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Mapping ergonomics application to improve SMEs working condition in industrially developing countries: a critical review

In industrially developing countries (IDC), small and medium enterprises (SMEs) account for the highest proportion of employment. Unfortunately, the working conditions in SMEs are often very poor and expose employees to a potentially wide range of health and safety risks. This paper presents a comprehensive review of 161 articles related to ergonomics application in SMEs, using Indonesia as a case study. The aim of this paper is to investigate the extent of ergonomics application and identify areas that can be improved to promote effective ergonomics for SMEs in IDC. The most urgent issue found is the need for adopting participatory approach in contrast to the commonly implemented top-down approach. Some good practices in ergonomics application were also revealed from the review e.g. a multidisciplinary approach, unsophisticated and low-cost solutions, and recognising the importance of productivity. The review also found that more work is still required to achieve appropriate cross-cultural adaptation of ergonomics application.

Keywords: industrial ergonomics, health and safety, small and medium enterprises, industrially developing countries, intervention effectiveness

Practitioner summary: Despite continuous efforts in addressing ergonomics issues in SMEs of industrially developing countries, workers are still exposed to poor work conditions. We reviewed factual based evidence of current ergonomics application to inform future strategies of ergonomics in IDC, using Indonesia as a case study.

Introduction

The role of SMEs as the major source of present and future employment in all countries has been recognised. However, due to their limited resources and technical capacity, SMEs are also more prone to occupational hazards and risks than large enterprises. This situation is worsened in industrially developing countries since SMEs are commonly overlooked by formal safety and health legislation. Unsurprisingly, the employment conditions in SMEs are frequently very poor e.g. low wages, insecure
employment, and unsanitary working conditions (Hil, 2002) which then result in low levels of productivity, often poor-quality products, and generally serving small, localized markets. While there have been efforts by International Labour Organisation (ILO) to overcome this situation e.g. Kawakami et al. (2005); Krungkraiwong et al. (2006), the contribution of the regional researchers through ergonomics application towards their efforts was unclear. Few studies, if any, attempt to chart and investigate the contribution of regional researchers in supporting the application of ergonomics in SMEs; and use this information as a roadmap to guide future research.

Ergonomics in Indonesia was begun with the establishment of the Indonesian Ergonomics Society (PEI) in 1987. It was founded to support the implementation of ergonomics methods and approaches by academics, researchers and industrial practitioners. Much effort has been applied to improve working conditions at Indonesian SMEs through ergonomics application (Wignjosebroto, 2007). However, despite this effort, the annual report of the National Employment Accident Insurance Program (Jamsostek, 2011) showed a steady increase of number of accidents occurring in workplaces. Furthermore, it was also reported that most of these accidents occurred in SMEs (Trihandoyo et al., 2001). The small impact of ergonomics in reducing work-related accidents in Indonesian SMEs suggests the possibility that contribution of the regional ergonomics researchers may not be effective. Therefore, reflection and evaluation based on current and factual ergonomics applications in Indonesian SMEs are needed. This will assist in mapping ergonomics application to date and identifying areas that need to be improved in order to achieve the ultimate goal i.e. a decrease in work accidents in Indonesian SMEs.

The main objective of this paper is to review and analyse the extent of ergonomics application in improving SMEs working conditions and, where possible,
identify its direct impact. This paper also aims to identify gaps in the ergonomics application in improving SMEs working conditions and providing recommendations for future research and area of improvements. To the extent of the authors’ knowledge, this paper is the first paper that provides a thorough review of the ergonomics application for SMEs in industrially developing countries (IDC) based on factual evidence. While existing papers such as Kawakami et al. (1999), O’Neill (2000), Nuwayhid (2004), etc., also discuss the ergonomic applications in developing countries, they were commonly based on theoretical views and did not specifically address SMEs in a wider context.

This paper begins by describing how studies that were included in the review were identified and how they were analysed. Next, the results of the review and analysis are explained in detail. The last section of the paper discusses recurrent issues or phenomenon from the reviewed studies and identifies emerging issues and future research questions that need to be addressed to advance the ergonomics application in Indonesian SMEs. This paper’s main contribution lies on the identification of gaps and how to address these gaps through recommendation for future research. Although this paper is limited to reviewing the application of ergonomics in Indonesian SMEs, it is highly likely that the findings will also be applicable for other IDC.

Methods

The articles included in this review were primarily identified from articles that are freely available online from Ei Compendex, Scopus, Indonesian Scientific Journal Database (ISJD) and Google Scholars from 2000 to May 2013. The search was not limited to publications with English-language communications as many of the published articles are in Indonesian. The term “ergonomics” and its Indonesian equivalences i.e. “ergonomi”, “ergonomika”, “ergonomis”, were used to perform the search. “Human factors” and its equivalent term in Indonesian (“faktor manusia”) were also used as a
search term. In addition to this, accessible hard copies of national conference proceedings (organised by the Indonesian Ergonomics Society in 2004, 2007 and 2013) and international conference proceedings (organised by the South East Asian Ergonomic Society in 2000 and 2008; and South East Asian Network Ergonomics Society in 2012) were also included. Only articles that reported ergonomics applications related to improving SMEs working conditions were included. SME terminology such as "industri rumah tangga" (household industry), “industry kecil” (small industry), “usaha kecil dan menengah” (small and medium business) were used. The number of employees of an SME was used to identify whether or not a study was related to an SME, according to Statistic Indonesia (Saputra and Rindrasih, 2012). An industry with less than five employees is considered a household industry (micro), five to nineteen employees is considered a small industry, and those with twenty to ninety-nine employees are considered a medium industry.

For each study, we identify four themes as follows:

(1) Sector of the SMEs. The sector categorisation given by Indonesian Statistic Centre Bureau (Badan Pusat Statistik, 2008) was adopted for the purpose of this paper. There are 8 sectors of SMEs: i) agriculture, forestry, husbandry and fisheries; ii) mining; iii) processing industry; iv) electricity, gas and water; v) construction; vi) trade, hotels and restaurants; vii) transportation and telecommunication; viii) finance and leasing; ix) services.

(2) Domain of ergonomics applications. The domain categorisation given by the International Ergonomics Association (International Ergonomics Association, 2013) was adopted. There are three main domains of ergonomics application: i) physical ergonomics – concerning with the relationship between physical activity and physical characteristics of a person and encompassing topics such as
working postures, materials handling, workplace layout, safety and health; ii) cognitive ergonomics – concerning with the mental processes and encompassing topics such as mental workload, work stress, training; and iii) organisational ergonomics – concerning with the optimisation of a sociotechnical system and encompassing topics such as work design, design of working times, participatory design.

(3) Chosen ergonomics method(s). Ergonomics method(s) that were used in the reviewed studies, commonly adopted ergonomics method(s), and evidence of a multidiscipline approach were identified.

(4) Reported outcome. The final outcome of each study and its level of contribution to the wider knowledge of ergonomics such as validation of a new method/framework were identified.

Results

Figure 1 provides a flow chart documenting the results of the study selection process which resulted in the inclusion of a total of 161 articles in this review. 124 articles were obtained from the systematic search encompassing publications in the form of journal articles, conference articles, master theses, dissertations and technical report. An additional 37 articles were extracted from hard copies of national conference proceedings (organised by the Indonesian Ergonomics Society in) and international conference proceedings (organised by the South East Asian Ergonomic Society and South East Asian Network Ergonomics Society). Appendix 1 provides an overview of all of the reviewed studies. It has to be noted that the list of studies in this review is not necessarily exhaustive since this review was primarily limited to full text scientific publications that were accessible online.
Figure 1. The results of the study selection process

Figure 2 shows the proportion of sectors in which the ergonomics investigations were applied. Two sectors i.e. Processing Industries and Agriculture, Forestry, Husbandry & Fisheries, were the areas in which ergonomics were most commonly applied. This is then followed by: Trade, Hotel and Restaurants; Constructions and Mining. With respect to domain of ergonomics application, the highest application is in the Physical Ergonomics domain (145 studies), followed by Organisational Ergonomics domain (17 studies). None of the reviewed articles falls in the Cognitive Ergonomics domain. The following subsections will report the details in each domain.

