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 proprotion 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 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 (Wignjosoebroto, 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 work places. 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.

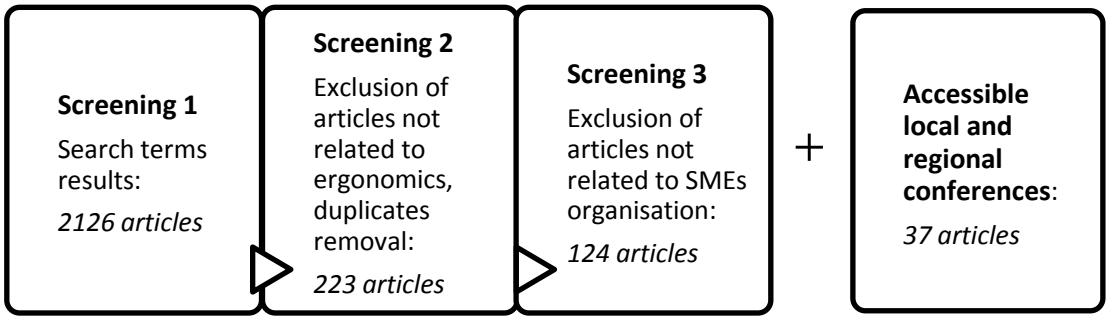

Figure 1. The results of the study selection process

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.

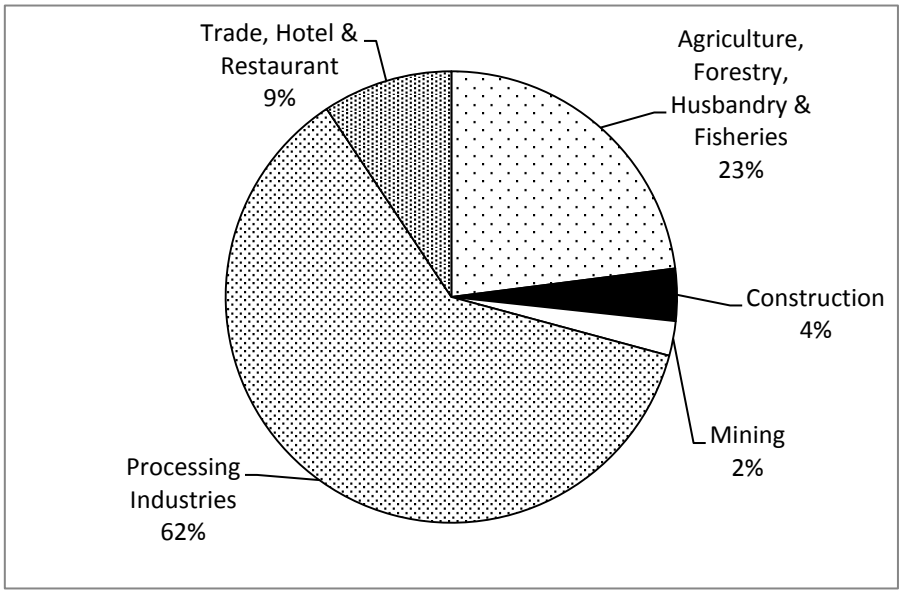

Figure 2. Sectors of ergonomics application in Indonesia

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.

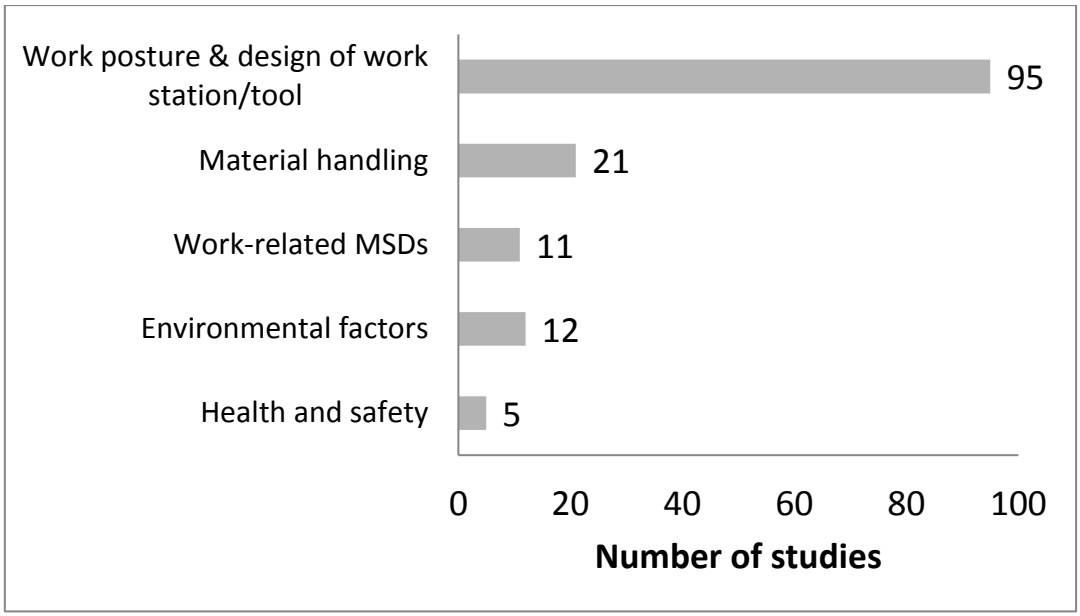

Figure 3. Ergonomics issues that were addressed in physical ergonomics domain

There is a noticeable trend of approaches in which existing or redesigned work stations 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 heath, 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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Appendix 1 – Articles which were included in the review

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.

