Survey Study of Notebook Computer Use and Preferred Work Postures among Thai University Students

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Abstract

A two-part survey study to investigate the use of notebook computers (NBCs) and preferred work postures during NBC operation among Thai university students is reported in this paper. In the first part, one hundred and two students (56 males and 46 females) who were NBC owners participated in this survey by answering questions about the NBCs that they own, reasons and places of use, and perceived body discomfort. In the second part, twenty-four students (13 males and 11 females) were seated at the workstation of their choice. Digital photographs were taken and a Rapid Upper Limb Analysis (RULA) technique was applied to analyze their work postures. The result shows that the students' work postures range from somewhat awkward to extremely awkward, and could be a major reason that contributes to their body discomfort.

Keywords: Notebook computer, work posture, RULA, ergonomics, perceived discomfort

1. Introduction

Initially, notebook computers (NBCs) were for professionals who need to travel and work in different places with a computer system. On long business trips they have all their important data with them and they can use the time for finishing or changing their presentations or reports. A big advantage is that NBCs need no external power supply for 2-3 hours, so the professionals can work wherever it is necessary or possible such as on the train or airplane.

These days NBCs play an increasingly important role in our daily life because of their portability, light weight, small size, convenience, and performance. Nowadays, NBCs have nearly the same performance as desktop computers and the decreasing price has made them more popular. Because of the better performance and cheaper price of NBCs, students, professors, engineers, businessmen, and others can afford an NBC and use it for their daily works.

However, there is a major disadvantage of NBCs. Ergonomically, they are poorly designed. The design of NBCs violates a basic ergonomic requirement for a computer; that is, the keyboard and screen need to be separated for independent adjustment [1]. In the early days of computers, the keyboard and monitor were integrated into a single unit and this resulted in widespread complaints of musculoskeletal discomfort.

Numerous research studies were conducted to give recommendations about Video Display

Terminal (VDT) operation and seated posture, resulting in the ANSI/HFS 100-1988 Standard [1]. On the other hand, limited information about ergonomic recommendations is available for workers who work with NBCs [2]. With the increasing growth in its popularity among office employees, ergonomics and safety problems caused by NBCs can be expected to accelerate progressively. Mekhora et al. [3] reported that neck and shoulder pain is prevalent in office employees especially those who work with VDTs. Physical implications of NBC operation on body posture have been reported [4, 5, 6, 7]. Straker et al. [6] presented a comparison of body postures during desktop computer and NBC operations. The results revealed that in terms of postural constraints and discomfort, desktop computer users felt better even after 20 minutes of computer use. Horikawa [8] did a quantitative examination on the relation between screen height and trapezius muscle hardness on subjects using desktop computers and NBCs. The results showed that with 15 minutes of data entry work on NBCs, the hardness of trapezius muscle is increased.

Straker et al. [6] suggested that an NBC user would assume a posture that would compromise their typing posture either by increased neck flexion in order to view a lower screen, or by increased shoulder and elbow flexion to reach a higher keyboard. Harbison and Forrester [4] also found that NBC users required an increased forward head inclination to adequately operate the NBC due to its lack of adjustability. In their study, all NBC users adopted a neck flexion of more than 30° greater than the neck posture recommended in the Australian Standard 3590.2–1990.

From the general recommendations given in the ANSI/HFS 100-1988 Standard and those from ergonomic researchers [6, 9, 10, 11, 12, 13], Jalil and Nanthavanij [14] summarized that the NBC user should sit with the back at an upright (or slightly reclined) position; neck flexion should not be more than 10°; shoulder flexion should not be more than 20°; elbow flexion should be about 90°; the lower arm and hand should form a straight line; the lower leg should form a right angle (90°) with the upper leg; both feet should rest comfortably on the floor. Additionally, the viewing distance should be between 38 and 62 cm.

To our knowledge, the number of research studies in Thailand on ergonomic issues related to NBCs is still small. This study is intended to investigate the use of notebook computers (NBCs) and preferred work postures during NBC operation among Thai university students. The paper is organized as follows. Firstly, we explain about the design of the survey study. Next, we discuss the data analysis, including the analysis of work postures during NBC operation. Then, we present the findings. Finally, the conclusions are given.

2. Design of Survey Study
2.1 Subjects

One hundred and two Thai university students (56 males and 46 females) responded to this survey without receiving monetary compensation. These students were from Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand. Their fields of study were engineering and management technology. All of them were NBC users who used NBCs on a regular basis. Additionally, all of them had their own NBCs.

Table 1 shows the summary of selected physical data and experience with computers of the 102 students.

Table 1. Summary of selected physical data and experience with computers

	Gender	Minimum	Maximum	Average	Std. Dev.
Age (year)	Male	18	25	20.8	1.4
	Female	19	24	20.4	0.9
Body height (cm)	Male	165	198	176.0	7.2
	Female	150	172	162.0	5.5
Experience with desktop computer (year)	Male	4	15	9.8	2.6
	Female	3	15	9.2	2.7
Experience with NBC (year)	Male	0.5	10	3.4	2.0
	Female	0.5	12	3.4	2.6

2.3 Data Collection

The first part of the research is the survey of NBC use. One hundred and two SIIT students voluntarily answered the questionnaire. The respondents were also asked if they would agree to have photographs of their work postures during NBC operation taken. From those respondents who agreed, twenty four persons were selected to be involved in the second part of the research, the preferred work posture during NBC operation. Among them, thirteen persons were male and eleven were female.