Figure 2. Sectors of ergonomics application in Indonesia
Ergonomics application in physical ergonomics domain

The proportion of ergonomics issues that were addressed in the physical ergonomics domain is shown in Figure 3. Working posture and design of work stations/tool was the most frequently addressed ergonomics issues in this domain. Most of the studies in this category were mainly aimed to redesign and evaluate work stations/tools in order to fit anthropometry dimensions of Indonesian workers and/or promote better working postures. None of the studies related to redesigning work stations/tools indicated any involvement of employees and employers during the redesign process. There was also no indication either in communicating the positive results of the implementation to employees or employers. Interestingly, some of the studies (e.g. Ilman et al., 2012; Kristanto and Sugiantoro, 2012; Apriyandhi, 2012; Achiraeniwati & Rejeki, 2010) implied the need for employers and employees to take more active roles in addressing issues related to work postures.

Material handling and work related MSDs are the next issues that were commonly addressed. Most of the studies in material handling were mainly aimed to evaluate existing working conditions and provide recommendations related to lifting tasks through widely adopted methods such as the Revised NIOSH (National Institute for Occupational Safety and Health) lifting equation (NIOSH, 1994). A similar widely adopted method i.e. Nordic Standardized Questionnaire (Kuorinka et al., 1997) was also commonly applied in studies of work-related MSDs. Surprisingly, environmental factors did not receive much attention, despite the fact that most of the tasks in SMEs demand physical exertion under hot, humid and tropical environmental conditions.
There is a noticeable trend of approaches in which existing or redesigned workstations and tools were evaluated. The three approaches that stood out as the most common methods to evaluate work station/tools were: i) work load; ii) working posture; and iii) productivity. Each will be discussed in details in the following:

1. Most of the studies utilised heart rate measurement to classify physical workload; most authors cited its practicalities as their main reason of use. A table that provides the relationship between physical work load, heart rate and/or energy consumption such as Åstrand and Rodahl (1986) and Sanders and McCormick (1987) were found to be commonly used to classify the physical workload. There is a major drawback associated with the use of heart rate is related to the susceptibility of an increase caused by other factors such as psychological, environmental, and emotional (Roscoe, 1992). This means that these factors need to be taken into account while collecting and interpreting the measurement results, especially when they cannot be controlled e.g. when measurements are performed in a real work setting. Unfortunately, despite the
fact that most of the reviewed studies collected heart rate measurements in a real work setting, only a few of the studies acknowledged the possible effects of some of these external factors e.g. Tirtayasa et al. (2003), Ariati & Dewantara (2011), Widana (2012). Another issue with the use of heart rate to classify work load is the fact that the heart rate depends on the nature of the work i.e. whether the work is static, involving only a small number of muscles (Grandjean and Kroemer, 1997). Therefore, ideally, the heart rate measurement is accompanied by direct measurement of oxygen consumption whenever possible. Based on the review, there was only one study that adopted this approach i.e. Fatah et al. (2011). The review also found that, in order to increase the accuracy of the heart rate measurement to predict the energy consumption, some studies e.g. Dewi (2011), Ernawan (2000), Sulistyosari (2010), Akbar (2008) incorporated step test results to provide baseline measurement of the workload. This was done in recognition that maximal aerobic power varies greatly from one person to another i.e. a work load that is fairly easy for one worker may be quite exhausting for another (Roscoe, 1992). Therefore, the work load was analysed based on the individual’s maximal aerobic power and the ratio between load and power was assessed individually (Rodahl, 1989).

(2) RULA (McAtamney & Corlett, 1993), REBA (Hignett & McAtamney, 2000) and OWAS (Karhu et al., 1977) were found to be the most commonly applied methods in assessing working posture, respectively. When direct assessment of the redesigned work place layout or tool design are not feasible, some studies utilised ergonomics digital human modelling such as Jack (Siemens PLM Software, 2013), ManneQuinPRO (NexGen Ergonomics, 2013) to aid the assessment of working postures e.g. Pratiwi et al. (2010), Muslim et al. (2012)
and Putro (2009). In one particular study by Muslim et al. (2012) a mannequin was created based on partial data of a worker and was then used to assess the digital work place layout. Although this approach is accommodated by the software, this approach should be adopted with care as data that were not supplied were interpolated based on US Army data (Blanchonette, 2010). This, in the end, may lead to an inaccuracy of the simulation results (Oudenhuijzen et al., 2000).

(3) Based on the review findings, productivity measurements were always applied as part of an evaluation of work place layout and tools design/redesign. The most common measure of productivity was the number of product outputs that was calculated based on a time study (Taylor, 1911). In addition to this, a few studies also used motion study (Gilbreth & Gilbreth, 1917) investigation to demonstrate the potential improvement in productivity e.g. Rohman (2008), Dewi (2011). Both methods are part of Industrial Engineering methodologies. The inclusion of these methods as part of ergonomics studies is likely due to the fact that ergonomics is mostly introduced as part of syllabus in Industrial Engineering major in Indonesia.

Ergonomics application in organisational ergonomics domain

As previously mentioned, organisational ergonomics is comparatively less popular than physical ergonomics. The review revealed that the main issue addressed in organisational ergonomics is improvement of work design; with a so called “total ergonomics approach” (Manuaba, 2006) cited as the most common method in some studies i.e. Sudiajeng et al. (2007), Purnomo et al. (2007), Oesman & Adiatmika (2007), Oesman & Adiatmika (2008), Purnawati (2008), Adiatmika (2009) and Josephus (2011). The total ergonomics approach specifically referred to adoption of technology
with consideration to six criteria i.e. technical, economic, ergonomic, socio cultural, energy consumption and environment. While analysing each criteria, a so called “SHIP (Systemic, Holistic, Interdisciplinary and Participatory)” approach is applied. This approach emphasises involvement of stakeholders (employers, employee, etc.) during the process. This is notably different than the application of ergonomics in physical ergonomics in which stakeholders acted passively. Another issue that is addressed in this domain is modelling the ideal working conditions by considering each aspect of a sociotechnical system i.e. Purnomo & Ferdianto (2011).

**Outcome of ergonomics application**

The outcome of ergonomics application, irrespective of sectors and domains, seem to suggest that application of ergonomics affects productivity positively; providing further support to similar findings (e.g. Mirka et al., 2003; Yeow and Sen, 2006). However, most of the productivity was measured in a short duration while putting the workers under direct observation of the researchers. There is a risk that this kind of approach could result in the unwanted Hawthorne effect (Rothlisberger and Dickson, 1939). This commonly occurs in a situation where a change proves to be very effective in terms of productivity because the workforces find themselves in the spotlight and respond positively to the extra attention they are receiving. The outcome of ergonomics application also varies from a simple recommendation to a practical intervention which directly involved real end-users/employees in their original work setting.

All of the reviewed studies were geared towards resolving existing and particular issues in SMEs. As a result, the contribution of the studies towards the wider knowledge of ergonomics was limited. However, there was a strong evidence of multidisciplinary approach in addressing ergonomics related issues e.g. the use of time and motion study
to quantify productivity to evaluate ergonomics intervention, and the inclusion of ergonomics aspects as part of computer modelling of productivity.

**Discussions**

The review and analysis of the 161 articles revealed that cognitive ergonomics is the least applied domain in Indonesian SMEs. It is likely that the low rate of ergonomics application in this area is due to the utilisation of simple tools at SMEs, shown by studies such as Sutjana (2000), Bangun (2009), Al-Faruqy (2011), Yusianto (2012), etc. Therefore, evaluations on cognitive demands while operating these tools are not necessary. The review also clearly demonstrated that ergonomics application in Indonesian SMEs is still focused on the physical ergonomics domain. Major issues addressed in this domain i.e. work layout and tool design, manual handling & work postures, corresponds to ergonomics issues identified in previous publications e.g. Kogi & Sen (1987), O’Neill (2000). This suggests that ergonomists in IDC still face the same basic ergonomics problems even though more than a decade has passed. The review also revealed that a large proportion of the studies addressed a classic ergonomics problem related to work layout by providing small-scale, unsophisticated and low-cost improvement that can be easily administered. This is considered as a positive approach in promoting the uptake of ergonomics in IDC (Scott & Charteries, 2004; Kogi et al., 2003), especially where “cost benefiting” is a critical element towards the acceptance of ergonomics change within a workplace.

