is in line with the results of research that many respondents experienced skeletal muscle complaints in the 36-55 years age category.

Betti'e, *et al* (1989) as quoted by Tarwaka (2011) have conducted a study on muscle static strength for men and women aged between 20-60 years. Their research was focused on the arms, back and legs. The results showed that the maximum muscle strength occurred between the ages of 20-29 years, then it continued to decrease with age. By the time people reach 60 years of age, the mean muscle strength decreases by 20%. Compared to our subjects of street sweepers from Denpasar, our subjects are still in the category of being able to do their activities optimally.

It is known from the measurements taken, the subject's elbow had an average height of about 100.17 ±6.25 cm, with an average palm length of 17.09 ±1.04 cm, the width of the palms had an average of approximately 7.94 ±0.80 cm and the average diameter of the handheld was 3.12 ±0.39 cm. The average hand grip diameter of the research subjects is used as a reference to determine the diameter of the broom handle that will be designed by the researcher.

Based on the rules of the anthropometric design process, the researcher determined the 95th percentile for the redesign of the ergonomics-based broomstick. The 95th percentile is used to determine the diameter of the broom handle, which is 3.5 cm, the height of the broom is 130 cm high and the weight is ±456 grams. After the researcher observes the process of sweeping the road, the researcher concludes that the limb that moves the most in this sweeping process is the upper body part. To facilitate the sweeping process, the researchers designed the broom handle to be 18 cm above the standing elbow. From the results of the interview, the street sweeper said that she felt comfortable using it.

Work pulse will describe the workload conditions felt by individuals. Santosa (2013) states that an individual's heart rate indicates the condition or activity that the individual is doing. When individuals are actively working, angry, or even scared, their pulse rate will also increase. In addition, from the total pulse of a person, it can be seen that their capacity or ability to complete work will also have an impact on their productivity. In this current study, it was found that the pulse rate decreased between the use of an old broom handle (from the mean score of 118.96 ±2.26 bpm) and the use of a new, redesigned broom handle (to 98.49 bpm). This means that there has been a decrease in pulse rate of 17.21%.

Based on Grandjean (2000) work rate category, if an individual has a pulse rate of around 75-100 bpm, it can be said that the individual has a light workload. Then for the number of beats 100-125 bpm, it can be said that the individual has a moderate workload. Finally, if the number of beats reaches 125-150 bpm, it will enter into a heavy workload condition. From this explanation, the we conclude that the workload resulting from the use of the old broom handle, for the workload variable is in the medium category, while the new broom handle which has been redesigned based on ergonomics gives the workload score in the light category. Therefore, providing design modifications to the broom handle with the ergonomic method, can reduce the workload of road sweepers.

Similar research has also proven that ergonomic interventions can reduce workload and increase worker productivity. Research by Rasna (2015) with a modification of ergonomics-oriented weighting on female rice thresher farmers in Subak Denpasar, showed that the workload score can be reduced by 42.3% ($p<0.05$). Likewise, Haryawan (2016) modification of handle shaft *roller* the paint can reduce the workload of 10.77%, on a painter ceiling

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shophouse in Denpasar.

In the old broom form, musculoskeletal complaints were found in all parts of the body starting from the neck to the calves. This complaint was caused by the sweeping process which involved a long bowing (lordotic) posture accompanied by a repetitive swinging motion. After using the newly designed broom handle, musculoskeletal complaints only occurred in the arms, shoulders, knees and calves. Manuaba (1998) states that musculoskeletal complaints at work can occur because of inefficient posture during work.

The results of the research that had been conducted showed that the scores of musculoskeletal complaints that occurred in the first team (control) were 91.63 ±2.70 and in the second team (treatment) around 63.56 ±2.73. The muscle complaints that occurred in the first team (control) were quite large due to the sweeping process that involved the performance of the body muscles (from the neck to the calves) in a standing and bowing position for a long time.

