WORKSTATION DESIGN FOR NAIL SALON

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Thesis
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WORKSTATION DESIGN FOR NAIL SALON

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ABSTRACT

This study was a quasi-experimental study using questionnaires and the observation of the manicurist's workstation to investigate the fatigue feeling of the manicurist. These observations were made before work, after they used the workstation, and before they used a new workstation in a nail salon in the district of Photharam in Ratchaburi province. Each manicurist worked at their existing workstation for 30 minutes then at a new workstation for 30 minutes before comparing the chemical concentration of each workstation. The manicurists were asked about their fatigue before and after working at their existing and new workstations, and then they were asked about the satisfaction of their new workstation and new table nail. Pair t-test was used to determine the difference between the study groups and variables. Descriptive statistics were used to analyze the finding's percentage, mean, and standard deviation (SD). Ninety-five percent confidence interval was used to determine the comparison between independent variables and the feeling of fatigue.

The objective of this study was to design a workstation which included a table and chair for a manicurist based on ergonomics to reduce the feeling of fatigue.

The results showed the main concentration of chemicals found at the workstations were toluene and butyl-acetate, which decreased by 80% for each concentration (P-value > 0.05). The muscular fatigue feeling was measured by comparing the existing workstation and the new workstation. The findings showed that the new workstation could reduce the fatigue feeling in the neck, shoulders, back, waist, thighs, and knees (P-value < 0.05). The feeling of fatigue was not reduced in the ischium and feet.

The results of the workstation and table nail satisfaction showed that the workers preferred the new workstation for reasons such as height, area, and light (P-value < 0.05). They felt satisfied with the table nail because it reduced unpleasant odors and noise (P-value < 0.05). The workers were not satisfied with the price of the table nail.

KEY WORDS: TABLE NAIL/ NAIL SALON/ SITTING POSTURE

107 pages

การออกแบบสถานีงานสำหรับช่างทำเล็บ

WORKSTATION DESIGN FOR NAIL SALON

สุพัตรา ละอองนวล 4836084 PHIH/M

วท.ม. (สุขศาสตร์อุตสาหกรรมและความปลอดภัย)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: วิชัย พฤกษ์ธาราธิกูล M.Sc. (INDUSTRIAL HYGIENE AND SAFETY), เฉลิมชัย ชัยกิตติภรณ์, Dr.P.H. (EPIDEMIOLOGY), สรา อาภรณ์ Dr.biol. Hum. (TOXIKOLOGIE), วชิระ สิงหะคเชนทร์, M.A.(DEMOGRAPHY).

บทคัดย่อ

การศึกษานี้เป็นการวิจัยแบบกึ่งการทดลองโดยการใช้แบบสอบถามและการออกแบบสถานีงานเพื่อลดความเมื่อยล้าร่างกายของช่างทำเล็บ โดยเปรียบเทียบระหว่างก่อน, หลังจากทำงานกับสถานีงานแบบเดิมและหลังจากทำงานกับสถานีงานแบบใหม่ กลุ่มตัวอย่างที่ศึกษาเป็นช่างทำเล็บที่อยู่ในอำเภอโพธิ์ธาราม จังหวัดราชบุรี โดยเป็นการเปรียบเทียบความเข้มข้นของสารเคมีในร้านทำเล็บเปรียบเทียบระหว่างมีชุดทำเล็บและไม่มีชุดทำเล็บ และความรู้สึกเมื่อยล้าก่อนทำงาน และหลังทำงานกับสถานีงานแบบเดิมและแบบใหม่ รวมถึงความพึงพอใจต่อสถานีงานที่ออกแบบใหม่ โดยสถิติที่ใช้ในการทดสอบคือ Pair t test เพื่อหาความแตกต่างของความรู้สึกเมื่อยล้าระหว่างสถานีงานแบบเดิมและสถานีงานแบบใหม่ทั้งนี้ที่ความเชื่อมั่น 95%

วัตถุประสงค์ของการศึกษาเพื่อออกแบบสถานีงานตามหลักการยศาสตร์ โดยในที่นี้สถานีงานหมายถึงโต๊ะและเก้าอี้ของช่างทำเล็บ เพื่อลดความรู้สึกเมื่อยล้า

ผลการศึกษาพบว่าความเข้มข้นของสารเคมีได้แก่ ทูโลอีนและบิวทิล อะซิเตท ในร้านทำเล็บ ลดลง 80% ทั้งนี้ที่ความเชื่อมั่น 95% ส่วนความรู้สึกเมื่อยล้าเปรียบเทียบระหว่างสถานีงานแบบเดิมและสถานีงานแบบใหม่พบว่า สถานีงานแบบใหม่สามารถลดความเมื่อยล้าลงได้เกือบทุกส่วนของร่างกาย ยกเว้นก้นกบและเท้า

ผลการศึกษาความพึงพอใจของช่างทำเล็บเกี่ยวกับสถานีงานและชุดทำเล็บที่สร้างขึ้นใหม่ พบว่าช่างทำเล็บมีความพอใจสถานีงานแบบใหม่ เช่น พื้นที่, ความสูงและแสงสว่าง เป็นต้น มากกว่าสถานีงานแบบเดิม (P-value < 0.05) โดยการจากสอบถามพบว่า ผลการประเมินส่วนใหญ่อยู่ในเกณฑ์พึงพอใจ ยกเว้นเรื่องของราคาของชุดทำเล็บที่พบว่าช่างทำเล็บส่วนใหญ่ยังไม่พึงพอใจ

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LIST OF ABBREVIATIONS

Abbreviation or symbol	Term
hr	hour
wk	week
BMI	body mass index
Fig.	Figure
NIOSH	The National Institute for Occupational Safety and Health
OSHA	The Occupational Safety and Health Administration

CHAPTER I
INTRODUCTION

1.1 Background and rationale

The beauty business is the service sector business. A survey of the Bureau of Business and Development showed that the rate of its economic growth as high as 4 percent in 2002. The report of the National Statistical Office in 2000 predicted the market value by the year 2002 would be over 1,104 million baht in foreign market. Business of beauty is increasing for the larger needs of customers. (1)

The beauty salons provided many types of services, such as haircut, hair shampoo, hair dyeing, hair styling or face beauty service for example make-up or manicure such as nail painting.

Working conditions in beauty salon (2) are.

- The most posture of beautician was standing posture, 90% of the whole working hour. Today, the posture of beautician for some services was changed to be sitting posture for example those among manicurists. The working hour in beauty salon normally show no break time even in the lunch time. The schedule of worker is necessary to operate the business.
- Equipment and materials in beauty salon included electric appliance and chemicals from beauty products such as nail polish, hair dye etc.
- If beautician uses habitat is a place of work place may open time of hours according the number of customers, and satisfaction of beautician. The average work time of beautician service for customer may have 10-12 people, which according to type of beauty services. The type of beauty service is not equal time according to the individual type services.
- The styles of service will vary according to customer needs. But it could not be estimated proportion of each style of works of service.

The nature business of beauty, it is exposed the many hazards such as hazardous chemicals, ergonomic, etc. In addition, beauticians are manicures or pedicures will have dangerous of light that is not enough, which it may be lead to the accident. Including the biological hazard or different pathogens from the customers may spread to the manicurist. In a reversal of disease from manicurist may spread to their customers.

And the researcher surveyed a preliminary questionnaire about health problem after career of manicurist are 10 manicurists of the Banleag district, Ratchaburi province. As table 1.1 showed that symptoms of manicurist in the first is tired or exhausted or drowsy and pain shoulder, neck and back, they had found 7 manicurists from 10 manicurists. The third symptoms were dry eye symptoms include itch eyes, it had found 5 manicurists of 10 manicurists.

Table 1.1 The symptom of the manicurist was surveyed

Symptom	%
To be tired or exhausted or drowsy	70
Pain shoulder, neck and back	70
Dry eye symptoms include itch eyes	50
To be dizzy or confused	40
Sore eyes	40
Dry and scratch skin	40
Whooping cough	30
Fever	30
Sore throat and phlegmon	30
Nasal congestion and runny nose	20
Sneeze	20
Cough	20
To be suffocated	20
Headache	20
Nauseate	10

And the priority of the problems or hazards by the manicurists showed as Table 1.2. The major hazard is a risk of expose chemistry. The researcher conducted air sampling in the work environment as a nail to the determination of chemical analysis of working environment. The analysis showed the volume chemical concentrations in the work environment were very lower than required by law. Because these chemistries were low odor threshold that cause the manicurists were smell of chemicals odor led to feel annoyed, but them did not effect to the health of manicurists. The 2nd hazard was significant as the risk of infection from the customers. This result of survey has not found the manicurists who infected a disease of the customers. This may be the first step is to clean nails. Sometimes the customers would be cleaning their nails yourself. That would be opportunity of the manicurists were infected by the customers were least. And 3rd hazard was significant as ergonomics hazards they would be cause subsequent health problems such as back pain, etc. This is consistent with the findings of preliminary research found that the manicurists had health problems related to neck and shoulder pain or back strain.

Table 1.2 The priority of the problems or hazard of a manicurist

Hazard	Risk estimation				
	Size of risk	**Severity of hazard**	**Control of risk**	**Need to solve problem**	**Risk rating**
Ergonomics	3.0	4.0	4.0	4.67	224
Chemical	6.0	4.0	3.0	5.33	383
Light inadequate	2.0	2.0	6.0	4.00	96
Nail infections	2.0	6.0	5.5	5.33	351
Accident	2.0	2.0	6.0	4.00	96

For foreign of the governments such as Occupational Safety and Health Administration or OSHA set guidelines for the manicurist used checklist, which has seven sections include licensed shops and manicurists information and train about chemistries they use, hygiene and prevent infection from working, the air quality within the shop, how to protect to contact with blood or substances secretions of our services, ergonomics and other. (3) But Thailand is currently no

standard for the manicurists (4). Several literature reviews have reported a relationship among musculoskeletal disorder and ergonomic risk factor in manicurists. However, the manicurists in Thailand are different in term of salary, life-style and culture, etc. Then the data from overseas may not be appropriate for Thai people.

Therefore, this research study interest in major hazard was ergonomics and chemical. The researcher will identify and protect the hazards of the manicurist in Thailand.

The research questions were 3, such as “did the chemical has effect upon the manicurist?”, “how different the chemical concentration in beauty salon from nail activity compare the existing workstation and new workstation have the local ventilation (table nail)?” and “how different did the feeling of fatigue compare the existence and new workstation?”.

1.2 Objectives

1.2.1 To design the workstation including desk and chair of manicurist based on ergonomics for reducing the fatigue feeling.

1.2.2 To design table nail for manicurist.

1.2.3 To compare satisfaction with the existence and new workstation.

1.3 Hypotheses of this study

1.3.1 The chemical concentration in workplace decreased by 80% while performed nail activity.

1.3.2 The new workstation based on ergonomics approach decreased the rate of tiredness, when compared to the existing workstation.

1.3.3 The increased in the satisfactions of created new table nail among manicurist.

1.4 Variables

1.4.1 Independent variables

1.4.1.1 New table nail was created.

1.4.1.2 New workstation was improved.

1.4.2 Dependent variables

1.4.2.1 The concentration of chemicals had in the work environment from nail activity.

1.4.2.2 Light intensity of work.

1.4.2.3 Muscle fatigue feeling of the manicurist

1.4.2.4 The satisfactions of manicurist about workstation such as high of table for workstation, area of workstation, high of chair for workstation, light for work station, comfort for workstation and overall with workstation including table nail such as disorder, odor, raw material, price, noise, and overall with table nail

1.5 Scope and limitation of the study

1.5.1 To improve workstation of manicurists based on anthropometric data for reducing the fatigue feeling.

1.5.2 To design table nail for reducing odor of chemicals in beauty salon while performed nail activity.

1.5.3 The limitation of this study was collected 35 manicurists had period of career no less than three months in Photharam district, Ratchaburi province it did not include the customers' satisfaction.

1.6 The benefits from this research study

1.6.1 The new workstation of the manicurist can reduce the health problems while performed nail activity.

1.6.2 The manicurist will have safety working condition after use new workstation.

1.6.3 The new workstation of manicurists based on ergonomics data.

1.7 Glossary of terms and operational definitions

Workstation refers to the table nail, chair's customer, chair's manicurist and light intensity of working area for nail activity.

Table nail refers to the local exhaust ventilation was designed to reduce the chemical concentration in working condition while perform nail activity.

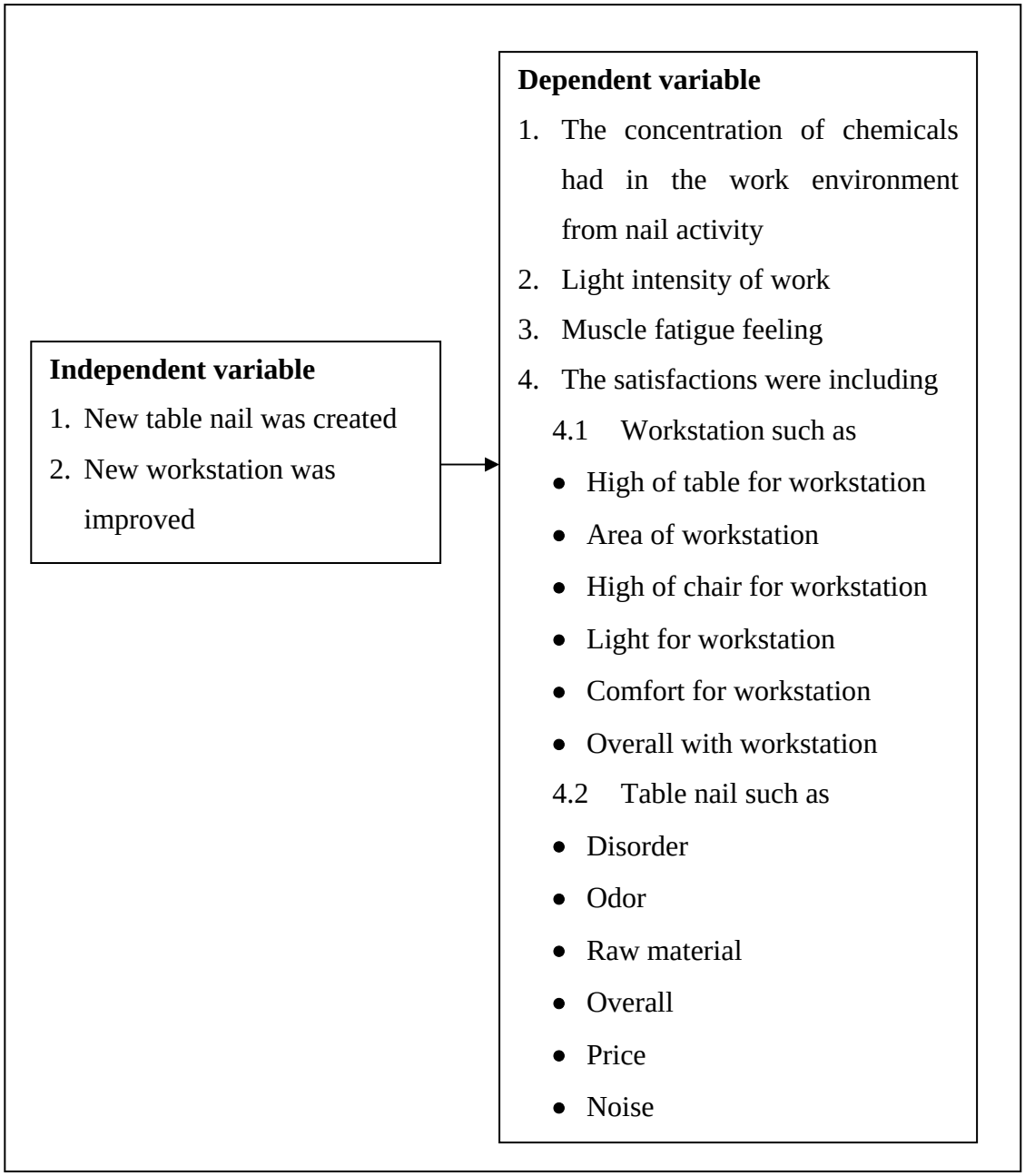
Nail polish refers to reagents also known as enamels or lacquers which used to paint nails. The brands were used widely in beauty salon in Ratchaburi province including Nee Nar, Christry, Moss, LD 2000, Calar etc. The principle ingredients in most, however, are toluene, butyl acetate and octadecanoic acid, methyl ester.

Nail polish remover refers is an organic solvent that is used to remove previously applied nail polish from nails. There are many different types of nail polish removers in the market and different brands may have different chemical compositions. The brands were used widely in beauty salon in Ratchaburi province including Aulentis, Mac, Augus etc. The principle ingredients in most, however, are acetone, ethyl acetate or butyl acetate and alcohol.

The liquid solution used for fill nail polish refers to the liquid chemical solution for fill in nail polish to be painted the same color. The brands were used widely in beauty salon in Ratchaburi province including Lostar, Aulentis, Augus and Miwin etc. The principle ingredients in most, however, are acetone and butyl acetate.

Unpleasant odors refers to odor is caused by one or more volatilized chemical compounds, generally at a very low concentration, that humans or other animals perceive by the sense of olfaction.

1.8 Conceptual framework



CHAPTER II
LITERATURE REVIEW

The objective of this study is to design workstation according to ergonomics and design table nail is local exhaust ventilation for manicurist. The related literature followed:

2.1 Characteristics of the manicurist.

2.2 Chemical hazard from nail technicians' activity.

2.3 Concept design Table nail for use in local exhaust system.

2.4 Physiology of sitting posture.

2.5 Concept design workstation of the manicurist according to ergonomics.

2.6 Concept design lighting of workstation.

2.7 Related research.

2.1 Characteristics of the manicurist.

Beautician means a trained person whose job it is to improve the appearance of a customer's face, body and hair, using creams make-up and other types of treatment, often in a beauty salon.(2)

Manicurist operated such as painting with nail polish, massage and Spa. And the researcher identified and risk assessment of the manicurist's activity as shown Table 2-1. In order that, the nail technician might sit to work for long ago, which caused to increase the stress of the muscle such as backache neckache and the shoulder pain more than standing work posture. The existing workstation of nail's technician would feel fatigue such as.

- The existing chairs in beauty salon, they were not adjustable and vary types depend on the size of business as shown in figure 2-1.
- The table was over height or lower than workstation.
- Unsuitable posture such as reach or inadequate lighting intensity.

Figure 2-1 The existing chairs of nail's technicians were used in beauty salon.

Table 2-1 The manicurist's activity could show the step by step, the potential hazard and protection.

Nail technicians' activity	Potential hazard	Protection
1. To wash feet or hand with liquid soap. **Raw material** - warm water - liquid soap - bowl of water - nailbrush	- Ergonomic hazards was sitting poor posture for a long period of time , thereby increasing risk for musculo-skeletal injuries.(5)	➢ To change the comfortable chair. ➢ Did not continue working for a long period of time. ➢ To stay for short time.
2. To clean hands or feet with alcohol. **Raw material** -Isopropyl alcohol -Ethyl alcohol - Cotton balls or pads	- Hazard of the chemicals were 1) Isopropyl alcohol Overexposure may cause irritation to skin, eyes, ingestion and inhalation including central nervous system depression.	➢ To use a ventilation table is one that has a fan that pulls the chemical vapors into a duct and prevents them from manicurist and customers.

Table 2-1 The manicurist's activity could show the step by step, the potential hazard and protection. (cont.)