In the second part, photographs of the front, side, and top views of work postures were taken using a digital camera (Sony, Cybershot DSC-P 8). The purpose of this image recording is for posture analysis using the Rapid Upper Limb Analysis (RULA) technique. Their preferred work postures during NBC work were then analyzed.

It is expected that the findings from the preferred work postures could partly explain the perceived discomfort at various body parts reported by the survey respondents in the first part of the research.

3. Data Analysis
3.1 Descriptive Statistical Analysis

The survey of notebook computer use is analyzed using descriptive statistical analysis. Bar graphs are used to represent the number of students falling in specific categories. Different shading/line patterns are used to differentiate between male and female students.

In addition to the bar graphs, the statistics such as average, standard deviation, maximum, and minimum are also shown.

Table 2. Information gathered by the questionnaire

Category	Information
Part 1: Personal data	Age Gender Body height Experience with desktop and notebook computers Number of notebook computers owned (since firstly used)
Part 2: Notebook computer data	Brand of the currently owned NBC Physical and performance specifications
Part 3: Reasons and places of use	Reasons of purchase Places where NBCs are used Workstation data (table and chair) Purposes of use Work session data
Part 4: Perceived body discomfort	Body parts where physical discomfort is usually experienced (i.e., neck, back, shoulder, wrist, arm, finger, eye) Level of discomfort

3.2 Perceived Body Discomfort

An assessment of body discomfort is based on subjective opinion. The discomfort is divided into 5 levels, where level 0 represents *"no or very little discomfort"* and level 5 *"much discomfort or painful."* In the questionnaire, students are asked to indicate the discomfort level that they usually experience during NBC operation or at the end of the work session by selecting the most appropriate number that represents the discomfort level. The body parts where discomfort or pain is likely to occur include neck, back, shoulder, wrist, arm, finger, and eye.

It is noted that the discomfort experienced during NBC operation could, to some extent, be influenced by the posture of the body. Due to its design deficiency, tall students who sit at a workstation with a low work surface may be able to use the keyboard relatively comfortably, but will have to bend their neck excessively to get a clear view of the screen. On the other hand, short students who sit at the same workstation may feel uncomfortable operating the keyboard, but will find that they can view the screen without having to bend their neck too much. That is to say, the body discomfort depends on the student's stature, size of NBC, and workstation.

3.3 Work Posture Analysis

The Rapid Upper Limb Assessment (RULA) was firstly developed by L. McAtamney and N. Corrett for evaluating individuals' exposures to postures, forces, and muscle activities that have been shown to contribute to repetitive strain injuries (RSI). The use of RULA results in a risk score from one to seven, where higher scores signify greater levels of apparent risk [15]. Later, Lauder [9] refined the RULA technique by introducing changes to increase its relevance for evaluating computer work.

Briefly, the upper arm, lower arm, and wrists postures are evaluated and scores are given for each body part posture. Then, the scores are combined (using a specially developed scoring table) to generate the upper limb posture score. Similarly, the neck, trunk, and legs postures are evaluated and scores are also given. They are combined to generate the neck-trunk-legs score. For both combined scores, scores for muscle use and force are added. Finally, the grand score is determined and action to be taken is recommended.

Action Level One: *A score of one or two indicates that posture is acceptable if it is not maintained or repeated for long periods of time.*

Action Level Two: *A score of three or four indicates that further investigation is needed and changes may be required.*

Action Level Three: *A score of five or six indicates that investigation and changes are required soon.*

Action Level Four: *A score of seven or more indicates that investigation and changes are required immediately.*

For more details on the RULA, see Lueder [9].

4. Results
4.1 Survey of NBC Use

The questionnaire contains questions about the NBCs that the students currently use. Brand, weight, screen size, and performance specifications are examples of the questions asked. The results indicate that the students have quite new NBCs ranging from six months to two years old. This finding is not surprising since the quick change in computer technology makes it a common practice to replace computer equipment relatively often.

The most popular NBC brand among Thai university students surveyed is Acer, followed by Sony, Compaq, Fujitsu, and Hewlett-Packard. The students specified the weight of their NBCs from one to seven kilograms. This wide range may be caused by the fact that some students added the battery and power adaptor when they answered about the weight while some did not.

The size of the NBC screen that is most popular among the students is 14", followed by 15", 15.4", and 17". Perhaps the reason why small-sized NBCs (such as 12.1" and 13.3") are not popular is because of their high price.

Figure 1 shows bar graphs of NBC brands and NBC sizes (as represented by the diagonally measured screen size).

The next group of questions deals with reasons why the students purchase/use NBCs and possible places where NBCs are used. It is found that price and quality are the two most important reasons why the NBC is purchased. Performance specifications, design, brand, size, and weight are also important factors considered
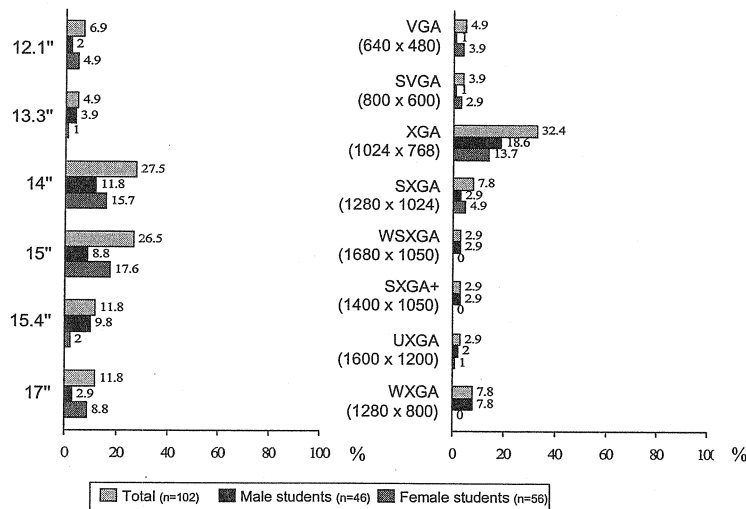
by the students. Between price and quality, the students rated them equally important.