The emphasis on productivity is an indicator of awareness and understanding of ergonomists in Indonesia towards the importance of productivity for SMEs. SMEs workers’ are often paid based on their productivity, even if that means higher exposure to MSDs, work related injuries, etc. Unlike many larger businesses or those that operate in industrially developed countries, financial costs of injuries may be far less of a
concern than their consequences, the loss of productivity. Therefore, demonstrating that the adoption of ergonomics can actually improve productivity and does not result in additional expense is essential. Unfortunately, most of the reviewed studies based their productivity evaluation on a short duration observation and simply extrapolated this data to predict daily, weekly or monthly productivity. Thus, more efforts are required to evaluate the long term effectiveness of ergonomics in increasing the productivity. This can only be easily achieved if both employers and employees are involved from the start of the ergonomics intervention. Sadly, this is not the case; the review revealed that most studies adopted a top down approach and simply focused on resolving existing problems without involving relevant stakeholders such as employees and employers. This finding suggests that, despite repeated calls for participatory approaches in ergonomics e.g. Kogi (1995), Shahnavaz (2000), O’Neill (2000), Scott & Charteries (2004), the implementation of a participatory approach is very limited. Apart from a few studies such as Oesman & Adiatmika (2008), Josephus (2011), Purnawati (2008), Adiatmika (2009), most studies did not seem to indicate any effort in establishing communications with stakeholders prior to and during the ergonomics intervention. This is certainly detrimental as most of the ergonomics application is aimed to support engineering controls in promoting health and safety by controlling or eliminating the hazard at its source. Failure in communicating, educating and encouraging the employees to adopt safe work practices will certainly impact on the sustainability of the ergonomics intervention, especially since, as shown from the reviewed studies, the workers in SMEs are mostly of low level education. Incidentally, a recent study by Bao et al. (2013) specifically identified participation of stakeholders as the key to a succesfull ergonomics intervention in two rural Nicaraguan coffee farmers.
The review findings also suggest that issues related to technology transfers to IDCs (Abeysekera & Shahnavaz, 1987; Shahnavaz, 1989) were not yet a prominent ergonomics issue in Indonesian SMES. This was likely due to the fact that most of Indonesian SMEs used either traditional or low level technology tools that can be accommodated locally. An initiative by the Indonesian government, managed by Indonesian Institute of Science (LIPI), has certainly played a key role in this. An example of the Indonesian Institute of Science’ initiatives is IPTEKDA (Implementation and Utilisation of Science and Technology) which encourages researchers from local universities and research institutes to take active roles in supporting SMEs through invention and implementation of low level technology tools. The initiative, which has gone on for the last 15 years, requires the researchers to work closely with the small and medium enterprise and solve their problems. A reflection on the initiative revealed that at least 75% of the technologies are suitable, well received and used sustainably by SMEs (Brojonegoro and Darwin, 2006).

The Indonesian government has put emphasis on the implementation of occupational health and safety for larger businesses. In fact, Indonesia is one of the Asian countries that has a comprehensive regulation and auditing mechanism on occupational health and safety, especially for high risk domains. Unfortunately, the same level of attention has not yet been given to SMEs. One of a few government initiatives related to SMEs is the formation of Advisory Team on Occupational Health and Safety (Panitia Pembina Keselamatan dan Kesehatan Kerja), which is intended to improve the enforcement of health and safety at work for SMEs with more than 50 employees. Unfortunately, this initiative was rarely followed and even if it was, it was a mere formality (Topobroto, 2002). Furthermore, the limit imposed on the minimum number of workers also excludes some of SMEs with less than 50 employees. On the
contrary, the Indonesian Statistic Centre Bureau (Badan Pusat Statistik, 2006) reported that 84.47% of the Indonesian workforce was employed in SMEs with less than 50 employees, leaving the majority of the Indonesian workforce uncovered by health and safety legislation. Expansion of the coverage of policy and better enforcement of the policy could potentially improve the uptake of ergonomics application in Indonesia by stakeholders. To complicate matters, there is also evidence of poor implementation and enforcement of health and safety law by Indonesian government which contributes further to lax attitude with respect to health and safety issues in SMEs (Sutjana, 2006). Several studies (e.g. Sinclair and Cunningham, 2013; Levinne et al., 2012; Haviland et al., 2010) have shown that enforcement of health and safety through inspection and penalties reduced work related incidents to a certain extent. Yani’s (2006) finding also showed that SME workers’ knowledge in occupational health and safety is more limited than those working in the larger business. The lack of knowledge, mainly due to low literacy and socio economic level furthers ignorance towards aspects and rights of health and safety at work. Thus, unsurprisingly, Markkanen (2004) has called for shifting the attention on occupational health and safety from workers in larger industries to workers in SMEs. Indonesian ergonomists could play an important role in this area by ensuring that they do not simply solve SMEs’ ergonomics problem, but also involve the stakeholders (both SMEs owners and workers) during the process as a means to raise their awareness and educate them on some aspect of occupational health and safety.

The review indicated that there was evidence of multidisciplinary approaches to address ergonomics issues, especially with respect to industrial engineering. The multidisciplinary approach is largely contributed by Indonesian universities which include ergonomics in various disciplines e.g. industrial engineering, agricultural
engineering, public health, occupational medicine. The inclusion of ergonomics in various disciplines will likely be beneficial in the future as this means that there are more “change agents” that can introduce and promote ergonomics in developing countries.

Another aspect that can be observed from the review is the type of ergonomics methods that were used. Most of the studies have used well known and established methods which have been validated, used worldwide, and are not likely to be affected by geography e.g. RULA, OWAS, REBA, and the NIOSH lifting equation. However, there were also a large number of studies that adapted SNQ without indicating whether or not the cross-cultural adaptation was assessed according to the internationally recommended methodology i.e. translation, back-translation; committee review, and pre-testing. A similar comment also applies to work fatigue questionnaire that was established by Research Committee in Industrial Fatigue – Japan (1969). There is also evident of inappropriate use of tools i.e. some studies attempted to utilise tools such as SNQ to show that the new design of tools or work place layout can potentially reduce MSDs whilst SNQ is likely to be inappropriate in assessing MSDs in such a short time. Overall, in terms of methodologies, apart from the total ergonomics/SHIP approach by Manuaba (2006), it is argued that the ergonomics application in Indonesia has showed little contribution to the wider knowledge of ergonomics.

Based on the results of the review and discussions, several points that could be adopted by Indonesian ergonomists, and possibly other IDC’s ergonomists, to improve working condition in SMEs are identified:

(1) *Adoption of participatory approach.* The steady increase of work related accidents despite continuous application of ergonomics suggests that current approach i.e. a top-down approach is not effective. This approach excludes
employers and employees from the process; thus wasting an opportunity to educate them regarding safe working practices and instil ownership on the ergonomics changes. In contrast, a participatory or bottom-up approach enables addressing ergonomics while simultaneously raising the awareness of safe working practices for both SMEs owners and workers. Indonesian universities could potentially play a key role to encourage the adoption of participatory approach by putting more emphasis on participatory ergonomics.

(2) More initiatives to encourage creation of local technology and tool for SMEs. Unlike larger businesses, this review found that technology transfer was not (yet) a big problem in SMEs. This was due to the fact that most of the tools and technology used by SMEs can be accommodated locally. Although it is unclear how much Indonesian ergonomists’ role is in this area, it is important that they continuously getting involved.

(3) Appropriate adaptation and modification of ergonomics tools. Having an appropriate adaptation and modification of ergonomics tools will definitely be beneficial in the future. For instance, by having an appropriate adaptation of SNQ, MSDs data from different studies can be compared and contribute towards documenting work related MSDs in Indonesian SMEs. A step towards adaptation and modification of ergonomics tools for Indonesian has been started by Widyanti et al (2013).

Conclusions

It is evident from the review that there are still issues that need to be addressed related to ergonomics application in Indonesian SMES. The most urgent issue is the need for adopting participatory approach as part of resolving ergonomics issues at work place. Despite repeated calls, the review clearly demonstrated that only few ergonomics
studies heeded this call. Ironically, most of the studies cited the need for more active roles from employers and employers in addressing some of the ergonomics problem. Some good practices in ergonomics application were also revealed from the review e.g. multidisciplinary approach, unsophisticated and low-cost solution, recognising the importance of productivity.

