SURVEY OF PERCEIVED WORK-RELATED MUSCULOSKELETAL DISCOMFORTS (WMSDS) AMONG THAI OFFICE EMPLOYEES WORKING PREDOMINANTLY WITH NOTEBOOK COMPUTERS

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Abstract: The objective of this survey research was to assess the prevalence of work-related musculoskeletal discomforts (WMSDs) in office employees who predominantly work with notebook computers. Four hundred and eighty Thai office employees mostly engaging in the document preparation task participated in this study by answering questions about the notebook computer use, workstation and work posture, and discomforts perceived at various body parts. The results show that more than 50% of the office employees experienced WMSDs at the moderate, very, or extreme level. The body parts where the discomforts were reported include the neck, shoulder, and back. Among the three work-related risk factors investigated, only the type of computer task was found to cause significantly different discomfort levels at the upper arm, elbow, and lower arm. The remedial action most popularly taken by Thai office employees was to do nothing and let the pain subside by itself.

1. INTRODUCTION

Since 1980’s, personal computers have become an essential business instrument that not only helps office employees accomplish their tasks quickly and conveniently but also increases their work efficiency and productivity. In this day and age, virtually all office employees use the computer on a daily basis. Personal (desktop) computers, popularly called video display terminals (VDTs) by ergonomists, are found in every business office, small or large. Unfortunately, prolonged VDT operation can lead to ergonomic hazards such as musculoskeletal disorders and cumulative trauma disorders. Among other work-related factors, awkward work posture, e.g., bent neck, bent wrists, and excessively flexed forearms, is perhaps the factor that has received the most attention from ergonomists and safety practitioners. Numerous research studies were conducted to give recommendations about VDT operation and work posture, resulting in the ANSI/HFS 100-1988 Standard (The Human Factors Society, 1988). Ergonomic research suggests that VDT workstations which promote awkward or constrained work postures predispose computer users towards musculoskeletal injuries, and that persistent musculoskeletal problems relate to poor workstation design and adjustability (Harbison and Forrester, 1995). Adjustable workstations are generally recommended for proper seating during VDT operation so as to minimize body discomfort. At least, the workstation should allow the keyboard and monitor to be adjusted independently.

Nowadays, several business offices start to provide either a desktop computer or a notebook computer (NBC) to each employee depending on one’s preference. However, limited information about ergonomic recommendations is available for employees who work with the NBC (Cossey, 2005). Very little research (when comparing to those related to VDT operation) has been conducted on health and safety issues associated with NBC operation. Given the current research results relating computer use to musculoskeletal symptoms and syndromes in office employees, it is reasonable to suspect that NBC operation is likely to induce musculoskeletal risks. Basically, the NBC has a built-in keyboard attached to a screen which is a flat panel display. The NBC has some inherent design features that make it a potential ergonomic danger especially when it is used on a prolonged basis. Unlike desktop computers in which the keyboard and monitor are separate units and can be independently adjusted to position the former at about the same level as the elbows and the latter around the eye level, NBCs lack such adjustment flexibility. If the keyboard is in the correct position for the user, then the screen is not. If the screen is in the correct
position, then the keyboard is not. These design inferiors together with prolonged use of NBCs lead some researchers to suspect that NBC operation could induce more musculoskeletal risks than desktop computer operation.

The number of research studies on VDT (both desktop and notebook computers) operation in Thailand is small when comparing to that in developed countries such as USA, UK, Australia, and Japan. Mekhora et al. (2000) conducted an ergonomic survey among Thai office employees and reported that neck and shoulder pain is prevalent in them especially those who work with VDTs. They also concluded that ergonomic intervention through workstation adjustments can help to reduce the discomfort level of subjects with tension neck syndrome. Rurkhamet and Nanthavanij (2004a) developed an analytical design method for computing workstation settings and positioning computer accessories so as to help desktop computer users sit with a correct posture. Later, Rurkhamet and Nanthavanij (2004b) developed EQ-DeX, a rule-based decision support system based on their analytical algorithm, which can provide quantitative adjustment recommendations and illustrate graphically the resulting workstation and computer accessories layout.

For NBC operation, Jalil and Nanthavanij (2007) proposed two analytical algorithms to give adjustment recommendations such as adding footrest, seat support, base support, etc. so that the correct work posture can be obtained. The algorithms were validated by a research study involving 22 NBC users. Using the Rapid Upper Limb Assessment (RULA) as an analysis tool, it was shown that the adjustment recommendations from the algorithms help to improve the NBC user’s work posture when comparing between the RULA grand scores of the pre- and post-adjustment postures (Jamjumrus and Nanthavanij, 2007). Raps and Nanthavanij (2007) did a preliminary survey at a selected Thai university to investigate the use of notebook computers among university students and their seated posture during NBC operation. Their results revealed that university students tend to use their NBC on a prolonged basis and their work posture ranges from poor to very poor based on the RULA grand scores.