The most popular place where the students use their NBCs is at home, followed by at the university, dormitory, and other places. See Figure 2 for the graphical comparison.
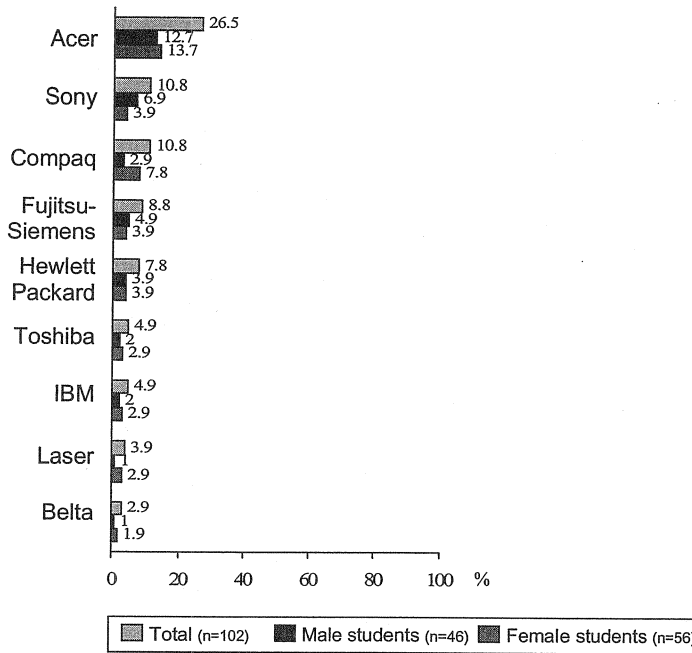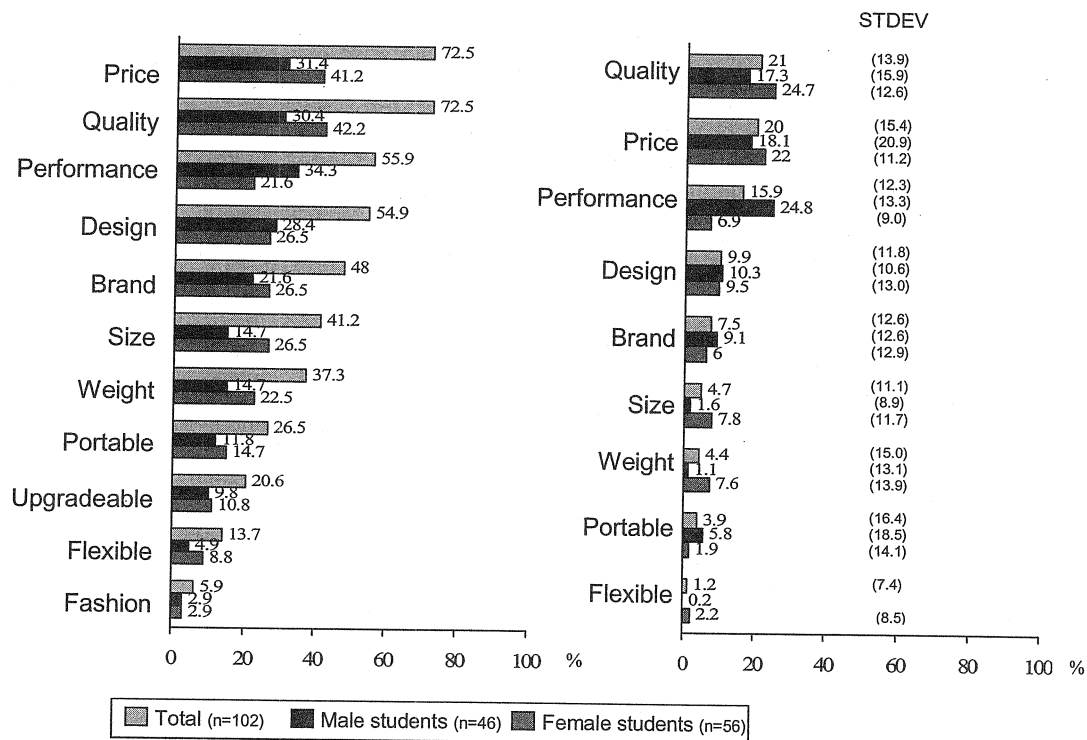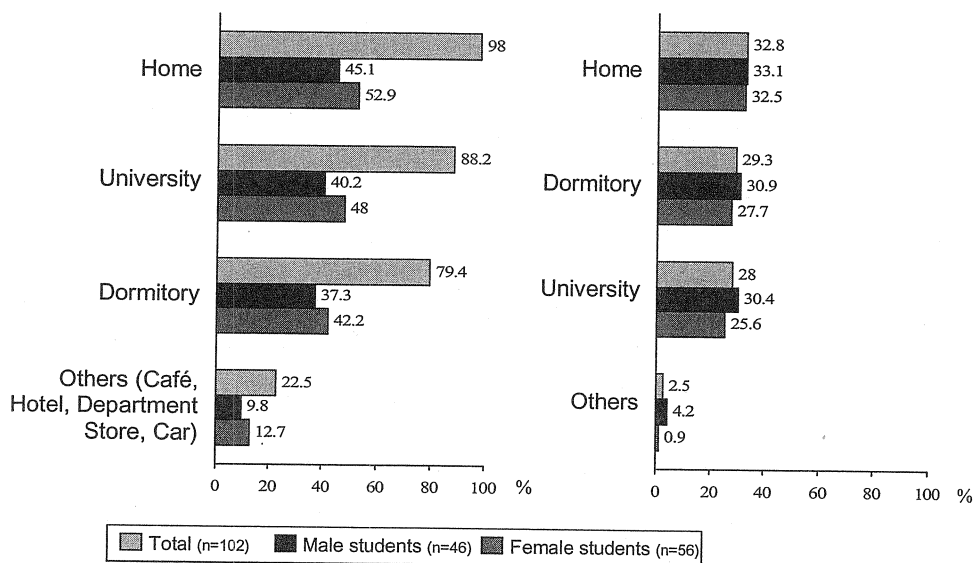

