Implementation of Total Ergonomics Approach through Multidisciplinary Sciences for the Improvement of Workers’ Health Quality: Literature Review Doctoral Dissertation Udayana Bali-Indonesia

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Abstract

Total Ergonomics Approach is application of SHIP (Systemic, Holistic, Interdisciplinary and Participatory) through appropriate technology consideration in conducting design of working condition, work attitude and work system. The Total Ergonomics Approach model has been implemented in various disciplines such as Industrial, Agriculture, Fisheries, and Computer design, Education, Health, Hospitality, Building and Religious. Since 2006 to 2016 (10 years) was found nine scientific sectors that apply the concept of Total Ergonomics Approach. The results of the implementation indicate an incensement in the quality of workers’ health through the reduction of musculoskeletal complaints, fatigue, workload and some other complaints as an impact of ergonomic intervention. The science of ergonomics can be applied to solve various problems in a multidisciplinary range of sciences. Ergonomic improvements take account of human abilities, skills and limitations. Humans become the main factor in every design and improvement work.

Keywords: Total Ergonomics, quality of work health, SHIP.

Introduction

The Total Ergonomic Approach is done Systemically, Holistically and through interdisciplinary and participatory approaches known as SHIP studies, so that the wants and needs can provide an alternative solution to the current problem [1, 2]. The SHIP approach is able to solve problems that are in various sectors [3, 4, 5, 6, 7].

Total Ergonomics considers ergonomic problem solving by using 8 elements, including: energy or nutritional status, musculoskeletal utilization, posture, time, social, environment, information, man-machine interface [8,9]. Implementation of Total Ergonomics Approach affects the improvement of workers’ health quality in the form of musculoskeletal complaint, fatigue and work load reduction.

Musculoskeletal Complaints

Musculoskeletal complaints are the level of complaints in the muscle and bone system, including joints and surrounding soft tissues that are caused by workers’ factors and work environment [10]. It is often called musculoskeletal disorder (MDS), some companies’ prevalence rates exceed in the amount of 80% [11, 12]. The development of work activity, especially in industry that does not pay attention to work environment and work equipment, impacts the onset of workers’ musculoskeletal disorder [12, 13, 14, and 15].
Unnatural and repetitive work attitudes can increase the risk of cumulative traumatic disorder [16, 17], as well as increasing the risk of accidents in various musculoskeletal disorders [18].

**Fatigue**

Fatigue is a condition of work capacity and body resistance reduction [19], impacting on performance degradation [20, 21]. Workers cannot do work activities again and receive workload. There are two types of fatigue, namely (1) physical fatigue that happens because of physiological changes, are caused by continuous stimulation, and (2) fatigue that is occurred and is seen in unstable mental conditions known as pseudo-fatigue [22].

**Workload**

There are two types of workloads: External load (stressor) for example workload that is obtained from work, which is being completed with special characteristics that apply to everyone, for example, task, organization and environment. The workload of internal load (strain) is the workload that comes from within the worker's own body such as expectations, desires and satisfaction [22, 23, 24]. The higher the activity of a person's body causes the body metabolism that can increase and impact on the need of O₂ which is also greater and the frequency of the pulse will continue to increase [25].

**Method**

The method that was undertaken in this article review is to trace all research reports especially doctoral dissertation at Udayana University, Denpasar, Bali-Indonesia by criteria research that apply the concept of Total Ergonomics Approach. It was found nine scientific sectors that apply the concept of Total Ergonomics Approach. The presentation of result in the researches or outcomes (dependent variable) of the ergonomic intervention is limited to the results review in improving workers' health quality through decreasing musculoskeletal complaints, fatigue, workload and other effects as a dominant effect on the improvement of work attitude.

**Result**

The results of the study are found that several scientific fields have applied the concept of Total Ergonomics Approach. This is as evidence that the concept of Total Ergonomics Approach can be applied to various disciplines. The fundamental difference is located in the range of interventions that are adapted to the scientific concentrations of each discipline by each researcher.