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

		that contributes to low back pain of workers at traditional weaving industries.	postures, demography data collection, work station measurements	station design showed significant relationships with low back pain.
9	Nugroho et al. (2013)	A study to investiagate the relationsip between mechanical vibration and the occurrence of CTS on workers in furniture industry	Virbration 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 contributes 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% , ncreased productivity by

				25,78%
12	Sudarma (2013)	A study to evaluate and redesign work-chair and use of computer software on traditional Balineese music players.	Work load (heart rate), fatigue (30 items rating), Nordic Body Map	Lower subjective level of fatigue and reduced musculoskeletal discomfort particulary at the neck, back, waist, and bottom.
13	Sutajaya (2013)	A study to assess workload, musculoskeletal discomfort and fatigue before and after work in sculpturing home industry.	Workload (heart rate), no information given on how to obtaine 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

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

		parameters as the driving design factors of hawkers' portable trays		
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

		tile industry.		discomfort data
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

	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
30	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
31	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

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

37	Sabarudin (2012)	A study to investigate working postures of hawkers with carts.	SNQ, own discomfort questionnaire	Musculoskeletal discomfort data
38	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
39	Taufan et al. (2013)	A study to design a tool related to manual material handling and transportation at sea weed 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
40	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

				postures of the same activities; musculoskeletal discomfort data
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

				than manual threshing.
45	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.
46	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
47	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
48	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
49	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

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

	Sugiharto (2011)	between sitting posture and cumulative trauma disorder (CTD) in sanding workers at a furniture manufacturer.	data collection, work station measurement, observation of sitting postures.	between sitting posture and CTD
56	Ristyowati (2011)	A study to redesign a trolley for manual material transportation for workers at a stone mining	Anthropometry, REBA, work load (heart rate)	A working prototype of trolley that improved working postures of workers and reduced their work load.
57	Sari (2011a)	A study to redesign a leaf trolleys to transfer tea-leaves between work stations	Own musculoskeletal discomfort questionnaire, anthropometry, RULA, productivity	A working prototype of leaf trolley that improved working postures and increased productivity
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

			workplace	
60	Siswiyanti & Luthfianto (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

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,	A design concept of work stations and

	(2010)	tofu manufacturer and redesign them	anthropometry	work tools that theoretically improved working postures and productivity
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	Observation	Recommendation of rest periods during

		farmers while ploughing paddy fields manually.		ploughing activities
78	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
79	Arimbawa et al. (2009)	An investigation of the effect of ergonomics interventions as a results 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.
80	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
81	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

			fatigue and musculoskeletal discomfort, work load (heart rate), productivity	load while at the same increased productivity.
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

		identification at a plastic processing manufacturer.	work stations	
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

		to reduce vibration on a hand operated tractor		vibration on hand tractor was reported.
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

		interventon for workers at a garment industry		musculoskeletal discomfort and increased productivity and product quality
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

			(heart rate)	machine which improved productivity and reduced energy expenditure
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

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

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)

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. based on operators' anthropometric data in ceramic vessels home industry to improve productivity and reduce torque load	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 toque 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

				expenditure
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		data of Indonesians
119	Marhaendra (2007)	A study to redesign rice-hulling machine	Noise measurement	A design concept to reduce noise by adding absorbing coating
120	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
121	Nawawinetu & Adiyani (2007)	A study to investigate the effect of noice to workers at a rice-milling industry	Interview, noise measurement	Noise level was above the recommended limit; there was significant relationshio between level of noise & headache.
122	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.
123	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,

	(2007)		industrial owners, medical & ergonomics students & immediate general public.	musculoskeletal discomfort, working time, physical enviroment, PPE, information and work cost.
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 discomfor & 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 contributes to reduced lung capacity as a results 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,

				physical environment, work-rest schedule, organisational culture
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 characteristicsfor 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

		machine workers		
132	Soewarno (2005)	A study to evaluate working posture and conditions of workers at a bullet hand craft industry	Observation, SNQ, thermal and lighting measurements	Dimensions of work station (table and chair) that theoretically improved working posture was recommended.
133	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	Anthropometry, productivity output, own questionnaire on musculokeletal discomfort	Productivity improvement was found as well as reduced musculoskeletal discomfort
134	Ahmad (2004)	A study to evaluate a redesigned seat for tailors at a grament industry	Work load (heart rate), productivity, work posture, own musculoskeletal discomfort questionnaire	The redesigned seat reduced work load, musculoskeletal discomfort and increased productivity

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 effectof 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 enviroment 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

				musculoskeletal discomfort, temperature was too high, noise exceed the permissible level & increased risk of silicosis due to lack of PPE usage.
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 &

	(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	Sucipta Putra (2004)	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
145	Tarigan et al. (2004)	A study to investigate the effect of work load 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
146	Ushada &	A study to redesign and evaluate work	Own questionnaire,	Lack of significant increased

	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 through out 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 fround; 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

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 questionaire, 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 (sharperning) 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

	(2002)		anthropometry	theoretically improved productivity and reduced the risk due to manual material handling
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 musculoksletal discomfort of workers who picked cloves	Work load (heart rate), fatigue assesment (RCIF - Japan)	Although the work load was still within the allowed limit, prolonged standing caused fatigue and musculoskletal discomfort
157	Sena (2000)	A study to evaluate various sitting posture (on the floor, on a slopped	Fatigue questionnaire (RCIF-Japan)	Siiting on a sloped chair or a balai chair decreased workers' fatigue

		chair, on a balai chair) for workers at a traditional loom industry		
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 musculokeletal 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	Productivty, 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