(a) Brand popularity

(b) Preferred NBC screen size

Figure 1. Comparison of brands and sizes of NBC screen owned by the students.
(The left chart in (b) shows the importance rating.)

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(a) Reasons of purchase

Price — 72.5 / 31.4 / 41.2
Quality — 72.5 / 30.4 / 42.2
Performance — 55.9 / 34.3 / 21.6
Design — 54.9 / 28.4 / 26.5
Brand — 48 / 21.6 / 26.5
Size — 41.2 / 14.7 / 26.5
Weight — 37.3 / 14.7 / 22.5
Portable — 26.5 / 11.8 / 14.7
Upgradeable — 20.6 / 9.8 / 10.8
Flexible — 13.7 / 4.9 / 8.8
Fashion — 5.9 / 2.9 / 2.9

Quality — 21 / 17.3 / 24.7 — (13.9) (15.9) (12.6)
Price — 20 / 18.1 / 22 — (15.4) (20.9) (11.2)
Performance — 15.9 / 24.8 / 6.9 — (12.3) (13.3) (9.0)
Design — 9.9 / 10.3 / 9.5 — (11.8) (10.6) (13.0)
Brand — 7.5 / 9.1 / 6 — (12.6) (12.6) (12.9)
Size — 4.7 / 1.6 / 7.8 — (11.1) (8.9) (11.7)
Weight — 4.4 / 1.1 / 7.6 — (15.0) (13.1) (13.9)
Portable — 3.9 / 5.8 / 1.9 — (16.4) (18.5) (14.1)
Flexible — 1.2 / 0.2 / 2.2 — (7.4) (8.5)

Total (n=102) | Male students (n=46) | Female students (n=56)

(b) Places of use

Home — 98 / 45.1 / 52.9
University — 88.2 / 40.2 / 48
Dormitory — 79.4 / 37.3 / 42.2
Others (Café, Hotel, Department Store, Car) — 22.5 / 9.8 / 12.7

Home — 32.8 / 33.1 / 32.5
Dormitory — 29.3 / 30.9 / 27.7
University — 28 / 30.4 / 25.6
Others — 2.5 / 4.2 / 0.9

Total (n=102) | Male students (n=46) | Female students (n=56)

Figure 2. Reasons why NBCs are purchased and places where they are used. (The left charts in (a) and (b) show the importance rating.)

One major advantage of NBCs is their portability. The students reported that they use their NBCs at various workstations. Most students placed the NBCs on writing desks and regular tables. Some used sofa tables as the work surface. For sitting, fixed height and adjustable height chairs were most popular as reported by the students. Surprisingly, there are some students who use the bed and floor as places for sitting. See Figure 3.

