Towards National Ergonomics Standards

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Ergonomics is a science which deals with human beings. It has long been realized that human characteristics differ from one population to another either physically, socially, or culturally. As a knowledge pioneered and developed in the United States and some European Countries, at least at its early stages, ergonomics is still Western population centered although Ergonomic research in non-Western countries has started to develop in recent years. As far as standards on human performances are concerned, Ergonomics standards developed in (for) a Western population should be applied with great care. Some Indonesian experiences have shown this to be true. This paper presents three Ergonomic subject matters which have been found to be some of the areas where population characteristics have to be considered when applying Ergonomics, namely, anthropometry, speed of motion, and product design. The findings are based on research results performed by the Bandung Institute of Technology at its Laboratory for Work Analysis and Ergonomics.

Anthropometrical dimensions

One of the most frequent accidents in construction works in Indonesia happens in the operation of heavy equipment. It is strongly felt that lack of anthropometrical fitness in the operator-machine systems is the main cause. The state railway company has long been concerned by the physical design of foreign-made locomotives which are too large for average Indonesian operators. This situation was confirmed. Measurements by the Laboratory of Work Analysis and Ergonomics in Bandung shows that the average height of Indonesian students are 166 cm. It can be reasonably predicated that due to social-economic conditions, locomotive operators are lower in height. Compare the figure to the average height of, for example, American males, which is 172 cm (Konz, 1983). There are of course other anthropometrical differences besides height between the Indonesian population and other populations which should also be considered.

Speed of motion

It is important to note that for a simulated manual assembly work, Indonesian subjects perform faster for work areas close to the body (< 20 cm), and slower for work areas far from the body (> 35 cm) (Sutalaksana, 1977) as compared to what would be shown by Western workers if calculated from there Predetermined Motion Time Systems (Work Factors, Methods Time Measurement, and Basic Motion Time). Time measurements for Indonesian experiments were performed with standard time study procedures. Another research result shows that Western workers are faster than Indonesian workers in 35% of the motions classified in the
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Maynard Operation Sequence Technique. The research was performed in the laboratory as well as practically at the Nusantara Aircraft Manufacturing Company in Bandung (SURYADI, 1986; SUTALAKSANA and SURYADI, 1988). However, it is quite interesting to note that for the motions which Indonesian workers perform faster (5% of them), most are for tool-use motions.

**Typewriter keyboard design**

The internationally widely used QWERTY typewriter keys layout design has been found to be less productive compared to a design specifically developed to be used for typing Indonesian words. The Indonesian design was developed through considering alphabet use in Indonesian words and physiological ability of the fingers. For 100,000 words of typing, the new design requires approximately thirty minutes less, compared to typing with the standard design typewriter (TIJAKRAATMADJA et al., 1987).

**The need to develop national ergonomic standards**

The three research results, which represent Indonesian cases, might be found as well in other countries. Many works have proved the existence of anthropometrical differences between populations. Besides strengthening these findings in anthropometry, this paper also shows differences in speed of motion. In an industrializing country like Indonesia, it is of importance to consider these facts since many practical aspects relate to them directly. Among others are efficiency and productivity which have become national issues. The design of products especially used for productive purposes are included also in this category, as shown through the typewriter keyboard layout design here.

This indicates the importance of developing national ergonomic standards, at least for relevant subject matters. Since there are many other Ergonomic subject matters which are strongly population-dependent, it is a challenge for Ergonomists anywhere in the world, especially in non-Western countries, to extend their research in this area. The more this has been explored, the more Ergonomics has shared in national developments, and in turn it receives more acceptance.

REFERENCES


Nationwide Anthropometric Survey in Korea—the Past, the Present, and Future
Chul J. Kim, Sue C. Park, Hyun M. Chang, and Jin O. Kim

Ergonomics Center, Korea Standard Research Institute, Daejon, Korea

This paper presents the 1986 national anthropometric survey in Korea. Eighty body dimensions were measured from 21,648 Korean males and females aged from 0 to 50 years. Subjects were selected randomly throughout the country. Martin-type anthropometers were used basically, but specially designed vehicles and supportive devices were adopted to facilitate the survey. The results were compared with previous surveys and with other ethnic groups’ data.

Anthropometric Data of Indonesians in Various Occupations
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In carrying out development, Indonesia still has to frequently import science and technology. In addition to the advantages, there are also various attendant impacts or disadvantages in the form of occupational diseases, accidents, ineffective and inefficient work processes, which result in unproductive work and additional costs. Efforts to minimize or eliminate these negative impacts have been carried out through transfer and choice of appropriate technology, which covers six basic aspects or criteria, namely economic, technical, health/ergonomics, socio-cultural, environmental and energy preservation and conservation. These aspects or criteria must be viewed and applied holistically and wisely to minimize or to eliminate negative impacts. But in practice, such an approach is not feasible for various reasons, including lack of knowledge and technical know-how, lack of anthropometric data of the consumers, lack of coordination between related institutions and lack of umbrella legislation and regulation. Facing all these obstacles and constraints, efforts have already been made to ameliorate this situation, e.g., establishing Indonesian anthropometric data. This study is one of those efforts, particularly in regard to the anthropometric data of drivers, passengers, industrial workers, government officials, and farmers.