Nail technicians' activity	Potential hazard	Protection
2. To clean hands or feet with alcohol. (cont.)	It may cause kidneys and liver damage.(6) 2) Ethyl alcohol Overexposure may cause headache, dizziness, nausea, drowsiness, central nervous system depression, irritation to skin and eyes including kidneys and liver damage**.** It may cause coma and possible death due to respiratory failure and reproductive system effects. (7)	➢ To wear preventive protection equipment (PPE) such as gloves, safety glasses and mask. ➢ To ensure the salon was well ventilated. General ventilation reduced the amount of chemicals in the air.
3. To clean hands or feet with nail polish remover. **Raw material** - Nail polish remover (The basis ingredients are acetone and butyl acetate.) - Cotton balls or pads	- Hazards of the chemical were. 1) Acetone Overexposure may cause headache, dizziness, irritation to skin, eyes and throat and central nervous system depression.(8)	➢ To use a ventilation table is one that has a fan that pulls the chemical vapors into a duct and prevents them from manicurist and customers. ➢ To wear preventive protection equipment (PPE) such as gloves, safety glasses and mask.

Table 2-1 The manicurist's activity could show the step by step, the potential hazard and protection. (cont.)

Nail technicians' activity	Potential hazard	Protection
3. To clean hands or feet with nail polish remover. (cont.)	2) Butyl acetate Overexposure may cause irritation to eyes, skin, nose, mouth, and throat, headache, drowsiness, skin rash, confusion and/or haziness.(8) - Ergonomic hazards was sitting poor posture for a long period of time, thereby increasing risk for musculoskeletal injuries.(5)	➢ To ensure the salon was well ventilated. General ventilation reduced the amount of chemicals in the air.
4. To cut nail and cuticle also called eponychium. **Raw material** - nail clipper	- Physical Hazard was inadequate light level or illuminance cause light-headness, eye strain.(9) - Biological hazard was the pathogens were spread by blood and body fluids from customer throught manicurist.(10) - Work hazard indentify has the accident from nail clipper.(11)	➢ To provide the local light. ➢ To wear preventive protection equipment (PPE) such as gloves, safety glasses and mask. ➢ To wash hands or feet thoroughly with soap and water before beginning. ➢ To wash hands or feet before and after working, going to toilet, eating, drinking and smoking.

Table 2-1 The manicurist's activity could show the step by step, the potential hazard and protection. (cont.)

Nail technicians' activity	Potential hazard	Protection
5. To paint with nail polish. **Raw material** - nail polish	- Hazards of the chemical were. 1) Acetone (see above) 2) Butyl acetate (see above) 3) Toluene Overexposure may cause irritation to eyes and nose, weakness,confusion,inappropriate feelings of happiness, headache, dilated pupils, runny eyes, anxiety, muscle fatigue, inability to sleep, feeling of numbness, skin rash and in more serious cases of overexposure or intentional abuse, liver and kidney damage.(8) - Physical Hazard was inadequate light level or illuminance cause light-headness, eye strain.(9) - Ergonomic hazards was sitting poor posture for a long period of time, thereby increasing risk for musculoskeletal injuries.(11)	➢ To use a ventilation table is one that has a fan that pulls the chemical vapors into a duct. ➢ To wear preventive protection equipment (PPE) such as gloves, safety glasses and mask. ➢ To provide the local light. ➢ To change the comfortable chair. ➢ To stay for short time.

The researcher found the problems of manicure and pedicure technician career. The nail technician could priorities of the problem as follows; the 1st was the hazard form chemical, the 2nd was the infection in nail salon and the 3rd was ergonomic hazard such as fatigue muscle, and the last problem was inadequated lighning, that led to the work-related accident and eye strain.

2.2 Chemical hazard from nail technicians' activity.

Chemical is often defined as pertaining to chemistry; characterized or produced by the forces and operations of chemistry; employed in the processes of chemistry; as, chemical changes; chemical combinations. (4) The researcher tested the air in nail salon by using Gas Chromatography Mass Spectrometry or GC-MS to finding the chemical composition form nail technicians' activity. The chemical productions of nail technicians' activity are nail polish, nail polish remover and the liquid solution. The result showed in Table 2-2, 2-3 and 2-4 about chemical elements and percentage in nail technicials' activity.

Table 2-2 The chemicals were found in nail polish remover.

Chemical	CAS no.	Nail polish remover	
		Type A	Type B
Butyl Acetate	000123-86-4	-	74.52%
Methyl palmitate	000112-39-0	1.53%	10.65%
Octadecanoic acid, methyl ester	000112-61-8	1.28%	7.95%
n-Butanol	000071-36-3	-	1.17%
Bis(2-ethylhexyl) adipate	000103-23-1	48.08%	-
Hexanedioic acid, dioctyl ester	000123-79-5	19.06%	-
Diisooctyl adipate	001330-86-5	27.71%	-

Table 2-3 The chemicals were found in nail polish.

Chemical	CAS no.	Nail polish		
		Type A	Type B	Type C
Toluene	000108-88-3	44.33%	61.81%	59.30%
Butyl acetate	000123-86-4	31.79%	28.04%	36.54%
Octadecanoic acid, methyl ester	000112-61-8	5.72%	0.35%	0.80%
n-Butanol	000071-36-3	-	0.55%	0.25%

Table 2-4 The chemicals were found in the liquid solution used for fill nail polish.

Chemical	CAS no.	The liquid solution used for fill nail polish	
		Type A	Type B
Butyl acetate	000123-86-4	90.65%	91.93%
Methyl palmitate	000112-39-0	4.53%	4.20%
Octadecanoic acid, methyl ester	000112-61-8	3.31%	3.07%
n-Butanol	000071-36-3	-	0.45%

The chemicals were found in nail polish, nail polish remover and the liquid solution used for fill nail polish such as toluene, butyl acetate, methyl palmitate, bis(2-ethylhexyl) adipate , hexanedioic acid, dioctyl ester and n-butanol. The chemicals were individual hazard as shown in Table 2-5.

Table 2-5 A syptom or disorder after exposure the chemical products in nail technicians' activity.

Chemical	A syptom or disorder after exposure chemicals.	Standard	product
Toluene CAS No. 000108-88-3	Overexposure may cause irritation to eyes and nose, exhaustion, dizzy, anxiety, headache, dilated pupils, runny eyes, muscle fatigue, inability to sleep, feeling of numbness, skin rash and liver and kidney damage. (8)	**OSHA** PEL-TWA:200 ppm PEL-STEL: 300ppm PEL-C: 500 ppm **ACGIH** TLV-TWA: 50 ppm **Thai's law**(9)**:** 200 ppm	A
Butyl acetate CAS No. 000123-86-4	Overexposure may cause irritation to eyes, skin, nose, mouth, throat, headache, drowsy, skin rash and haziness.(8)	**OSHA** PEL-TWA:150 ppm PEL-STEL: 200ppm **ACGIH** TLV-TWA: 150ppm TLV-STEL:200ppm	A, B, C
Methyl palmitate CAS No. 000112-39-0	Overexposure may cause irritation to eyes, skin, respiratory tract, and digestive tract rumpus.(12)	-	B

Table 2-5 A syptom or disorder after exposure the chemical products in nail technicians' activity. (cont.)

Chemical	A syptom or disorder after exposure chemicals.	Standard	product
Bis(2-ethylhexyl) adipate CAS No. 000103-23-1	Overexposure may cause irritation to eyes, skin, and respiratory tract. (13)	-	B
n-Butanol CAS No. 000071-36-3	Overexposure may cause irritation to skin, eyes, ingestion and inhalation Inflammation of the eye is characterized by redness, watering, and itching. Inflammation of the skin is characterized by itching, scaling, reddening, or, blistering. (8)	**OSHA** PEL-TWA: 150 mg/m^3 50 ppm **ACGIH** TLV-TWA: 152 mg/m^3	A, B, C

Remark A meant nail polish
B meant nail polish remover
C meant the liquid solution used for fill nail polish

The result was shown the chemical concentrations in nails' product, were found very low (< 50 ppm) in nail salon. The researcher thought the chemical concentration in nail salon, will less than the regulation law. The odor threshold can be devided 2 types such as.

- **The odor detection threshold** meant the minimum concentration at which an odor can be detected without any requirements to identify or recognize the stimulus.

- **The odor recognition threshold** meant the minimum concentration at which a stimulus can be identified or recognized.

And the product was studied as shown in Table 2.6, which identified the chemicals and the odor threshold.

Table 2-6 The odor threshold of nails' product (14)

Products	Chemical	Standard	Odor threshold
- nail polish - nail polish remover - the liquid solution used for fill nail polish	Butyl acetate	150 ppm	3.00 ppm
- nail polish - nail polish remover - the liquid solution used for fill nail polish	n-Butanol	20 ppm	0.12 ppm
- nail polish	Toluene	200 ppm	0.16 ppm

From Table 2-6, the manicurist had unpleasant odors, this problem feel annoyed to nail technicians and customers. So then the major chemical problem was felt to annoy from nails' activity.

2.3 Concept design Table nail for use in local exhaust system.

Exhaust ventilation system are classified in two generic groups:

- **Dilution exhaust ventilation system** can be used for heat control and removal of contaminants generated in a space by flushing out a given space with large quantities of air. When used for heat control, the air may be tempered and recycled. When used for contaminant control, enough outdoor air must be mixed with the contaminant so that the average concentration is reduced to a safe level. The

contaminated air is then typically discharged to the atmosphere. A supply system is usually used in conjunction with a general exhaust system to replace the air exhausted.(15)

- **Local exhaust ventilation system (LEV)** operate on the principle of capturing a contaminant at or near its source. It is the preferred method of control because it is more effective and the smaller exhaust flow rate results in lower heating costs compared to high flow rate general exhaust requirements. The present emphasis on air pollution control stresses the need for efficient air cleaning devices on industrial ventilation systems, and the smaller flow rates of the local exhaust system result in lower costs for air cleaning devices.

Local exhaust sytems are comprised of up to four basic elements: the hood, the duct system (including the exhaust stack and recirculation duct), the air cleaning device, and the fan. (16)

2.3.1. Hood

To collect the contaminant generated in an air stream directed toward the hood, and then transport the contaminated air to duct system.

2.3.1.1. Hood design factors

- **Capture velocity** is the minimum hood-induced air velocity necessary to capture and convey the contaminant into the hood is referred to as capture velocity. This velocity will be a result of the hood air flow rate and hood configuration. The capture velocity recommended for hood was shown in Table 2-7.

Table 2-7 Range of capture velocity.(16)

Condition of dispersion of contaminant	Examples	Cap. Velocity (m/s)
- Released with practically no velocity into quiet air.	- Evaporation from the tank, degreasing, etc.	0.25 – 0.5
- Released at low velocity into moderately still air.	- Spray booths, intermittent container filling, low speed conveyou transfers, welding, plating, pickling	0.5 – 1.0
- Active generation into zone of rapid air motion.	- Spray painting in shallow booths, barrel filling, conveyor loading, crushers	1.0 – 2.5
- Released at high initial velocity into zone at very rapid air motion.	- Grinding, abrasive blasting, tumbling	2.5 – 10.0

In each category above, a range of capture velocity is shown. The proper choice of values depends on several factors.

Lower End of Range

1) Room air currents minimal or favorable to capture.
2) Contaminants of low toxicity or of nuisance value only.
3) Intermittent, low production.
4) Large hood-large air mass in motion.

Upper End of Range

1) Disturbing room air currents.
2) Contaminants of high toxicity.
3) High production, heavy use.
4) Small hood-local control only.

The researcher designed capture velocity 0.5 m/s because the disturbing room air currents and small hood-local control in this study.

- Hood flow rate determination, considered characteristic of chemical in nails product, which the chemical always falls on the ground. So that the hood type was called Downdraft, was suitable. Then the hood for nails' activities were flanged multiple slot openning. Hood flow rate can be approximatetd by

$$Q = 0.75V(10X^2 + A)$$

Where: Q = air flow, cfm

V = centerline velocity at X distance from hood, fpm

X = distance outward along axis in ft.

A = area of hood opening, ft^2

D = diameter of round hoods or side of essentially square hoods, ft

2.3.2. Dust system

To transport the contaminate air to the air cleaning device, if present, or to the fan. A minimum design velocity was required to prevent settling and plugging of the duct. By minimum recommended design velocities are higher than theoretical and experimental values to protect against practical contingencies.

2.3.3. Air cleaning devices

The contaminants were removed from an air or gas stream. They are available in a wide range of designs to meet variations in air cleaning requirements. Degree of removal required, and conditions of the air or gas stream will all have a bearing on the device selected for any given application. In addition, fire safety and explosion control must be considered in all selections.

2.3.4. Fan

To move air in ventilation or exhaust system, energy is required to overcome the system losses. This energy can be in the form of natural convection or buoyancy. Most systems, however, require some powered air moving device such as a fan or an ejector.

Fan can be divided into three basic groups; axial, centrifugal, and special types. As a general rule, axial fans are used for higher flow rates at lower resistances and centrifugal fans are used for lower flow rates at higher resistances.

2.3.4.1. Centrifugal flow often called a "squirrel cage" (because of its similarity in appearance to exercise wheels for pet rodents), the centrifugal fan has a moving component (called an impeller) that consists of a central shaft about which a set of blades, or ribs, are positioned. Centrifugal fans blow air at

right angles to the intake of the fan, and spin the air outwards to the outlet (by deflection and centrifugal force). The impeller rotates, causing air to enter the fan near the shaft and move perpendicularly from the shaft to the opening in the scroll-shaped fan casing. A centrifugal fan produces more pressure for a given air volume, and is used where this is desirable such as in leaf blowers, blowdryers, air mattress inflators, inflatable structures, climate control, & various industrial purposes. They are typically noisier than comparable axial fans.

2.3.4.2. Axial flow has blades that force air to move parallel to the shaft about which the blades rotate. Axial fans blow air along the axis of the fan, linearly, hence their name. This type of fan is used in a wide variety of applications, ranging from small cooling fans for electronics to the giant fans used in wind tunnels. Examples of axial fans are table fan, ceiling fan.

2.3.4.3. The special types or crossflow or tangential fan, sometimes known as a tubular fan was patented in 1893 by Mortier, and is used extensively in the HVAC industry. The fan is usually long in relation to the diameter, so the flow approximately remains two-dimensional away from the ends. The CFF uses an impeller with forward curved blades, placed in a housing consisting of a rear wall and vortex wall. Unlike radial machines, the main flow moves transversely across the impeller, passing the blading twice.

2.3.5. Exhaust stack

It is the final component of the ventilation system, an extension of the exhaust duct above the roof. There are two reasons for the placement of an exhaust stack on a ventilation system. First, the air exhausted by a local exhaust system should escape the building envelope. Second, once it has escaped the building envelope, the stack should provide sufficient dispersion so that the plume does not cause an unacceptable situation when it reaches the ground.

2.4 Human physiology

The human skeleton consists of both fused and individual bones supported and supplemented by ligaments, tendons, muscles and cartilage. It serves as a scaffold which supports organs, anchors muscles, and protects organs such as the brain, lungs and heart. The biggest bone in the body is the femur in the thigh, and the smallest is the stapes bone in the middle ear. In an adult, the skeleton comprises around 30-40% of the total body weight, and half of this weight is water.

Fused bones include those of the pelvis and the cranium. Not all bones are interconnected directly: there are three bones in each middle ear called the ossicles that articulate only with each other. The hyoid bone, which is located in the neck and serves as the point of attachment for the tongue, does not articulate with any other bones in the body, being supported by muscles and ligaments.

There are 206 bones in the adult human skeleton, a number which varies between individuals and with age - newborn babies have over 270 bones some of which fuse together. These bones are organized into a longitudinal axis, the axial skeleton, to which the appendicular skeleton is attached. (17)

2.4.1. Human anatomy

In human anatomy, the vertebral column (backbone or spine) is a column usually consisting of 33 vertebrae, the sacrum, intervertebral discs, and the coccyx situated in the dorsal aspect of the torso, separated by spinal discs. It houses and protects the spinal cord in its spinal canal.

The vertebral column presents several curves, which correspond to the different regions of the column, and are called cervical, thoracic, lumbar, and pelvic. The cervical curve, convex forward, begins at the apex of the odontoid (*tooth-like*) process, and ends at the middle of the second thoracic vertebra; it is the least marked of all the curves.

There are a total of 33 vertebrae in the vertebral column, if assuming 4 coccygeal vertebrae. The individual vertebrae, named according to region and position see Figure 2-1 and Figure 2-2, from superior to inferior, are:

- Cervical curvature: 7 vertebrae (C1–C7)
- Thoracic curvature: 12 vertebrae (T1–T12)
- Lumbar curvature: 5 vertebrae (L1–L5)
- Sacrum: 5 (fused) vertebrae (S1–S5)
- Coccyx: 4 (3–5) (fused) vertebrae (Tailbone)

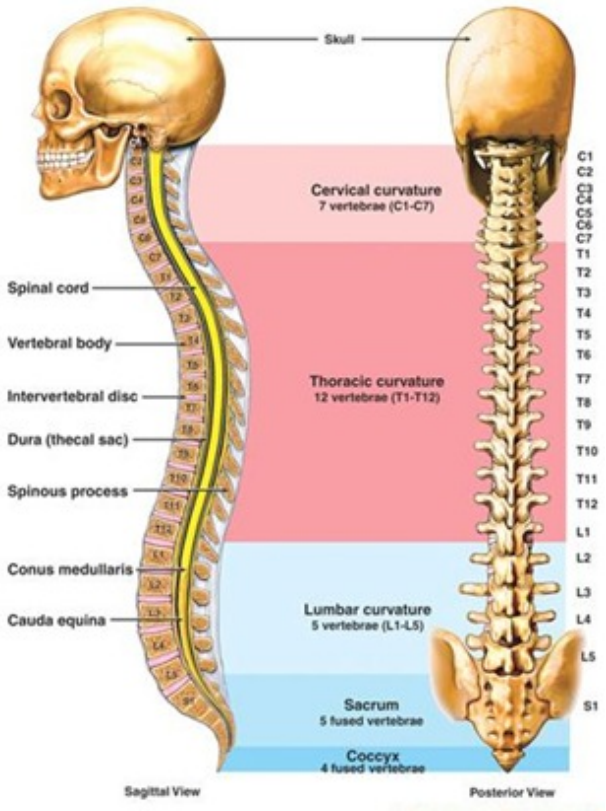


Figure 2-2 The vertebral column seen from the side. (18)

Although individual vertebrae move little from one to the next, the human spinal column as a whole is a chain flexible enough to allow us to touch our toes. Its unique S-shape (see Figure 2-2) centers the weight of our long bodies over our feet, keeping us from toppling. Animals that walk on all four legs have straighter spines that provide even support for their horizontal bodies. Natural curves are important. Without these curves the spine would not have the strength and resilience to act as a shock absorber during movement. The back's curves are designed to absorb shock and to facilitate the full range of motion throughout the spinal column. The natural curves act as a coiled spring to absorb force or jarring during activity. Jogging or jumping

rope would be impossible without these curves. The yielding curves are the pillars of strength, resilience, and flexibility in the spine. Nonetheless, our back's flexibility is not without its own set of problems.

The vertebral column is the flexible structure that forms the longitudinal axis of the skeleton. The vertebrae are separated by intervertebral disks. They provide attachment for various muscles, such as the iliocostalis thoracis and the longissimus thoracis, which give the column strength and flexibility.

Intervertebral discs lie between adjacent vertebrae in the spine. Each disc forms a cartilaginous joint to allow slight movement of the vertebrae, and acts as a ligament to hold the vertebrae together. Discs consist of an outer annulus fibrosus, which surrounds the inner nucleus pulposus as shown in figure 2-3.