When asked about their purposes of using NBCs, the majority of students responded that they use their NBCs primarily for internet purpose (which includes information search and chatting). Using the NBCs for pleasure such as listening to music, watching movies, playing video games, etc. is also popular among the students. Studying is the least popular purpose among the students. See Figure 4.
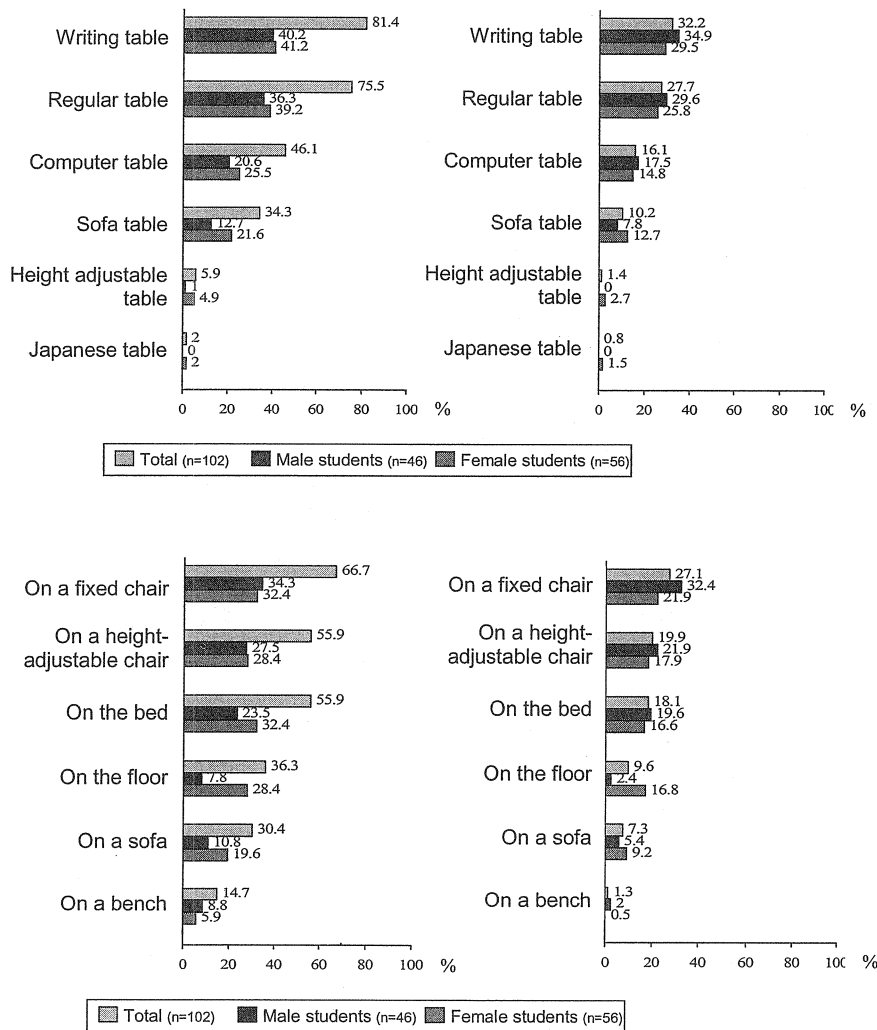
Figure 3. Work surface (top) and sitting surface (bottom) where NBCs are used.
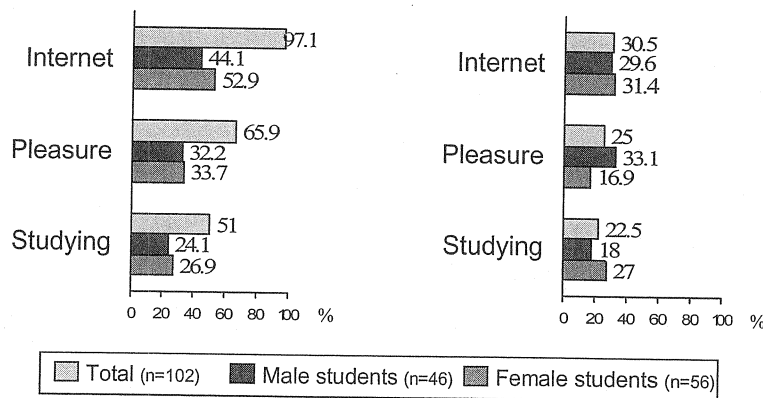
Figure 4. Purposes of using NBCs as reported by the students.

4.2 Perceived Discomforts

Among the seven body parts where discomfort or pain is likely to occur, the neck, back, and shoulder are reported to be the body parts where most students (over 50%) experienced discomfort (see Figure 5). Wrist discomfort is reported only by about 30% of the students. This is perhaps because the students do not mainly use their NBCs for their study (e.g., preparing reports). Discomfort at the neck, back, and shoulder are believed to be the result of a mismatch between the body size, NBC size, and workstation dimensions.

The students rated the discomfort at the neck and back with an average of 3.2 (out of 5), which indicates that they felt *moderate* to *painful* discomfort during NBC operation. The discomfort at the wrist, arm, shoulder, and finger were rated with the averages of 2.6, 2.5, 2.4, and 2.3, respectively.
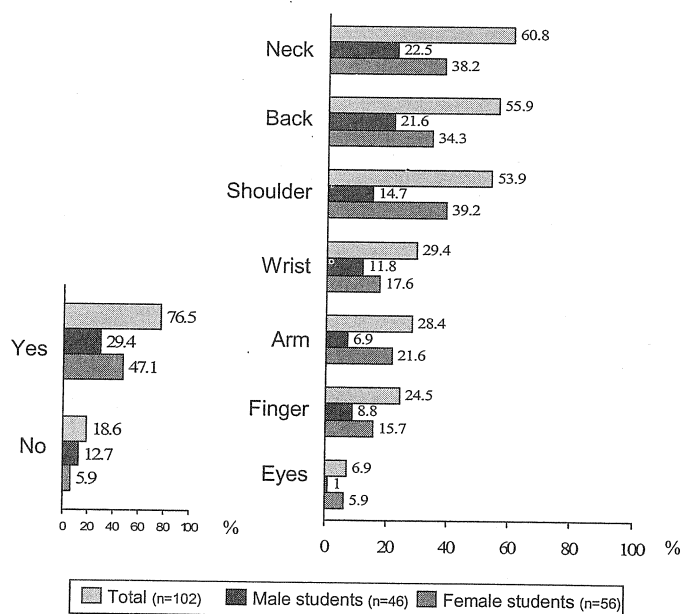
Figure 5. Percent of students experiencing physical discomforts at various body parts.

4.3 Preferred Work Postures

Photographs of the students working with NBCs were taken at various places, namely, student common area (on campus), graduate office, university canteen, private dormitory, and university dormitory. Figure 6 shows that there are a variety of chairs and tables that can be used as NBC workstations, resulting in different seat and work surface heights.

The following paragraphs summarize common postures of the body parts where the students experience physical discomfort.