**Improvement of Workers Health Quality through Total Ergonomic Model Interventions in Industrial Sector**

Adiatmika [26], improves working conditions with a total ergonomic approach to metal painting craftsmen in Kediri Tabanan. The results are obtained that the existence of total ergonomic intervention through improvement of working conditions that cause a change in the form of workers' musculoskeletal complaints in the metal foundry industry in amount of 5.53%, and reduction of fatigue in amount of 6.97%.

Purnomo [27], improves work system through Total Ergonomic Approach at Pottery Industry in Kasongan, Bantul. The result of this research can be concluded that working system with total ergonomic approach can decrease workers' musculoskeletal complaint in amount of 87.8%, decrease workers' fatigue in amount of 77.5%, decrease workers' workload in amount of 21.55 beats / minute in amount of 21.69%.

Priambadi [28], performs improvements of working condition of alloy smelting workers at Balinese gamelan in Tihingan Klungkung Village. The results show that there is a reduction of workload in amount of 7.65%, musculoskeletal complaints in amount of 71.65%, reduction of general fatigue in amount of 11.30%

Siswantoro [29], modifies ergonomics-based hand grinding. Operators after using modified hand grinding, reduction of musculoskeletal complaints in amount of 19.6%, fatigue reduction in amount of 17.7% Santoso [30], improve working conditions and environments with ergonomic interventions. The results are obtained reduction of workload in amount of 17.11%, reduction of musculoskeletal complaints in amount of 37.35%, reduction of fatigue in amount of 34.11%.

Setiawan [31], designs an ergonomic Wet Blanket work station at PT. Sunan Rubber
Palangka Raya, South Borneo Province. The results show that there is a reduction of average workload in amount of 16.06%, reduction of cardiovascular in amount of 35.30%, reduction of musculoskeletal complaints in amount of 21.02%, reduction of fatigue in amount of 18.84%

Susihono [32], implements Total Ergonomic in Clean Production Technology at Batur Metals Printing Station, Ceper, Klaten. The results are obtained that there is a reduction of workload in amount of 11.31%, reduction of musculoskeletal complaints in amount of 24.87%, reduction of fatigue in amount of 20.32%, and increment of peripheral oxygen saturation in amount of 0.57%.

**Improvement of Workers’ Health Quality through Total Ergonomic Model Intervention in Agriculture Sector**

Surata [33] redesigns dryer tool and work system that is done by seaweed farmers in Ped Nusa Penida village. The results show that there is a reduction of musculoskeletal complaints in amount of 56.15%, reduction in fatigue in farmers in amount of 50.85%, reduction of physical fatigue in amount of 41.48%

Widana [34], implements ergonomics on land cultivation is done for vegetable farmers in Tabanan Bali. After the implementation of ergonomic, there is a reduction of farmers’ workload in amount 18.67%, reduction of musculoskeletal complaints in amount of 14.27% and reduction of farmers’ fatigue in amount of 13.06%. Yusuf [35], designs mulch plastic mulching tools and work systems by using ergonomic interventions for farmers in Bedugul Bali. There is a reduction in workload, musculoskeletal complaints and general fatigue.

Ratu [36], conducts a total ergonomic intervention based on the value of old ladi’s wisdom in ejection tapper in Kupang city. The results show a reduction in muscle energy in amount of 32.92%, reduction of fatigue in amount of 7.7% and reduction of musculoskeletal complaints in amount of 17.13%

**Improvement of Workers’ Health Quality through Total Ergonomic Model Intervention in Fishery Sector**

Josephus [37] conducts an ergonomic intervention in fishing process with trawling fishermen in Amurang, South Minahasa regency, North Sulawesi province. The results show that there is an increment in performance in the form of reduction in fishing workload in amount of 53.56%, reduction of general fatigue level in amount of 16.15%, reduction of musculoskeletal complaints in amount of 53.55%

Susana [38], designs the ergonomic Hybrid Solar Dryer in Banyubiru Jembrana village. The results show that there is a reduction in workload in amount of 12.99% and 14.57%, musculoskeletal complaints in amount of 26.70% and 27.02%, fatigue in amount of 23.06% and 30.43%.