Method

By using anthropometer, anthropometric measurements were conducted in nine cities—Meda, Padang, Palembang, Bandung, Semarang, Yogyakarta, Surabaya, Ujung Pandang, and Denpasar. Subjects were drivers of buses and trucks (all male), female and male passengers, government officials, industrial workers, and farmers. Items being measured were selected based on practical purposes.
Table 1. Anthropometric data of Indonesians in various occupations.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>DRIVERS</th>
<th></th>
<th>PASSENGERS</th>
<th></th>
<th>COVT.OFFICIALS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck</td>
<td>Bus</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Number</td>
<td>460</td>
<td>491</td>
<td>459</td>
<td>448</td>
<td>450</td>
<td>400</td>
</tr>
<tr>
<td>Age (years)</td>
<td>31.92± 8.65</td>
<td>32.43± 7.94</td>
<td>25.08± 6.22</td>
<td>24.98± 8.78</td>
<td>30.66± 7.30</td>
<td>28.77± 7.39</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>58.36± 9.49</td>
<td>55.92± 10.05</td>
<td>54.35± 6.68</td>
<td>47.10± 6.84</td>
<td>56.10± 8.09</td>
<td>47.57± 7.15</td>
</tr>
<tr>
<td>Stature (cm)</td>
<td>162.51± 5.59</td>
<td>161.86± 6.18</td>
<td>162.86± 6.43</td>
<td>152.31± 6.16</td>
<td>161.84± 6.24</td>
<td>152.31± 11.10</td>
</tr>
<tr>
<td>Shoulder breadth</td>
<td>48.34± 5.72</td>
<td>40.65± 4.75</td>
<td>40.36± 3.32</td>
<td>36.11± 6.38</td>
<td>40.27± 3.26</td>
<td>36.65± 2.51</td>
</tr>
<tr>
<td>Forward gripreach</td>
<td>70.31± 5.27</td>
<td>70.61± 5.84</td>
<td>69.26± 3.54</td>
<td>66.38± 4.61</td>
<td>70.61± 4.99</td>
<td>65.93± 5.67</td>
</tr>
<tr>
<td>Side arm reach</td>
<td>54.35± 4.73</td>
<td>54.29± 4.53</td>
<td>53.51± 4.08</td>
<td>53.51± 3.79</td>
<td>55.86± 7.33</td>
<td>52.27± 6.60</td>
</tr>
<tr>
<td>Sitting height</td>
<td>84.43± 3.89</td>
<td>90.12± 13.99</td>
<td>83.43± 6.88</td>
<td>78.71± 4.61</td>
<td>83.86± 4.84</td>
<td>79.10± 3.71</td>
</tr>
<tr>
<td>Eye level</td>
<td>73.35± 3.89</td>
<td>74.10± 5.03</td>
<td>74.35± 35</td>
<td>67.78± 4.60</td>
<td>73.57± 4.19</td>
<td>68.54± 3.49</td>
</tr>
<tr>
<td>Elbow rest ht</td>
<td>23.09± 3.41</td>
<td>22.74± 3.10</td>
<td>22.30± 2.72</td>
<td>21.56± 2.97</td>
<td>23.18± 3.35</td>
<td>21.88± 3.09</td>
</tr>
<tr>
<td>Vertical reach sitting</td>
<td>116.90± 5.29</td>
<td>115.75± 7.80</td>
<td>116.61± 5.98</td>
<td>108.87± 5.73</td>
<td>116.02± 5.78</td>
<td>107.04± 9.49</td>
</tr>
<tr>
<td>Hip breadth</td>
<td>31.64± 3.46</td>
<td>32.42± 13.02</td>
<td>31.38± 3.18</td>
<td>30.72± 3.81</td>
<td>32.23± 2.83</td>
<td>30.17± 4.49</td>
</tr>
<tr>
<td>Knee height</td>
<td>51.16± 4.07</td>
<td>50.44± 3.15</td>
<td>50.16± 3.66</td>
<td>47.40± 3.15</td>
<td>50.37± 3.04</td>
<td>47.74± 2.93</td>
</tr>
<tr>
<td>Popliteal height</td>
<td>42.23± 2.99</td>
<td>41.32± 2.84</td>
<td>41.60± 2.55</td>
<td>39.22± 2.72</td>
<td>41.48± 2.48</td>
<td>38.99± 2.86</td>
</tr>
<tr>
<td>Buttock poplit. length</td>
<td>44.88± 3.45</td>
<td>43.82± 4.02</td>
<td>44.78± 3.35</td>
<td>43.31± 3.48</td>
<td>44.67± 3.54</td>
<td>43.89± 3.60</td>
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<tr>
<td>Buttock knee length</td>
<td>54.36± 3.51</td>
<td>53.90± 3.72</td>
<td>54.92± 4.05</td>
<td>51.50± 3.73</td>
<td>54.20± 3.91</td>
<td>52.51± 3.51</td>
</tr>
<tr>
<td>Buttock finger length</td>
<td>81.73± 10.78</td>
<td>86.99± 8.12</td>
<td>80.55± 4.35</td>
<td>82.72± 4.64</td>
<td>85.37± 11.01</td>
<td>81.85± 7.86</td>
</tr>
<tr>
<td>Buttock leg length</td>
<td>95.62± 6.64</td>
<td>99.52± 8.52</td>
<td>94.14± 7.87</td>
<td>89.46± 7.74</td>
<td>95.46± 6.43</td>
<td>90.41± 7.81</td>
</tr>
</tbody>
</table>
Table 2. Anthropometric data of Indonesians in various occupations.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Industrial workers</th>
<th></th>
<th>Farmers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Number</td>
<td>419</td>
<td>420</td>
<td>417</td>
<td>450</td>
</tr>
<tr>
<td>Age (years)</td>
<td>29.02±7.65</td>
<td>26.07±8.37</td>
<td>33.37±10.39</td>
<td>29.53±9.57</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>53.69±7.45</td>
<td>46.42±6.00</td>
<td>50.82±6.72</td>
<td>45.96±6.08</td>
</tr>
<tr>
<td>Stature (cm)</td>
<td>160.97±7.95</td>
<td>151.07±5.38</td>
<td>160.0±6.02</td>
<td>149.62±5.56</td>
</tr>
<tr>
<td>Eye level Std</td>
<td>150.14±6.35</td>
<td>139.33±5.43</td>
<td>148.93±6.14</td>
<td>138.0±5.55</td>
</tr>
<tr>
<td>Shoulder height</td>
<td>136.46±6.36</td>
<td>126.55±6.27</td>
<td>133.5±5.96</td>
<td>124.7±5.34</td>
</tr>
<tr>
<td>Elbow height</td>
<td>99.07±4.98</td>
<td>92.96±4.67</td>
<td>98.77±5.22</td>
<td>91.46±5.16</td>
</tr>
<tr>
<td>Grip height</td>
<td>69.75±4.64</td>
<td>65.4±3.72</td>
<td>69.21±4.42</td>
<td>64.74±4.53</td>
</tr>
<tr>
<td>Vertical reach height</td>
<td>193.18±8.39</td>
<td>180.28±7.95</td>
<td>191.1±8.45</td>
<td>177.3±5.23</td>
</tr>
<tr>
<td>Forward grip reach</td>
<td>68.8±4.78</td>
<td>65.0±5.01</td>
<td>71.39±9.32</td>
<td>63.41±5.23</td>
</tr>
<tr>
<td>Side arm reach</td>
<td>53.65±4.17</td>
<td>51.26±4.57</td>
<td>54.49±5.27</td>
<td>49.29±4.36</td>
</tr>
<tr>
<td>Sitting height</td>
<td>82.61±4.75</td>
<td>77.63±3.95</td>
<td>81.81±4.84</td>
<td>77.16±3.66</td>
</tr>
<tr>
<td>Eye level st.</td>
<td>71.92±4.30</td>
<td>65.85±3.98</td>
<td>70.62±4.69</td>
<td>66.34±3.91</td>
</tr>
<tr>
<td>Elbow rest height</td>
<td>22.22±3.26</td>
<td>20.79±2.80</td>
<td>21.15±3.70</td>
<td>21.06±3.61</td>
</tr>
<tr>
<td>Hip breadth</td>
<td>31.36±2.81</td>
<td>30.16±4.14</td>
<td>30.56±2.97</td>
<td>30.23±3.27</td>
</tr>
<tr>
<td>Knee height</td>
<td>50.17±3.25</td>
<td>47.03±2.83</td>
<td>49.80±3.42</td>
<td>46.22±3.57</td>
</tr>
<tr>
<td>Popliteal height</td>
<td>41.35±3.15</td>
<td>38.81±2.92</td>
<td>41.26±2.95</td>
<td>38.67±2.61</td>
</tr>
</tbody>
</table>