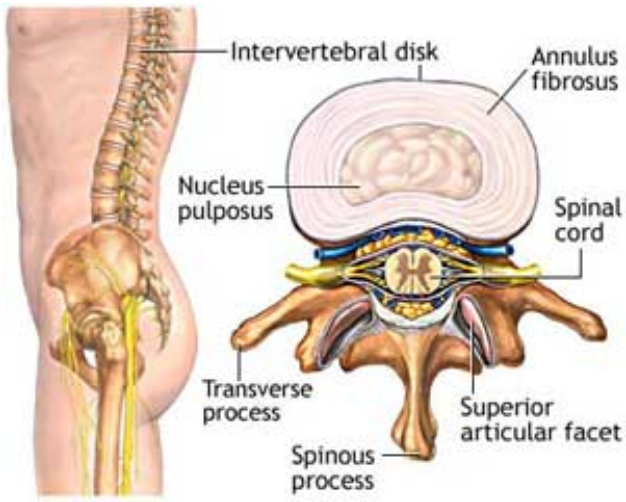


Figure 2-3 The cross section of of intervertebral discs. (19)

The annulus fibrosus consists of several layers of fibrocartilage. The strong annular fibers contain the nucleus pulposus and distribute pressure evenly across the disc. The nucleus pulposus contains loose fibers suspended in a mucoprotein gel with the consistency of jelly. The nucleus of the disc acts as a shock absorber, absorbing the impact of the body's daily activities and keeping the two vertebrae separated. The disc can be likened to a doughnut: whereby the annulus fibrosis is similar to the dough and the nucleus pulposis is the jelly. If one presses down on the front of the doughnut the jelly moves posteriorly or to the back. When

one develops a prolapsed disc the jelly/nucleus pulposus is forced out of the doughnut/ disc and may put pressure on the nerve located near the disc. This can give one the symptoms of sciatica.

2.4.2. Physiology of the sitting posture

Long-term sitting in conventional postures increases the risk of developing chronic musculoskeltal disorders, particularly involving the neck, back and shoulders(20). The rates of spinal disorders in particular have continued to in crease in the general population and have become more severe and expensive, affecting our discomfort, health, quality of life and effectiveness at work. Research shows that in sitting there is a significantly increased load on the lower lumbar discs compared to standing erect, and an even larger load when sitting in a stooped posture.

An estimated 50% of people in the industrialized world suffer some form of back complaint and many of these are related to poor seat design. How we sit and what we sit on affects the health of the spine. The lumbar region is the most frequently damaged (L4 and L5). The vertebrae in the lumbar region are the largest in the spine. (21)

Sitting is a body position in which the weight of the body is transferred to a supporting area mainly by the ischial tuberosities of the pelvis and their surrounding soft tissue. The purpose of sitting to remove weight from the feet and maintain a stable posture so muscles not directly involved with the work can relax. And the ideal is no single ideal sitting posture. Illustrated 90-degree person sitting posture is for anthropometric reference only. The chair could allow different users to each sit in a variety of postures.

The posture is the relative orientation of parts of the body in space, for example the best posture imposes the least postural stress. Muscles must do work to counteract the effects of gravity and other forces as the body stands or moves through space. The opposite, the bad posture would fidget the body defense against postural stress of which discomfort is a sign.

Biomechanics of sitting was depending on chair and posture, some proportion of total body weight is transferred to the floor via the seat pan and feet, armrests, and backrests. The sitting postures could identify 3 postures as shown in figure 2-4;

- Anterior (forward leaning) center of mass in front of the ischial tuberosities. Floor supports more than 25% of body weight. Common posture for desk work.
- Middle (relaxed, unsupported) center of mass directly above ischial tuberosities. Floor supports 25% of body weight. Straight or slightly kyphotic lumbar spine.
- Posterior (backward leaning) center of mass behind ischial tuberosities. Floor supports less than 25% of body weight. Common for chairs with large, inclined, backrests. Preferred for resting.

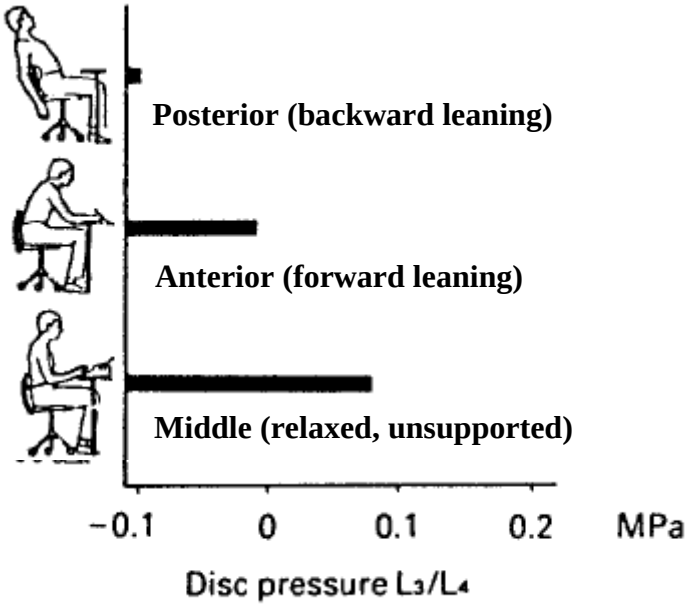


Figure 2-4 The disc pressure variety of sitting posture. (22)

2.4.2.1. Problem with sitting

The results of sitting in high loads to the vertebral discs, can expain following; the first, the distinction must be made between the back muscles and the vertebral disks. When you stand for long periods, the disk pressure is relatively low, but you nevertheless feel pain, which is a result of fatigued lowback muscles. The second, increased pressure on the disks in and of itself does not necessarily result in immediate pain. Thus, we are often unaware of this pressure, which in the long term can lead to deformative changes in the discs. And then upon sitting down, which causes a majority of your bodyweight to load the discs. As we mentioned earlier, you probably will not feel any pain at all when this happens. But over the long term, the constant, increased load upon the disks can result in a multitude of problems, from impinged nerve roots to degenerative osteoarthritic changes.

The exact cause of back pain is often difficult to pinpoint. However there are a number of factors that have been scientifically shown to increase the risk of developing back pain or a back injury:

- Loss of the lordotic curve in the lumbar region – Often called the lumbar curve, this curve is where the upper body connects with the lower body. When the body moves from a standing to a sitting position, the hips rotate, causing the lumbar curve to lose its outward curve. This loss of curve is detrimental to spinal health.

- Muscle Tension – When seated with poor posture the muscles in the anterior of the trunk (abdominal muscles) tend to relax. Contraction of these muscles is required to maintain a healthy curvature in the spine. Decreased activity in these muscles results in increased pressure being placed on the intervertebral discs.

- Uneven pressure distribution – When the lumbar curve flattens out in the seated posture, the pressure on the intervertebral discs increases. This increase in pressure does not occur evenly. The anterior (front) of the disc has much more pressure compared to the posterior (back) of the disc. This creates conditions where the gel-like center of the disc can move posteriorly (herniation). If the gel-like center does move, it can press on the nerves in the spine and lead to back pain.

- Static loading in the back muscles – When seated the muscles in the posterior of the trunk (erector spinae) are placed under static loading (constant contraction) conditions. This constant contraction can increase the risk of fatiguing the lower back muscles and lead to back spasm, cramps or injury. This constant contraction results in increased pressure on the intervertebral discs.

Sitting without arm rests – When seated the weight of the upper body presses down into the hips. Properly adjusted armrests provide support for the weight of the arms and partial support for the weight of the upper body. Increased support of the upper body results in less pressure on the intervertebral discs.(24)

2.4.2.2 Abnormalities of vertebrae

Occasionally the coalescence of the laminae is not completed, and consequently a cleft is left in the arches of the vertebrae, through which a protrusion of the spinal membranes (dura mater and arachnoid), and generally of the spinal cord (medulla spinalis) itself, takes place, constituting the malformation known as spina bifida. This condition is most common in the lumbosacral region, but it may occur in the thoracic or cervical region, or the arches throughout the whole length of the canal may remain incomplete.

The following abnormal curvatures may occur in some people as shown in figure 2-5:

- **Kyphosis** is an exaggerated kyphotic (posterior) curvature in the thoracic region. This produces the so-called "humpback" or "dowager's hump", a condition commonly observed in osteoporosis.
- **Lordosis** is an exaggerated lordotic (anterior) curvature of the lumbar region, "swayback". Temporary lordosis is common among pregnant women.
- **Scoliosis**, lateral curvature, is the most common abnormal curvature, occurring in 0.5% of the population. It is more common among females and may result from unequal growth of the two sides of one or more vertebrae. It can also be caused by pulmonary atelectasis (partial or complete deflation of one or more lobes of the lungs) as observed in asthma or pneumothorax.

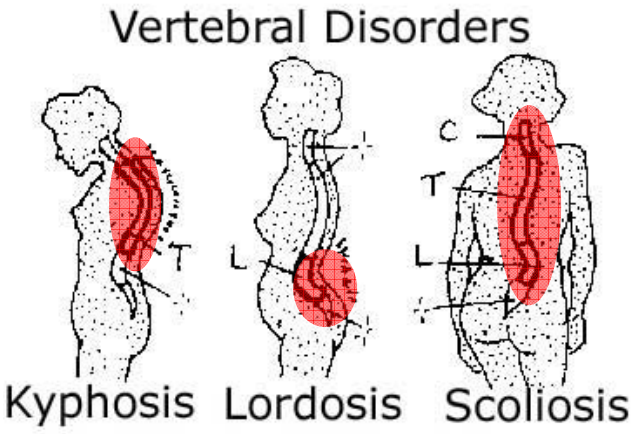


Figure 2-5 The abnormal curvatures were found in human. (25)

From many researchs studied about problem of sitting posture could be summarized as shown in Table 2-8.

Table 2-8 The results were caused the problem from sitting posture.(26)

Sitting posture.	**The part of bodies would injury.**
Sit down straight without backrest.	Back muscles
Chair is too high.	Knee, thigh and feet
Chair is too low.	Calves, knees and feet
Table is too high.	Shoulder, hip and neck
The bodies bent in front of, or hand	Shoulder and neck
extended in front of or the top.	The waist; the degeneration of the spine
Forward or backward Head	Shoulder and upper arm.
	Throat; the degeneration of the spine

2.5 Concept design workstation of the manicurist according to ergonomics.

Ergonomics is the science of designing user interaction with equipment and workplaces to fit the user. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long-term disability. (27)

The International Ergonomics Association defines ergonomics as follows:

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. (28)

Ergonomists draw on the principles of industrial engineering, psychology, anthropometry (the science of human measurement), and biomechanics (the study of muscular activity) to adapt the design of products and workplaces to people's sizes and shapes and their physical strengths and limitations. Ergonomists also consider the speed with which humans react and how they process information, and their capacities for dealing with psychological factors, such as stress or isolation. Armed with this complete picture of how humans interact with their environment, ergonomists develop the best possible design for products and systems, ranging from the handle of a toothbrush to the flight deck of the space shuttle.

A well-designed workstation is important for productive work. If performed efficiently and quickly, could result in greater productivity. Further, each workstation should be designed to suit the needs of the individual worker (dependant upon height, reach, size, etc) and take into account the type of machine being used and the task being performed. A well-organised workstation will improve efficiency and reduce worker fatigue. Sometimes even minor ergonomic changes in the design of equipment, workstations or job tasks, that cost very little, can make significant improvements in worker comfort, health, safety and productivity.

The working condition inappropriates to suit, will bring a problem about the muscle at in the body, will have two character symptoms is acute, mean the symptoms occur suddenly such as lift of then have a backache immediately, and chronic or cumulative injuries have no the symptoms immediately, but the symptoms will happen when exposure risk for a long time period.

2.5.1. Principle of ergonomic workstation design.

Workstation design for sitting posture was that most workers sit at the same workstation to perform the same tasks on a daily basis, it makes sense to almost "personalise" the machine, chair etc or make it easy for such equipment to be adjusted

to suit each worker. If the workstation is poorly designed it can lead to lower back injury, the development or aggravation of RSIs (Repetitive Strain Injuries) and circulatory problems in the legs.(29)

Anthropometrics and design could separate following; (30)

- **Design for the "average" person**, since there are no people whose body dimensions are all at the 50th percentile. Body dimensions aren't linearly correlated so people with short arms don't necessarily have short legs, etc. While the use of the 5th and 95th percentiles on one body dimension may exclude 10% of the population, the use of these on 13 dimensions actually can exclude 52% of the population.
- **Design for 5-95th percentile** designed to include the ranges between the 5th and 95th percentiles of anthropometric data doesn't fit everyone.
- **Use appropriate anthropometric data** are only specific to the populations which they describe. If the population is poorly specified the percentiles may be biased. Also, percentiles are only specific to the dimension which they describe.

- **Maximum value** examples include door clearances and door widths for wheelchairs and users (arms must work the chair), getting a gurney through a door, and railings.

- **Minimum clearances** examples include safety clearances for railings and elevator buttons.

- **Design for an adjustable range** but beware of the cost/benefits of including more percentiles. Each successive percent of the population to be accommodated increases the costs relative to the benefits, i.e. there are no diminishing returns.

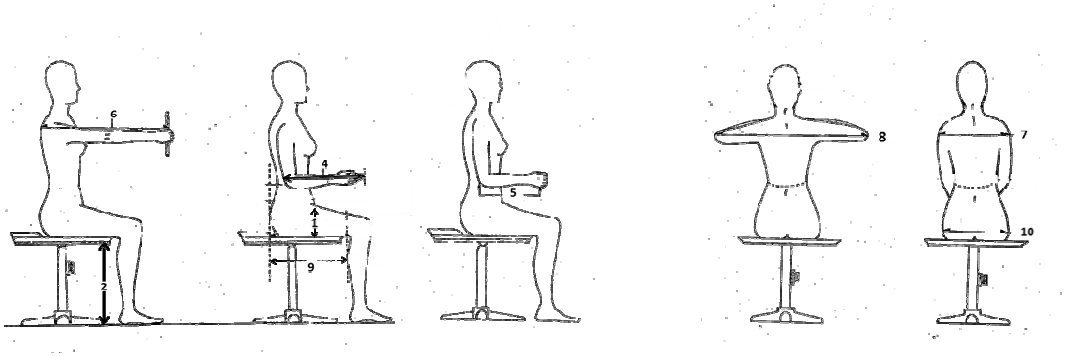
2.5.2. Sitting and chair Design

2.5.2.1. Human anthropometry

The individual people have different information about human body size, posture, movement, surface area, volume, and mass. Anthropometry refers to the measurement of the human individual for the purposes of understanding human physical variation. Today, anthropometry plays an important role in industrial design,

clothing design, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products. Changes in life styles, nutrition and ethnic composition of populations lead to changes in the distribution of body dimensions (e.g., the obesity epidemic), and require regular updating of anthropometric data collections. The chairs were design from anthropometry of foreign countries sometimes it did not suitable with a Thai character of all part of the body.

Anthropometry is the science that measures the range of body sizes in a population. When designing products it is important to remember that people come in many sizes and shapes as shown in figure 2-6. Anthropometric data varies considerably between regional populations. For example, Scandinavian populations tend to be taller, while Asian and Italian populations tend to be shorter.



Side view **Back view**

Figure 2-6 The body dimension of sitting posture.

The Industrial Standards, Institute Ministry of Industry, Rajamangala University of Technical Krungthep, Thai Wacoal Co., Ltd. (Thailand) and Sagittarius look Ltd. (Thailand) measured the major body of the Thai people in 2543-2544, which measure the proportion of the body can be expressed as shown in Table 2-9.

Table 2-9 Body Measurements of Thai female base on 30 – 39 years old. (31)

No.	Body Measurements	unit	P 5	P 50	P 95
1	Thigh thickness	cm	11.7	13.7	15.9
2	Popliteal height	cm	35.7	38.5	41.5
3	Chest depth	cm	18.2	21.6	26.1
4	Upper limb length	cm	39.2	42.3	45.3
5	Shoulder-fingertip length	cm	26.8	29.2	31.8
6	Forward grip length	cm	62.7	67.8	73.0
7	Shoulder breadth	cm	36.2	40.0	44.8
8	Elbow span	cm	76.2	81.8	87.4
9	Buttock-popliteal length	cm	38.8	42.7	46.7
10	Hip breadth	cm	31.0	35.2	40.0

2.5.2.2. Sitting workstation design

Sitting may be required in certain tasks, eg, in work requiring such as fine manipulative hand movements, a high degree of body stability and equilibrium, precise foot control actions, all materials and tools be located within the seated workplace, no havey material handling tasks (more than 4.5 kg) and relatively fixed body posture for extended time periods

The sitting workstation design was including seat and table. The criteria of design described following;

1) Seat must consider this condition for design.(32)

- **Seat Height** adjustable the height so that your hips are level or higher than your knees. The whole of your foot should be on the floor, do not lower your chair to suit the desk height. Raise the desk! Ideally the seat pan would have a rounded ‘waterfall’ padded edge to avoid pressure on the back of the knees. Thus, seat height was adjustable from 43 cm to 51 cm for standard, 38 cm to 46 cm for low height.

- **Seat pan** was includeing the measurement of seat depth, seat width and seat angle as following;

(1) Seat Depth adjustable to accommodate thigh length. With your back fully contacting the back rest there should be a gap of about the width of your fist from the edge of the seat pan to your knee. The researches recommended were 42 cm for fixed seats and 36 cm – 47 cm for adjustable seats. If the seat depth is greater than the buttock-popliteal length (fifth percentile woman is at 43 cm) then the user won't be able to use the backrest.

(2) Seat Width around 31 cm – 40 cm to accommodate clothed persons. If seat has armrests then elbow to elbow breadth may be more relevant.

(3) Seat Angle helped user to maintain good contact with backrest. For most purposes a 5 - 10 angles is recommended.

- **Armrests** were not always necessary. Incorrect use can cause problems. If provided arm rests would ideally be height, width and depth adjustable to 19-24 cm or fixed within same range and should not prevent you from sitting close to your table with a distance between armrests of at least 45 cm or adjustable.

- **Backrest** was height of the lumbar curve differs from person to person, so adjust height to accommodate your individual body shape. Higher backrests give better trunk weight support. There were 3 categories such as

(1) Low-level backrest supported the lumbar region only. Depth of the lumbar curve of the backrest should be 1.5 cm – 5 cm. Backrest heights of 13 cm, 18 cm, and 23 cm seem equally effective.

(2) Medium-level backrest gave full shoulder support (e.g. car seat, office chair) and may need to be about 66 cm high to accommodate the 95th percentile man.

(3) High-level backrest fulled support of head and neck (e.g. plane seat) and may need to be about 91 cm for a 95th percentile man.

The backrest of the chair should allow recline angle of at least 150^{o}, but the other research recommended optimal angle seems to be between 100^{o}-110^{o}

- **Footrests** were necessary, should have a stable surface and be large enough to accommodate both feet easily. The footrest angle could be adjustable, though a fixed footrest is suitable if it allows for comfortable ankle angles (roughly 90° between foot and leg). Generally fixed footrest angles are in the range of 0 - 30°.

2) Table must consider this condition for design.(33)

The best way to provide the proper heights for all operators is to use split-level tables or desks that allow each height to be adjusted independently. This allows for proper work postures for a range of user sizes. However, a fixed desk of suitable height, the correct use of an adjustable chair, and a footrest where necessary, will also allow for suitable postures.

- **Table height** was given guideline by The Canadian Standards Association: (CSA) adjustable work surfaces for table heitht of of 73 cm ±2.5 cm. The ideal is for the user to be able to sit at the work station and be able to easily maintain a 90-100 degree elbow angle and straight wrists while working.

- **Leg room** must be deep enough the worker. The CSA guideline recommends a minimum of 76 centimetres. There should be sufficient leg-room. The CSA guideline calls for 43 centimetres of horizontal knee space and 60 centimetres of "toe space", the total horizontal space for leg and foot. The vertical clearance at the front edge of the work surface should be at least 68 cm. The width of the leg space should be at least 50 cm. But NC STATE University found leg room could adjustable between 58 cm and 71 cm to accommodate most-but not all-users. 66 cm is a recommended compromise position while leg clearance must still be considered.