This survey research was designed to conduct an ergonomic survey among Thai office employees working predominantly with NBCs as part of their job in order to assess the prevalence of work-related musculoskeletal discomforts (WMSDs) in them. Selected risk factors, namely, type of task, workload, and work posture were separately investigated if different levels of the risk factor cause different discomfort levels at the affected body parts.

2. SURVEY METHOD

2.1 Subjects

Subjects for this survey research were office employees from several government agencies and private organizations in Thailand. All offices were located in the Bangkok Metropolitan area. All subjects were engaged in office jobs which require them to use the computer daily. Only office employees who used the NBC only or those who declared that the NBC is their predominant computer equipment were recruited. They were selected using the convenience sampling technique.

Based on the forecast given by the Association of Thai Computer Industry (ATCI) and Software Industry Promotion Agency (SIPA), the number of NBCs sold in Thailand in 2005 was 210,600 units and the number in 2006 was 280,000 units. Assuming that the number of NBCs sold in 2006 (280,000 units) roughly represents the estimated number of NBC users in Thailand, the appropriate sample size for this survey research can be determined using the formula given in Yamane (1973).

\[
n = \frac{N}{1 + N \cdot e^2}
\]

where:

- \( n \) = sample size (person)
- \( N \) = population size (person)
- \( e \) = significance level

For \( N = 280,000 \) persons and \( e = 0.05 \), the recommended size of survey sample \( n \) is 400 persons.

To make up for some subjects who might be excluded because had previously been diagnosed with postural anomalies or recently received physical injuries, the total number of subjects was 480 office employees. However, since none reported to have previous injuries, all 480 subjects were included in the survey research.
2.2 Questionnaire

The questionnaire was divided into 5 parts.

In Part 1, the subject was asked to answer questions about his/her personal data and experience with computer (including the typing skill level).

In Part 2, there were 12 questions which were grouped into task questions, workload questions, and work posture questions. For task questions, the subject was asked about the nature of task (keyboard-oriented, touchpad-oriented, or mixed) that he/she is routinely assigned to perform. For workload questions, the subject was asked about work duration and work-rest pattern. For work posture questions, the subject was asked about the external peripheral devices, if any, that he/she normally used with the NBC, the workstation (table and chair), and the adjustment settings of the workstation and NBC.

In Part 3, the subject was asked about how he/she used the computer (either desktop or notebook computer) at home during weekdays and weekends. This part consisted of four questions.

In Part 4, the subject was asked to indicate the body parts where the WMSDs were felt and the levels of discomfort both before and after work. Seven body parts where the discomfort was normally experienced were displayed using the Nordic questionnaire (Kuorinka et al., 1987). The subject could choose one of the five levels of discomfort that best reflected his/her perceived discomfort at each body part.

- Level 0 – No discomfort
- Level 1 – Little discomfort
- Level 2 – Moderate discomfort
- Level 3 – Very discomfort
- Level 4 – Extreme discomfort

In addition, there were four questions that asked about the actions taken by the subject to remedy the symptom.

In Part 5, the subject was given an opportunity to express his/her opinions about work condition and any suggestion about work improvement.

2.3 Work-related Risk Factors

Three work-related risk factors were investigated. They were task, workload, and work posture.

**Task:** From a list of computer tasks given in the questionnaire, the tasks were grouped according to the type of input device used as follows.

- **Keyboard tasks**
  - Document preparation
  - Numeric data entry
  - Computer programming
  - E-communications (sending/receiving e-mails)

- **Touchpad tasks**
  - Graphics design
  - Internet (web) browsing

That is, the subject is said to perform the keyboard task if the majority (at least 60%) of his/her computer tasks are document preparation, numeric data entry, computer programming, or E-communication. Suppose that the subject normally performs keyboard tasks about 40-60% of his/her work time, it then implies that he/she performs touchpad tasks for 40-60% as well. Thus, the subject is said to perform mixed tasks.

**Workload:** The answers to questions on work duration and work-rest pattern helped to qualitatively define the level of workload that the subject had to endure when working with the NBC. Here, the workload was divided into five levels, namely, very light, light, moderate, heavy, and very heavy.