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### Table 1. Summary of articles which were included in the review

| No | Study                          | Description                                                                 | Method                                      | Outcome                                                                 |
|----|--------------------------------|----------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------|
| 1  | Abdillah (2013)                | A study to investigate working postures of manual handling workers at a food distributor. | SNQ, RULA, interview                        | Most of working postures posed MSDs risks for workers; musculoskeletal discomfort data |
| 2  | Andarini et al. (2013)         | A study to evaluate redesigned furnace and addition of exhaust fan on workers’ fatigue and temperature in soybean industry. | Fatigue (30 items rating), temperature measurement | Reduced temperature & subjective level of fatigue                        |
| 3  | Anizar & Ariani (2013)         | A study to investigate workload, musculoskeletal discomfort & work posture in a pressing work station of small snack industry. | Workload (heart rate), Nordic Body map, Fingert tap (using tapping tester), REBA | Highest musculoskeletal discomfort for the neck; right upper arm & forearm, moderate workload; low or medium working postures. |
|   | Author(s) (Year) | Description | Methodology | Results |
|---|-----------------|-------------|-------------|---------|
| 4 | Anwar et al. (2013) | A study to redesign a work station at a food processing industry to reduce work related MSDs. | SNQ, REBA, Anthropometry | A concept of the work station that theoretically reduced the risk of MSDs |
| 5 | Dewi & Velnando (2013) | A qualitative study on the application of participatory approach to evaluate existing working conditions in a home-industry. | WISH (Work Improvement for Safe Home) checklist | Priorities for improvement were identified and low-cost improvements were proposed. |
| 6 | Herianto (2013) | A study to design a tool related to manual material transportation at a brick manufacturer. | Anthropometry, REBA, RULA | A concept of manual transportation tool that theoretically reduced MSDs risk related to manual material transportation |
| 7 | Kakerissa (2013) | An experimental study to evaluate new hoes design with two different heights (97 & 70 cm). | Energy expenditure (heart rate), productivity | The higher hoe design increased productivity and reduced energy expenditure. |
| 8 | Khaizun (2013) | A qualitative study to establish factors | REBA, observation of sitting | Age, length of employment and work |
| No. | Authors and Year | Research Description | Methodology | Findings |
|-----|------------------|----------------------|-------------|----------|
| 9   | Nugroho et al. (2013) | A study to investigate the relationship between mechanical vibration and the occurrence of CTS on workers in furniture industry | Vibration measurement, CTS physical inspection | Odd ratio was 28.5 suggesting that the risk of having CTS 28.5 higher for those who operated machine with above threshold level value. |
| 10  | Sari (2013) | A qualitative study to establish factors that contribute to low back pain to workers at shrimp paste industries. | Observation, interview and demography data collection | There was a significant relationship between sitting posture and low back pain. |
| 11  | Suarbawa (2013) | A study to evaluate and redesign casting work station for workers in a traditional musical instruments manufacturing. | Workload (heart rate), musculoskeletal discomfort (Nordic Body Map), fatigue (30 items rating), productivity | Lower level of workload (from heavy to moderate), heart rate lowered by 4.2%, musculoskeletal discomfort reduced by 64.95%, less perceived fatigue by 62.99%, increased productivity by |
| No. | Author(s) (Year) | Study Title | Methods | Findings |
|-----|------------------|-------------|---------|----------|
| 12  | Sudarma (2013)   | A study to evaluate and redesign workchair and use of computer software on traditional Balinese music players. | Work load (heart rate), fatigue (30 items rating), Nordic Body Map | Lower subjective level of fatigue and reduced musculoskeletal discomfort particularly at the neck, back, waist, and bottom. |
| 13  | Sutajaya (2013)  | A study to assess work load, musculoskeletal discomfort and fatigue before and after work in sculpturing home industry. | Workload (heart rate), no information given on how to obtain musculoskeletal discomfort and fatigue | Workload, musculoskeletal discomfort and fatigue increased by 13.5%, by 41.3%, 46.8%, respectively. Redesign of aid tools & rest time were recommended. |
| 14  | Sidik & Putri (2013) | A study to redesign and evaluate power thresher. | Anthropometry | New design of thresher with discharge path for collecting process waste (hay). |
| 15  | Setiadi et al. (2013) | A study to design a tool related to manual material transportation at a brick manufacturer. | SNQ, biomechanical analysis, REBA | A concept of manual transportation tool that theoretically reduced risks related to manual material transportation |
| No. | Author(s) (Year) | Title | Methodology | Findings |
|-----|-----------------|-------|-------------|----------|
| 16  | Wahyuni (2013)  | A qualitative study to establish factors that contributes conjunctivitis to welding workers at various SMEs. | Observation and demography data collection | Length of exposure posed a greater risk of conjunctivitis |
| 17  | Widana (2013)   | A study to evaluate snack and water provision during short-break for farmers | Workload (heart rate), own questionnaire on musculoskeletal complaint | Level of workload and musculoskeletal discomfort were lowered by 19.59% and 31.61%, respectively. |
| 18  | Yusuf & Santiana (2013) | An experimental study to evaluate ergonomics intervention (new design of aid tool, work-rest reschedule, use of PPE) on farmers. | Work load (heart rate), fatigue (30 items rating), Nordic Body Map, productivity (cycle-time) | Reduced workload by 10.4%, improved productivity by 346.4%, less musculoskeletal discomfort. |
| 19  | Agustina & Maulana (2012) | A study to evaluate working postures of workers and redesign work tools at a batik making industry | RULA | A concept of work tools that theoretically improved working postures of the workers |
| 20  | Akbar et al. (2012) | An adaptation of QFD (Quality Function Deployment) with ergonomics | Anthropometry | A concept of hawkers’ portable trays that theoretically reduced MSDs risk |
|   | Study Title | Methods | Findings |
|---|-------------|---------|----------|
| 21 | Anugrah et al. (2012) | A study to evaluate and redesign work stations at a shoes manufacturer. | 10 physical ergonomics principles (Macleod, 2013), REBA, Recommendation on concept of work stations and tools that theoretically reduced risks related to MSDs |
| 22 | Apriyandhi (2012) | A study to improve productivity at thread spinning work station of a small textile industry | Observation, interview and own questionnaire on the existing work station; anthropometry, A concept of the work station that theoretically improved working posture |
| 23 | Arta et al. (2012) | A study to evaluate working postures while operating a traditional ice cream making machine and redesign of the machine | SNQ, anthropometry, A concept design of ice cream maker that theoretically improved working postures; musculoskeletal discomfort data |
| 24 | Herdiana (2012) | An evaluation of manual material handling activities of workers at a roof | REBA, own musculoskeletal discomfort questionnaire, Some of the working postures posed risks of MSDs, musculoskeletal discomfort |
| No. | Author(s) | Study Description | Method(s) | Findings |
|-----|-----------|-------------------|------------|----------|
| 25  | Indriastuti (2012) | An investigation of working postures and manual handling activities of traditional pottery workers | Quick exposure check (QEC) | Some of working postures were of high risk due to awkward posture and repetitive motion. |
| 26  | Ilman et al. (2012) | A study to evaluate and redesign work stations at a shoes manufacturer. | QEC | A concept of work stations that theoretically reduced risks related to MSDs |
| 27  | Kristanto & Arifin (2012) | A study to evaluate working posture at a work station (bamboo slicer) of a bamboo fan manufacture and redesign of the work station | SNQ, productivity | A working prototype of bamboo slicer that reduced musculoskeletal discomfort and improved productivity and quality. |
| 28  | Kristanto & Sugiantoro (2012) | A study to redesign a sand machine for a wood craft industry | Anthropometry, productivity | A working prototype of sanding machine that improved productivity |
| 29  | Kusmawari & | A study to redesign and evaluate a new | Perceived discomfort (Borg) | Plastering with the new tool |
| Reference                      | Description                                                                                      | Methods                                                                                           | Result                                                                                           |