- **The depth and width of workstation** should be allowed space not only for all necessary equipment, but also for other materials needed while working at the nail’s activitied. Working with materials on chairs and at odd angles has the potential for neck and other body strain. Frequently used items should be kept close to avoid long reaches. A general recommendation is that work area top should be at least as big as the standard office desk – 76 cm by 125 cm. A depth of at least 76 cms allows flexibility in use of the work area. The important requirement was consider from body size of width of user comfortably. But, it must to accommodate the 95th percentile man

- **The proper angle of table**, Kitti recommended that slope down 15^{O}, but Pheasant told appropriate is valuable about 30^{O} (34)

3) Relationship between the table and seat

ISO (International Organization for Standardization) is the world's largest developer and publisher of International Standards set ISO 5970-1979 (Furniture -- Chairs and tables for educational institutions -- Functional sizes), that said the assessment about the relation of table, chair and the sitting posture. It had 7 crieterias as shown in figure 2-7.

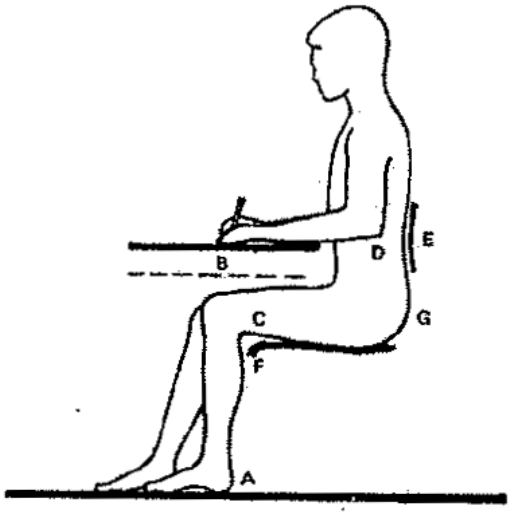


Figure 2-7 The relationship of table, chair and sitting posture according to ISO 5970-1979.

The details were following.

A Feet must be placed flat on the floor.

B Have enough space between the above thighs and under the table so that the legs are moving freely.

C Must no pressure at the front edge of the pad to sit under the thigh.

D The height of support to write was the same level of elbow.

E The backrest must support waist and be lower the shoulder.

F Have space between the inner thighs and the front edge of the seat pad.

G Enough space between the bottom edge of the backrest with lumbar support and the seat pad, for hip was moving freedom.

2.6 Concept design lighting of workstation

2.6.1 Principle of light(35)

Light is electromagnetic radiation of a wavelength that is visible to the human eye (in a range from about 380 or 400 nanometres to about 760 or 780 nm) as shown Figure 2-9. In physics, the term light sometimes refers to electromagnetic radiation of any wavelength, whether visible or not. Five primary properties of light are intensity, frequency or wavelength, polarization, phase and orbital angular momentum.

The speed of light in a vacuum is presently defined to be exactly 299,792,458 m/s (approximately 186,282 miles per second). The fixed value of the speed of light in SI units results from the fact that the metre is now defined in terms of the speed of light. Different physicists have attempted to measure the speed of light throughout history. Galileo attempted to measure the speed of light in the seventeenth century. An early experiment to measure the speed of light was conducted by Ole Rømer, a Danish physicist, in 1676. Using a telescope, Ole observed the motions of Jupiter and one of its moons, Io. Noting discrepancies in the apparent period of Io's orbit, Rømer calculated that light takes about 22 minutes to traverse the diameter of Earth's orbit(24). Unfortunately, its size was not known at that time. If Ole had known the diameter of the Earth's orbit, he would have calculated a speed of 227,000,000 m/s.

Another, more accurate, measurement of the speed of light was performed in Europe by Hippolyte Fizeau in 1849. Fizeau directed a beam of light at a mirror several kilometers away. A rotating cog wheel was placed in the path of the light beam as it traveled from the source, to the mirror and then returned to its origin. Fizeau found that at a certain rate of rotation, the beam would pass through one gap in the wheel on the way out and the next gap on the way back. Knowing the distance to the mirror, the number of teeth on the wheel, and the rate of rotation, Fizeau was able to calculate the speed of light as 313,000,000 m/s.

Léon Foucault used an experiment which used rotating mirrors to obtain a value of 298,000,000 m/s in 1862. Albert A. Michelson conducted experiments on the speed of light from 1877 until his death in 1931. He refined Foucault's methods in

1926 using improved rotating mirrors to measure the time it took light to make a round trip from Mt. Wilson to Mt. San Antonio in California. The precise measurements yielded a speed of 299,796,000 m/s. (36)

Electromagnetic spectrum (EM) radiation (the designation 'radiation' excludes static electric and magnetic and near fields) is classified by wavelength into radio, microwave, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays as shown in figure 2-8.

The behavior of EM radiation depends on its wavelength. Higher frequencies have shorter wavelengths, and lower frequencies have longer wavelengths. When EM radiation interacts with single atoms and molecules, its behavior depends on the amount of energy per quantum it carries.

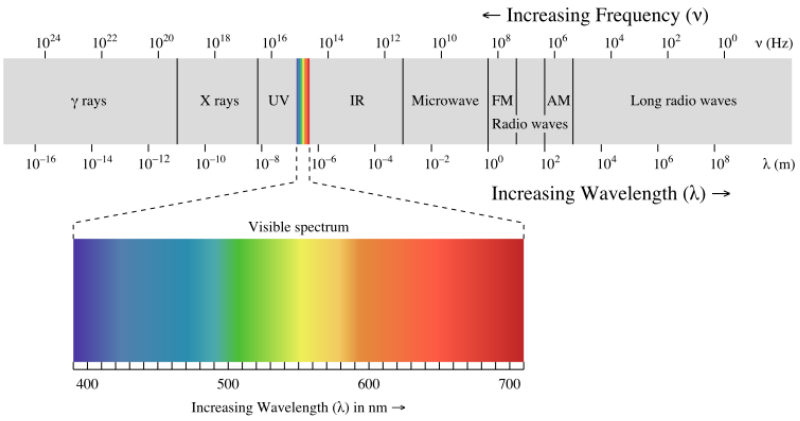


Figure 2-8 The electromagnetic spectrum

Illuminance is a measure of photometric flux per unit area, or visible flux density. Illuminance is typically expressed in lux (lumens per square meter) or foot-candles (lumens per square foot). The inverse square law defines the relationship between the irradiance from a point source and distance. It states that the intensity per unit area varies in inverse proportion to the square of the distance.(37)

$$E = I / d^2$$

The inverse square law can only be used in cases where the light source approximates a point source. A general rule of thumb to use for irradiance measurements is the “five times rule”: the distance to a light source should be greater

than five times the largest dimension of the source. For a clear enveloped lamp, this may be the length of the filament.

The sources of light can be devided 2 sources followed;

1. Natural sources such as sun.

2. Artificial sources or light man-made up such as Incandescent lamps sodium lamps, such as moonlight glow lamps etc.

2.6.2 Physiology and anatomy of visual system

- **Physiology and anatomy of eyes** (38)

The eye is not properly a sphere, rather it is a fused two-piece unit. The smaller frontal unit, more curved, called the cornea is linked to the larger unit called the sclera. The corneal segment is typically about 8 mm (0.3 in) in radius. The sclera constitutes the remaining five-sixths; its radius is typically about 12 mm. The cornea and sclera are connected by a ring called the limbus. The iris – the color of the eye – and its black center, the pupil, are seen instead of the cornea due to the cornea's transparency. To see inside the eye, an ophthalmoscope is needed, since light is not reflected out. The fundus (area opposite the pupil) shows the characteristic pale optic disk (papilla), where vessels entering the eye pass across and optic nerve fibers depart the globe.

The dimensions differ among adults by only one or two millimeters. The vertical measure, generally less than the horizontal distance, is about 24 mm among adults, at birth about 16–17 mm. (about 0.65 inch) The eyeball grows rapidly, increasing to 22.5–23 mm (approx. 0.89 in) by the age of three years. From then to age 13, the eye attains its full size. The volume is 6.5 ml (0.4 cu. in.) and the weight is 7.5 g. (0.25 oz.)

The Components of eye is made up of three coats as shown in Figure 2-8, enclosing three transparent structures. The outermost layer is composed of the cornea and sclera. The middle layer consists of the choroid, ciliary body, and iris. The innermost is the retina, which gets its circulation from the vessels of the choroid as well as the retinal vessels, which can be seen in an ophthalmoscope. Within these coats are the aqueous humor, the vitreous body, and the flexible lens. The aqueous humor is a clear fluid that is contained in two areas: the anterior chamber between the

cornea and the iris and exposed area of the lens; and the posterior chamber, behind the iris and the rest. The lens is suspended to the ciliary body by the suspensory, made up of fine transparent fibers. The vitreous body is a clear jelly that is much larger than the aqueous humor, and is bordered by the sclera, zonule, and lens. They are connected via the pupil. (38)

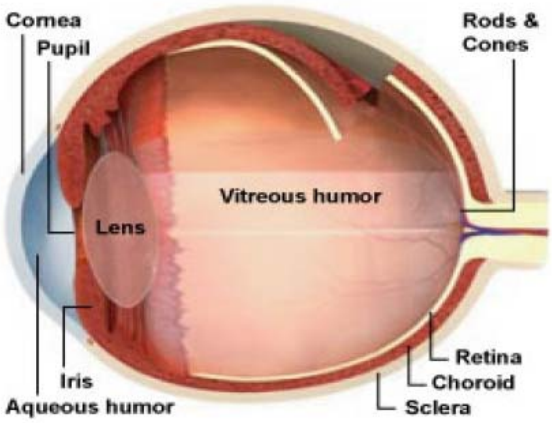


Figure 2-9 The anatomy of human eye

- **Mechanism of vision**

The eye works on the same principle as that of the camera. The light rays from the object pass through the conjuctiva, cornea, aqueous humour, lens and vitreous humour in that order. All these structures refract the light such that it falls on the retina. This is called focussing. Maximum focussing is done by the cornea and the lens. The light then falls on the retina as shown in figure 2-10.

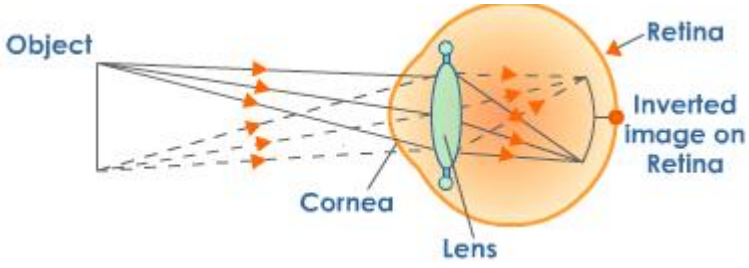


Figure 2-10 The mechanism of vision (39)

This light is received by the photoreceptors - rods and cones, on the retina. The absorbed light activates the pigments present in the rods and cones. The pigments are present on the membranes of the vesicles. Thus, the light is then converted into

action potentials in the membranes of the vesicles. These travel as nervous impulses through the rod or the cone cell and reach the synaptic knobs. From here the impulses are transmitted to the bipolar nerve cells, then to the ganglions and then to the optic nerves. Thus the nervous impulses generated in the retina are carried to the brain by about a million neurons of the optic nerve. The vision is controlled by the occipital lobe at the back of the brain. The information received is processed and we are able to see the image. The image formed on the retina is inverted. However, the brain makes us see the image erect. So, though the eyes are essential for vision, any damage to the optic nerves also results in impairment of vision.(40)

- **The factor of visual system**

An important factor that affects workers' ability to see well in the workplace is the quality of light. Quality lighting created by attention to brightness, contrast, quantity, and color of light, results in visibility and visual comfort. Contrast between a task object and its immediate background must be sufficient to enable the worker to clearly view the task. Contrast ratios should be established to maximize productivity without increasing eyestrain. In general, a 1:3:10 ratio is ideal; that is, the task area should be less than 3 times as bright as its immediate surroundings (within 25 ^{O}C of the visual target) and 10 times brighter than the peripheral area (past 25^{O}C) (40)

2.6.3 Problem with the light

Light ergonomics is the relationship between the light source and the individual. Poor light can be divided into the following: (35)

- Insufficient light such as eyestrain and headache: eye muscles can become tired when constantly focused on close work. To identify if this is an issue in your office, ask people if they get tired eyes or other eye strain symptoms. To control visual fatigue, a change of focus, such as a view out of a window or to a picture along a hallway at a distance from the operator, can provide exercise to other muscles of the eyes while resting the tired muscles.

- Glare occurs when one part of an area is much brighter than the background or vice versa. For example, if a bright window is positioned behind a computer screen, the contrast (difference between dark and light) can be so great that the eyes have to constantly adapt to the change. This may cause eye fatigue and

headaches, as well as decreased ability to view the screen. Glare can be identified by observation as well as complaints and comments from people working in the area. There are several ways to reduce glare in the office environment

- Color spectrum (amber street lighting) can determine the mood of an environment and the level of reflection from a surface. It is recommended that ceilings have high reflectance, (reflecting around 80% of the light) and are usually white or off white. Walls should have 50 – 75% reflectance (subdued cool colours) and a gloss or semi gloss finish. Floors should have low (less than 20%) reflectance and therefore should be darker and not glossy. The use of colourful posters or non-reflective paintings can relieve monotony and provide visual relief.

- Flicker is some lights can be a source of annoyance, particularly older fluorescent tubes which may flicker when malfunctioning. Regular maintenance will help control the effects of light flicker.

The effects of poor light can include the following: low productivity, high human error rates, reduction in mental alertness, general malaise and low employee morale. (41)

2.6.4 Lighting legistration

Thailand had 2 laws were related to light in the environment such as since A,D. 2003 Department of Industrial Works set legistration of light in environment and in A.D. 2006 legistration of light was set again gy Department of Labour Protection and Welfare. From the 2 legistrations were indicated the intensity of light according to the work by nails salon in moderate detail. The light must be 600 lux. (4)

2.6.5 Lighting design

When identifying, assessing or controlling lighting issues in offices, take into account the time of day and year, as this will affect the quantity and quality of natural light in a work area. This is particularly important when designing lighting systems. Some of the office lighting issues may be caused by natural light entering a work area. By providing staff with control and adjustment of natural light, for example, Venetian or vertical blinds, many of these issues can be addressed.(29)

Good lighting in workplaces is essential to enable people to see clearly and perform their work safely. The key factors to consider when determining the adequacy of lighting are the:

- Amount of light in an area;
- Number, type and position of the light sources; and
- Tasks or activities performed, how often and for how long these are performed.

In general, good lighting should enable people to easily view their work and environment without the need to strain their eyes. However, different activities require different levels and qualities of light. The visual demands of the activity or task performed determine the lighting needs of an area. Activities that do not require a high level of visual acuity for example, walking through a corridor do not require high levels or an optimum quality of light. On the other hand, tasks such as drawing or checking a document for errors involve fine and detailed work requiring a moderate to high level of visual control, and so greater levels and a higher quality of light are required.

Quality of light, this refers not only to the level of lighting, but also to other factors which have a significant impact on how well we are able to perform a task. These include:

- The number of lights in use having the correct number of lights will provide evenness of lighting over the area and the position of the lights should be positioned to illuminate the workstations.
- The type of lights, e.g. fluorescent tubes, tungsten and halogen lights, the most common type of office lighting is fluorescent, most resembling natural light and long-lasting. Fluorescent lights can provide different qualities of light, such as white, warm, natural, daylight or colours as shown in table 2-10.
- The type of light fittings used design and maintenance of the lighting system.

All these factors need to be taken into account when designing lighting for office environments. A lighting designer should be consulted for designing lighting in a new office area.

Table 2-10 Light Bulbs*

Type	**Common Application**	**Efficiency**	**Colour Rendering****
Incandescent	homes	poor	good
Fluorescent	offices	good	fair to good
Mercury	factories, offices	fair	fair to moderate
Low pressure sodium	roadway	good	poor
High pressure sodium	factories, commercial	good	fair to good
Metal Halide	factories, commercial	good	good

*Bulbs are often referred to as lamps in many technical publications.

** Colour rendering is the effect of light on the colour of objects. (35)

2.6.6 Detail of lighting design.(42)

- Provide light intensity is equal to 600 lux
- Light source must be installed in positions that are not induced reflected to the workers.
- To provide a shield of light source
- Line from eye of light and with parallel line to the ground must be angle greater than 30^{O}, if unavoidable will must shield the light source.
- Avoid using your color or material had reflective colors of equipment, tools, machines or table surface, the control panel
- Provide maintenance light source continued.

2.7 Related research

2.7.1. Chemical hazard from nail technicians' activity, Health problem and protection.

- Nail Salon Workers found the experimental group was made aware of health hazards from employment up to 80% of the total and had health problems of 62% which will see more work at higher age (over 10 years). (43) Industry of beauty was using chemicals more than 10,000 kinds and the 89% of the ingredients were not set safety standards. This here is a native of Vietnam to 39% of the study this was the study of chemicals group Phthalates long be associated with cancer, and abortion. The survey also found that the manicurist pregnanted would usually stop this career.(44)

- And many studies found health problem such as HSE(11) found more such problems with shoulders, which were up 38%, problems with neck, which was up 33.8%, and problems with hand and wrist, which was up 29.6%. It also found other health problems such as a headache, upper back problems and back pain etc.