Results and discussion

Results are shown in Tables 1 and 2, which are grouped according to similar character. In fact, not all data are presented due to space limitation. And there are no significant differences between those various occupations. But these data can be used in designing agricultural and industrial machines and equipment, office furniture, and motor cars. By so doing, it is hoped that more “fit” man-task systems in conducting development will be attained, which will result in better working conditions and environments.

Workplace Design, New Technology, and Ergonomic Implications

Eklund JÖRGEN A. E.

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The distribution and extent of musculoskeletal disorders in industry has undergone a change in Sweden during the last decades. Back disorders were earlier the most common afflictions. These were considered to be partly caused by work and workplace features. Examples of risk factors shown to be important are heavy lifting, bending, stooping, twisting, repetitive movements, forceful movements, and vibration exposure (ANDERSSON, 1981).

Industry has during many years introduced counteractions in attempts to prevent work-related back pain. The strategies have been to decrease lifting, un-
suitable postures, and vibrations. This has mainly resulted in lifting aids, sometimes automated production systems, improved workplace design such as adjustable working heights and decreased working distances. New designs of lifting aids have evolved, e.g., hand-maneuvered force-amplifying devices and vacuum-regulated lifting aids, allowing fast and easy handling of goods. The increased use of forklift trucks and pallets has also decreased the need for manual lifting. Use of bigger containers instead of smaller boxes or sacks also eliminates manual handling which is replaced by mechanical aids instead. Jobs have transformed from physical handling to regulation of equipment, machines, and vehicle driving. All these changes together are believed to be the reason for the decrease in work-related back disorders which now can be seen in Sweden.

Today, however, there is a strong increase of work-related neck and shoulder disorders. The risk factors for these disorders are less known, but are considered to be static work postures, repetitive tasks, rapid movements, raised arms, and stress, among others (Kvarnström, 1983). There is less experience concerning prevention in industry, partly since these problems are relatively "new." In fact, many of the manual jobs described above have transformed into seated work tasks in which neck and shoulder disorders have become common instead. Examples of occupational groups which have undergone this development can be found in forestry and industrial production. Lumberjacks previously had back pain. They have now partly been replaced by machines and forest machine drivers, who are affected by shoulder pain. The earlier heavy manual materials-handling in industry has now largely been eliminated, and is now instead performed by the use of fork lift-trucks. The drivers of these trucks are often affected by neck pain due to the excessive demands of neck movements.

The strategies in industry to prevent these disorders are now to create good seated postures which cause minimal postural workload, and to create variation between several work tasks and work postures. In other words, work organizational changes are now seen as very important means to improve the situation in relation to the introduction of new technology.

In the application of ergonomics, the analysis of the work is central for all preventive measures. It is not enough to identify bad postures and the presence of risk factors for musculoskeletal disorders. For effective prevention, also the causes of an unsatisfactory situation emanating from the work demands must be identified. One way to analyse these causes, which has been shown to be a useful tool (Eklund, 1986), is presented below:

**Analysis of Work Task**

<table>
<thead>
<tr>
<th>Visual demands</th>
<th>Demands on physical manipulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>light</td>
<td>precision</td>
</tr>
<tr>
<td>contrasts</td>
<td>forces</td>
</tr>
<tr>
<td>glare</td>
<td>directions</td>
</tr>
</tbody>
</table>
During prolonged physical work, the individual’s performance capacity depends largely upon his or her ability to take up, transport, and deliver oxygen to the working muscles. Consequently, the physical work capacity (PWC) or aerobic capacity is probably the most appropriate measure of a worker’s physical fitness (Astrand and Rodahl, 1977). Both maximal and submaximal exercise tests can be employed to determine the PWC values. Though the first protocol is more accurate, the latter can predict the PWC with sufficient reliability and accuracy (deVries, 1980; Fox and Mathews, 1981). This submaximal test can also be applied to sedentary or older individuals without discomfort and potential hazards associated with maximal tests (Astrand and Rodahl, 1977; de Vries, 1980). Both of the methods, however, are rather time-consuming. Thailand, as a developing country, also faces a particular problem, i.e., equipment employed in the experiment, oxygen and carbon dioxide analyzer in particular, is very expensive. Therefore, the need for a simple and rapid method is obvious if one wants to test larger groups of people. Besides, models developed in the Western countries may not be applicable due to different kinds of equipment, methods, and ethnic groups of subjects.
The purpose of this study was to develop and test mathematical models using simple significant variables to predict oxygen consumption and the aerobic capacity. Such variables were so simple that no expensive equipment was required. These models will be very useful for the collection of ergonomic data in the field being conducted in Northeast Thailand.