|-------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Yassierli (2012)              | working tool for plastering ceiling to reduce workers fatigue                                    | CR-10 scale for perceived exertion, hand grip strength, workload (heart rate and blood pressure), Maximum Voluntary Contraction (MVC) of the middle deltoid muscle | significantly cause less fatigue than the traditional tool                                      |
| Nasution and Nazlina (2012)   | A study to evaluate and redesign a work station of a farming tools manufacturer. Biomechanical analysis and human error analysis was used to quantify the improvement at the work station. | SNQ, HTA (hierarchical task analysis), FTA (fault tree analysis), HEART (human error assessment and reduction technique), biomechanical analysis | A concept of the work station and recommendation of new working procedures that theoretically reduced workers’ error & physical demand |
| Norfiza & Syahputra (2012)    | A study to redesign pineapple slicer commonly used in pineapple crisps manufacturer               | Anthropometry, productivity, own questionnaire on existing pineapple slicer tool                   | A working prototype of pineapple slicer that improved productivity and quality                   |
| Page | Reference | Study Title | Methodology | Findings/Recommendations |
|------|-----------|-------------|-------------|--------------------------|
| 32   | Nova (2012) | A study to investigate viewing distance of batik canting workers | Lighting measurement, viewing distance | Recommendation on lighting |
| 33   | Pramana (2012) | An evaluation of working postures at a small laundry service | Own questionnaire on musculoskeletal discomfort, RULA | Musculoskeletal discomfort data; some working postures posed musculoskeletal disorders risk. |
| 34   | Purwati (2012) | A study to evaluate and redesign a chair to improve sitting posture of tailor workers at a garment industry | Own questionnaire on current work station, anthropometry | A concept of a chair that theoretically improved sitting postures of workers |
| 35   | Putri & Ichsyan (2012) | A study to evaluate working postures while operating a traditional songket weaver and redesign of the weaver | RULA, anthropometry | A prototype of an improved traditional songket weaver that theoretically improved working postures |
| 36   | Rochman et al. (2012) | A study to evaluate working postures at a work station (bindery) of a printing industry and redesign of the work station | SNQ, anthropometry | A design concept of the work station that theoretically improved working posture; musculoskeletal discomfort data |
| Source | Study Description | Methods | Findings |
|--------|-------------------|---------|----------|
| Sabarudin (2012) | A study to investigate working postures of hawker with carts. | SNQ, own discomfort questionnaire | Musculoskeletal discomfort data |
| Siska & Teza (2012) | A study to investigate manual handling activities of workers at a small brick manufacturer. | NIOSH lifting equation, energy expenditure (heart rate measurement) | RWL & LI values of some activities were above the recommended limit; work load of existing working condition |
| Taufan et al. (2013) | A study to design a tool related to manual material handling and transportation at seaweed jelly manufacturer. Biomechanical analysis and REBA was used to quantify the improvement. | SNQ, REBA, biomechanical analysis | A concept of a manual handling & transportation assistant tool that theoretically reduced risks related to manual material transportation |
| Utomo (2012) | A study to evaluate working posture and musculoskeletal discomforts of tailor workers at various garment industries | SNQ, REBA | Differences in the work station arrangement of the observed industries resulted in different risk of musculoskeletal discomfort for working |
| No. | Author(s)                  | Description                                                                                   | Methods/Measurements                          | Findings/Results                                                                 |
|-----|---------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------|
| 41  | Widana (2012)             | A study to redesign a hand operated tractor                                                  | SNQ, work load (heart rate)                  | A working prototype of a hand tractor that reduced work load and musculoskeletal discomfort; and increased productivity. |
| 42  | Yuliani et al. (2012)     | An evaluation of working postures of female workers at a traditional stone mining            | REBA, own questionnaire on musculoskeletal discomfort | 40% of working activities posed high risk of musculoskeletal discomfort due to awkward posture, repetitive motion and heavy weight; musculoskeletal discomfort data |
| 43  | Yusianto (2012)           | A study to redesign a corn seeds planter                                                     | Anthropometry                                 | A working prototype of corn seed planter that improved productivity.           |
| 44  | Af-Faruqy (2011)          | A study to compare manual threshing and a pedal operated thresher                            | Work load (heart rate), productivity         | The pedal operated thresher resulted in higher productivity and lower work load |
| Reference | Title | Methodology | Results/Findings |
|-----------|-------|-------------|-----------------|
| Ariati & Dewantara (2011) | A study to investigate workload of workers and thermal condition at a small foundry industry | Work load (heart rate), thermal measurement | Work load of workers were found to be high. Recommendation on rest period was given. |
| Dewi (2011) | A study to evaluate activities of farmers while using a traditional work tool for tillage in marshland and redesign the work tool | Workload (heart rate), anthropometry, motion study | A design concept of the work tool that theoretically reduced work load during the activities |
| Atmanto (2011) | A study to investigate factors that contribute to the use of PPE in a foundry industry | Observation, interview and own questionnaires | Organisation, availabilities & practicalities of PPE affected the use of PPE by workers |
| Fatah et al. (2011) | A study to investigate work load of a hand operated soybean dehuller | Work load (heart rate, oxygen consumption) | A modification was required to reduce the workload of an operator |
| Fitriasari (2011) | A study to analyse and redesign work stations at a crackers manufacturers. | SNQ, OWAS, biomechanical analysis, anthropometry | Improved work stations that resulted in better working postures for workers |
| Page | Authors                        | Title                                                                 | Methodologies                              | Findings/Results                                                                 |
|------|-------------------------------|----------------------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------------------------|
| 50   | Hanafi et al. (2011)          | A study to improve an existing design of turntable for pottery workers | SNQ, work load (heart rate), RULA          | A design concept of turntable & its seating                                       |
| 51   | Hanafie et al. (2011)         | A study to redesign a hand operated combined harvester                | Anthropometry                              | A prototype of combined harvester                                                  |
| 52   | Josephus (2011)               | An ergonomics intervention for fisherman of small seiners fleet       | Total ergonomics approach                  | The intervention resulted in a lower workload, fatigue, musculoskeletal discomfort and increased productivity |
| 53   | Muslim et al. (2011)          | An evaluation of working postures of workers at various work stations at a garment industry | Virtual assessment of PEI (LBA, RULA and OWAS) in Jack | Some of work stations required improvement to reduce musculoskeletal disorder risks |
| 54   | Purnomo & Ferdianto (2011)    | An investigation of macro ergonomics factors that affected productivity in a traditional mendong (globe fimbry) hand craft industry | Own questionnaire                         | Organisation was found to affect productivity                                       |
| 55   | Rahmawati &                   | A study to investigate the relationship                              | Anthropometry, demography                  | There was a significant relationship                                              |
|   | Author(s)                        | Study Title                                                                 | Methodologies                                                                 | Outcome                                                                 |
|---|----------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------|
| 56| Sugiharto (2011)                 | between sitting posture and cumulative trauma disorder (CTD) in sanding      | data collection, work station measurement, observation of sitting postures.    | between sitting posture and CTD                                         |
|   |                                  | workers at a furniture manufacturer.                                        |                                                                               |                                                                        |