- Cora Roelofs found the major rank of health problems related-work was musculoskeletal disorders, it was found 33% of all. The second was symptoms of respiratory system, such as respiratory distress disappeared cough, nasal irritation, etc., it was 31% of all. And the third was the skin rash it was 22% of all. And after nail technician finished work would recovery(45)

- Occupational Health Clinic for Ontario Workers Inc. found the hazards of nail salon come from nail enamel/polish remover, which are organic solvents can cause many problems: Nose, throat. Lung, skin and eye irritation or headaches or light-headedness or nausea or increased pulse rate or confusion. And nail adhesives can produce a hypersensitive response in the airways of the lung. Pre-existing asthma may also be aggravated by such substances. Signs and symptoms of asthma are as follows: wheezing, coughing, chest tightness and/or shortness of breath. Other hazards of nail salon from the solvents and chemicals used, which are suspected reproductive toxins.(46)

- Brown and Nanayakkara report the case of 15-month-old girl who became comatose after sucking on nail polish remover pads, the main ingredient of

which was gamma butyrolactone. The patient's course was complicated by upper airway obstruction, bilateral pneumothoraces, and pneumomediastinum. After 5 days of ventilator support, the child had a complete recovery.(47)

- In 2004, American Association of Poison Control Center, reported about exposures to cosmetics and personal care products were the most common poisons in the pediatric population, and third among adults, after analgesics and cleansing agents, respectively. Nail products, including polish, polish removers, and artificial nail adhesives, were all responsible agents.(48)

- Nail care products and cosmetics become more popular each year in the United States and Europe, it is necessary for dermatologists to familiarize themselves with the potential adverse effects of these products. Allergic contact dermatitis to components of artificial nails, nail glue, and nail polish remains the most important medical consequence of nail cosmetics, and these patients will present to dermatologists.(49)

- Protecting of nail salon workers had checklist for nail technician and shop owner about how management products such as the closure when not in use or not, wear a slap, gloves and eye protection devices. The subject to the MSDS of the chemical exposure, not a liquid containing MMA or not, the equipment personal protective as prescribed in the MSDS to employees the workplace safe.(8) Air quality problems that are found mainly in compounds that are not toxic, but often complained that the weather is bad. Common symptoms when the ventilation system is not headache, coughing, sneezing, as well as eye and bronchial irritation. Cause fatigue, abnormal this will vary for each person. By the ventilation systems are only recommended ventilation table that will prevent chemicals in the range of breathing zone manicurist and customers well. This is not recommended by charcoal filter or dust filter for air because it is difficult to know how often to change a new filter.(50)

2.7.2. Sitting posture and problem

- The subjects felt that it was more difficult and less safe to rise and sit at lower (80% and 90% Popliteal height (PH)) and higher (110% PH) seat heights (SH). Younger subjects felt that it was only a little difficult and less safe in lower SH (80%

PH). Results also demonstrate that rising was faster than sitting and that the elderly were slower than their younger counterparts. Non-linear regression analysis shows that the best SH ranges from 40.72 cm to 41.10 cm for elderly subjects, and 45.23 cm to 48.93 cm for younger ones whilst using subjective rating scores as dependent variables.(51)

- The objective of the research was to assess the effect on lower limb venous blood flow of sitting in two ergonomic chairs. In a cross-cover design 12 healthy subjects had popliteal vein blood flow measured by Doppler ultrasound in different sitting positions, in the Aeron and air centric chairs. Measurements were made lying prone, sitting with the leg flexed 90o and sitting with the leg flexed 120o in one chair. For the Aeron chair, the prone to 90^{o} position resulted in a reduction in peak systolic velocity from 27.8 to 3.5 cm/s, adjusted difference 21.0 (95% CI 17.3 to 24.8), and for the air Centric chair from 21.4 to 3.7 cm/s, adjusted difference 21.2 (95% CI 17.4 to 24.9). There was no statistically significant difference in peak systolic velocity between the two chairs, in the two sitting positions. There was a marked reduction in popliteal vein blood flow with sitting, but no significant difference in effect between the two ergonomic chairs.(52)

- H. Strasser found occupational medicine point of view sitting postures, especially in an office environment, are of great importance, and ergonomically-designed seats have a high potential with respect to preventive occupational safety. Therefore, it shall be pointed out, that in functional fields compatibility must rank higher than aesthetic and design demands.(53)

2.7.3. Light and problem

- Psychologists estimate that 80% of the information people obtain from their external environment is by means of visual pattern, indicating the important role vision plays in daily activities. Eyes are dependent on light and lighting, one of the most overlooked and underemphasized components of workplaces. Lighting is effective in the workplace when it allows the worker to see the details of a given task easily and accurately. Lighting and vision are interdependent and both must be considered when designing a working environment for maximum efficiency.(54)

- An important factor that affects workers' ability to see well in the workplace is the quality of light. Quality lighting, created by attention to brightness, contrast, quality, and color of light, results in visibility and visual comfort. Contrast between a task object and its immediate background must be sufficient to enable the worker to clearly view the task. Contrast ratios should be established to maximize productivity without increasing eyestrain. In general, a 1:3:10 ratio is ideal; that is, the task area should be less than 3 times as bright as its immediate surroundings (within 25^{o} of the visual target) and 10 times brighter than the peripheral area (past 25^{o}). Too much or too little light can inhibit the worker's ability to effectively see task. Comfortable light levels will vary by individual. For example, a 60-year-old worker needs 2 to 3 times as much light as a 20-year-old worker to achieve the same visual performance. Comfortable light levels will also vary by task. The more rapid, repetitive, and lengthy the task, the more important it is to have enough light. With these types of tasks, the eye is more vulnerable to fatigue and the worker to declining productivity.(9)

- And the reduce physiological cost but also for quick and safe information transmission between a technical means and the sense organ "eye" also demands an orthogonal top view; this means an inclination and lowering of the monitor on a semi-divided table in such a way that a right angle between the relaxed visual axis, the preferred line of sight angle and the monitor surface is created.(55)

CHAPTER III
MATERIALS AND METHODS

3.1 Study design

This quasi-experimental study was consisted of the design set manicure safety so called Table nail and the design workstation of a manicurist appropriate to the behavior of the manicurist, and to ensure safety, including disease prevention at may be caused by work exposure to chemicals or working posture.

3.2 Population and subjects

Population in this study is the manicurist Photharam district, Ratchaburi province. The 35 selected manicurists had period of career no less than three months of this study group.

3.3 Materials and equipment

- Air sampling pump was used to require the adjustable low flow holder.
- Lux meter.
- Questionnaire consists of three parts. The first part was the general information including gender and level of education. The second part was Information on career manicurist such period of occupation of manicurist, the number of days worked per week, hygiene at work, and judgment of the manicurist about the workstation, including contaminants in air, wind chill, light, temperature and the comfortable to use tables and chairs to work. And the last part was information on the

history of illness and health status of the manicurist or disease symptoms before and after being a manicure and the smoking history of the manicurist.

3.4 Data collection

The data collection step in this study can be divided into four steps.

3.4.1. General characterization of the random sample group

- The data were collected by using questionnaires related to general characterization, information about the workplace and history of illness and health status of manicurist.
- The data collection on industrial hygiene monitoring, including chemicals in the salon, (while the manicurists were doing nails for customers, for classification of chemicals found in the activity of a manicure) and level of intensity of light while the manicurist provides services to customers.

3.4.2. Design a table nail, workstation and the lighting system for manicurist in term of their safety at work.

3.4.3. Construct a table nail, workstation and the lighting system mentioned in 3.3.2

3.4.4. Experiment and collection data from using the created or redesigned Table nail and workstation. It was a process of trial Table nail and new workstation.

The detail of data collection processes are as followed.

Step 1 The collection the basic data of samples from a manicurist Photharam district, Ratchaburi province. The 35 selected manicurists had period of career no less than three months **.**

(1) Questionnaire consists of three parts.

1.1.) General information including gender and level of education.

1.2.) Information on career manicurist such period of occupation of manicurist, the number of days worked per week, hygiene at work, and

judgment of the manicurist about the workstation, including contaminants in air, wind chill, light, temperature and the comfortable to use tables and chairs to work.

1.3.) Information on the history of illness and health status of the manicurist or disease symptoms before and after being a manicure and the smoking history of the manicurist.

The result of questionnaire might cause errors result from the subjects' judgment. The misunderstanding of questions were controlled by the researcher described the questions meaning, the researcher protected this error by used one person for asked all subjects. However, it had the error of fatigue and satisfaction that could happen from the difference of threshold level and acclimatization the researcher protected by asked all subjects about fatigue could happen before worked, after used existence workstation and new workstation to control this error.

(2) Chemical and light intensity monitoring in working environment

2.1.) Air samples for chemical monitoring was collected according NIOSH METHOD, while the manicurists were servicing to customers. The sampling method was very important so the researcher was advised by the technician with the correct sampling method. And then the researcher practiced it before used in the study. And protection of wind was recommended to turn off fan. Air samples were collected by activated charcoal attached near the nose and mouth of manicurist or call breathing zone for determination of concentrations, The major chemicals were found in manicurists' activities was shown in Table 3-1 for 30 minute per sample.

Table 3-1 The NIOSH METHOD of air samples collected for chemical monitoring.

No.	Chemical	NIOSH METHOD NO.
1	Toluene	1501
2	Butyl acetate	1450
3	Butanol	1405

And this study had recognized the accuracy and reliability of the instruments were used in this study such as wrong type of personal pump and charcoal tubes and the limit or error of The Gas Chromatography Perkin-Elmer Model Clarus500. They were controlled for instrument error as follow:

- The pump was chosen high flow rate and the researcher used adjust flow rate to collect the sample in beauty salon. And charcoal tubes were chosen to according the type of contaminate in beauty salon. In this study was chosen coconut shell charcoal no.226-01 from SKC.
- The Gas Chromatography Perkin-Elmer Model Clarus500 with auto-sampler was used for analysis the concentration of chemical in work station, but the chemical in work station was found very low concentration in part/million unit. It might be inaccurate data because it was the lower limit of instrument. The researcher controlled by used the Gas Chromatography Perkin-Elmer Model Clarus500 with auto-sampler has regular calibrated and showed in good condition. And the researcher selected the certification of laboratory to analyze the concentration of chemical.

This study had recognized the accuracy and reliability of techniques and methods. Therefore, the researcher had practiced to good skill and consulted with the technician that intended to decrease the error from researcher's skill about air sampled in workstation that made no difference of researcher and technician.

2.2.) The measurement of illuminance (unit Lux) was performed while the manicurist provided services to customers. Spot measurement was introduced for working condition or areas were operating, by put the photo cell in the plane and then recorded the result in the table sheet.

(3) Collected anthropometry data of Thai's female.

The Industrial Standards, Institute Ministry of Industry, Rajamangala University of Technical Krungthep, Thai Wacoal Co., Ltd. (Thailand) and Sagittarius look Ltd. (Thailand) measured the major body of the Thai people in 2543-2544, which measure the proportion of the body can be expressed as shown in Table 3-2.

Table 3-2 Anthropometry of Thai female for workstation designed.

	Size	Body Measurements	unit	P 5	P 50	P 95
Table	Table height	Thigh thickness	cm	11.7	13.7	15.9
		Popliteal height	cm	35.7	38.5	41.5
	Depth of table	Chest depth	cm	18.2	21.6	26.1
		Upper limb length	cm	39.2	42.3	45.3
		Shoulder-fingertip length	cm	26.8	29.2	31.8
		Forward grip length	cm	62.7	67.8	73.0
	Width of table	Shoulder breadth	cm	36.2	40.0	44.8
		Elbow span	cm	76.2	81.8	87.4
	Footrests	Popliteal height	cm	35.7	38.5	41.5
Chair	Seat Height	Popliteal height	cm	35.7	38.5	41.5
	Seat Depth	Buttock-popliteal length	cm	38.8	42.7	46.7
	Seat Width	Hip breadth	cm	31.0	35.2	40.0
	Backrest	Shoulder breadth	cm	36.2	40	44.8

Remark: The pilot study found the average was 30 – 39 years old from manicurist in Phrotharam district, Ratchaburi province.

Step 2 Design for Table nail, workstation and lighting intensity system.

(1) Table nail

The instruments were used in this study such as no standard for table nail in Thailand. Table nail was the equipment for decrease the concentration of chemical in workplace. Then the researcher designed it applied to Industrial Ventilation: A manual of Recommended Practice (Metric version) by American Conference of Governmental Industrial Hygienist.

- It was the local hood type Downdraft because the specific of chemical was fall on the ground.
- The capture velocity was 0.5 m/s because the wind chill in the beauty salon was low and the chemical was low toxicity.

- Minimum duct velocity equaled to 10 m/s because it was vapor.

So the researcher could design the table nail as shown in figure 3-1. Table nail included local ventilation and lamp.

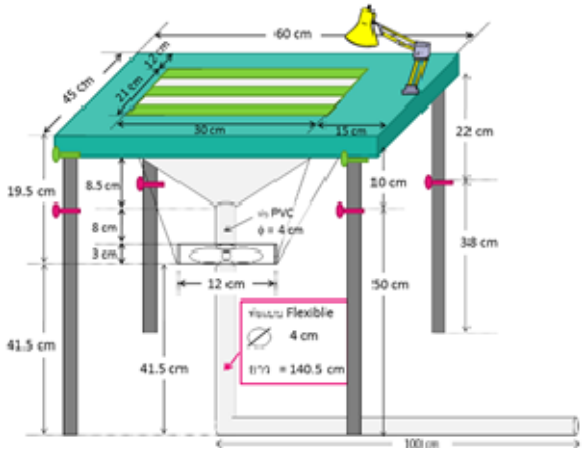


Figure 3-1 Drawing of Table nail.

Remark: the calculation of table nail could see in appendix D

(2) The workstation was shown in figure 3-1 and 3-2.

The workstation including table and chair of manicurist was designed based on the anthropometrical data of female was average 30-39 years old.

The researcher could design the workstation of manicurist from applies anthropometry as showed in table 2-9:

The detail of table was designed.

- **Table height** was mean of thigh thickness (13.7 cm) and P 95 of popliteal height (41.5 cm). The table height was equal 55.2 cm. This study was selected height between 50 – 60 cm. The table height was 50 cm for pedicure, but 60 cm for manicure.
- **Depth of table** was P 95 of upper limb length (45.3 cm). In the study, the depth of table was designed 45 cm.
- **Width of table** was between P95 of shoulder breadth (44.8 cm) and P 95 of elbow span (87.4 cm). This study, the width of table was selected 60 cm.
- **Angle of table** was 12^{O}-15^{O} below the parallel line to the ground.

The detail of manicurist's chair was selected.

- **Seat Height** selected between P5 and P95 that was adjustable between 35 cm – 45 cm. The manicurist's chair selected from general chair.

(3) Lighting design at work.

The intensity of lighting for 600 lux was provided and the design avoid for light interference, reflections and direct glare. The type of lighting was fluorescent tube**.** It was good efficiency and color rendering was fair to good.

Figure 3-2 A manicurist workstation of safety at worked manicure and pedicure.

<u>Step 3</u> Create construction of Table nail, workstation and light.

After the workstation has been designed in Step 2 , workstation was then constructed to be appropriate to the characteristics of a manicurist in figure 3-3.

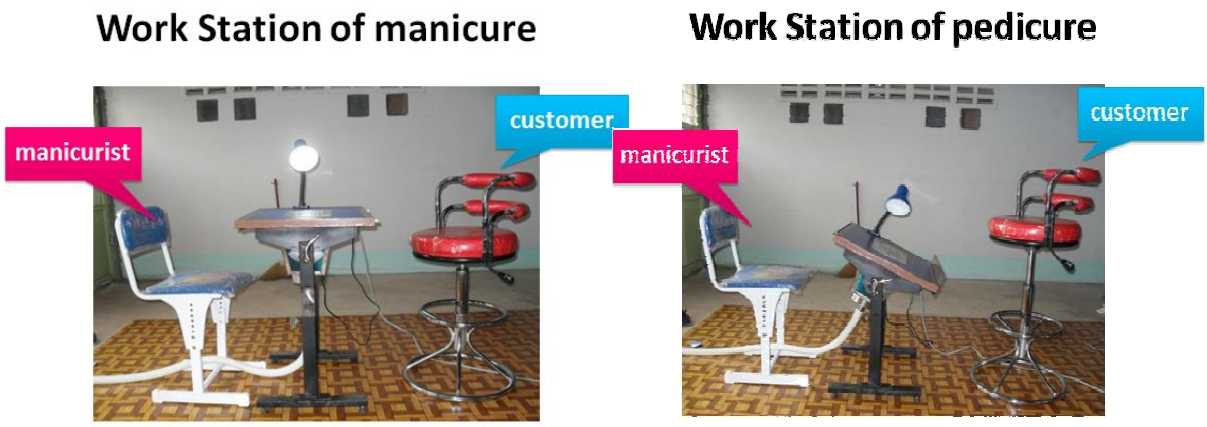


Figure 3-3 The safety table nail was constructed

Step 4 The experiment and collecting data at workplace were performed, and satisfaction for Table nail and workstation was interviewed.

(1) The table nail was tested for the effective by comparing the measured concentration of chemicals in the workplace before and after installing Table nail. These measure chemicals such as Toluene, Butyl acetate and Butanol at Breathing zone by using the pump for suction air weighs about 0.5 kilograms on to the waist of a manicurist and charcoal Sampling for chemicals near the collar where manicurist breathing using T-tape contact with the manicurist were performed as shown in figure 3-4 and 3-5. The duration of air collection was approximately 30 minutes per sample. Then the charcoal tube would be determined for mentioned chemicals by using Gas Chromatography, while satisfaction of manicurist surveyed by the questionnaire was performed.

(2) Workstation was collected information about the manicurist was ergonomic, and the light.

2.1.) Ergonomics data were collected such as pains and aches while using new workstation compared to the existing workstation by questionnaire.

2.2.) The light measured data compared before and after improvement by using Lux meter.

2.3.) The manicurists' satisfaction on new workstation compared to existing workstation was conducted.

The existing workstation **New workstation**

Figure 3-4 The manicurist's workstation pedicure in Thailand

The existing workstation **New workstation**

Figure 3-5 The manicurist's workstation manicure in Thailand

Table 3-3 The protocol of data collection: Process of research and data collection can be described as follows.

Work-station		**Manicurist's activities**	**Researcher activities.**	**Remark**
Existing Workstation	**Fingernail**	Open salon	1. Manicurists were asked about Part 1 General information Part 2 Information about career manicurist Part 3 The fatigue or the discomfort of the body's manicurist, before work, after used existing workstation and new workstation.	Questionnaires were used to investigate the manicurist about workstation design.
		Customers into the store.	-	
		Wash hands with soap.	1. Tools preparation for the quantitative measurement such as activated charcoal tube and air pump.	
		Nail clean with alcohol.	1. To install monitoring equipment on the amount of air a person using activated charcoal tube and pump it on the breathing zone of the manicurist.	

Table 3-3 The protocol of data collection (Cont.)

Work-station		Manicurist's activities	Researcher activities.	Remark
Existing Workstation	Fingernail	Clean fingernail to clean out the original color.	-	
		Cut nails and the remove the epidermis did not want.	1.Provide light meter	
		To paint the fingernail	1. To measure light intensity at work by using Lux meter.	Fill the measure in the table of sheet.
		Nail the paint dry.	-	
	Toenail	Pedicure clean with soap.	-	
		Pedicure cleaning with alcohol.	-	
		Clean the toenail to clear out old color.	-	
		Cut nails and remove the epidermis did not want.	1.Provide light meter	
		To paint the toes.	1. To measure light intensity at work by using Lux meter.	Fill the measure in the table of sheet.
		Nail the paint dry	1. To remove the air volume measuring equipment with a Label that activated charcoal tube.	

Table 3-3 The protocol of data collection (Cont.)

Work-station		Manicurist's activities	Researcher activities.	Remark
Existing Workstation	**Toenail**	Nail the paint dry	2. Manicurists were asked about Section 4. Satisfaction of the manicurist by used existing workstation and new workstations with Table Nail.	Questionnaires were used to investigate manicurist about workstation.
			3. Customers were asked about Part 1 General. Section 2.Satisfaction of the manicure by used existing workstation and new workstation. 4. Take Table nail and a new chair in the salon	Questionnaires were used to investigate manicurist about workstation.
New Workstation	**Fingernail**	Clean fingernail to clean out the original color.	1. To install monitoring equipment on the amount of air a person using activated charcoal tube and pump.	30 minute per workstation.
		Cut nails and the remove the epidermis did not want.	1. Provide light meter	

Table 3-3 The protocol of data collection (Cont.)

Work-station		Manicurist's activities	Researcher activities.	Remark
New Workstation	Fingernail	To paint the fingernail	1. To measure light intensity at work by using Lux meter.	Fill the measure in the table of sheet.
		Nail the paint dry.	-	
	Toenail	Pedicure clean with soap.	-	
		Pedicure cleaning with alcohol.	-	
		Clean the toenail to clear out old color.	-	
		Cut nails and remove the epidermis did not want.	1. Provide light meter	
		To paint the toes.	1. To measure light intensity at work by using Lux meter.	Fill the result's measure in the table of sheet.
		Nail the paint dry	1. To remove the air volume measuring equipment with a label that activated charcoal tube.	
			2. Manicurists were asked about Section 4.Satisfaction of a manicurist by used existing workstation and new workstations with Table Nail.	Questionnaires were used to investigate the manicurist about their workstation.

Table 3-3 The protocol of data collection (Cont.)

Work-station		Manicurist's activities	Researcher activities.	Remark
New Workstation	Toenail		3. Customers were asked about Part 1 General Section 2: Satisfaction of a manicure by used existing workstation and new workstation. 4. Take Table nail and a new chair in the salon	Questionnaires were used to investigate the manicurist about their workstation.

Remark: After sampling each day to complete the activated charcoal tube stored in a refrigerator or water bottle with ice and the activated charcoal tube send lab to analyze chemical substances in the working condition.

3.5 Data Analysis

All data from this survey were analyzed by using program computers.

3.5.1 The descriptive statistics, which include percentage, mean, standard deviation, were used to summarize the general information of physical health status and score of feeling fatigue.

3.5.2 Paired Simple T-test statistic was introduced for the statistical analysis. It was used to compare means on the same or related subject over time or in differing circumstances such as chemical concentration, fatigue feeling and satisfaction of workstation between the existing and new workstation.