Subjects and methods

One hundred male subjects, 20–49 years of age, participated in the experiment. All of them were agricultural workers in Northeast Thailand and were accustomed to hard working activity.

The test protocol required each subject to pedal the bicycle ergometer (Monark) at 4 different workloads for 5 min at each load at a speed of 50 rpm. All subjects started off with a low workload. After resting for 15–30 min, they continued at a higher workload. During the last minute of each load, the oxygen uptake was determined by the Douglas-bag method collecting expired air through a half-face mask (HANS-RUDOLPH). The gas analyses were made by an AVL 954 Blood Gas Analyzer. With all variables corrected to STPD condition, the oxygen consumption was computed using a generalized formula (Fox and Mathews, 1981). The corresponding heart rate was recorded by a cardiograph recorder (Minigraph MG-1A). The PWC was then calculated by extrapolating the regression line of 4 values of oxygen uptake and corresponding heart rate to the predicted maximum heart rate (220-Age) and projecting for the PWC in l/min as described by Kamon and Ayoub (1976) and DeVries (1980).

To check on the reliability of the experiment, 20 subjects were randomly chosen from the original group and retested. Results were then statistically compared using a t-test.

To validate the models, an additional experiment was conducted using an extra 20 male agricultural workers from other villages. They were asked to do the same test of the previous protocol. All data were recorded and later computed.

Results and conclusions

Attempts were made to develop the mathematical models, from data of 100 subjects, using the stepwise multiple linear regression technique (least square criterion) from SPSS/PC Package. There were 3 types of models developed:

1) to predict PWC from age (A), a workload (L) in watts and the corresponding heart rate (HR) in a form of Von Dobeln et al. (1967), labelled Model 1,

\[ PWC = \left( \frac{L^{0.492}}{HR^{0.927}} \right) \cdot \exp(3.662 - 0.019A) \text{ l/min of oxygen} \]

2) to predict PWC from age, oxygen uptake (VO) in l/min at STPD and the corresponding heart rate, labelled Model 2,

\[ PWC = \left( \frac{VO^{0.591}}{HR^{1.380}} \right) \cdot \exp(7.6 - 0.008A) \text{ l/min of oxygen} \]
3) to predict oxygen consumption using age and ventilation volume (VE) at STPD as independent variables. After executing several computer programs, it was decided to use an exponential form for the model, labelled Model 3,

$$\text{VO} = 0.172 \cdot \frac{\text{VE}^{0.918}}{A^{0.307}} \text{ l/min of oxygen}.$$  

The model validation employed data from an additional 20 subjects. Table 1 shows the comparison of PWC values estimating from Model 1 and Model 2 as opposed to the predicted ones of selected researches. A one-way ANOVA procedure was conducted to compare the mean of PWC predicted values which proved to be significantly different at 5% confidence level. Further Duncan’s test showed that Von Dobeln’s was statistically lower than the others’.

Table 2 illustrates the comparison of oxygen uptake values predicted by Model 3 and by BERNARD et al. (1979). Based on the one-way ANOVA procedure, no significant differences occurred.

In all cases the predicted models from this study produced less errors (SSE, sum of square of the estimates) and smaller deviations. Test-retest analysis using a standard $t$-test showed no significant difference ($t=1.64$) between the mean PWC values. The results confirm the validity of the research methods and equipment employed. The models will be used for data collected from the field where less expensive equipment is employed.

REFERENCES


Relation between the VDT Operating Time and Worker’s Estimation of Work Load

Toru ITANI, Toru OTANI, Sigeki KODA and Hideyasu AOYAMA

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In Japan, rapid computerization in office and manufacturing work has caused various kinds of health problems, such as psychosocial stress, eye and vision symptoms, musculoskeletal strain, disorder of autonomic nerves, and reproductive problems. In order to ascertain preventive measures for such occupational hazards, it is important to define the characteristic of VDT work load. Especially, operating time analysis is considered to be important, as VDT is used in different manners in various kinds of jobs. To delineate the characteristic of VDT work load, a study on VDT operating time by recording the usage of machines and a questionnaire study on work load and health condition of workers were carried out in an electronics company.

Method

Operating time of 86 VDTs was recorded for 20 working days, and the data of 19 VDTs at a purchasing and selling section (Job 1), 11 CAD (Computer-Aided Drawing) units at a designing section (Job 2), and 12 VDTs at a production management section (Job 3) were analyzed to compare with the results of a questionnaire study about work load and health condition of the workers at the sections. The main task of the workers is data searching at Job 1, CAD at Job 2, and data entry at Job 3. The number of the workers who operated the VDT was 50, 21, and 48 in Jobs 1, 2, and 3, respectively. A questionnaire study was also carried out for the workers at those sections.

Result

Figures 1, 2, and 3 show the distributions of average operating time a day, maximum operating time a day, and maximum continuous operating time of the workers in Jobs 1, 2, and 3. From these results, the following characteristics of the distribution of operating time are pointed out: 1) At Job 1, the variation of operating time a day among the operators is not as big as that at Jobs 2 and 3. 2) Many of the workers in Job 2 are working for a long time without rest. 3) At
Job 3, half of them are working less than 30 min a day in average, but a few workers are working, a long time.