Neck Flexion

Nearly all students (both male and female) had their neck bent forward excessively during NBC operation. While some students seemed to be able to maintain reasonably straight neck posture, they had to compensate by extending the back and lean against the backrest of the chair. The reason for this neck flexion is because the screen is positioned at a level that is much lower than the student's eye height (sitting). Male students seemed to have more awkward neck posture than female students because of their tall stature.
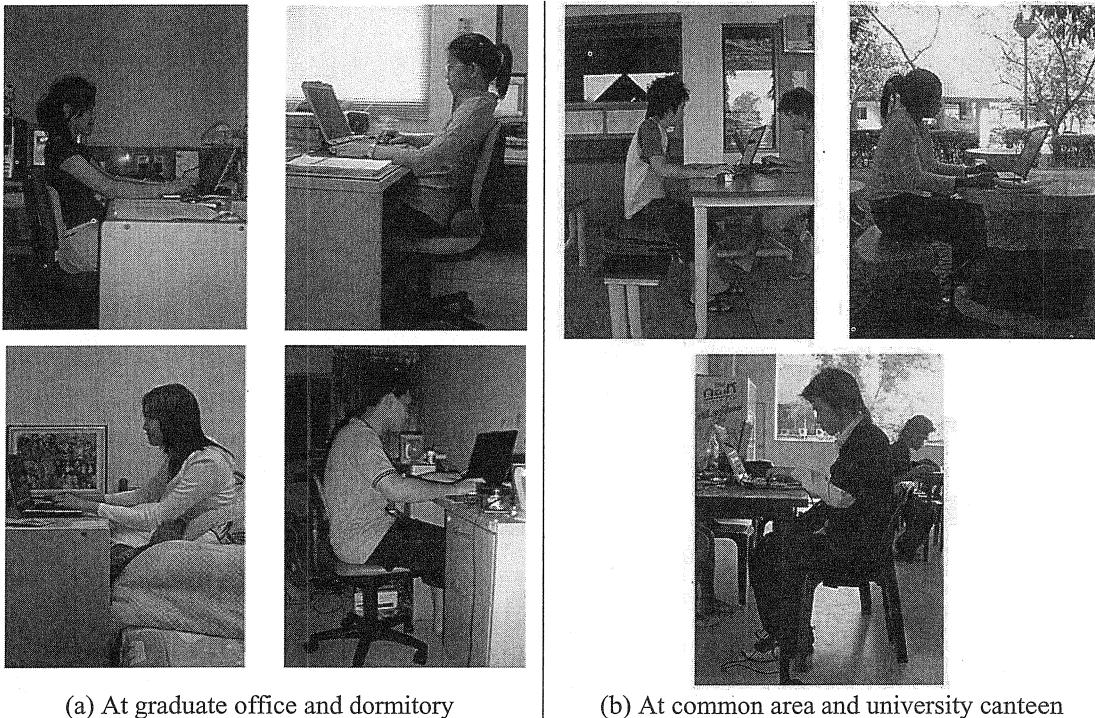
| (a) At graduate office and dormitory | (b) At common area and university canteen |

Figure 6. Places where the students use their NBCs.

Shoulder Flexion

The students who prefer placing the NBC far in front of the body are forced to flex their shoulders extensively in order to reach the keyboard. This posture is also observed in female students who lean against the backrest. It is also believed that placing the NBC too far in front of the body affects both the student's shoulder and neck.

In several occasions, the students rest their lower arms on the work surface when typing.

There is a possibility that the edge of the work surface will press against the underside of the lower arms, causing blood flow occlusion and, possibly, pain.

Back Flexion

Back flexion is also a common work posture during NBC operation. Together with neck flexion, it helps the NBC user to view the screen more comfortably. This awkward posture is inevitable when the work surface is

low, the seat is high, the NBC is small, and the user is tall. Thus, male students are likely to show more back flexion than female students.

Wrist Deviation

Wrist deviation, especially palmar flexion, is observed in most students. This awkward posture is intensified when the NBC is laid flat on the work surface. Some students chose to place the NBC far in front of the body to allow them to maintain a straight wrist posture. In return, shoulder flexion becomes more excessive.

There is usually a trade-off between wrist deviation and neck flexion. When the NBC is positioned relatively high, the high keyboard will cause the wrist to flex excessively while neck flexion is found to be reduced. On the other hand, when the NBC is positioned relatively low, wrist flexion will be alleviated but neck flexion will be worsened.

Top-view photographs (not shown here) also show that several students bent their wrists horizontally in an ulnar deviation when typing. This deviation is caused mainly by placing the NBC too close to the body and using a small NBC (with narrow keyboard width).

4.4 RULA Scores

The RULA technique is applied to analyze the students' work postures. Figure 9 shows a detailed analysis of a male student (Male 3) as an example. Table 3 shows the summary of RULA scores from the 13 male students and 11 female students. From the mean scores, action level three is required for both male and female students. Additionally, it should be noted that most RULA scores of both male and female students are 6. This is not surprising after viewing their awkward work postures in Figures 7 and 8.

Table 3. Summary of RULA scores

	Mean	SD	Max	Min
Males	5.7	0.6	6	4
Females	5.0	1.3	7	3

Attempting to improve the NBC user's work posture is not an easy task, especially when the keyboard and screen cannot be independently adjusted. It is necessary to use external workstation accessories to help adjust the NBC and workstation so that the user can assume a correct work posture.

5. Conclusions

This paper reports a survey study conducted among Thai university students to learn about their decision in purchasing the NBCs, for what purposes they use NBCs, and where they use them. In addition, the survey was intended to find out about physical discomfort at different body parts experienced by the students. For selected students, work postures were photographed and analyzed using the RULA technique.