3.5.3 The confidence level was set at 95%.

CHAPTER IV
RESULTS

The study was conducted on the anthropometrical data of manicurist in Photharam district, Ratchaburi province to determine the appropriate size desk and chair of nail technicians and customers. The opinions of the manicurist about comfortable and satisfaction from using traditional work station compare new work station were made. . The findings were obtained from data collected by sampling manicurist 35 in Photharam district, Ratchaburi province. The research topics can be expressed as follows.

4.1. The result of general and work related-information

4.2 The result of light intensity before and after using new workstation.

4.3. The analysis body-fatigue or discomfort before and after using new workstation.

4.3. The analysis satisfaction of manicurist's activity with old work station and new work station with including table nail.

4.4. The test of hypothesis.

4.1 The result of general and work related-information

The questionnaires were consisted of question related to musculoskeletal trouble compared before and after being a manicure history of the manicurist in eight body areas and Information on careers in manicurist, all questions were based on Dutch Musculoskeletal Questionnaires (DMQ). And Musculoskeletal Pain Assessment; all questions were based on pain scale. Table 4 – 1 demonstrates the demographic, work and health data of the subject. The subject were 35 manicurists, the most of age was between 30-34 year (28.57%), the most body weight was between 50 - 59 kg (42.86%) and the most of height was below 150 centimeter (37.14%).The

most of body mass index (BMI) were between 20 – 24.99 (37.14%), and the most of education was diploma (68.57%). And the part of career information, the most period of occupation of manicurist was between 1 - 3 years (34.29%), the most of period of work per week was between 1 – 2 hours (66%). The hygiene of the workplace, the most was cleaned (51.43%) and the most of manicurists had not symptoms or disease (62.86%).

Table 4-1: The general information about career manicurist in Photharam district, Ratchaburi Province.

Personal characteristics	**Subject (n=35)**	
	Frequency	**Percent**
Age (Year)		
20 - 24	6	17.14
25 - 29	5	14.29
30 - 34	10	28.57
35 - 39	7	20.00
≥ 40	7	21.00
Mean = 33.26, SD. = 8.41, Min = 20,Max = 51		
Weight (Kg)		
< 50	12	34.29
50 - 59	15	42.86
≥ 60	8	22.85
Mean =54.31, SD. = 7.36, Min = 43 ,Max = 72		
Height (cm)		
≤ 150	13	37.14
151 - 159	10	28.57
≥ 160	12	34.29
Mean =154.37, SD. = 4.37, Min = 148 ,Max = 162		

Table 4-1: The general information about career manicurist in Photharam district, Ratchaburi Province (Cont.)

Personal characteristics	Subject (n=35)	
	Frequency	Percent
BMI		
15.00 - 19.99	10	28.57
20.00 - 24.99	13	37.14
≥ 25.00	12	34.29
Mean =22.90, SD. = 3.70, Min = 16.80 ,Max = 32.00		
Education		
Primary education	8	22.86
High school education	2	5.71
Diploma	24	68.57
Bachelor's degree	1	2.86
Period of occupation of manicurist (year)		
1 - 3	12	34.29
4 - 6	7	20.00
7 - 9	7	20.00
≥ 10	9	25.71
Mean =6.23, SD. = 4.09, Min = 2 ,Max = 22		
Period of manicure per day		
1 - 2	23	65.71
3 - 4	7	20.00
≥ 5	5	14.29
Mean =2.11, SD. = 1.997, Min = 1 ,Max = 10		
Hygiene of the workplace		
Dirty	17	48.57
every time	1	2.86
sometimes	16	45.71
Clean	18	51.43
Symptoms or disease in the past		
Yes	13	37.14
No	22	62.86

The symptoms or disease in the past included sneeze, cough and allergy symptoms or disease, as for the present symptoms or disease showed congestion, nasal irritation, and be confused,. The addition symptoms or diseases when compared to the past were nasal irritation, sneeze, to be confused and queasy. And the specific symptom or disease for manicurist were irritant of throat and low respiratory tract and other symptoms such as eye pain, etc.

Table 4-2: The percentage of symptom or disease in the past and present

Symptom	Past		Present	
	frequency	%	frequency	%
Sneeze	12	34.3	15	42.9
Allergy	7	20.0	7	20.0
Nasal congestion	2	5.7	6	17.1
Dizzy	2	5.7	32	91.4
Cough	10	28.6	11	31.4
Irritant of nose	1	2.9	26	74.3
Groggy	2	5.7	18	51.4
Asthma	0	0.0	0	0.0
Queasy	1	2.9	9	25.7
Sinusitis	0	0.0	0	0.0
Breathless	1	2.9	4	11.4
Migraine	2	5.7	5	14.3
Irritant of throat and low respiratory tract	0	0.0	5	14.3
Other	0	0.0	8	22.9

4.2 The result of light intensity before and after using new workstation.

The researcher measured the light intensity in nail salon. The result was shown in table 4-3. Light intensity compared before and after using new workstation was difference. New workstation was better than the existing workstation.

Table 4-3: The light intensity in nail salon

Range	Light intensity (lux)	
	Before	After
< 200	13	0
200 - 800	22	16
> 800	0	19
Mean (SD.)	256 (141.4)	974.91 (426.84)
Min-Max	40 - 586	523 - 2630

4.3. The analysis body-fatigue or discomfort before and after using new work station.

The fatigued of the part of body among manicurist before started to work, worked with existing workstation and new workstation were at back, neck and shoulder in order as Table 4-4. The criteria for the classification fatigue were as follows:

- The average score less than or equal to 1.90 meant no problems or impacted on the body. That it was called no problems scale; NP scale.
- The average score between 1.90 and 2.50 meant it will have problems or impacted on the body. That it was called will have problem scale; WHP scale.
- The average score over 2.5 indicates showed health impact (problem). That it was called health problem scale; HP scale.

The different level of fatigue of all parts of the body was found when compared the existing and new workstation. The existing workstation showed level of fatigue higher than the new work station.

Table 4-4: The fatigued of the part of body among manicurist before started to work, worked with existing workstation and new workstation

The part of body	Subject (n=35)					
	Before		Existing workstation		New workstation	
	mean	result	mean	result	mean	result
Neck	1.54 (SD. = 0.561)	NP	3.06 (SD. = 0.482)	HP	0.71 (SD. = 0.622)	NP
Shoulder	1.66 (SD. = 0.539)	NP	3.03 (SD. = 0.568)	HP	0.77 (SD. = 0.600)	NP
Back	1.8 (SD. = 0.759)	NP	3.4 (SD. = 0.736)	HP	0.86 (SD. = 0.770)	NP
Waist	1.37 (SD. = 0.490)	NP	2.09 (SD. = 0.887)	WHP	0.4 (SD. = 0.497)	NP
Ischium	1.06 (SD. = 0.236)	NP	1.17 (SD. = 0.453)	NP	0.09 (SD. = 0.284)	NP
Thighs	1.37 (SD. = 0.547)	NP	1.77 (SD. = 0.808)	NP	0.31 (SD. = 0.530)	NP
Knees	1.49 (SD. = 0.562)	NP	1.94 (SD. = 0.684)	WHP	0.49 (SD. = 0.562)	NP
Feet	1.03 (SD. = 0.169)	NP	1.06 (SD. =0.236)	NP	0.03 (SD. = 0.169)	NP

The results could be summarized that, the level of fatigue the parts of body before started to work showed scores less than 1.90 which indicated that no problems or impacted on the body. But the level of body fatigue with the existing workstation showed scores greater than 2.50 with fatigue neck, shoulder and back in order, which indicated health problem. And it showed scores between 1.90 and 2.40 such as waist and knee that showed the problems will happen soon. After the implementation of new

workstation, the scores were less than 1.90 indicated no problems or impacted on the body.

The interview of the manicurists showed general entire body fatigue. It was found that the level of fatigue before started to work was 1.66 which indicated pain or discomfortable. The average level of fatigue was 3.00, while using the existing workstation. It indicated health problems or impacted on the body. And the level of fatigue while using new workstation was 1.66. It indicated no problems or impacted on the body, which showed in Table 4-5.

Table 4-5: The fatigue of the entire body of manicurists.

Fatigue	**Subject (n=35)**	
	Mean	**SD**
Before started to work	1.66	0.591
Use existing workstation	3.00	0.485
Use new workstation	1.66	0.539

The causes of fatigue or discomfort among manicurists from using existing workstation were to cut nail and cut leather, it showed score above 2.50 meant this activity caused health impact or problem. The activities will have problem such as wash hands or feet with soap, and paint nail because they showed score between 1.90 and 2.50. The table 4-6 was shown the most fatigue of manicurist's activities such as wash hands or feet with soap, paint nail and nail polish and clean nail with alcohol, while using existing workstation were higher than working at new workstation.

Table 4-6: The level of fatigue among manicurist in different activities of nail salon process

Activity of nail technical	Subject (n=35)			
	Existing workstation		New workstation	
	Mean	result	Mean	result
Wash hands or feet with soap	2.51 (SD. = 0.853)	WHP	1.51 (SD. = 0.507)	NP
Clean nail with alcohol	1.69 (SD. = 0.530)	NP	1.09 (SD. = 0.507)	NP
Clean nail with polish nail	1.83 (SD. = 0.382)	NP	1.03 (SD. = 0.169)	NP
Cut nail	3.17 (SD. = 0.453)	HP	1.03 (SD. = 0.169)	NP
Paint nail	2.17 (SD. = 0.514)	WHP	1.29 (SD. = 0.458)	NP

4.4. The analysis satisfaction of manicurist's activity with old work station and new work station with including table nail.

The satisfaction of manicurist's activity could separate by the criteria were as follows:

- The average score less than or equal to 60% that was 3.40 meant the manicurist did not satisfaction, that it was called NS scale.
- The average score between 60% and 79% that was between 3.40 and 4.19 meant the manicurist was low satisfaction because it would improvement that it was called LS scale.
- The average score over 80% that was more than or equal to 4.20 meant the manicurist was very satisfaction it was called VS scale.

The satisfaction of manicurist from using existing workstation was less than new workstation for all topics. The manicurist did not satisfaction of existing workstation, so the score less than 3.40. After the manicurist used new workstation found the satisfaction increased. Almost of topics were shown the manicurist was very satisfaction except comfort for workstation, but all topic of satisfaction of new workstation more than existing workstation, by the Table 4-7 showed that satisfaction in all workstation topics.

Table 4-7: The satisfactions of manicurist from using existing workstation and new workstation

Satisfaction	**Subject (n=35)**			
	Existing workstation		**New workstation**	
	mean	**result**	**mean**	**result**
Workstation				
Height of table for workstation	3.06 (SD. = 0.416)	NS	4.77 (SD. = 0.426)	VS
Area for work station	3.11 (SD. = 0.404)	NS	4.66 (SD. = 0.482)	VS
High of chair for workstation	2.2 (SD. = 0.473)	NS	4.69 (SD. = 0.676)	VS
Light for workstation	2.2 (SD. = 0.584)	NS	5.00 (SD. = 0.00)	VS
Comfort for workstation	3.14 (SD. = 0.430)	NS	3.91 (SD. = 0.612)	LS
Overall with workstation	3.09 (SD. = 0.373)	NS	4.34 (SD. = 0.539)	VS

Table nail was a new installation for ventilation of a manicure workplace. The manicurists were very satisfaction almost topic as shown in Table 4-8. The exception the price of table nail was found the average score of 1.89. It indicted that most manicurists did not satisfaction because the price was too expensive.

Table 4-8: The satisfaction of table nail

Satisfaction	**Subject (n=35)**	
	New workstation	
	mean	**result**
Table nail		
Reduce disorder such as irritant of eye	4.77 (SD. = 0.426)	VS
Reduce odor of table nail	4.86 (SD. = 0.355)	VS
Raw material of table nail	4.37 (SD. = 0.690)	VS
Overall with table nail	4.43 (SD. = 0.558)	VS
Price of table nail (approximately 7,000 BT)	1.89 (SD. = 0.758)	NS
Noise from table nail	4.74 (SD. = 0.611)	VS

4.5. The test of hypothesis.

4.5.1 The chemical concentration in the workplace decreased by 80% while performed nail activity.

The samples of chemicals in the workplace were collected, while using the existing workstation and using new workstation. The analysis was conducted by using Gas Chromatography Perkin-Elmer Model Clarus 500 with auto-sampler technique GC-FID. Most chemicals were found such as toluene, butyl-acetate and butanol, respectively. The results could be expressed in Table 4.9.

Table 4.9: The concentration of chemicals in the workplace

No.	Toluene (ppm)			Butanol (ppm)			Butyl-acetate (ppm)		
	Before	**After**	**(%)**	**Before**	**After**	**(%)**	**Before**	**After**	**(%)**
1	0.014	0.003	79%	0.001	ND	100%	0.003	0.001	67%
2	0.012	0.004	67%	0.001	ND	100%	0.006	0.002	67%
3	0.015	0.002	87%	0.001	ND	100%	0.011	0.004	64%
4	0.012	0.001	92%	ND	ND	-	0.007	0.001	86%
5	0.017	0.006	65%	ND	ND	-	0.010	0.004	60%
6	0.013	ND	100%	ND	ND	-	0.002	ND	100%
7	0.012	0.002	83%	ND	ND	-	0.001	ND	100%
8	0.013	ND	100%	ND	ND	-	0.002	0.001	50%
9	0.013	0.001	92%	0.001	ND	100%	0.001	ND	100%
10	0.012	ND	100%	ND	ND	-	0.006	ND	100%
11	0.015	0.010	33%	ND	ND	-	0.006	0.002	67%
12	0.013	0.005	62%	0.001	ND	100%	0.006	0.001	83%
13	0.012	0.002	83%	0.001	ND	100%	0.005	0.002	60%
14	0.018	0.002	89%	0.001	ND	100%	0.007	0.002	71%
15	0.017	0.001	94%	ND	ND	-	0.006	0.002	67%
16	0.014	ND	100%	0.001	ND	100%	0.006	0.002	67%
	Average		**83%**			**100%**			**75%**

Remark ND meant the equipment cannot detect the chemical concentration or the chemical concentration was less than 0.001 ppm.

Table 4.10: Paired samples test of chemical concentration between before and after using table nail

Chemical		Mean	SD.	t	df	P-value
Toluene	Before & after	0.011	0.003	15.79	15	<0.001
Butanol	Before & after	0.001	0.001	3.87	15	0.002
Butyl-acetate	Before & after	0.004	0.002	7.73	15	<0.001

Statistical test showed the reduction of the chemical concentration such as toluene, butanol and butyl-acetate, during the in activity of manicurists after using table nail at $\propto = 0.05$.

Table 4.11: One sample statistics of chemical concentration decreased 80%

Chemical	Test Value = 0.8					
	Mean	SD.	n	df	t	P-value
Toluene	0.828	0.183	16	15	0.616	0.547
Butanol	1.000	0.000[a]	8	-	1.315	-
Butyl-acetate	0.755	0.168	16	15	-1.08	0.298

Remark: a mean t cannot be computed because the standard deviation is 0.

Statistical test showed the chemicals concentration in the workplace decreased by 80% while performed nail activity such as toluene and butyl-acetate after using table nail at $\propto = 0.05$.

4.5.2 The new workstation based on ergonomics approach decreased the rate of tiredness, when compared to the existing workstation.

The comparison of body fatigue can be expressed as follows.

Table 4-12: The comparison of body fatigue before and after introducing of existing workstation.

The body fatigue	Before		After		Paired t	df	P-value
	Mean	SD.	Mean	SD.			
Neck	1.54	0.56	3.06	0.48	-15.938	34	<0.001
Shoulders	1.66	0.54	3.03	0.57	-11.098	34	<0.001
Back	1.80	0.76	3.40	0.74	-9.411	34	<0.001
Waist	1.37	0.49	2.09	0.89	-5.951	34	<0.001
Ischium	1.06	0.24	1.17	0.45	-1.675	34	0.103
Thighs	1.37	0.55	1.77	0.81	-4.279	34	<0.001
Knees	1.49	0.56	1.94	0.68	-1.966	34	0.058
Feet	1.03	0.17	1.06	0.24	-1.000	34	0.324

Statistical test showed the comparison of body fatigue before and after introducing of existing workstation such as neck, shoulders, back, waist and thigh at $\propto = 0.05$ except such as ischium, knees and feet.

Table 4-13: The comparison of body fatigue before and after introducing of new workstation.

The body fatigue	Before		After		Paired t	df	P-value
	Mean	SD.	Mean	SD.			
Neck	1.54	0.56	1.71	0.62	-2.240	34	0.032
Shoulders	1.66	0.54	1.77	0.60	-1.675	34	0.103
Back	1.80	0.76	1.86	0.77	-0.572	34	0.571
Waist	1.37	0.49	1.40	0.50	-1.000	34	0.324
Ischium	1.06	0.24	1.09	0.28	-1.000	34	0.324
Thighs	1.37	0.55	1.31	0.53	1.435	34	0.160
Knees	1.49	0.56	1.49	0.56	∞	34	∞
Feet	1.03	0.17	1.03	0.17	∞	34	∞

Remark: t, Sig. cannot be computed because the standard error of the difference is 0.

Statistical test showed the comparison of body fatigue before and after introducing of new workstation at $\propto = 0.05$ except neck.

Table 4-14: The comparison of body fatigue after introducing of existing and new workstation.

The body fatigue	Existing workstation		New workstation		Paired t	df	P-value
	Mean	SD.	Mean	SD.			
Neck	1.54	0.56	3.06	0.48	14.733	34	<0.001
Shoulders	1.66	0.54	3.03	0.57	10.032	34	<0.001
Back	1.80	0.76	3.40	0.74	10.712	34	<0.001
Waist	1.37	0.49	2.09	0.89	6.000	34	<0.001
Ischium	1.06	0.24	1.17	0.45	1.785	34	0.083
Thighs	1.37	0.55	1.77	0.81	4.824	34	<0.001
Knees	1.49	0.56	1.94	0.68	5.351	34	<0.001
Feet	1.03	0.17	1.06	0.24	1.000	34	0.324

Statistical test showed the comparison of body fatigue after introducing of existing and new workstation such as neck, shoulders, back, waist, knee and thigh at $\propto = 0.05$ except ischium and feet.

4.5.3 The increased in the satisfactions of created new table nail among manicurist.

Table 4.15: Paired samples test of satisfaction between using existing workstation and new workstation.

Satisfaction	Existing workstation		New workstation		Paired t	df	P-value
	Mean	SD.	Mean	SD.			
High of table for workstation	3.06	0.42	4.77	0.43	-17.716	34	<0.001
Area for work station	3.11	0.40	4.66	0.48	-16.282	34	<0.001
High of chair for workstation	2.20	0.47	4.69	0.68	-17.239	34	<0.001
Light for workstation	2.20	0.58	5.00	0.00	-28.36	34	<0.001
Comfort for workstation	3.14	0.43	3.91	0.61	-5.413	34	<0.001
Overall with workstation	3.09	0.37	4.34	0.54	-10.032	34	<0.001

Statistical test showed satisfactions of manicurist after introducing of existing and new workstation at $\propto = 0.05$.

Table 4.11: One sample statistics of satisfaction of table nail

Satisfaction	Test Value = 3.4					
	Mean	**SD.**	**n**	**df**	**t**	**P-value**
Reduce disorder such as irritant of eye	4.771	0.426	35	34	19.044	<0.001
Reduce odor of table nail	4.857	0.355	35	34	24.281	<0.001
Raw material of table nail	4.371	0.690	35	34	8.333	<0.001
Overall with table nail	4.429	0.558	35	34	10.913	<0.001
Price of table nail	1.886	0.758	35	34	-	<0.001
(approximately 7,000 Baht)					11.816	
Noise from table nail	4.743	0.611	35	34	13.006	<0.001

Statistical test showed satisfactions of table nail at $\propto = 0.05$ except the price of it.