Workers' self estimations of the frequencies of using a keyboard or "mouse," reading manuscripts, and watching CRT are shown in Figs. 4, 5, and 6. Computer-aided drawing units operators are using keyboards and watching CRT more frequently than the operators in other jobs. Subjective complaints about work and health condition are shown in Figs. 7 and 8. The workers in Jobs 1 and 2
Fig. 4. Frequency of key-board usage.

Fig. 5. Frequency of reading manuscripts.

Fig. 6. Frequency of watching CRT.

Fig. 7.
Fig. 8.

complain of eye and visual problems and general fatigue more frequently than the workers in Job 3. The rate of the complaints about mental stress is higher among the worker in Job 2 than others.

**Conclusion**

Work load and health condition of the workers of three groups using VDT in different manners was estimated by analyzing the record of operating time, and the result of subjective questionnaire. The result showed that there exist some differences in the work load among the three groups and the workers are complaining about health problems related to such differences in work load.

**Ergonomics Problems of Campus “Bemo” Transportation**

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Since 1986, University of Udayana started to use its new campus, which is located at the Bukit area, about 30 km distance from the old one. It is about 30-40 min by car, using a form of public transport called a “bemo.” But in fact, in daily practice, less than 30 min were very often experienced by passengers who are mostly students. In addition, practically more than 10 passengers were accommodated in the small bemo, which was done by the driver for economic reasons. In such a situation, it was assumed that various unexpected things might happen, ranging from inconvenience of the trip up to accident, particularly with the bad traffic engineering found in several places. Of course, one of the reasons might be the unfit or unmatch of passenger and driver-seats systems, which could be prevented if the ergonomics principle was implemented during the designing phase of these small buses. And, certainly it can be done easily, since most of those buses are new ones and the body was designed and built in Bali. Since frequent trips will be made by the students, and trip comfort and safety will influence their academic performances, *e.g.*, in following lectures, laboratory works, and examinations as well, ergonomic transportation means become a must. Especially in view of
the fact that more students will be using the new campus in the coming years in accordance with the Rector Poincy, such transportation means are vital. To attain that condition, an ergonomic study of current problems faced by passengers in a campus bemo was carried out to acquire base data for improvements.

**Method**

Relevant anthropometric data of students and parts of the campus bemo as well were collected. Questionnaires were also given to students, particularly in regard to their feelings and comments as passengers. Students proposals for improvements were noted as additional data.

**Results and discussion**

The questionnaires showed that 67.0% of the students said “travelling in that bemo was really uncomfortable.” This is due to the squeezing condition (97.0%), with no space for leg movement (100%), and the air within the bemo felt too hot (91%). In addition, about 97% said travelling in that bemo creates headache and feelings of unsafety, caused by too many passengers (73%), too fast driving (73%), and rough driving (82%). And finally about 73% were afraid of travelling in that bemo due to inconvenience of last experiences (91%). With all those comments, it is evident that it is very inconvenient travelling in that campus bemo, and that condition will certainly influence the performance of students in carrying out their academic tasks.

Those comments were strongly supported by the fact that unfit passenger-seats system existed, in regard to seat width/length, space for legs and head for passengers, etc.

Table 1 shows that seat length is shorter than 10 hip breadths, which causes inconvenient sitting. Although there is about 10 cm space for legs (122.0±11.4), practically it is still difficult to move the legs due to forced sitting posture as a consequence of low seat height compared to popliteal height. An average 2 cm difference between average sitting height+seat height and ceiling height make the

<table>
<thead>
<tr>
<th>Table 1. Anthropometric data of bemo and passenger (cm).</th>
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<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Seat length “long”</td>
</tr>
<tr>
<td>“short”</td>
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<tr>
<td>Hip breadth</td>
</tr>
<tr>
<td>6 students</td>
</tr>
<tr>
<td>4 students</td>
</tr>
<tr>
<td>Seat height</td>
</tr>
<tr>
<td>Popliteal height</td>
</tr>
<tr>
<td>Space width</td>
</tr>
<tr>
<td>Buttock knee of</td>
</tr>
<tr>
<td>two students</td>
</tr>
<tr>
<td>Ceiling height</td>
</tr>
<tr>
<td>Sitting height+seat height</td>
</tr>
</tbody>
</table>
movement also impossible. In short, it is exceptionally inconvenient riding in that bemo.

In regard to driver-equipment relationship, foot reach average is 81.02±6.58 cm, while distances of brake, clutch, and accelerator is 77.23±3.34 cm on average. It meant that, theoretically, equipment operated by foot is reachable. In relation to hand reach, 72.12±3.52 is the average, while all hand controls distances are 69.3±1.3 on the average; thus, these also are still within reach. It is difficult to say whether such an ergonomics condition encourages drivers to drive roughly and quickly.

The shortcomings in regard to passenger aspects need improvement particularly in light of the future development of the new campus.

Mastery, Satisfactory Operation, or Downgraded Mode of Transferred Technology

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Technology transfer is an old, universal process, but one which has taken on tremendous importance in the last ten years or so. This importance is all the more striking when, in addition to machines and operation and maintenance manuals, it includes organization systems, training programmes, and experts' know-how.

The usual form of transfer involves very little adaptation to the real conditions of use in the purchaser country. Unfortunately, voltage variations or power failures, the insufficient quality and quantity of the water supply (salty, sandy, hard, etc.), the mediocrity of transport and telecommunications systems and the lack of competent workers, technicians, and managers creates situations where the technical system fails to work or works abnormally: this is the *downgraded mode*. It has been shown (WISNER et al., 1988) that, in this case, the planned production level may be reached within a certain time of delivery but the quality level is often disastrous, with goods barely finding a local use. In addition, the transferred technical system has numerous elements (controls, automated systems, alerts, etc.) which rapidly turn out to be useless in these unfavourable operation conditions: this is *wasting of the technical apparatus* (KERBAL, 1988). The activity of operators, which is sometimes very significant in the field of communication and control, is not sufficient to compensate for the failure of automated systems (SAGAR, 1988).