**Improvement of Workers’ Health Quality through Total Ergonomic Model Intervention in Computer Design Sector**

Wijaya [39], There is efficiency of electrical energy usage in computer laboratory of electrical engineering department of Udayana university and ergonomic design. The results show that there is 58% reduction in eye fatigue, general fatigue reduction in amount of 47%, 40% reduction in musculoskeletal complaints, and 3% reduction in workload.

Swamardika (2012) [40], improves lighting system design capabilities via ergonomic-based lighting system software. The results show that there is a reduction in fatigue complaints in amount of 14.61%, reduction of boredom in amount of 4.95%

**Improving of Workers’ Health Quality through Total Ergonomic Model Interventions in Education Sector**

Sutayana [41], interventions on learning process with Interdisciplinary and Participatory (Holistic Systemic Approach/SHIP) of Learning Process of Biology Students IKIP Singaraja. Results are obtained the reduction of students’ exhaustion of majoring Biology Education IKIP Singaraja amount of 47.4%, reduction of musculoskeletal complaints in amount of 43.1%

Wijaya [42], interventions on science learning through ergonomic approach is done to elementary school students in 1 Sang sit Sawan sub district Buleleng regency. The
total ergonomic approach can increase musculoskeletal complaints of elementary students in amount of 99.88%, reduction of fatigue in amount of 73.76%.

Suprapta [43], an intervention in biotechnology learning process with ergonomic community science approach at IKIP Saraswati Tabanan students. The results show that the study of biotechnology with STMBE approach can decrease musculoskeletal complaints in amount of 43.68%, reduction of fatigue in amount of 34.90%, reduction of boredom in amount of 22.64%.

Tjahjoanggoro[44], interventions on the ergonomic thesis-based tutoring process on the students of XY Faculty. The results show that there is reduction in students’ fatigue in amount of 62.4%, reduction of students’ boredom in amount of 87.2%.

Suhartana [45] An intervention on Keboard Balinese smart-based ergonomics. The results show that subjects after being given total ergonomic intervention have reduction of pulse rate, lower arm and arm muscle load, cognitive load and fatigue reduction.

**Improvement of Workers’ Health Quality through Total Ergonomic Model Interventions in Health Sector**

Herdiman [46], A total ergonomic-based prosthetic ankle modification of amputee transtibiais done in Solo-Central Java. The results show that there is an increment in satisfaction of using prosthetic foot in amount of 22.60%, reduction of workload when amputee is donein amount of 40.31% and reduction of cardiovascular load in amount of 40.19%, reduction of musculoskeletal complaints when amputee is done in amount 21.13%, reduction of physical fatigue when amputee is done in amount of 21.26%

**Improving of Workers’ Health Quality through Total Ergonomic Model Interventions in Hospitality Sector**

Purnawati [47], Application of working stress management program based on ergonomic (Ergo-JSI) is done to the employees of X National Private Bank in Denpasar Bali. The results show that there is a reduction of stressors (6.8%) and blood cortisol (23.7%), reduction of musculoskeletal (10.5%), increment of WAI (4.7%) and increment of work satisfaction in amount of 13%.

Adiputra [48], Ergo-Psychophysiology is doneat accounting division of Balli Hyatt hotel in Denpasar. The results show that there is a reduction in employee fatigue in amount of 22.18%, reduction of musculoskeletal complaints in amount of 9.08%.

Irwanti [49], an ergonomically oriented internal service is done at Pramugrahra hotel. The results of the study find that there is a reduction of workload in amount of 13%, 33.5% reduction in fatigue, reduction of musculoskeletal complaints in amount of 28.89%.

**Improvement of Workers’ Health Quality through Total Ergonomic Model Interventions in Building Sector**

Suardana [50], ergonomic approaches in architectural design (Ergo-Architecture) can decrease fatigue, increase accuracy and concentration as well as reduction of boredom.