CHAPTER V
DISCUSSION

This study purposed to design work station for nail salon based on ergonomics guidelines and ventilation guidelines. The 35 subjects used the existing work station compare the new work station with satisfaction, comfortable and fatigue after used each workstation.

5.1 Result of the concentration of chemical in workstation

The major chemistries were found in workstation i.e. toluene, butyl-acetate and butanol, respectively. The manicurists used existence workstation compared with used the table new found the concentration decreased. When I used pair t-test statistics for tested the concentration of chemical in the existence workstation compared with new workstation was decreased 80 percents of each concentration chemical, I was found toluene and butyl-acetate concentration significance with 95% of confidence interval (P-value > 0.05). But I could not determine butanol concentration because the workstation had very low the chemical concentrations, their units were shown in part per million or ppm which limited the equipment. Example if the concentration of chemical was 0.003 ppm, it must to be found less than 0.0006 ppm that which the equipment could not detect it and inadequate the numbers of sample. That it made this error. But the table nail could decrease each concentration of the chemical compared with existing workstation was shown at table 4-7.

5.2 Result of muscular fatigue feeling compared the existence workstation and the new workstation

The existence workstation fatigued most than the new workstation almost the parts of body such as neck, shoulders, back, waist, thighs and knees with 95% of confidence interval (P-value < 0.05) expected ischium and feet because ischium and feet did not difference the level of fatigue before and after work with existing

workstation or new workstation with 95% of confidence interval as shown in table 4-10 and 4-11. And the average score less than or equal to 2.5 indicates meant the parts of body about fatigue did not have problems or impact on the body as shown in table 4-3.

The result was similar to the study of Khalil,et al., Nachemson,et al. and Vilai Chinsakul. They found sitting for a long time was increased hazard of health i.e. neck pain, shoulder pain, headache, leg pain, and it was caused waist stress, that led to back pain.

5.3 Result of workstation and table nail satisfaction

The manicurists satisfied the new workstation more than the existence workstation. The result showed the satisfaction of the new workstation such as

- Satisfaction of height of table for workstation
- Satisfaction of area for workstation
- Satisfaction of height of chair for workstation
- Satisfaction of light for workstation
- Satisfaction of workstation

They found satisfaction of new workstation more than existence workstation all topics with 95% of confidence interval (P-value < 0.05).

And they satisfied the table nail with 95% of confidence interval (P-value < 0.05). The satisfaction of the table nail included;

- Satisfaction for reduce disorder etc. irritant of eye.
- Satisfaction for reduce odor of table nail.
- Satisfaction for raw material of table nail
- Satisfaction for noise form table nail

But they did satisfy the table nail about the prize of table nail, was equaled to 7,000 baht with 95% of confidence interval (P-value > 0.05). They thought it more expensive. Cost depended on volume of table nail. If they ordered many table nail, it might be reduce cost of table nail.

5.4 Discussion of difference of light flux intensity

The study showed difference of the light intensity and distance from the source between before and after setting new workstation. The satisfaction of light was increased after using new workstation. The study found the light intensity was difference in light intensity of same source according to distance. The researcher did not set the source distance then the manicurist set the lamp comfortable so the light intensity would difference.

This result was similar to The National Framework for Energy Efficiency, and also correlated with the theory that the inverse square law defines the relationship between the irradiance from a point source and distance as described in section 2.6.1.

5.5 Discussion of difference size of beauty salon

The size of beauty salon would affect the ventilation inside. The large size (open air) beauty salon have better ventilation than small one. The chemicals concentration also effected by ventilation because the concentration was less in the large or open beauty salon than the small or closed beauty salon.

The result was similar ACGIH suggestion. The ventilation depends on volume of beauty salon.

5.6 Discussion of new workstation design

Workstation design would affect the distance between nail activity and breathing zone, then the manicurist would be received chemical concentration lower than existing workstation. That is a good condition for the manicurist that would protect the chemical hazard from nail activity to be less than ever.

The result was similar OSHA law. They said the reduction of chemicals in the range of breathing zone manicurist and customer it would prevent the chemical hazard.

5.7 Discuss satisfaction of customer

This study was found the satisfaction of customer compare existing and new workstation. The researcher interviewed 20 customers about satisfaction of workstation. They satisfied new workstation more than existing workstation at $\alpha = 0.05$. The satisfaction of table's high, area and chair's high were not difference compare existing and new workstation. While they were satisfying overall topic increased when they used new workstation.

CHAPTER VI
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study was designed workstation for reduce the level of fatigue from work of manicurist rate and designed the table nail was local ventilation of nail activities. The type of research was a Quasi-experiment research. The research studied the chemical concentration of workstation reduce 80% measured by Gas Chromatography (GC) analyzed. The questionnaire was used for fatigue feeling and satisfaction of the new table nail.

Sample of this study were selected 35 manicurists in Photharam district, Ratchaburi province had period of career no less than three months. The samples works with existing workstation 30 minutes and new workstation 30 minutes from compare the chemical concentration. And the samples were asked about fatigue feeling before and after work with existing or new workstation, and then they were asked about satisfaction of new workstation and new table nail.

The result of the concentration of chemical in workstation such as toluene and butyl-acetate was decreased 80% of each concentration (P-value > 0.05).

The result of this study was shown the muscular fatigue feeling compare the existing workstation and the new workstation. That found the new workstation could reduce fatigue feeling of neck, shoulders, back, waist, thighs and knees (P-value < 0.05) except ischium and feet.

The results of workstation and table nail satisfaction were shown the workers satisfied new workstation more than existing workstation (P-value < 0.05). And they felt satisfaction of table nail to reduce unpleasant odors and noise from table nail (P-value < 0.05). But the workers did not satisfaction for prize of table nail.

6.2 Recommendation for further study

1. To further study would find the other risk factor from beauty's technician such as dyed hair.
2. The further study would increase the samples size for designing workstations were used all age groups.
3. To further study would find the other material for reducing cost from table nail.
4. The further study set fix the workstation of nail's technician including chair's technician, chair's customer and table.
5. Table nail should have air cleaning system and including time of period to replace absorbents.
6. The further study would set period time of manicure and the difficulty of manicure to control variable.

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APPENDICES

APPENDIX A
INFORMATION SHEET AND CONSENT FORM

เอกสารชี้แจงการวิจัยแก่ผู้ยินยอมตนให้ทำการวิจัย

ชื่อโครงการวิจัย การออกแบบสถานีงานสำหรับช่างทำเล็บ

สถานที่ที่ทำการวิจัย ตำบลโพธิ์ธาราม จังหวัดราชบุรี

หัวหน้าโครงการและผู้ร่วมโครงการ และที่อยู่ที่ติดต่อได้

ผู้วิจัย นางสาวสุพัตรา ละอองนวล ที่อยู่ที่ติดต่อได้ 1292 ม.6 ถ.วินยานุโยค ต.อู่ทอง อ.อู่ทอง จังหวัดสุพรรณบุรี 72160

อาจารย์ผู้ควบคุมวิทยานิพนธ์ รศ.วิชัย พฤกษ์ธาราธิกุล

บทนำและเหตุผลในการศึกษาวิจัยของโครงการวิจัยนี้ (อย่างย่อ)

ธุรกิจเสริมสวย เป็นการให้บริการเสริมแต่งความงามให้กับลูกค้า เช่น การให้บริการเกี่ยวกับผม เช่น การตัดผม, การสระผม, การทำสีผม รวมถึงการแต่งทรงผม หรือการให้บริการเกี่ยวกับใบหน้า เช่น การแต่งหน้า หรือการให้บริการเกี่ยวกับเล็บ เช่น การตกแต่งเล็บ เป็นต้น จากการสำรวจโดยสำนักส่งเสริมและพัฒนาธุรกิจ ใน พ.ศ. 2545 มีอัตราการขยายตัวของเศรษฐกิจสูงถึงร้อยละ 4 จากปีที่ผ่านมา และจากข้อมูลของสำนักงานสถิติแห่งชาติในปี 2543 ประมาณมูลค่าตลาดภายในปี 2545 มีมูลค่าสูงถึง 1,104 ล้านบาท สำหรับมูลค่าตลาดต่างประเทศ ทำให้ธุรกิจเสริมสวยเพิ่มจำนวนมากขึ้นตามความต้องการของลูกค้าที่มีแนวโน้มเพิ่มสูงขึ้น

จากการประเมินความเสี่ยงของผู้วิจัยเอง พบว่าช่างเสริมสวยต้องสัมผัสกับอันตรายจากการทำงานหลายด้าน อาทิเช่น อันตรายจากสารเคมี, อันตรายด้านการยศาสตร์ เป็นต้น นอกจากนี้ช่างเสริมสวยที่ทำเล็บนั้นไม่ว่าจะเล็บมือหรือเล็บเท้าจะพบอันตรายจากแสงสว่างที่ไม่เพียงพอซึ่งอาจจะนำไปสู่การเกิดอุบัติเหตุได้ รวมถึงอันตรายทางด้านชีวภาพ หรือเชื้อโรคต่างๆ จากลูกค้าอาจแพร่สู่ช่างทำเล็บได้ ซึ่งก็สอดคล้องกับการศึกษาของนักวิจัยหลายท่านที่พบว่าการประกอบอาชีพช่างทำเล็บมีโอกาสเสี่ยงต่อการผิดปกติของร่างกาย เช่น การหายใจผิดปกติ การหายใจลำบาก หรือการระคายเคืองทางเดินหายใจ รวมถึงการปวดเมื่อยกล้ามเนื้อไหล่ เป็นต้น แต่ทั้งนี้พบว่าสำหรับประเทศไทยนั้นปัจจุบันยังไม่มีการกำหนดมาตรฐานสำหรับการทำงานของช่างทำเล็บ ดังนั้น ผู้วิจัยจึงได้ทำการศึกษาเพื่อค้นหาอันตรายและวิธีป้องกันอันตรายสำหรับช่างทำเล็บในประเทศไทย เพื่อให้เกิดความปลอดภัยในการทำงาน

วัตถุประสงค์ของโครงการ

1. เพื่อออกแบบสถานีงานที่เหมาะสมตามหลักการยศาสตร์ เพื่อที่จะลดอัตราการปวดเมื่อยจากท่าทางการทำงาน
2. เพื่อออกแบบชุดทำเล็บที่เหมาะสม สำหรับใช้ในการระบายอากาศเฉพาะที่ในการทำเล็บของช่างทำเล็บ
3. เพื่อเปรียบเทียบความพึงพอใจของช่างทำเล็บระหว่างสถานีงานแบบใหม่และสถานีงานแบบเดิม

วิธีการวิจัย

หากท่านตัดสินใจเข้าร่วมการวิจัยแล้ว จะมีขั้นตอนการวิจัยดังต่อไปนี้คือ

1. ผู้วิจัยจะทำการสัมภาษณ์ท่าน เกี่ยวกับข้อมูลทั่วไป, ข้อมูลเกี่ยวกับการประกอบอาชีพช่างทำเล็บ, ความเมื่อยล้าหรือไม่สบายของร่างกายที่เกิดก่อนการทำเล็บ และความพึงพอใจและความเมื่อยล้าจากการทำเล็บโดยสถานีงานแบบเดิม
2. ผู้วิจัยจะทำการตรวจวัดสภาพแวดล้อมในการทำงานของท่านจากสถานีงานแบบเดิมในขณะที่มีการทำเล็บมือและเล็บเท้า ได้แก่ การตรวจวัดปริมาณสารเคมีในบรรยากาศการทำงาน โดยมีการติดอุปกรณ์เก็บตัวอย่างอากาศหนีบไว้บริเวณที่เอวของท่านขณะที่ท่านทำการทาสีเล็บของลูกค้า เป็นเวลานาน 30 นาที โดยทั้งนี้อุปกรณ์ดังกล่าว มีน้ำหนักประมาณ 0.5 กิโลกรัมเท่านั้น และตรวจวัดแสงสว่างขณะที่ท่านทำงานโดยใช้เครื่องมือในการตรวจวัด
3. ผู้วิจัยจะทำการออกแบบชุดทำเล็บและสถานีงานใหม่เพื่อให้เกิดความปลอดภัยแก่ท่านแล้วให้ท่านทดลองใช้ชุดทำเล็บและสถานีงานแบบใหม่ แล้วทำการตอบแบบสอบถามเกี่ยวกับความพึงพอใจในการใช้งานชุดทำเล็บและสถานีงานแบบใหม่

ผู้วิจัยทำการตรวจวัดสภาพแวดล้อมในการทำงานของท่านซ้ำอีกครั้ง เพื่อเปรียบเทียบชุดทำเล็บและสถานีงานแบบเดิมและแบบใหม่

เหตุผลที่เชิญชวนให้ท่านให้ทำการวิจัยเข้าโครงการวิจัย

ท่านเป็นผู้หนึ่งที่ประกอบอาชีพเป็นช่างทำเล็บจึงได้รับเชิญเข้าร่วมโครงการวิจัยในครั้งนี้ เพราะท่านเป็นช่างทำเล็บในจังหวัดราชบุรี ที่มีสุขภาพร่างกายแข็งแรง ผู้วิจัยจึงขอเชิญชวนท่านให้เข้าร่วมโครงการวิจัยในครั้งนี้

ระยะเวลาที่ต้องทำการทดลอง/ทดสอบในท่านให้ทำการวิจัย

ท่านจะได้รับการสัมภาษณ์ เป็นเวลา 10 นาทีโดยประมาณสำหรับการสอบถามเกี่ยวกับข้อมูลทั่วไป, ข้อมูลเกี่ยวกับการประกอบอาชีพช่างทำเล็บ และความพึงพอใจกับสถานีงานกับสถานีงานแบบใหม่ และชุดทำเล็บ และจะได้รับการตรวจวัดปริมาณสารเคมีในบรรยากาศการทำงานในสภาพแวดล้อมการทำงานแบบเดิมและแบบใหม่เป็นเวลา 50 นาที รวมระยะเวลาในการเก็บตัวอย่างเป็นเวลา 60 นาที

ประโยชน์ที่คาดว่าจะเกิดขึ้นทั้งต่อท่านให้ทำการวิจัย และต่อผู้อื่น

1. ได้สถานีงานที่เหมาะสมกับอาชีพช่างทำเล็บ ซึ่งจะช่วยลดปัญหาสุขภาพ
2. ได้สถานีงานที่เหมาะสมกับอาชีพช่างทำเล็บ ซึ่งปรับสภาพแวดล้อมในการทำงานให้ปลอดภัย
3. ได้สถานีงานที่เหมาะสมกับอาชีพช่างทำเล็บที่ถูกต้องตามหลักการยศาสตร์

ความเสี่ยง หรือ ความไม่สบายใดๆที่คาดว่าจะเกิดขึ้นกับท่านให้ทำการวิจัย ในระหว่างการเข้าร่วมการศึกษาวิจัย

1. แบบสอบถามที่ใช้ในการศึกษาเป็นการตอบคำถามถึงข้อมูลทั่วไป โดยทั้งนี้อาจจะมีคำถามที่ทำให้ท่านเกิดความรู้สึกอึดอัด หรือไม่สบายใจ

2. อุปกรณ์เก็บตัวอย่างอากาศ อาจมีสายพาดผ่านตัวของช่างทำเล็บในขณะปฏิบัติงานอาจก่อให้เกิดความรำคาญในขณะปฏิบัติงานแก่ผู้เข้าร่วมการวิจัย

มาตรการหรือวิธีการในการป้องกัน หรือลดความเสี่ยงหรือความไม่สบายใดๆ ที่อาจเกิดขึ้นในระหว่างการเข้าร่วมโครงการ

1. แบบสอบถามที่ใช้ในการศึกษาเป็นการตอบคำถามถึงข้อมูลทั่วไป และทัศนคติ ซึ่งแทบไม่มีความเสี่ยงหรืออันตรายใดๆ ต่อท่าน โดยทั้งนี้ผู้วิจัยจะระวังในการถาม จะถามโดยใช้วาจาที่สุภาพอ่อนโยน และจะหยุดถามทันทีที่ท่านให้ทำการวิจัยแสดงความรู้สึกอึดอัด หรือไม่สบายใจ

2. อุปกรณ์เก็บตัวอย่างอากาศ อาจมีสายพาดผ่านตัวของช่างทำเล็บในขณะปฏิบัติงานอาจก่อให้เกิดความรำคาญในขณะปฏิบัติงานแก่ผู้เข้าร่วมการวิจัย ดังนั้นผู้วิจัยจึงได้เตรียมเทปผ้าและที่หนีบให้ติดกับชุดของผู้เข้าร่วมการวิจัย เพื่อป้องกันไม่ให้ขัดขวางการปฏิบัติงานของผู้เข้าร่วมการวิจัย

การดูแลรักษาความลับของข้อมูลต่างๆ ของท่านให้ทำการวิจัย (ได้แก่ การเก็บรักษาข้อมูลจะทำอย่างไร เก็บไว้ที่ไหน ใครสามารถเข้าถึงข้อมูลได้บ้าง และมีวิธีการทำลายข้อมูลอย่างไร และเมื่อไร)

ผู้วิจัยจะเก็บรักษาข้อมูลของท่านไว้เป็นความลับ โดยจะมีการเก็บข้อมูลโดยการปิดบังชื่อและนามสกุล ซึ่งข้อมูลที่ได้ผู้วิจัยจะจัดเก็บไว้อย่างมิดชิด และจะทำลายข้อมูลทันทีที่สิ้นสุดการวิจัยเพื่อป้องกันการความลับของข้อมูลรั่วไหล

สิทธิท่านให้ทำการวิจัยจะถอนตัวออกจากโครงการวิจัยได้ทุกเมื่อ
ท่านให้ทำการวิจัยมีสิทธิที่จะถอนตัวจากการเข้าร่วมโครงการวิจัยได้ทุกเมื่อโดยไม่มีผลกระทบต่อท่าน

ผู้รับผิดชอบที่ท่านให้ทำการวิจัยสามารถติดต่อได้โดยสะดวก กรณีมีเหตุจำเป็น หรือฉุกเฉิน
ชื่อ นางสาวสุพัตรา ละอองนวล
ที่อยู่ (ในเวลาราชการ)
177 ม.4 ถ.ปทุมธานี-ลาดหลุมแก้ว ต.ระแหง อ.ลาดหลุมแก้ว จ.ปทุมธานี 12140
โทรศัพท์ 0866165737
ที่อยู่ (นอกเวลาราชการ)
190 ม.1 ซ.โรงเรียนวัดบ่อทอง ถ.ปทุมธานี-ลาดหลุมแก้ว ต.คูขวาง อ.ลาดหลุมแก้ว จ.ปทุมธานี
12140 โทรศัพท์ 0866165737

หนังสือยินยอมตนให้ทำการวิจัย

โครงการวิจัยเรื่อง

การออกแบบสถานีงานสำหรับช่างทำเล็บ

วันที่ให้คำยินยอม วันที่ …….. เดือน …….. พ.ศ. …….