On the other hand, in countries or regions which have a more extensive and more developed industrial fabric, there are situations where the difficulties relative to local conditions have been systematically studied previous to the transfer. Solutions which are more or less efficient or more or less costly have been developed
and applied in such a way that the technical system transferred operates in a way that is satisfactory in terms of quantity and quality. These efficient operating conditions are sometimes the result of original developments of the initial technology: developments themselves which could be transferred.

This was noted, for example, in the French sector of electricity production in nuclear power stations. In fact, the original technology is American, but major changes made to this technology in France led to original power stations which are exported. This situation of mastery of technology could be compared to that analyzed by C. Rubio (1988) in Filipino telephones using the old technology of electromechanical relays. Everything gradually became Filipino, including the production of spare parts under inventive conditions. Technical apparatus, including measuring instruments, were changed or replaced by Filipino design apparatus. As such, mastery of imported technology means that the purchasing company is able to find new solutions in order to develop and improve production.

In other cases, in between the situation of mastery and that of downgrading, there is a stage of satisfactory operation which complies with the conditions of the sale contract. Sometimes the compliance of system operation is very comprehensive, like the Rio Metro which uses technology very similar to that of the Paris Metro. Dos Santos (1985) showed that in this case the patterns of operators' visual fixations in the control room are similar in Rio and Paris. Unfortunately, in the same technology transfer, there may be more unfavourable aspects linked to insufficient transfer of know-how in the field of maintenance and the turnover of competent staff attracted by higher salaries outside the company which provided the training. In this case, there is also the fact that the stock of spare parts is not suited to the type of breakdowns observed locally. There are also major difficulties in solving rare and serious problem which may arise after a certain period of use. This no doubt explains the fact, observed very often, of the gradual downgrading of a system which operated satisfactorily at the outset. Finally, there is the extreme example in the "test run" where a satisfactory result is obtained on the day of inauguration, like a chemical plant in Senegal (Aw, 1988) thanks to exceptional conditions: stable power supply, excellent water quality, presence of a large delegation from the seller country with experienced design office, production and maintenance staff using know-how which will never be transferred to the purchaser country.

As such, the situation of satisfactory operation is naturally very unstable when it does not result from the active acquisition of the technology by staff of the purchasing company, through mastery of the process. However, as shown by C. Rubio (1988), in the modern electronics technology stage which Filipino telephones have now reached, the expression of the purchaser’s mastery is sometimes very restricted in the sale contract. In this case, for example, the software must not be changed, even when this is required by the local situation, except where these changes are “transparent.” Equipment repairs under guarantee are done by a firm associated
with the seller. Maintenance is provided by the seller at the request of the purchaser. Although there is no obligation to buy spare parts from the sellers nor to have them repair equipment after the guarantee period, the fact is that the continued support of the seller is necessary for certain inevitable demands such as the supply of special spare parts, the advice of the seller's specialists for major, complex changes in the software, and for lots of hardware repairs.

However, there is a slow but continuous change in the operations done by the purchaser due to the professional progress of its staff and the development of scientific know-how in the Philippines.

Ergonomic analysis of work in the modern form of study of the course of action in the context of local pragmatic constraints is an excellent way in which to situate each company or company section on the continuum, ranging from downgrading to mastery, and to advance the company along this line.

REFERENCES


Ergonomic Workstations for Production Sewing Tasks

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Within the last few years, upper limb strain injuries have been recognised as a serious problem in the textile industry. Other industries which require highly repetitive, short-cycle tasks and which experience similar problems are the electronics industry (assembly tasks) and food processing. For the industries concerned, the costs in sickness absence and high labour turnover are very serious indeed. It is, however, notoriously difficult to record statistics from the textile industry in order to judge the true scale of the problem.

The present study of sewing workstation was undertaken as a result of wrist pain and injuries reported by machinists. Observations of several production
Sewing tasks have been drawn together to produce preliminary recommendations for the design or redesign of sewing workstations, and to form the basis for detailed study of the sewing task which will be aimed at identifying the changes which need to be made to reduce the levels of injury.

Investigation of the sewing task

The sewing tasks were studied on the production line in some detail using video film. In addition to this, machinists were interviewed and a larger number were asked to complete questionnaires in order to obtain information about the work they were performing, their experience of fatigue and discomfort during the working day, and the influence of the workplace layout on how they performed their task.

A great deal of information was obtained from the workers themselves, which helped to illuminate both the problems identified by the managers and the measurements taken from video. In one study, it was found that well over half of the machinists felt that they were not able to work at full efficiency throughout the working day due to the pain or discomfort they experienced in doing the task. Some experienced serious fatigue as early as mid-morning, while others reported such fatigue as occurring in the second half of the working week. This was closely related to the type of work in which they were engaged.

Sewing task

The responses to the questionnaires showed that machinists were able to identify very specific sites of discomfort which were related to the task. For instance, several grips are used in sewing both for holding material and for performing fine operations such as tying off or sealing threads. These can cause strain injuries to the fingers as well as the more commonly reported wrist injuries.

The study also showed that the upper limb strain injuries were not simply related to the primary (right-handed) task of feeding the material through the sewing machine. Machinists reported other problems in the left hand and in the fingers. The left hand is typically used to spread out the bulk of material across the sewing table, moving it at the same rate as the seam. The movements performed by this hand are not as fine as those of the right hand and there are fewer movements, but the hand is lifting a greater weight of material.

Workstation design

The main objective of the studies reported was to reduce strain injuries occurring among machinists, and the direction was to look at modifications which might improve arm postures for these operations. However, it was found that the overall design of the workplace had to be considered first. The design of sewing tables resulted in poor working postures for the machinists, which appeared to be the cause of much of the fatigue and discomfort reported by them.