Sutarja [51], Redesign based on ergonomics and local wisdom in traditional houses in Pengotan village. The results show that there is an increment of lung function (% FVC) 12.76%, increment of occupant satisfaction in amount of 27%.

**Improving the Workers’ Health Quality through Total Ergonomic Model Interventions in Religion Sector**

Purnamawati [52], Ergonomic Intervention on the Process of Making Banten Ngaben Pranawa Ceremony in Denpasar City. The results showed that with total ergonomic intervention there was a decrease of fatigue equal to 36.24%, decrease of musculoskeletal complaint 37.98%, decrease workload 13.22%.

Adnyana [53], Application of Synergy Ergo-Mechanical System for Women Workers is done in Banten Facility Industry at Blahbatuh Gianyar Bali. The results show that there is a reduction of workload in amount of 21.90%, reduction of musculoskeletal complaints by 15.10%, reduction of fatigue in amount of 22.23%.
Discussion

The concept of Total Ergonomics Approach has been developed by Manuaba since 1996, ergonomics can be applied to various sectors such as in hospitality [54], shift work [55], agriculture sector, tourism sector and small industry sector [56].

The impact is experienced when working conditions do not apply the concept of ergonomics such as the reduction in quality of workers’ health, the reduction in physiological conditions of humans. Musculoskeletal system disorders occur due to: a) inadequate workplaces, b) repetitive activities, c) inappropriate equipment design, inefficient work organization, d) irregular breaks, e) un natural work attitude [57].

These complaints can be overcome by repairing the work tools, work systems and resting managements [58].

Methods that are done from the research results that have been done to assess musculoskeletal complaints subjectively are done by Nordic Body Map questionnaire with rankings [59]. Nordic Body Map (NBM) questionnaire is divided into three parts: a) trunk muscle section; Upper extremities, lower neck, back, waist, buttocks, b) upper extremity muscles: left shoulder, right shoulder, left and right upper arm, left and right elbow, left and right bottom arm, Left and right wrists, left and right hands, c) lower extremity muscle portion; Left and right thighs, left and right knees, left and right legs.

The search results from the research that has been done, fatigue measurements are generally done by subjective feelings of fatigue that is developed by the Subjective Self Rating Test of the Japan Industrial Fatigue Research Committee (IFRC) [60], containing 30 items of rating scale, which consists of 3 categories; work-weakening activities (items 1-10), reduction of motivation (items 11-12), physical fatigue (items 21-30) [61].

Research Results of the studies that has been done, assessment of workload through heart rate measurement during work is a method for assessing cardiovascular strains, can be recorded manually by using stopwatch with 10 pulse method [62]. The pulse rate can be used to predict the workload by converting to workload category tables based on [63] calculating the frequency of pulses per minute.

Table 1: Disciplines science, publication year, researcher and percentage of changes of workers’ health quality