**Work posture:** Questions that were used to define work posture of the subject include those asking about the use of external peripheral devices, the workstation (table and chair), and the orientation of essential body parts such as neck, back, and wrists. As a result, the work posture was classified as appropriate, moderately (or somewhat) appropriate, and inappropriate postures.

3. RESULTS

From the 480 subjects who participated in this survey research, 244 persons (or 50.83%) were male and the remaining 236 persons (or 49.17%) were female. The general physical data of the subjects are summarized as shown in Table 1.
Table 1. Selected Physical Data of the Male and Female Subjects

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD*</td>
<td>Mean</td>
</tr>
<tr>
<td>Age (year)</td>
<td>34.39</td>
<td>7.85</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>68.86</td>
<td>9.79</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>171.23</td>
<td>5.83</td>
</tr>
</tbody>
</table>

*Standard deviation

3.1 Prevalence of Work-related Musculoskeletal Discomforts (WMSDs)

From the five classification of discomfort level, the subject was later put in one of the following three groups: (1) the group with no or little discomfort, (2) the group with moderate discomfort, and (3) the group with very or extreme discomfort, based on the maximum level of discomfort that the subject reported at any part. This level reflects his/her overall WSMD. Table 2 shows that more than 50% of Thai office employees (in either gender group) experienced WMSDs at the moderate or very/extreme level after work. It is also seen that both gender groups showed similar distributions of WMSDs.

Table 2. Percentages of Employees based on Three Discomfort Levels of Overall WMSD (After Work)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Overall WMSD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No/Little</td>
</tr>
<tr>
<td>Male</td>
<td>49.18</td>
</tr>
<tr>
<td>Female</td>
<td>44.92</td>
</tr>
</tbody>
</table>

Figures 1 to 7 show the percentages of male and female employees in each discomfort level for the neck, shoulder, back, upper arm, elbow, lower arm, and wrist, respectively.

Figure 1. Percentages of Employees based on Five Discomfort Levels at the Neck

Figure 2. Percentages of Employees based on Five Discomfort Levels at the Shoulder
Figure 3. Percentages of Employees based on Five Discomfort Levels at the Back

Figure 4. Percentages of Employees based on Five Discomfort Levels at the Upper Arm

Figure 5. Percentages of Employees based on Five Discomfort Levels at the Elbow

Figure 6. Percentages of Employees based on Five Discomfort Levels at the Lower Arm
3.2 Effects of Work-related Risk Factors

For each risk factor, the one-way analysis of variance (ANOVA) test was applied to test the effect of the risk factor under investigation on the discomfort level of WMSDs at each of the seven body parts. Additionally, the one-way ANOVA test was separately applied to the male and female groups.

3.2.1 Effect of Task on WMSDs

Thai office employees were grouped according to the type of task that they normally performed using the NBC. Three tasks were defined, namely, keyboard task, touchpad task, and mixed task, according to the type of input device used. Most office employees (either male of female) who participated in this survey research reported to perform the keyboard task as their predominant task.

At individual body parts, the following null hypothesis was tested.

Null hypothesis: The effect of the three NBC tasks (keyboard task, touchpad task, and mixed task) on the perceived WMSDs of Thai office employees is not significantly different at the specific body part.

Table 3 shows the summary of $F$-statistics and $p$-values from the one-way ANOVA tests performed on the data of both male and female groups.

<table>
<thead>
<tr>
<th>Body Part</th>
<th>$F$-statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>1.001</td>
<td>0.369</td>
</tr>
<tr>
<td>Shoulder</td>
<td>3.019</td>
<td>0.051</td>
</tr>
<tr>
<td>Back</td>
<td>2.325</td>
<td>0.100</td>
</tr>
<tr>
<td>Upper arm</td>
<td>3.683</td>
<td>0.027*</td>
</tr>
<tr>
<td>Elbow</td>
<td>3.713</td>
<td>0.026*</td>
</tr>
<tr>
<td>Lower arm</td>
<td>3.810</td>
<td>0.023*</td>
</tr>
<tr>
<td>Wrist</td>
<td>0.436</td>
<td>0.647</td>
</tr>
<tr>
<td>Female employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>0.072</td>
<td>0.931</td>
</tr>
<tr>
<td>Shoulder</td>
<td>0.226</td>
<td>0.798</td>
</tr>
<tr>
<td>Back</td>
<td>0.129</td>
<td>0.879</td>
</tr>
<tr>
<td>Upper arm</td>
<td>1.132</td>
<td>0.324</td>
</tr>
<tr>
<td>Elbow</td>
<td>0.967</td>
<td>0.382</td>
</tr>
<tr>
<td>Lower arm</td>
<td>0.406</td>
<td>0.667</td>
</tr>
<tr>
<td>Wrist</td>
<td>1.318</td>
<td>0.270</td>
</tr>
</tbody>
</table>

*Significant at $\alpha = 0.05$.