Surata's research in 2011 stated that the reduction in muscle complaints experienced by workers could be reduced by redesigning the tools used by workers. The decrease obtained can reach 56.15%. Suarjana (2018) stated that the application of ergonomics in the redesign the coconut grater reduces musculoskeletal complaints by 28.07%, among workers dough (industry melting in the satay) in Kaba-kaba Village, Kediri Tabanan. Subsequent research conducted by Yasa (2018) shows that the redesign of sanding and tools *hand stretching* can reduce musculoskeletal pain. 53.8% ($p<0.05$) of motorbike paint sanders in Tabanan.

In this current research, there was a decrease in musculoskeletal complaints in street sweeping cleaners by 30.63% with an ergonomic approach method with a score of $p<0.05$, which means that design changes on broom handles with ergonomic and anthropometric approaches can reduce musculoskeletal complaints and create better work convenience.

A tired condition in the body is an early warning that the body is not in good condition and needs a rest to prevent a worse effect in the future, which ultimately results in a decrease in work productivity. This study found a significant difference between fatigue in Team I (control) and Team II (treatment) with a score of $p<0.05$. The fatigue that occurred in Team I (control) could occur due to several factors, both internal (less than optimal body energy) or external (temperature and working environmental conditions). The decrease in fatigue can occur due to the ergonomics application of the new broom design which has been adapted to the anthropometric conditions of the road sweeper during the work process.

In line with this study, the results of by Santosa (2013) who also used ergonomics applications in the design of *dodol* mixer work equipment in Penglatan Buleleng village reduced the level of work fatigue by 22.09%. Research by Rasna (2015) with ergonomically-oriented *gebotan* modification on female rice thresher farmers reduced the level of fatigue in workers by 28.57% ($p<0.05$). Research by Susanta (2017) revealed that the use of an X-ray tube handle that has been redesigned based on ergonomics can significantly reduce general fatigue by 22.38% ($p<0.05$) in radiographers at Sanglah Hospital. And finally, research from Suarjana (2018) states that the application of ergonomics in the redesign of coconut grater reduced fatigue by 25.98%.

In this study, the design of work tools based on ergonomic aspects and anthropometric conditions has succeeded in reducing the level of work fatigue by 25.91% with a score of $p<0.05$. This decrease is the result of the novel broom designs that have succeeded in providing more comfort to workers through the new form of brooms, with designs that encourage the formation of a natural working posture so that the energy required is not too large. Based on this explanation, it can be concluded that the application of ergonomics with consideration of anthropometric aspects and the addition of a sponge to the broom handle is proven to reduce the level of workload, musculoskeletal complaints, and work fatigue experienced by street sweeping cleaners in Denpasar City.

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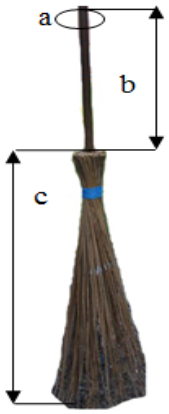

Weight	: 519.06 ± 32.52 gram
Girth (a)	: ± 2.23 cm
Shaft length (b)	: ± 42 cm
Broom length (c)	: ± 53 cm

Figure 1. Broomsticks before redesign with ergonomics applications

Weight	: 456 ± 32.39 gram
Girth (a)	: ± 3.5 cm *(percentile 95)*
Shaft length (b))	: ± 70 cm
Broom length (c)	: ± 60 cm

Figure 2. Broomsticks after Redesign with ergonomics applications

Figure 3.
The work posture of street sweeper cleaners before the broomstick is designed with ergonomics applications.

Figure 4.
The work posture of street sweeper cleaners before the broomstick is designed with ergonomics applications.

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CONCLUSION

The results of the redesign the broomstick with ergonomics applications, with dimensions of 130 cm high, 3.5 cm in diameter and 456 grams of weight can significantly reduce the workload, by 17.21% ($p<0.05$). The redesign of the broomstick with the application of ergonomics was able to significantly reduce musculoskeletal complaints, by 30.63% ($p<0.05$). The redesign of the broomstick with the application of ergonomics significantly reduced work fatigue, by 25.91% ($p<0.05$).