| 57| Ristyowati (2011)                | A study to redesign a trolley for manual material transportation for workers  | Anthropometry, REBA, work load (heart rate)                                  | A working prototype of trolley that improved working postures of workers and reduced their work load. |
|   |                                  | at a stone mining                                                           |                                                                               |                                                                        |
| 57| Sari (2011a)                     | A study to redesign a leaf trolleys to transfer tea-leaves between work      | Own musculoskeletal discomfort questionnaire, anthropometry, RULA, productivity| A working prototype of leaf trolley that improved working postures and increased productivity |
|   |                                  | stations                                                                     |                                                                               |                                                                        |
| 58| Sari et al. (2011b)              | A study to redesign the finishing work station at a guitar manufacturer.      | Interview, observation, SNQ, RULA, anthropometry.                             | An improved work station that resulted in better working postures for workers |
| 59| Setiawan et al. (2011)           | A qualitative study to investigate the implementation of occupational health and safety at a wood processing SME | Interviewing employee and employers, observation at and risks identification of the | Recommendation to improve the occupational health & safety measures     |
| Page | Author(s)            | Title                                                                 | Methods                                                                                           | Findings                                                                                                                                                                                                 |
|------|----------------------|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 60   | Siswiyanti & Lutfianto (2011) | An investigation of two sitting postures of batik canting workers | SNQ, industrial fatigue questionnaire (RCIF - Japan), work load (heart rate), productivity output | The use of stool (instead of sitting on the floor) significantly increased productivity and reduced musculoskeletal discomfort and fatigue.                                                                                   |
| 61   | Sundari (2011)       | A study to investigate working posture of pottery workers              | Work load (heart rate), SNQ                                                                       | Work load and musculoskeletal discomfort data.                                                                                                                                                          |
| 62   | Surata et al. (2011) | A study to evaluate and redesign working postures of workers while drying seaweed. | SNQ, workload (heart rate measurements), fatigue (30 items of fatigue questionnaire), productivity, quality of dried seaweed | An improved work station which reduced MSD complaints, fatigue, workload; and increase of productivity & quality.                                                                                       |
| 63   | Widhyasari (2011)    | A study of workers' activities on board of a small fishing ship       | Interview, observation                                                                             | Recommendation of design and work tools to improve existing working condition.                                                                                                                            |
| 64 | Wijaya (2011) | A study to redesign a hand operated mechanised corn seed planter | Anthropometry, productivity | A prototype of a corn seed planter |
|----|---------------|---------------------------------------------------------------|-----------------------------|-----------------------------------|
| 65 | Yahya (2011)  | A study to redesign manual traditional weaver                | Anthropometry, productivity | A prototype of an improved weaver |
| 66 | Achiraeniwati & Rejeki (2010) | A study to evaluate working postures at a work station (sole installation) of a shoes manufacture industry and redesign the work station | Interview, own musculoskeletal discomfort questionnaire, RULA, anthropometry | The new work station improved productivity and promote better working postures |
| 67 | Hastuti & Sugiharto (2010) | A qualitative study to establish factors that contributes to cumulative trauma disorders to tailors at a garment industry. | SNQ, anthropometry measurements, work station measurements, observation of sitting postures | There was significant relationship between CTD and sitting posture |
| 68 | Izzhati (2010) | An evaluation of a redesigned tofu slicer at a tofu manufacturer | RULA | A design concept of tofu slicer that theoretically improved working postures |
| No. | Author(s)          | Research Question/Methodology                                                                 | Data Collection Tools                                                                 | Findings/Results                                                                 |
|-----|--------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 69  | Kristanto & Manopo (2010) | A study to evaluate working postures at a work station (cutting) of a chrome plating industry and redesign the work station | Anthropometry, productivity, own musculoskeletal discomfort questionnaire | The new work station improved productivity and reduced musculoskeletal discomfort. |
| 70  | Netrawati (2010)     | An ergonomics intervention for workers at a tofu manufacturer                                | Work load (heart rate), productivity, own questionnaire on fatigue | Allocating rest period accompanied with providing sweet beverage increased the productivity of workers and reduced workers' work load and fatigue. |
| 71  | Nisa (2010)          | A comparison of environmental ergonomics (sound and lighting) between a SME & non-SME garage specialising in farming machineries and tools. | Noise and lighting measurements                                                         | No differences were found; noise level at both places was above the recommended limit. |
| 72  | Pratiwi et al.       | A study to evaluate of work stations at a SNQ, own questionnaire,                            | SNQ, own questionnaire,                                                              | A design concept of work stations and |
|    | Author (Year) | Research Description | Methods | Key Findings |
|----|---------------|----------------------|---------|--------------|
| 73 | Riyadi (2010) | A qualitative study to establish factors that contributes to carpal tunnel syndrome for workers at a dairy farming | Own questionnaire on CTS, direct inspection (Phlane's test, Tinel's test, Pressure Test) | The length of employment had significant relationship with the prevalence of carpal tunnel syndrome |
| 74 | Setyaningsih et al. (2010) | A study to identify occupational risk of female workers at a traditional stone mining | Hazard Identification and Risk Assessment (HIRA), interview | There was a high accident rate (61%), risks for work activities were identified. |
| 75 | Setyaningrum, R. (2010) | A study to evaluate workers' manual material handling activities at a construction industry | Work load (heart rate) | Work load assessment showed that current manual material handling activities required improvements. |
| 76 | Sulistyosari (2010) | An evaluation of various weeding activities of paddy fields | Work load factor (heart rate measurement), productivity | Mechanized weeder was found to be the most effective. |
| 77 | Sundari (2010) | A study to evaluate working postures of tofu manufacturer and redesign them | Observation | Recommendation of rest periods during |
| Study Reference | Description | Methods | Findings |
|-----------------|-------------|---------|----------|
| Adiatmika (2009) | An evaluation of participatory ergonomics intervention at a metal crafting industry | Total ergonomics approach | Ergonomics intervention increased productivity and reduced musculoskeletal complaints and fatigue |
| Arimbawa et al. (2009) | An investigation of the effect of ergonomics interventions as a result of working tools redesign. The study involved workers at coconut oil manufacturer. | Workload (heart rate measurements), fatigue (30 items rating), productivity, SNQ | Redesigning working tools increased the workers performance. |
| Bangun (2009) | A study to evaluate and redesign a workstation (cassava peeling) at a cassava crisps industry. | SNQ, reaction time. | Dimensions recommendation for the work station that theoretically improved work postures and reduced fatigue |
| Hutagalung & Manuaba (2009) | An ergonomics intervention for female traditional porters at a traditional market | Anthropometry, biomechanics analysis, own questionnaire on | The intervention reduced fatigue, musculoskeletal discomfort and work |