The survey was conducted at Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand. SIIT is well-known for its technology-oriented educational programs and for having students from wealthy families. Thus, the number of students using NBCs is undoubtedly large as compared to other universities. This is to justify why only SIIT was chosen as a site for this survey study.

From the survey, the most popular brand among the students is Acer. The students reported that they purchase their NBCs based on two important decision factors, namely, price and quality. The NBCs of medium sizes (i.e., 14" and 15") are most popular among students, perhaps due to their inexpensive price as compared to other sizes.

Favorite places where the students use their NBCs are at home, at the university, and at the dormitory. It is worth noting here that the majority of SIIT students stay at university and private dormitories. The students also reported that they use NBCs mostly for internet, followed by for pleasure, and for studying.
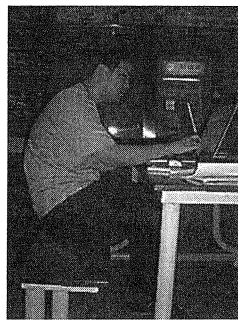
The majority of the students claimed to have physical discomfort during NBC operation especially at their neck, shoulder, and back. Discomfort at these three body regions is common among computer users. Awkward work posture is believed to be a leading cause of physical discomfort.
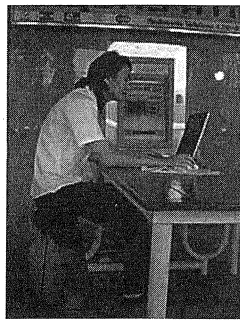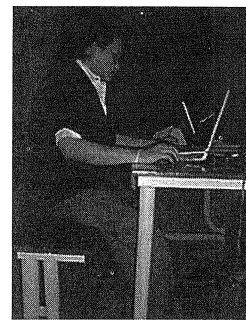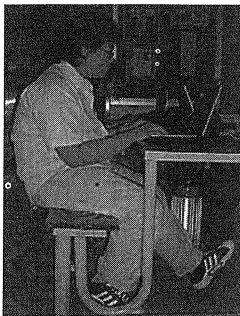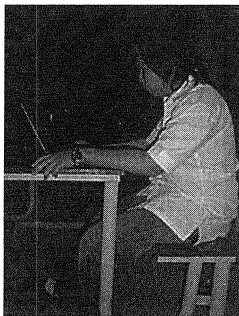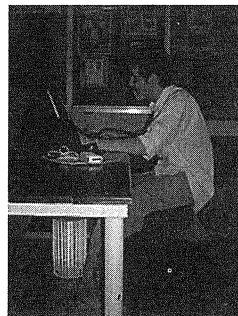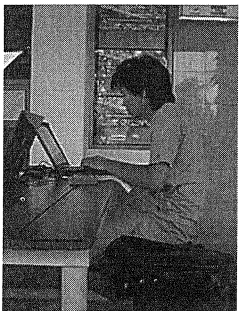
Male 1 | Male 2 | Male 3 | Male 4
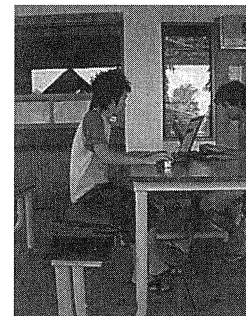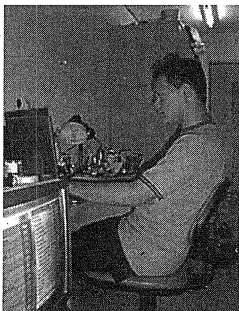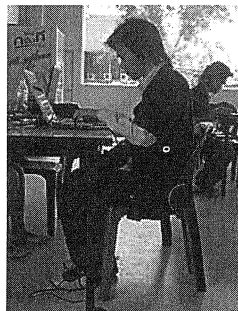

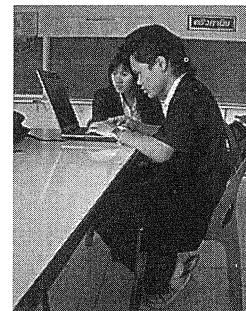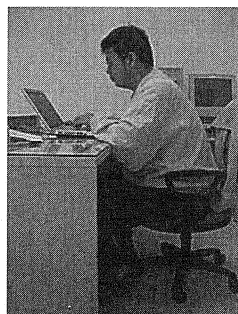Male 5 | Male 6 | Male 7 | Male 8