<table>
<thead>
<tr>
<th>Disciplines Science</th>
<th>Publication year</th>
<th>Author</th>
<th>Changes of workload after total ergonomic intervention (%)</th>
<th>Changes of Musculoskeletal Complaints after total ergonomic intervention (%)</th>
<th>Changes of general fatigue level after total ergonomic intervention (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Sector</td>
<td>2006</td>
<td>Purnomo</td>
<td>21.69</td>
<td>87.8</td>
<td>77.5</td>
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<tr>
<td></td>
<td>2007</td>
<td>Adiatmika</td>
<td>5.53</td>
<td></td>
<td>6.97</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>Priambadi</td>
<td>5.65</td>
<td>71.65</td>
<td>11.3</td>
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<tr>
<td></td>
<td>2013</td>
<td>Siswantoro</td>
<td>19.6</td>
<td></td>
<td>17.7</td>
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<td></td>
<td>2013</td>
<td>Santoso</td>
<td>17.11</td>
<td>37.35</td>
<td>34.11</td>
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<tr>
<td></td>
<td>2013</td>
<td>Setiawan</td>
<td>16.06</td>
<td>21.02</td>
<td>18.84</td>
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<tr>
<td></td>
<td>2016</td>
<td>Sisihono</td>
<td>11.31</td>
<td>24.87</td>
<td>20.32</td>
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<td>Agriculture Sector</td>
<td>2011</td>
<td>Surata</td>
<td>18.67</td>
<td>14.27</td>
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<tr>
<td></td>
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<td>Widana</td>
<td>18.67</td>
<td>14.27</td>
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<td></td>
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<td>17.13</td>
<td></td>
<td>7.7</td>
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<td>2015</td>
<td>Ratu</td>
<td>17.13</td>
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<tr>
<td>Fishery Sector</td>
<td>2011</td>
<td>Josephus</td>
<td>53.56</td>
<td>53.55</td>
<td>16.15</td>
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<tr>
<td></td>
<td>2014</td>
<td>Susana</td>
<td>12.99</td>
<td>26.70</td>
<td>23.06</td>
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<td></td>
<td>2014</td>
<td>14.57</td>
<td>27.02</td>
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<tr>
<td>Computer Design Sector</td>
<td>2011</td>
<td>Wijaya</td>
<td>3</td>
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<td>2012</td>
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<td></td>
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<td>Adiputra</td>
<td>9.08</td>
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<td>22.18</td>
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<tr>
<td></td>
<td>2016</td>
<td>Irwanti</td>
<td>13</td>
<td>28.80</td>
<td>33.5</td>
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</tbody>
</table>
Different percentage changes in outcome after intervention in the form of workload reduction, reduction of musculoskeletal complaints, reduction of general fatigue that is caused by different total ergonomic interventions also, and the characteristics subjects between the studies are different with each other. Even in the same discipline, no one has the same percentage of changing value.

The number of subjects, the study design and the duration of the subject's adaptation time influence the change of final outcome. However, the principle of output or variables depending on the application of Total Ergonomics Approach that cannot be separated partially, because the changes that occur due to ergonomic intervention in whole or holistic, so that the relationship between one factor with other factors very closely occur.

The slight change of the independent variables affects the percentage change of output (variable dependent) of the research. In terms of changing percentage, the highest value of all researches traced is industrial research [27] those are improvement of work system through Total Ergonomic Approach at Pottery Industry in Kasongan, Bantul as much as 186.99% consisting of (reduction of Musculoskeletal complaint in amount of 87.8%, 77.5% fatigue reduction, reduction of workload in amount of 21.69%).

Then it is followed by research in education sector [39] that is to intervene in science learning through ergonomic approach in elementary school students 1 Sangsit Sawan Sub district Buleleng Regency in amount of 173.64% consisting of (reduction of musculoskeletal complaints in amount of 99.88% and fatigue in amount of 73.76%) then research in fishery sector is reported as research results [37] that ergonomic intervention in the process of fishing with a trawl ring to fishermen in Amurang South Minahasa District North Sulawesi Province as much as 123.26% consisting of (reduction of workload in amount of 53.56%, reduction of fatigue in amount of 16.15% and reduction of musculoskeletal complaints in amount of 53.55%).

**Conclusion**

Total Ergonomics Approach model is proven to be implemented in various disciplines such as Industrial, Agriculture, Fisheries, Computer Design, Education, Health, Hospitality, Building and Religious. Interventions in the Total Ergonomics Approach model have been shown to improve the quality of workers’ health by decreasing musculoskeletal complaints, fatigue, workload and other complaints as a result of the interrelated ergonomic interventions. The concept of ergonomics is to see human beings as the main factor in every planning and improve working conditions.

Humans have different abilities, skills and limitations, so that the characteristics of intervention and subject conditions affect any ergonomic intervention. The difference in percentage change in outcome after intervention is influenced by the choice of treatment on the independent variable and the subject characteristics. Output or variable depending on the application of Total Ergonomics Approach cannot be separated, because the changes that occur due to ergonomic intervention in whole or holistic, so there is a link between one factor with other factors.

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