farmers while ploughing paddy fields manually.
| Page | Study | Description | Methodology | Findings |
|------|-------|-------------|-------------|----------|
| 82   | Mulyaningrum (2009) | A study to evaluate manual material handling of workers at a computer store and repair centre | Work load (heart rate), biomechanical analysis | While the workload was still within the recommended limit, the results of biomechanical analysis showed that changes on manual material handling was required. |
| 83   | Pratiwi et al. (2009) | A qualitative study to establish factors that contributes to low back pain for jamu gendong (sellers carrying traditional beverages) workers | Interview & observation | Sitting posture was found to significantly affect low back pain. |
| 84   | Prihandoyo et al. (2009) | An assessment of environmental ergonomics factors (sound, temperature, vibration and lighting) and risk | Noise level, temperature, lighting and vibration measurements; observation at | Recommendation on environmental ergonomics and identified risk. |
| #  | Reference | Study Title                                                                 | Methodology | Conclusion |
|----|-----------|------------------------------------------------------------------------------|-------------|------------|
| 85 | Putro (2009a) | A study to design a pedal operated cassava slicer | Anthropometry, productivity | A prototype of a pedal operated cassava slicer which was |
| 86 | Putro (2009b) | A study to redesign a cart used by porters to manually transport batik at a batik market | Anthropometry, digital human modelling | A prototype of the new design that theoretically improved working postures |
| 87 | Wibawa (2009) | An assessment of manual material handling of work stations at a brick manufacturer. | NIOSH lifting equation, energy expenditure (heart rate measurement) | Modifications of lifting distance and working posture at the work stations that theoretically reduce the risk of MSDs |
| 88 | Widharto (2009) | An evaluation and redesign of work stations at traditional pottery industries. | OWAS, energy expenditure (heart rate measurement) | Modifications on work stations that resulted in better working postures and lower energy expenditure |
| 89 | Abdullah (2008) | A study to investigate suitable materials | Vibration measurement | Suitable material & thickness to reduce |
| #  | Author (Year)                | Study Description                                                                 | Measures                                                                 | Findings                                                                 |
|----|------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 90 | Akbar (2008)                 | A study to simulate suitability of two different hand operated tractors to optimise productivity | Thermal, noise and vibration measurements, anthropometry, productivity, work load | A hand tractor with rotary implement should be used in low environment temperature |
| 91 | Andriyanto (2008)            | An evaluation of working postures and work load of workers at a paddy hulling industry | Work load (heart rate measurement), OWAS                                | Working postures related to manual material handling posed musculoskeletal discomfort risk |
| 92 | Aryanto (2008)               | An investigation of working postures of tailors at various garment industry        | REBA, SNQ                                                                | Differences in the work station arrangement of the observed industries resulted in different risk of musculoskeletal discomfort for working postures of the same activities; musculoskeletal discomfort data |
| 93 | Fitrihana (2008)             | A study to evaluate an ergonomics                                                | Participatory ergonomics                                                  | The intervention resulted in reduced                                     |
| #  | Author(s)                   | Study Description                                                                 | Methodology                                                                 | Findings/Recommendations                                                                 |
|----|-----------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 94 | Herdiman et al. (2008)      | A study to improve productivity at a furniture manufacturer. Industrial engineering-based approach and ergonomics analysis were applied. | Biomechanical analysis, work station design, a plant layout study, productivity rate | Recommendation of plant layout and work stations design                                   |
| 95 | Kurniawan et al. (2008)     | A qualitative study to establish factors that contributes to Carpal Tunnel Syndrome to jasmine flower pickers | Interview, own questionnaire on MSD | Repetitive motions had significant relationship with carpal tunnel syndrome.             |
| 96 | Mardiyanto (2008)           | An evaluation of working postures at a tofu making industry                        | RULA, SNQ                                                                  | Musculoskeletal discomfort data; a recommendation of changes in work stations and tools that theoretically improved working postures |
| 97 | Nugroho (2008)              | A study to redesign peanut peeler                                                | SNQ, productivity, work load                                                | A working prototype of peanut peeling                                                  |
|   | Author(s) | Title | Methods | Findings |
|---|-----------|-------|---------|----------|
| 98 | Nurmiyanto (2008) | A study to evaluate working posture of handicraft workers and redesign their work station | SNQ, anthropometry, RULA | Adjustable table and height theoretically improved working postures and was perceived positively by workers. |
| 99 | Nurullita (2008) | An assessment of environmental condition (lighting, noise, thermal) in a tofu manufactures | Lighting, noise and thermal measurements; interview with employees | Most of lighting, noise and thermal parameters were beyond the recommended limit, resulting in discomforts from employees |
| 100 | Oesman & Adiatmika (2008) | A practical guideline in applying participatory ergonomics for small scale industries | Total ergonomics approach | Practical guideline |
| 101 | Purnawati (2008) | A practical guideline in applying participatory ergonomics to reduce pesticides intoxication on farmers | Total ergonomics approach | Practical guideline |
|   | Name                          | Study Description                                      | Methodologies                          | Findings                                                                 |
|---|-------------------------------|--------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------|
| 102 | Prastiwi(2008)                | A study to evaluate activities of workers at a tofu making industry | Strain Index                           | Dimension adjustment and additional work tool were required for one of work stations |
| 103 | Rohman (2008)                 | A study to investigate activities of farmers while harvesting sugarcane plants | Biomechanics analysis, time and motion study | A recommendation on a new method of harvesting                             |
| 104 | Simanjutak (2008)             | A study to investigate manual material handling at a roof tile manufacturer | NIOSH lifting equation, job severity index | Change of load’s horizontal location was recommended for one of manual material handling that was of high risk |
| 105 | Siswiyanti et al. (2008)      | A study to design a fish smoking equipment              | Anthropometry, Quality Function Deployment (QFD) | A design concept of smoking equipment created based on anthropometry measures of Indonesian |
| 106 | Susetyo et al. (2008)         | A study to investigate musculoskeletal discomfort and fatigue of workers at a silver handicraft industry | Lighting & thermal measurement, fatigue questionnaire (RCIF - Japan) | Fatigue and musculoskeletal discomfort were reported by workers; a recommendation |
| Number | Author(s) (Year) | Study Description | Methodology | Findings |
|--------|-----------------|-------------------|-------------|----------|
| 107    | Suwondo et al. (2008) | A study to investigate intervention on drinking water consumption to workers of a work station (deep frying) at a traditional banana snack industry | Thermal measurements, blood pressure before and after work were compared. | Consuming drinking water hourly reduced the effect of constant exposure to high temperature |
| 108    | Wijaya (2008) | A study to evaluate work stations at a tofu making industry and redesign them | OWAS, SNQ, anthropometry, digital human modelling | Musculoskeletal discomfort data; a design concept of work station that theoretically improved working postures |
| 109    | Andjarsari (2007a) | A study to design charcoal briquettes oven for peanuts drying processing. | Anthropometry, productivity | Improved productivity as indicated by lower standard time & higher standard-output.; reduction of fuel cost by 29%. |
| 110    | Andjarsari (2007b) | A qualitative study on the implementation of health and safety in small industries. | Observational study, interview with workers and owners (sample size not reported), | Human (people, unsafe action), unsafe conditions & technical equipment accounted for 85%, 10% & 5% of work-related accidents (respectively) |
| Page | Author(s) | Title | Methods | Findings |
|------|-----------|-------|---------|----------|
| 111  | Astuti & Suhardi (2007) | An evaluation and redesign of manual material handling activities at a tiles manufacturers. | SNQ, OWAS | Identification of working postures that posed MSDs risk to workers. |
| 112  | Budiharti (2007) | A study to evaluate and redesign furnace in ceramic home industry. | Anthropometry, productivity, biomechanics analysis | A new design of combination of hot furnace & drying machine increased productivity and reduced torque load at the back. |
| 113  | Gustopo & Andjarsari (2007) | A study to evaluate and redesign banana chips slicer in food home industry. | Anthropometry, productivity, biomechanics analysis | Improved productivity (lower standard time & higher standard-output); reduced torque load at the back. |
| 114  | Hanafie (2007) | A study to redesign a paddy thresher | Work load (heart measurement), SNQ, productivity | A prototype of a paddy thresher that increased productivity and reduced musculoskeletal discomfort and energy |
| Page | Authors (Year) | Study Title | Key methodologies | Result |
|------|---------------|-------------|-------------------|--------|
| 115  | Haslindah (2007) | An evaluation and redesign of paddy thresher | Anthropometry, biomechanics analysis | Biomechanical load was theoretically reduced following adjustment of the height of thresher was modified to |
| 116  | Indriani (2007) | A study to evaluate and redesign autoclave for tenderizing meat based on current workers anthropometry data to increase productivity (standard-time & standard product output) | Anthropometry, productivity | Improved productivity (lower standard time & higher standard-output). |
| 117  | Kalsum (2007) | A study to compare the use of stool and a combination of ergonomically designed chair and table for workers at a traditional broomstick | Body area discomfort (Daley et al., 1995), productivity | The use of chair and table increased productivity and reduced musculoskeletal discomfort |
| 118  | Liquiddanu et al. (2007) | A study to design a work tool to assist quality control at a shuttle cock | Anthropometry | A design concept of the work tool that was created based on anthropometry |
| Manufacturer | Study Title | Methods | Results |
|--------------|-------------|---------|---------|
| Marhaendra  (2007) | A study to redesign rice-hulling machine | Noise measurement | A design concept to reduce noise by adding absorbing coating |
| Muslikhatun (2007) | A study to compare the use of traditional and conventional corset in female porters | SNQ, work load (heart rate) | Traditional corset was more effective than conventional corset |
| Nawawinetu & Adiyani (2007) | A study to investigate the effect of noise to workers at a rice-milling industry | Interview, noise measurement | Noise level was above the recommended limit; there was significant relationship between level of noise & headache. |
| Oesman, T. I. | A study to evaluate redesigned rattan chair & provision of background music in textile-based hand-craft workers | Anthropometry, Nordic Body Map, Nordic Finger Map, fatigue (30 items rating) | Reduced musculoskeletal discomfort and fatigue; improved productivity. |
| Oesman & Adiatmika | A study to identify problems of working conditions in a metal painting industry. | Total ergonomic approach (SHIP) involving workers, | 49 problems were identified which included, among others, |
| 124 | Purnomo et al. (2007) | An evaluation of participatory ergonomics of pottery workers | Total ergonomics approach | The approach increased productivity and reduced workload, fatigue and musculoskeletal discomfort |
| 125 | Radiwan & Ariati (2007) | Redesign of traditional split tool to reduce musculoskeletal discomfort & workload | Anthropometric, Nordic Body Map questionnaire, heart rate measurement | Musculoskeletal discomfort and workload were significantly reduced by 7.84% and 36%, respectively. |
| 126 | Sucipto (2007) | A qualitative study to establish factors that contribute to reduced lung capacity as a result of limestone processing industries | Air quality measurements, lung capacity measurement | The location of furnace had significant relationship with reduced lung capacity |
| 127 | Sudiajeng et al. (2007) | A study to analyze risk & hazard during stone walls construction | Total ergonomics approach/SHIP | Proposed affordable solutions w.r.t. nutrition, working posture, muscle use, |
| Page | Study Reference   | Description                                                                 | Tools/Methods                                                                 | Findings/Results                                                                 |
|------|-------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| 128  | Utomo (2007)      | Evaluation of work posture (sitting on the floor) in a shoes production home industry | Nordic body map questionnaire, own questionnaire to assess fatigue. | Provision of desks & chairs for workers and dust collection-equipment in existing work station reduced subjective fatigue & musculoskeletal discomfort |
| 129  | Hadiguna & Monasari (2006) | A study to redesign a wheel barrow                                             | Own questionnaire on musculoskeletal discomfort, anthropometry, biomechanical analysis | A set of design characteristics for a wheelbarrow was recommended |
| 130  | Muslimah et al. (2006) | A study to evaluate manual material handling activities of porters          | NIOSH lifting equation, work load (heart rate)                              | Although the workload was low, the weight of loads was above the recommended limit. |
| 131  | Najamuddin (2006)  | A study to evaluate productivity and workload of traditional weaving       | Work load (heart rate), productivity output                                | Unnecessary movements increased workload                                         |
| Reference | Description |
|-----------|-------------|
| Soewarno (2005) | A study to evaluate working posture and conditions of workers at a bullet hand craft industry. Dimensions of work station (table and chair) that theoretically improved working posture was recommended. |
| Adan et al. (2004) | Work bench design of emping cracker's production using Indonesian anthropometric data based on interpolation of British & Hongkong anthropometric data. Product capacity was recorded throughout 30 days before and after using the new work-bench. Productivity improvement was found as well as reduced musculoskeletal discomfort. |
| Ahmad (2004) | A study to evaluate a redesigned seat for tailors at a garment industry. The redesigned seat reduced work load, musculoskeletal discomfort and increased productivity. |