Male 9 | Male 10 | Male 11 | Male 12

Male 13

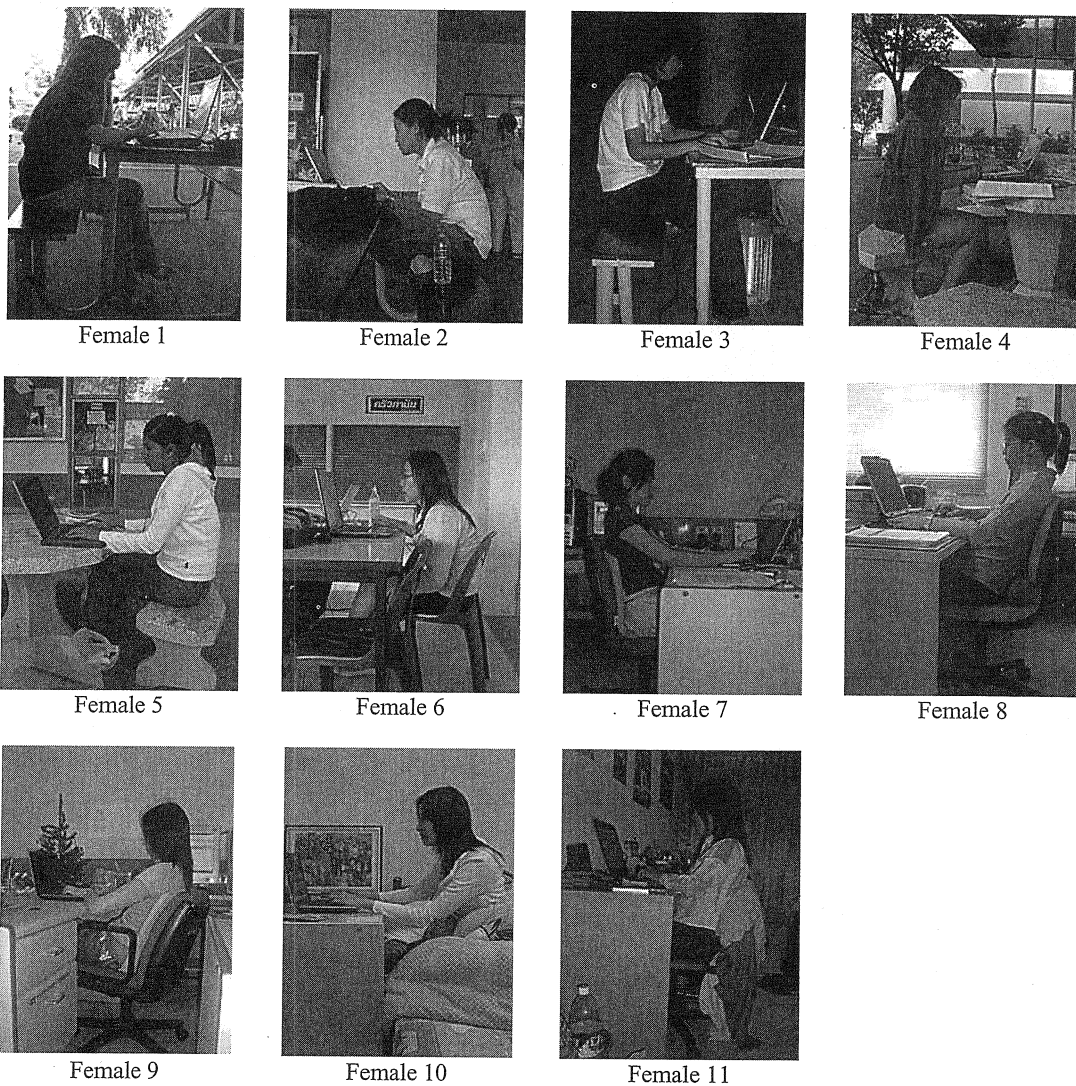**Figure 7.** Preferred work postures of the 13 male students.

Figure 8. Preferred work postures of the 11 female students.

When evaluating the students' work postures, it is seen that all students' work postures range from somewhat awkward to extremely awkward. Excessive neck flexion, shoulder flexion, back flexion, and wrist deviation are seen from the photographs of work postures. These awkward postures are, to some extent, caused by the NBC's non-ergonomic design. To be more specific, the way the keyboard and screen is designed as a single unit causes the adjustment conflict which prevents the NBC user from assuming the correct work posture.

The average RULA scores of 5.7 for male students and 5.0 for female students indicate that investigation and changes are required soon. However, it is inevitable that external workstation accessories must be utilized to help adjust the NBC and workstation to achieve the correct work posture.

Acknowledgments

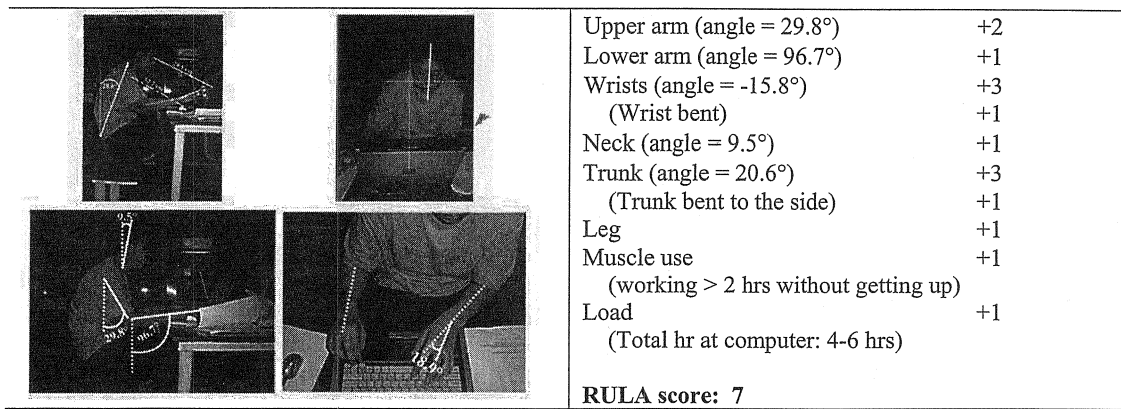| Upper arm (angle = 29.8°) | +2 |
Lower arm (angle = 96.7°)	+1
Wrists (angle = -15.8°)	+3
(Wrist bent)	+1
Neck (angle = 9.5°)	+1
Trunk (angle = 20.6°)	+3
(Trunk bent to the side)	+1
Leg	+1
Muscle use	+1
(working > 2 hrs without getting up)	
Load	+1
(Total hr at computer: 4-6 hrs)	
RULA score: 7	

Figure 9. Detailed posture analysis of one male student (Male 3).

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