The results show that the three NBC tasks imposed significantly different discomfort levels at the upper arm, elbow, and lower arm of Thai male office employees. Multiple comparisons were then performed on all pairs of the three NBC tasks. The significant differences were found between the keyboard and mixed tasks at the above three body parts. More specifically, the male employees who predominantly used the keyboard felt more discomfort at the upper arm, elbow, and lower arm than those
who used the keyboard and touchpad alternately (or perform mixed tasks). Between the keyboard and touchpad tasks and the touchpad and mixed tasks, no significant differences were found.

3.2.2 Effect of Workload on WMSDs

In this survey research, five levels of workload were qualitatively defined, namely, very light, light, moderate, heavy, and very heavy. About 70% of office employees indicated that their workload was at the moderate, heavy, or very heavy level.

To test the effect of the five workload levels on perceived WMSDs at each of the seven body parts, the following hypothesis was formulated.

Null hypothesis: The effect of the five workload levels (very light, light, moderate, heavy, and very heavy) on the perceived WMSDs of Thai office employees is not significantly different at the specific body part.

The results of the one-way ANOVA tests performed on the seven body parts of the male and female groups are shown in Table 4. It can be seen that the effect of the five workload levels on the perceived WMSDs was not significantly different at any body part of the male and female groups.

Table 4. Summary of the One-Way ANOVA Test Results (Workload Factor)

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Male employees</th>
<th>Female employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F-statistic</td>
<td>p-value</td>
</tr>
<tr>
<td>Neck</td>
<td>0.605</td>
<td>0.659</td>
</tr>
<tr>
<td>Shoulder</td>
<td>1.413</td>
<td>0.230</td>
</tr>
<tr>
<td>Back</td>
<td>0.237</td>
<td>0.918</td>
</tr>
<tr>
<td>Upper arm</td>
<td>1.187</td>
<td>0.317</td>
</tr>
<tr>
<td>Elbow</td>
<td>0.359</td>
<td>0.838</td>
</tr>
<tr>
<td>Lower arm</td>
<td>0.609</td>
<td>0.656</td>
</tr>
<tr>
<td>Wrist</td>
<td>1.046</td>
<td>0.384</td>
</tr>
</tbody>
</table>

3.2.3 Effect of Work Posture on WMSDs

The subject’s work posture was derived from the answers when being asked about the use of external peripheral devices, the workstation (table and chair), and the orientation of essential body parts such as neck, shoulder, and wrists. Three work postures were defined in this study, namely, appropriate, moderately (or somewhat) appropriate, and inappropriate postures. Very few employees (a little more than 15% of male employees and less than 15% of female employees) were judged to sit appropriately when working with the NBC. Note that in order to be considered as having seated appropriately, the subject had to indicate that their neck, back, upper arm, lower arm, and wrist postures were all appropriate.

The following null hypothesis was formulated to test if the three work postures imposed significantly different discomfort levels at the seven body parts.

Null hypothesis: The effect of the three work postures (appropriate, somewhat appropriate, and inappropriate) on the perceived WMSDs of Thai office employees is not significantly different at the specific body part.

Table 5 shows the summary of F statistics and p-values obtained from the one-way ANOVA tests of the seven body parts and two subject groups. The results show that the effect of the three work postures on the perceived WMSDs was not significantly different at any body part of the male and female groups.
Table 5. Summary of the One-Way ANOVA Test Results (Work Posture Factor)

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Male employees</th>
<th>Female employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F$-statistic</td>
<td>$p$-value</td>
</tr>
<tr>
<td>Neck</td>
<td>0.011</td>
<td>0.989</td>
</tr>
<tr>
<td>Shoulder</td>
<td>0.016</td>
<td>0.984</td>
</tr>
<tr>
<td>Back</td>
<td>0.606</td>
<td>0.547</td>
</tr>
<tr>
<td>Upper arm</td>
<td>0.432</td>
<td>0.650</td>
</tr>
<tr>
<td>Elbow</td>
<td>0.603</td>
<td>0.548</td>
</tr>
<tr>
<td>Lower arm</td>
<td>0.474</td>
<td>0.623</td>
</tr>
<tr>
<td>Wrist</td>
<td>0.996</td>
<td>0.371</td>
</tr>
</tbody>
</table>

3.3 Common Remedial Actions

Figure 8 shows the percentages of office employees based on different actions to remedy the symptom. It was found that the majority of office employees chose to do nothing and let the symptom go away by itself. Very few would seek treatments from physicians and/or physical therapists. A large number of office employees also reported that they either tried to cure the symptom by applying hot/cold packs or ointments, or getting traditional massage.