Methods used:
- Observation, SNQ, thermal and lighting measurements
- Anthropometry, productivity output, own questionnaire on musculoskeletal discomfort
- Work load (heart rate), productivity, work posture, own musculoskeletal discomfort questionnaire
| No. | Author(s) (Year) | Description | Measured Parameters | Results |
|-----|-----------------|-------------|---------------------|---------|
| 135 | Astika (2004)   | Addition of coupling on hand tractors to reduce workload and musculoskeletal discomfort | Workload (heart rate), Nordic body map questionnaire, productivity output | Reduced workload by 13%, musculoskeletal discomfort 22%, and increased productivity by 17% |
| 136 | Gustopo et al. (2004) | Redesign silver flattening tool using current operators' anthropometric data | Anthropometry, productivity | Reduced product completion time by 35% & increased product output by 76% |
| 137 | Ismayenti (2004) | A study to evaluate a redesigned tobacco leaves slicer | Own musculoskeletal discomfort questionnaire, productivity | The redesigned tobacco slicer increased productivity and reduced musculoskeletal discomfort |
| 138 | Mughni (2004)   | Evaluation of the effect of multi scenario rest-break schedule (30" work/5" break, 15" work /2.5" break) on ironing tasks in laundry service | Own questionnaire, productivity | 15" work /2.5" break resulted in highest productivity improvement and reduced musculoskeletal discomfort |
| 139 | Nuada (2004)    | Assessment of workload, musculoskeletal discomfort & work environment on 6 rock cutting workers | Workload (heart rate), Nordic Body Map, measurement of thermal, humidity and noise | Workload level was identified as light work, static muscular loading in repetitive works caused |
| Study Number | Reference | Description | Methodology | Findings |
|--------------|-----------|-------------|-------------|----------|
| 140          | Oesman (2004) | Assessment of working posture (carrying the load on the back) in manual handling workers | Biomechanics analysis | Compression force at joint L5/S1 is still within permitted limit by NIOSH standard |
| 141          | Sarimurni & Murtopo (2004) | A study to compare the use of stool and ergonomically designed chair for batik workers | Anthropometry study, reaction time, own fatigue questionnaire | The use of ergonomically designed chair significantly reduced reaction time measured after work and reduced fatigue level |
| 142          | Santiana & Yusuf (2004) | Design and evaluation of traditional power thresher for female farmers. | Nordic body map questionnaire, workload (heart rate), anthropometry | Improvement on productivity and reduced discomfort and workload |
| 143          | Suarbawa | Assessment of snack & fluid provision | Nordic Body map | Workload, subjective level of fatigue & |
| Source | Year | Methodology | Findings |
|--------|------|-------------|----------|
| Sucipta Putra (2004) | 2004 | During short break on 36 workers towards work load, subjective level of fatigue & musculoskeletal discomfort | Questionnaire, workload (heart rate), musculoskeletal discomfort were significantly reduced |
| 144 | Observation to describe current existing conditions (workload & physical environment) in a forging workstation. Workload was assessed by workers' heart rate measurement (5 subjects) while thermal environment & humidity were also assessed. | Temperature was not in a comfortable range (extreme heat), workload was categorized as low |
| Tarigan et al. (2004) | 2004 | A study to investigate the effect of workload on low back pain (LBP) in manual labourer | Apley Solomon & Oswestry LBP Disability questionnaire, Weight lifted exceeded the government's RWL (40 kgs); no significant relationship between lifting frequency and LBP |
| 145 | Ushada & | A study to redesign and evaluate work | Own questionnaire, Lack of significant increased |
|   | Author(s) (Year) | Description | Methodology | Findings |
|---|-----------------|-------------|-------------|---------|
|147| Purwanto (2004) | station & methods based on preference of workers in emping cracker's industry. | observation, productivity | productivity mainly due to reluctance of workers to adopt the redesigned work station & methods. |
|147| Wahyu et al. (2004) | Evaluation of productivity in relation to worker's fatigue on workers in emping cracker's production work station for 3 weeks | Fatigue (heart rate), productivity | Productivity (output rate and defect) varied throughout the day whereas the heart rate increased between 7 - 9 am & followed by steady decrease. |
|148| Wardhani et al. (2004) | Evaluation of working environment (temperature, lighting & noise) on furniture production work station | Temperature, lighting and noise measurements | No significant differences on lighting & noises between morning & noon were found; however, significant differences were found w.r.t. temperature |
|149| Yusuf & Santiana (2004) | Evaluation of short break and snack intake on workers workload, musculoskeletal discomfort & productivity | Workload (heart rate), Nordic body map questionnaire, productivity | Workload & musculoskeletal discomfort were significantly reduced & productivity was improved |
| Page | Author(s)         | Title                                                                 | Methods                          | Findings/Results                                                                 |
|------|------------------|----------------------------------------------------------------------|---------------------------------|---------------------------------------------------------------------------------|
| 150  | Jasman (2003)    | An investigation of comfort related to the use of chair and table with various dimensions for workers at a cracker manufacturer. | Own discomfort questionnaire, productivity | Ergonomically designed chair and table reduced discomfort and increased productivity |
| 151  | Tirtayasa et al. (2003) | A study to investigate ergonomics intervention on working posture through the introduction of alternate sitting and standing for workers of a work station (sharpening) at a Balinese gamelan manufacturer | Work load (heart rate), SNQ | Alternate sitting and standing reduced musculoskeletal discomfort and work load in comparison to prolonged sitting working posture |
| 152  | Dhafir (2002)    | A study to evaluate the use of a hand tractor                         | Anthropometry, work load (heart rate), time and motion study | The workload to operate the hand tractor was categorised as heavy; it performed best in straight line trajectory. |
| 153  | Kadarusman       | A study to redesign rice polisher                                      | NIOSH lifting equation,          | A design concept of rice polisher that                                           |
| Page | Author(s) | Title | Methods | Findings |
|------|-----------|-------|---------|----------|
| 154  | Mualim (2002) | A qualitative study to establish factors that contributes to pesticide intoxication in farmers | Observation, interview, blood analysis | Nutritional status had significant relationship with pesticides intoxication |
| 155  | Nasir (2001) | A study to develop a simulation to help decision making on the suitability of hand operated tractors | Anthropometry | A software which reported hand tractors suitability to anthropometry dimension of farmers as the main factor |
| 156  | Budiastra et al. (2000) | A study to investigate fatigue and musculoskeletal discomfort of workers who picked cloves | Work load (heart rate), fatigue assessment (RCIF - Japan) | Although the work load was still within the allowed limit, prolonged standing caused fatigue and musculoskeletal discomfort |
| 157  | Sena (2000) | A study to evaluate various sitting posture (on the floor, on a slopped | Fatigue questionnaire (RCIF-Japan) | Sitting on a sloped chair or a balai chair decreased workers' fatigue |
| Page | Reference | Study Title | Methods | Findings |
|------|-----------|-------------|---------|----------|
| 158  | Susila (2000) | A study to evaluate working postures of stone carvers | Observation, interview, digital human modelling | A combination of awkward and static sitting posture on a stool caused musculoskeletal discomfort and the use of a table and bench was recommended; musculoskeletal discomfort data. |
| 159  | Sutjana (2000a) | A study to evaluate a redesigned sickle for farmers | Productivity, work load (heart rate), interview | The redesigned sickle improved productivity and reduced energy expenditure of farmers. |
| 160  | Sutjana (2000b) | A qualitative study to investigate the relationship between machine use and working accidents in roof tile industries. | Interview, observation, anthropometry | A combination of the absence of safety devices on the mill and lack of workers' knowledge and adoption of safety behaviour were found to be major causes of work related accidents. |
| 161 | Wignjosoebroto & Sutaji (2000) | A study to redesign and evaluate a traditional weaver | Biomechanics analysis, anthropometry, work load (heart rate), SNQ | A prototype of traditional weaver reduced energy expenditure and musculoskeletal discomfort |