REFERENCES

Azis, A.H. 2018. "Faktor yang berhubungan dengan keluhan nyeri otot skeletal *(musculoskeletal disorders)* pada pekerja bongkar muat di Pelabuhan Soekarno Hatta Makassar tahun 2018" *(skripsi)*. Fakultas Kesehatan Masyarakat. Universitas Hasanudin Makassar.

Cris, P. 2012. Masa Kerja, Sikap Kerja dan Kejadian Sindrom Karpal pada Pembatik. *Jurnal Ke-mas*, Vol. 7(2):170-176.

Guyton, H. 2014. *Fisiologi Kedokteran Edisi Keduabelas*. Indonesia: Saunders Elsevier.

Haryawan. I G.A. 2016. Penggunaan tangkai pegangan *roller* cat yang dimodifikasi meningkatkan kinerja pengecat plafon rukan di Denpasar. *Jurnal Ergonomi Indonesia.* Vol. 2(2).

Manuaba, I.B.A. 2004. Pendekatan Total Perlu Untuk Adanya Proses Produksi Dan Produk Yang Manusiawi, Kompetitif Dan Lestari, disampaikan pada; *Seminar Teknik Industri Universitas Atma Jaya*, Yogyakarta.

Palilingan, R. 2017. Analisis keluhan *muskuloskeletal* pada kusir bendi di kota Tomohon. Prosiding Seminar dan Workshop PEI.

Rasna, I M. 2015. Modifikasi gebotan berorientasi ergonomic meningkatkan kinerja petani wanita perontok Padi di subak margaya desa pemecutan kelod. *Jurnal Ergonomi Indonesia*. Vol. 1(1).

Surata, I W. 2011 "Redesain Alat Pengering Dan Sistem Kerja Meningkatkan Kinerja Petani Dan Mutu Rumput Laut Di Desa Ped Nusa Penida" (*disertasi*). Denpasar: Program Pascasarjana Universitas Udayana.

Santosa, I G. 2013, "Perbaikan Kondisi Dan Lingkungan Kerja Dengan Intervensi Ergonomi Meningkatkan Kinerja Dan Mutu Produk Pada Perajin Dodol di Desa Penglatan, Buleleng" (*disertasi*). Denpasar: Program Pascasarjana Universitas Udayana.

Sengadji, M.I. 2015. Hubungan Antara Posisi Mengemudi Terhadap Low Back Pain Pada Sopir Angkot Di Kota Malang. *Jurnal Bidang Kedokteran dan Kesehatan.* Vol. 11(1).

Susanta, I P.A. 2017. Redesain pegangan tabung sinar-x yang ergonomis di Radiologi RSUP Sanglah menurunkan keluhan Muskuloskeletal, mengurangi kelelahan umum dan Meningkatkan kecepatan pemeriksaan. *Jurnal ergonomi Indonesia*. Vol. 3(2).

Suarjana, I.W.G. 2018. Redesain alat pemarut kelapa mengurangi beban fisiologis dan Meningkatkan produktivitas kerja pada pekerja industri adonan (*luluh*) sate di desa Kaba-kaba Kediri Tabanan. *Jurnal Ergonomi Indonesia* Vol. 4(2).

Tarwaka, 2011. *Ergonomi Untuk Keselamatan, Kesehatan, dan Produktivitas*. Surakarta: UNBA Press.

Tarwaka, 2015. *Ergonomi Industri Dasar-dasar Pengetahuan dan Aplikasi di Tempat Kerja* Edisi II. Solo: Harapan Press.

Yasa, I M.A. 2018. Redesain alat kerja pengamplas dan *hand stretching* dapat menurunkan beban kerja dan nyeri Muskuloskeletal serta meningkatkan produktivitas Kerja pekerja

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bengkel bagian proses pengamplasan di desa Tengkudak Tabanan. *Jurnal Ergonomi Indonesia* Vol. 4(2).