![Figure 8. Percentages of Employees based on Different Remedial Actions](image)

4. DISCUSSION

The graphs shown in Figures 1 to 7 reveal the following interesting results.

1. At each body part, the percentages of Thai office employees reporting to have perceived WMSDs at different discomfort levels are relatively similar irrespective of their gender.
2. The percentages of Thai office employees, both male and female, reporting to have perceived WMSDs at the moderate, very, or extreme discomfort level at the neck, shoulder, and back are greater than those at the other four body parts.
3. Judging from the perceived WMSDs at the neck and wrist, it seems that Thai office employees prefer placing the notebook computer at a level where they could type comfortably, not at a level where they could view the screen conveniently.
4. The results indicate that the prevalence of perceived WMSDs is identical in both male and female office employees.
Task, workload, and work posture were investigated since they are well-known risk factors of the musculoskeletal disorders. They have also been accepted as major risk factors of WMSDs especially when working with the desktop computer. In this study, the above three risk factors were qualitatively defined as determined from the survey respondent’s answers. Three types of task were defined, namely, keyboard task, touchpad task, and mixed task. Unlike desktop computer operation in which keyboard and mouse tasks can be differentiated in terms of arm movement, the keyboard task and the touchpad task are not that much different from each other since maneuvering the touchpad does not require the NBC user’s arm to move around. The static arm posture might cause the NBC user to experience more discomfort at the upper arm, elbow, and lower arm. However, performing the mixed task can require the user to move his/her arm up and down frequently to relocate the index finger between the keyboard and the touch pad. This task requirement (arm movement) can help to lessen the discomfort in the NBC user’s upper arm, elbow, and lower arm.

For the other two risk factors, workload and work posture, the five workload levels and three work postures were also defined using similar qualitative basis. The one-way ANOVA tests showed that the effects of different workload levels and those of different work postures on the discomfort level were not significantly different at any body part. Readers should note that the distributions of survey respondents over the five workload levels and three work postures might not be completely undoubtedly distributed among different workload levels and work postures. This could have caused the statistical analyses to fail to reject the null hypotheses. Another possible explanation for this could be the interactions from other risk factors not investigated in this research such as exposure to NBC operation hazard (i.e., computer experience). Since the majority of survey respondents already experienced the discomfort at the moderate, very, and extreme levels. They could have probably been using the computer (either desktop or notebook) for years. Therefore, although their workload level might be light or their work posture might be appropriate, the symptom could have already been apparent.

At present, very few organizations in Thailand are aware of office ergonomics and computer operation hazard. Work environments, work conditions, and workstations are still not seriously considered by management as essential ingredients for achieving the maximum work efficiency and productivity. Thus, it is not surprising that Thai office employees are not adequately educated about possible hazards from office work involving desktop computer or NBC. This may explain why most Thai office employees who are suffering from WMSDs tend to think that the discomforts that they have do not originate from their work and tend to remain quiet about the problems instead of seeing the physicians and/or physical therapists or complaining to their immediate supervisor.

5. CONCLUSION

The results from the survey clearly show that WMSDs was prevalent in both male and female office employees. More than 50% of the employees reported their WMSD symptoms to be at the moderate, very, or extreme level. The body parts where WMSDs were commonly perceived in Thai office employees are the neck, shoulder, and back. When investigating the effects of three work-related risk factors on the discomfort level, only the task factor was found to have a significant different effect. The effects of the other two factors, workload and work posture, on the discomfort level were not significantly different. It is suspected that the classification of survey respondents based on different workload levels and work postures might not be accurate and could have affected the statistical analyses. Additionally, interactions from other work-related risk factors not considered in this research could have influenced the statistical analyses. The survey results also indicate that office employees seemed to be unaware that their body discomforts were work-related. This conclusion is extracted from the fact that most employees chose to do nothing about the symptoms. Very few employees reported that they visited the physicians and/or physical therapists for help.

It is clear that ergonomic intervention is necessary to improve work conditions in business offices. Office works especially those requiring the employees to use the computer (desktop or notebook computer) to perform also need to be ergonomically evaluated to eliminate or reduce ergonomic hazards and enhance workplace safety. Office employees should be well educated about possible dangers caused by VDT operation and should be trained about how to work properly with computers.

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7. REFERENCES