The main workplace factors which influence the visual and postural demands of the task, and which need to be considered by the manufacturers of sewing machines, were identified as:

* Seating posture and relationship between the heights of the seat and work
surface

* Clear view of the sewing point and needle foot
* Fore/aft and lateral position of the pedal in relation to the sewing head
* Adequate knee room under the sewing table.

It is hoped that the further studies which are planned to investigate arm movements in sewing operations will provide more detailed guidelines for manufacturers on the interrelationships between the layout of the machine controls, the seating and delivery of material, as well as improvements to the detailed elements of the task itself.

The Effect of Height of House Floors on Performance of Broiler Chicks

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In order to produce good broilers, the chicks must be comfortably housed with adequate room in the house, a moderate temperature, sufficient air space and ventilation to prevent stuffness in the house, dry living quarters, light [WINTER and FUNK (1960) and SIREGAR et al. (1980) suggested that for day-old chicks (DOC) this should be uniform], and good-quality feed. The circulation of the air in the house is very important in tropical countries, particularly Indonesia where dirty air usually has a high ammonia (NH₃) concentration, which is dangerous for the chicks. ENSMINGER (1980) said that the amount of fumes (NH₃ fumes) is a good indicator of the adequacy of ventilation. SOSROAMIDJOJO and SOERADJI (1978) suggested that an animal house should be healthy (easy to clean, good ventilation, keep away defected light), strong, low cost but suitable and comfortable for the animal, while overcrowded conditions cause chicks to develop faults such as picking, feather eating, cannibalism, and high mortality rate.

Concerning the above, an experiment on broiler chicks was carried out at Madra farm, Gianyar, Bali, to study their response on low-high of house floors for 6 weeks (February–March, 1985). Here, the observation on the farmer also was carried out during the work. The design of the experiment was CRD with 3 treatments comprising ground floors with rice hull (T₁), 0.7 m height of floors with rice hull (T₂), and 1.0 m height of bamboo slotted floors from the ground (T₃). Three hundred DOC of CP 707 were used in each treatment. They were fed ad lib with Charoon 511 and 512 for the first 3 weeks and the last 3 weeks respectively. Water was available at all times.

The chicks data were analyzed with ANOVA (SNEDECOR and COCHRAN, 1961), and if there was a significant difference among the treatments the analysis was continued with the Duncan's multiple rang test (STEEL and TORRIE, 1960). No statistical analysis was carried out on the farmer data. The results showed that the
Table 1. The effect of height of house floors on performance (±SE) of broiler chicks.

<table>
<thead>
<tr>
<th>Response</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T_1$</td>
</tr>
<tr>
<td>Initial wt/head (g)</td>
<td>46.3 ±0.1a</td>
</tr>
<tr>
<td>Final wt/head (kg)</td>
<td>1.586±0.013b</td>
</tr>
<tr>
<td>Weight gain/head (kg)</td>
<td>1.540±0.114b</td>
</tr>
<tr>
<td>Feed Consumption/head (kg)</td>
<td>2.887±0.010a</td>
</tr>
<tr>
<td>FCR/head</td>
<td>1.91 ±0.01a</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>6.00 ±0.01a</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>8.0 ±1.2a</td>
</tr>
</tbody>
</table>

Within each raw, values with different superscripts show significances ($p<0.05$) between treatments.

final live weight, and weight gain per head of the $T_3$ were significantly higher ($p<0.05$) and its mortality and respiratory disease was significantly lower ($p<0.05$) than the others (Table 1). This may have been due to the better circulation of the air than in $T_1$ and $T_2$. In $T_3$, NH$_3$ and CO$_2$ from manure and respiration could easily escape from the house (SOSROAMIDJOJO and SOERADJI, 1978). Good air circulation could maintain O$_2$, keep CO$_2$ levels low, remove dust or moisture and NH$_3$ from the building, and maintain suitable temperatures (ENSMINGER, 1980).

In this experiment, high mortality rate and respiratory diseases in $T_1$ and $T_2$ were indicators of the high concentration of the NH$_3$ and CO$_2$ in the house.

REFERENCES


Neck and Shoulder Complaints among Garments Workers in Denpasar

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In Bali, during the last few years garment industries have become one of the most important industries in developing foreign currencies earnings and employment opportunity as well. In 1986, US $ 6,254,879 was earned and about 40,000 workers, mostly female, were employed through these industries. In 1988, an increase of 100% was achieved. It is one of the very successful development programmes, beside other attainments achieved from tourism and agriculture. And it will keep growing, and become one of the industries expected to solve employment matters. And since particular skill is needed to work in such an industry, both employees and employers hope that they could keep on working as long as possible, as far as financial matters are concerned. Beside that, both are also having similar motivation: how to gain as much benefit as possible through productive works. Of course to attain such a condition of work, it must be done in a healthy, safe, comfortable, and efficient way, and this can only be achieved if a fit man-task system can be organized and developed.

But such a condition was assumed to be too difficult to achieved, since workers are mostly obliged to work with existing work condition provided by the employers. Very often they have to work in a very bad working environment as far as ventilation and lighting are concerned. Beside that, they have to work with sewing machines and sit on seats, both of which are not appropriately designed. Sewing machines have to be purchased as such from the market, while seats were provided when suitable, without thinking whether they fit each other. This unfit condition was proved by observing unnatural working posture of the workers. And with such kind of work, neck and shoulder beside other complaints are usually raised by the workers, which will influence their performances due to conditions which result in inefficiency. To show that such a condition of work really exists, a study was carried out.

Method

A questionnaire was conducted among sewing machine workers about their comments of work being done, particularly in regard to impacts on neck and shoulder in the form of complaints. Years of work and anthropometric measurement of relevant body parts were also noted.

Results and discussion

Data collected from the questionnaires showed that as a whole about 32.17% of workers were having neck and 43.48% were having shoulder complaints. In regard to work period, years of work had correlation with those complaints, also sitting height and stature had a similar result.
Table 1. Correlation of complaints, work period, sitting height, and stature.

<table>
<thead>
<tr>
<th>Complaint (%)</th>
<th>Work period years</th>
<th>Sitting height (cm)</th>
<th>Stature (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43.75</td>
<td>0-1</td>
<td>77.63±3.95</td>
<td>152.34±4.94</td>
</tr>
<tr>
<td>52.08</td>
<td>2-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62.50</td>
<td>4-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63.63</td>
<td>&lt;5</td>
<td></td>
<td></td>
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</table>

N=115, r=0.3.

Table 2. Anthropometric data of workers and sewing machines.

<table>
<thead>
<tr>
<th>Item</th>
<th>Workers (cm)</th>
<th>Sw. Mach. (cm)</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting height</td>
<td>77.63±3.95</td>
<td></td>
<td>Seat height</td>
</tr>
<tr>
<td>Elbow height</td>
<td>19.6±2.06</td>
<td></td>
<td>Table width</td>
</tr>
<tr>
<td>Popliteal height</td>
<td>36.3±2.02</td>
<td>49.3</td>
<td>Seat width</td>
</tr>
<tr>
<td>Lower arm reach</td>
<td>41.2±1.50</td>
<td>39.0</td>
<td>Distance between margin of table and needle</td>
</tr>
<tr>
<td>Hip breadth</td>
<td>36.63±2.99</td>
<td>27.0</td>
<td>21.8</td>
</tr>
<tr>
<td>Buttock popliteal length</td>
<td>41.51±2.80</td>
<td>27.0</td>
<td>Seat depth</td>
</tr>
</tbody>
</table>

Anthropometric data of particular parts of the body and sewing machine height and size showed an unfit condition in relation to each other, which was also supported by observation of unnatural body posture. The situation became worse when workers had a body height above 160 cm.

There was a similar problem when body height was lower than 140 cm. Table 2 clearly shows these results.

Considering the above data and the result of observation at the work place, it is understandable that neck and shoulder complaints emerged. And such a condition cannot be tolerated, especially in view of the fact that this is a prime industry and will continue to grow in the coming years. Therefore improvement is vital.

Ergonomic Aspects of Balinese Traditional Housing

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In the traditional life of Balinese people, material and spiritual matters are always combined in their efforts to attain well-being ("jagadhiita") and permanent happiness ("moksha"), as final objective where all elements forming the human body reflect and return to their sources. This concept led to an ergonomic approach to life, both spiritually and physically. Man (as microcosm) is believed to have similar elements with the universe (as macrocosm), where man is the contents and the universe is the container that is suitable for life, giving source of life
and also as the final objective. Man has very restricted elements consisting of spirit, energy, and body and the universe has the unrestricted ones.

The human body can be divided into three parts (legs, body, and head); the universe is similarly divided into “bhur loka” (lower stratification), “buah loka” (middle stratification) and “shuah loka” (upper stratification).

Both are made from five kind of elements called “Panca Maha Butha” (solid things, liquid things, air, light, vacuum: pratiwi, apah, bayu, teja, and akasa).

Based on this concept, Balinese (as microcosm) attempt to imitate the macrocosm in constructing their environment and buildings.

The problem is that man cannot know the form and the dimension of the macrocosm. Nonetheless, they believe there is a similarity between the microcosm and macrocosm in element composition and also in physical divisions. To imitate the macrocosmos will thus be the same as imitating man.

This concept has been applied at various levels of the environment, such as for the space structure of the traditional village pattern, houses, buildings, even the components of the building, and people will live in the middle parts.

Vertically, the three-part divisions will consist of lower, middle, and upper parts. Horizontally the direction of the axis will follow the position of a mountain as a holy (head) direction and the position of the sea as a lowest direction. For more detailed division, sunrise directions or the direction of earth movement can be used as an additional factor. This is matter influenced the arrangement of the sleep position, where spiritually the head is directed to the mountain and mechanically to the east direction.

The Balinese traditional houses have several kinds of buildings, each with a special function such as the buildings for praying, sleeping, ceremony, cooking, and paddy storage. The central outdoor space is the center of orientation of buildings. The buildings are arranged as a compound pattern where the setting follows tight traditional building codes and setting/zoning regulation (astha kos ala and astha bumi).

The distances between buildings allow good circulation of the air that touches each side of the buildings, and maintain a good ratio between covered and open area. The distance is determined by a traditional measurement based on the length of the foot as the basic unit measurement with a traditional accounting called “asthat wara” (Sri, Indra, Guru, Yama, Ludra, Brahma, Kala, Uma).

The dimension of the door for the entrance gate of houses is derived from a man who holds up his right hand with an additional measurement (pengurip) depend on the direction of the door face for the whole height, and the width of a man with arms akimbo for the wide hole of the door.

The height of the floor is arranged to overcome the humidity caused by the capillarity of ground water (since the floor is made of traditional building material). The level of the floor corresponds to the values of building function. The higher
the level, the higher the functional value of the building.

The width of steps can be determined by the length of a foot plus an additional foot width, and the height of the step with one fist ("musti").

Other ergonomic aspects can be found also in the height and dimension of fixed bed and the arrangement of the number or position of the joists that support an elastic sheet made of bamboo.

The space between the edge of the roof and the top of the wall always allows the movement of the air and creates a good cross-ventilation.

The above examples show that Balinese traditional housing has many ergonomic aspects that, in principle, can be developed and maintained. But we know the development should include several kinds of facilities that have not been traditionally regulated. So the basic principle an Balinese traditional ergonomic aspects should be modified and take into account adaptations based on development needs.

User-focused Method of Education and Training for Ergonomics in Developing Countries

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Occupational Health Conditions at Open Pit Work Posts and Improvements

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Work Place Pollution, Health and Well-being of Workers

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Job Involvement as Related to Job Anxiety and Some Demographic Factors

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An Ergonomic Study on Sickle Designs for Reaping Task in Indian Agriculture

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