ข้าพเจ้า (นาย/นาง/นางสาว) ……..……..……ขอทำหนังสือนี้ไว้ต่อหัวหน้าโครงการเพื่อเป็นหลักฐานแสดงว่า

ข้อ 1. ก่อนลงนามในใบยินยอมตนให้ทำการวิจัยนี้ ข้าพเจ้าได้รับการอธิบายจากผู้วิจัยให้ทราบถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย หรืออันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

ข้อ 2. ผู้วิจัยรับรองว่าจะตอบคำถามต่างๆ ที่ข้าพเจ้าสงสัยด้วยความเต็มใจ ไม่ปิดบัง ซ่อนเร้น จนข้าพเจ้าพอใจ

ข้อ 3. ข้าพเจ้าเข้าร่วมโครงการวิจัยนี้โดยสมัครใจ และข้าพเจ้ามีสิทธิที่จะบอกเลิกการเข้าร่วมในโครงการวิจัยนี้เมื่อใดก็ได้ และการบอกเลิกการเข้าร่วมวิจัยนี้จะไม่มีผลกระทบใดๆ ต่อข้าพเจ้า

ข้อ 4. ผู้วิจัยรับรองว่า จะเก็บข้อมูลเฉพาะเกี่ยวกับตัวข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปที่เป็นสรุปผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่างๆที่เกี่ยวข้อง กระทำได้เฉพาะกรณีจำเป็นด้วยเหตุผลทางวิชาการเท่านั้น

ข้อ 5. ผู้วิจัยรับรองว่าหากเกิดอันตรายใดๆอันเนื่องจากการวิจัยดังกล่าว ข้าพเจ้าจะได้รับการรักษาพยาบาลโดยไม่คิดมูลค่าตามมาตรฐานวิชาชีพ และจะได้รับการชดเชยรายได้ที่สูญเสียไประหว่างการรักษาพยาบาลดังกล่าวตลอดจนเงินทดแทนความพิการที่อาจเกิดขึ้น

ข้อ 6. ผู้วิจัยรับรองว่า หากมีข้อมูลเพิ่มเติมที่ส่งผลกระทบต่อการวิจัย ข้าพเจ้าจะได้รับการแจ้งให้ทราบทันทีโดยไม่ปิดบัง ซ่อนเร้น

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้วมีความเข้าใจดีทุกประการ และได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ

ลงชื่อ …… ผู้ยินยอม

(……..)

ลงชื่อ ……..…… พยาน

(……..)

ลงชื่อ ……..…… พยาน

(……..)

APPENDIX B
QUESTIONNAIRES FORM

แบบสอบถามเพื่อการวิจัย
เรื่อง การออกแบบสถานีงานสำหรับช่างทำเล็บ

คำชี้แจง

1. แบบสอบถามฉบับนี้ มีวัตถุประสงค์เพื่อสอบถามความพึงพอใจของท่านที่มีต่อสถานีงานแบบเดิมเปรียบเทียบกับแบบสถานีงานและชุดทำเล็บแบบใหม่ โดยมีรายละเอียดของคำถามดังต่อไปนี้

ส่วนที่ 1 ข้อมูลทั่วไป จำนวน 3 ข้อ

ส่วนที่ 2 ข้อมูลเกี่ยวกับการประกอบอาชีพช่างทำเล็บ จำนวน 7 ข้อ

ส่วนที่ 3 ความเมื่อยล้าหรือไม่สบายของร่างกายที่เกิดก่อนการทำเล็บ, สถานีงานแบบเดิมและสถานีงานแบบใหม่ จำนวน 4 ข้อ

ส่วนที่ 4 ความพึงพอใจจากการทำเล็บโดยสถานีงานแบบเดิมและสถานีงานแบบใหม่พร้อมชุดทำเล็บ จำนวน 2 ข้อ

2. โปรดตอบคำถามทุกข้อตามความเป็นจริง เพราะคำตอบที่เป็นจริงและสมบูรณ์เท่านั้น จะช่วยให้การวิจัยในครั้งนี้เกิดประโยชน์อย่างเต็มที่

3. โปรดทำเครื่องหมาย √ ลงในช่องหรือหน้าข้อความที่ตรงกับคำตอบของท่าน หรือเติมข้อความให้สมบูรณ์

4. คำตอบของท่าน ผู้วิจัยจะเก็บเป็นความลับ และจะประมวลผลเป็นรายงานในภาพรวม เพื่อการวิจัยเท่านั้น

ส่วนที่ 1 ข้อมูลทั่วไป

1. อายุ ( ) ต่ำกว่า 20 ปี ( ) 20 – 29 ปี ( ) 30 – 39 ปี
( ) 40 – 49 ปี ( ) 50 - 59 ปี ( ) มากกว่า 60 ปีขึ้นไป

2. ข้อมูลด้านกายภาพ น้ำหนัก.....กิโลกรัม ส่วนสูง.....เซนติเมตร

3. การศึกษา

( ) ประถมศึกษา ( ) มัธยมศึกษาหรือเทียบเท่า

( ) อนุปริญญาหรือเทียบเท่า ( ) ประกาศนียบัตรวิชาชีพ

( ) ปริญญาตรี ( ) สูงกว่าปริญญาตรี

( ) อื่นๆ .....

ส่วนที่ 2 ข้อมูลเกี่ยวกับการประกอบอาชีพช่างทำเล็บ

1. ระยะเวลาที่ท่านประกอบอาชีพช่างทำเล็บจนถึงปัจจุบัน โปรดระบุ.....ปี

2. จำนวนวันที่ที่ท่านทำเล็บให้กับลูกค้าต่อสัปดาห์ โปรดระบุ.....
วัน/สัปดาห์

3. จำนวนชั่วโมงที่ท่านใช้ในการทำเล็บให้กับลูกค้าในแต่ละวัน โปรดระบุ.....
ชั่วโมง/วัน

4. ท่านคิดว่าสุขลักษณะของสถานที่ทำงานของท่านเป็นอย่างไร

( ) สกปรกมาก ( )สะอาดมาก ( )บางครั้งสกปรก
บางครั้งสะอาด

5. ท่านมีอาการหรือโรคก่อนทำงานนี้หรือไม่

( ) มี ( ) ไม่มีข้ามไปข้อ 7

6. อาการหรือโรคที่ท่านเป็นก่อนที่จะทำงานช่างทำเล็บ (เลือกได้มากกว่า 1 ข้อ)

( )จาม ( )ภูมิแพ้ ( )คัดจมูก ( )เวียนศีรษะ

( )ไอ ( )ระคายเคืองจมูก ( )มึนงง ( )หอบหืด

( )คลื่นไส้ ( )ไซนัสอักเสบ ( )หายใจลำบาก อึดอัดและแน่นหน้าอก

( )ปวดศีรษะข้างเดียว ( )ระคายคอ และทางเดินหายใจส่วนล่าง

( )อื่นๆ โปรดระบุ.....

7. อาการหรือโรคที่ท่านเป็นขณะที่ทำงานช่างทำเล็บ (เลือกได้มากกว่า 1 ข้อ)

( )จาม ( )ภูมิแพ้ ( )คัดจมูก ( )เวียนศีรษะ

( )ไอ ( )ระคายเคืองจมูก ( )มึนงง ( )หอบหืด

( )คลื่นไส้ ( )ไซนัสอักเสบ ( )หายใจลำบาก อึดอัดและแน่นหน้าอก

( )ปวดศีรษะข้างเดียว ( )ระคายคอ และทางเดินหายใจส่วนล่าง

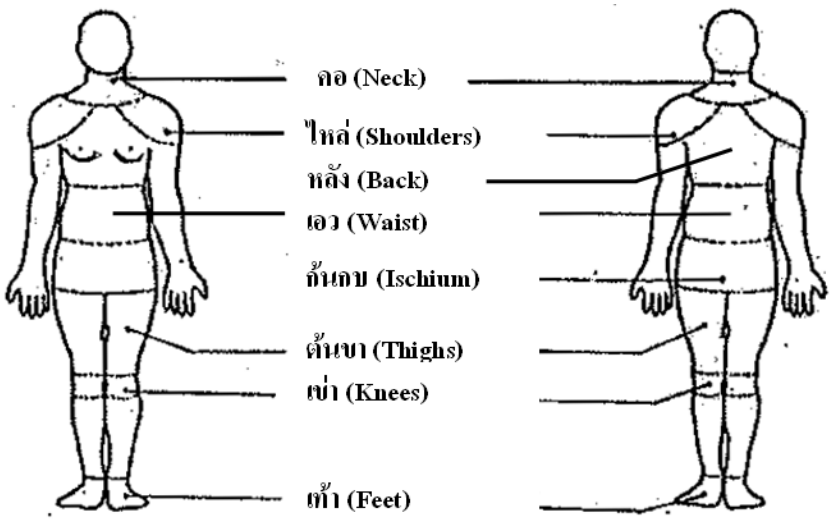
( )อื่นๆ โปรดระบุ.....

ส่วนที่ 3 ความเมื่อยล้าหรือไม่สบายของร่างกายที่เกิดก่อนการทำเล็บ, สถานีงานแบบเดิม และสถานีงานแบบใหม่

1. ท่านมีอาการเมื่อยล้า หรือรู้สึกไม่สบายบริเวณคอ,ไหล่,หลัง,เอว,ก้นกบ,ต้นขา,เข่าหรือเท้าหรือไม่

   ( ) มี ( ) ไม่มี

2. ให้ท่านใส่เครื่องหมาย √ ลงในช่องที่ท่านมีความรู้สึกเมื่อยล้าหรือไม่สบายในขณะนี้



ภาพด้านหน้า ภาพด้านหลัง

ส่วนของร่างกาย	ก่อนเริ่มงาน				สถานีงานแบบเดิม				สถานีงานแบบใหม่			
	1	2	3	4	1	2	3	4	1	2	3	4
2.1 คอ												
2.2 ไหล่												
2.3 หลัง												
2.4 เอว												
2.5 ก้นกบ												
2.6 ต้นขา												
2.7 เข่า												
2.8 เท้า												

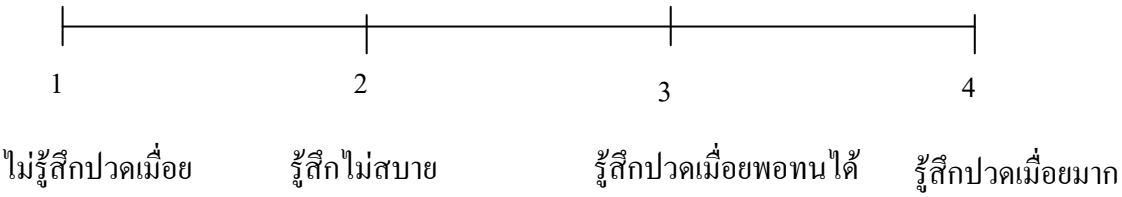
ระดับความรู้สึกปวดเมื่อย

1	หมายถึง	รู้สึกสบายไม่ปวดเมื่อยหรือไม่มีความรู้สึกปวดเมื่อยหรือไม่สบายเลย
2	หมายถึง	รู้สึกไม่สบายหรือรู้สึกรำคาญเล็กน้อย
3	หมายถึง	ปวดเมื่อยพอทนได้หรือรู้สึกปวดเมื่อย แต่พอที่จะทนได้โดยที่ไม่ต้องได้รับการรักษาโดยแพทย์ แต่ต้องหายามาทาเพื่อบรรเทาอาการ
4	หมายถึง	ปวดเมื่อยทนไม่ได้หรือปวดเมื่อยมากหรืออาการปวดเมื่อยมากที่ต้องการพบแพทย์เพื่อบรรเทาอาการปวด

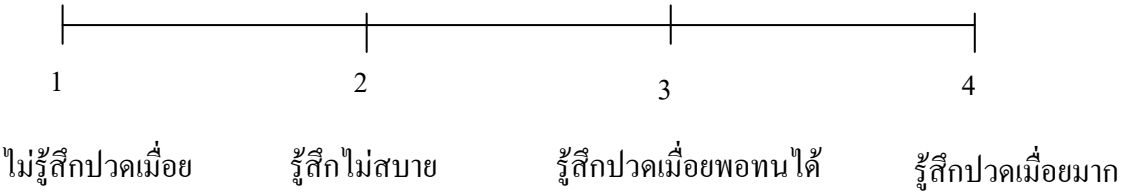
3 .ความเมื่อยล้าทั่วไปโดยรวมของร่างกาย

กรุณาแสดงความรู้สึกเมื่อยล้าทั่วไปของร่างกายโดยวงกลมที่ระดับคะแนนความเมื่อยล้า ระดับ 4

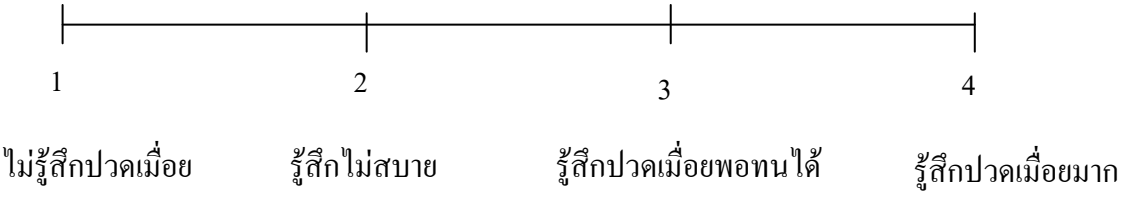
ก่อนเริ่มงาน



สถานีงานแบบเดิม



สถานีงานแบบใหม่



4. ความปวดเมื่อยจากสถานีงานแบบเดิมและสถานีงานแบบใหม่

4.1 ท่านมีอาการเมื่อยล้า หรือรู้สึกไม่สบายบริเวณคอ,ไหล่,หลัง,เอว,ก้นกบ,ต้นขา,เข่าหรือเท้าหรือไม่

( ) มี ( ) ไม่มี หยุดตอบแบบสอบถามในส่วนที่ 3

4.2 โปรดทำเครื่องหมาย √ ลงในช่องข้อความที่ตรงกับระดับความเมื่อยล้าหรือไม่สบายของแต่ละกิจกรรมของท่านลงในตารางต่อไปนี้

กิจกรรม	สถานีงานแบบเดิม				สถานีงานแบบใหม่			
	1	2	3	4	1	2	3	4
4.2.1 การล้างเล็บด้วยน้ำสบู่								
4.2.2 เช็ดเล็บด้วยแอลกอฮอล์								
4.2.3 การล้างเล็บด้วยน้ำยาล้างเล็บ								
4.2.4 การตัดเล็บและหนัง								
4.2.5 การทาสีเล็บ								

ระดับความรู้สึกปวดเมื่อย

1	หมายถึง	รู้สึกสบายไม่ปวดเมื่อยหรือไม่มีความรู้สึกปวดเมื่อยหรือไม่สบายเลย
2	หมายถึง	รู้สึกไม่สบายหรือรู้สึกรำคาญเล็กน้อย
3	หมายถึง	ปวดเมื่อยพอทนได้หรือรู้สึกปวดเมื่อย แต่พอที่จะทนได้โดยที่ไม่ต้องได้รับการรักษาโดยแพทย์ แต่ต้องหายามาทาเพื่อบรรเทาอาการ
4	หมายถึง	ปวดเมื่อยทนไม่ได้หรือปวดเมื่อยมากหรืออาการปวดเมื่อยมากที่ต้องการพบแพทย์เพื่อบรรเทาอาการปวด

ส่วนที่ 4 ความพึงพอใจจากการทำเล็บโดยสถานีงานแบบเดิมและสถานีงานแบบใหม่พร้อมชุดทำเล็บ

1.ความพึงพอใจต่อสถานีงาน

กรุณาทำหมายเลขลงในช่องที่ตรงกับคำตอบของท่านมากที่สุด

ข้อมูลความพึงพอใจ	ระดับความพึงพอใจ	
	สถานีงานแบบเดิม	สถานีงานแบบใหม่
1.ความพึงพอใจต่อสถานีงาน 1.1 ระดับความพึงพอใจของท่านต่อความสูงของโต๊ะทำเล็บหรือพื้นที่ที่ทำเล็บให้กับลูกค้า		
1.2 ระดับความพึงพอใจของท่านต่อพื้นที่ในการทำเล็บกว้างเพียงพอในการทำเล็บให้กับลูกค้า		
1.3ระดับความพึงพอใจของท่านต่อความสูงของเก้าอี้มีความเหมาะสมกับร่างกายของท่าน		
1.4ระดับความพึงพอใจของท่านต่อแสงสว่างในบริเวณที่ทำเล็บเพียงพอและเหมาะสม		
1.5 ท่านสามารถทำเล็บได้อย่างสะดวกสบาย		
1.6ระดับความพึงพอใจของท่านต่อสถานีงานที่ใช้อยู่ปัจจุบัน		

หมายเหตุ

1	หมายถึง	พึงพอใจน้อยที่สุด
2	หมายถึง	พึงพอใจน้อย
3	หมายถึง	พึงพอใจปานกลาง
4	หมายถึง	พึงพอใจมาก
5	หมายถึง	พึงพอใจมากที่สุด

2.ความพึงพอใจต่อชุดทำเล็บที่ติดตั้งใหม่

กรุณาทำเครื่องหมาย √ ลงในช่องข้อความที่ตรงกับคำตอบของท่าน

ข้อมูลความพึงพอใจ	ระดับความพึงพอใจ				
	มากที่สุด (5)	มาก (4)	ปานกลาง (3)	น้อย (2)	น้อยที่สุด (1)
2. ความพึงพอใจต่อชุดทำเล็บที่ติดตั้งใหม่ 2.1 ชุดทำเล็บที่ติดตั้งใหม่สามารถช่วยลดปัญหาด้านสุขภาพของท่าน เช่น ตาแห้ง คันตา ระคายเคืองตาได้					
2.2 ชุดทำเล็บที่ติดตั้งใหม่สามารถลดกลิ่นรำคาญของสารเคมีขณะที่ท่านทำงาน					
2.3 ท่านพึงพอใจต่อวัสดุและอุปกรณ์ของชุดทำเล็บ					
2.4 ท่านพึงพอใจต่อชุดทำเล็บที่ติดตั้งใหม่โดยภาพรวม					
2.5 ท่านพึงพอใจกับราคาชุดทำเล็บ (ประมาณ 7000 บาท) ที่ติดตั้งใหม่					
2.6 ท่านพึงพอใจกับระดับเสียงที่เกิดขึ้นกับชุดทำเล็บที่ติดตั้งใหม่					

ข้อคิดเห็น/ข้อเสนอแนะ

.....

.....

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ขอขอบคุณผู้ตอบแบบสอบถามทุกท่านมา ณ โอกาสนี้ด้วย

APPENDIX C

DOCUMENTARY PROOF OF ETHICAL CLEARANCE

Documentary Proof of Ethical Clearance
Ethics Committee for Human Research
Faculty of Public Health, Mahidol University

Proof Number	MUPH2010-021
Project Title	Design work station for nail salon
Project Number	160/2552
Principal Investigator	Miss Supattra La-ongnuan
Official Address	Master of Science Program in Industrial Hygiene and Safety Faculty of Public Health, Mahidol University 420/1 Rajvithi Road, Bangkok, Thailand

The aforementioned project and informed consent have been reviewed and approved by Ethics Committee for Human Research, according to the Declaration of Helsinki.

P. Luksamijarulkul

(Assoc. Prof. Pipat Luksamijarulkul)
Chairman of Ethics Committee for Human Research

Phitaya Charupoonphol

(Assoc. Prof. Phitaya Charupoonphol)
Dean of Faculty of Public Health

Date of Approval : 15 January 2010
Date of Expiration : 14 January 2011

เอกสารรับรองจริยธรรมการวิจัยในมนุษย์
โดยคณะกรรมการจริยธรรมการวิจัยในมนุษย์
คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล

เอกสารรับรองเลขที่ MUPH2010-021

ชื่อโครงการ การออกแบบสถานีงานสำหรับช่างทำเล็บ

รหัสโครงการ 160/2552

ชื่อหัวหน้าโครงการ นางสาวสุพัตรา ละอองนวล

ที่ทำงาน หลักสูตร วิทยาศาสตรมหาบัณฑิต
สาขาวิชาสุขศาสตร์อุตสาหกรรมและความปลอดภัย
คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล
420/1 ถนนราชวิถี กรุงเทพมหานคร

ขอรับรองว่าโครงการดังกล่าวข้างต้นได้ผ่านการพิจารณาเห็นชอบโดยสอดคล้องกับคำประกาศเฮลซิงกิ จากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ คณะสาธารณสุขศาสตร์ มหาวิทยาลัยมหิดล

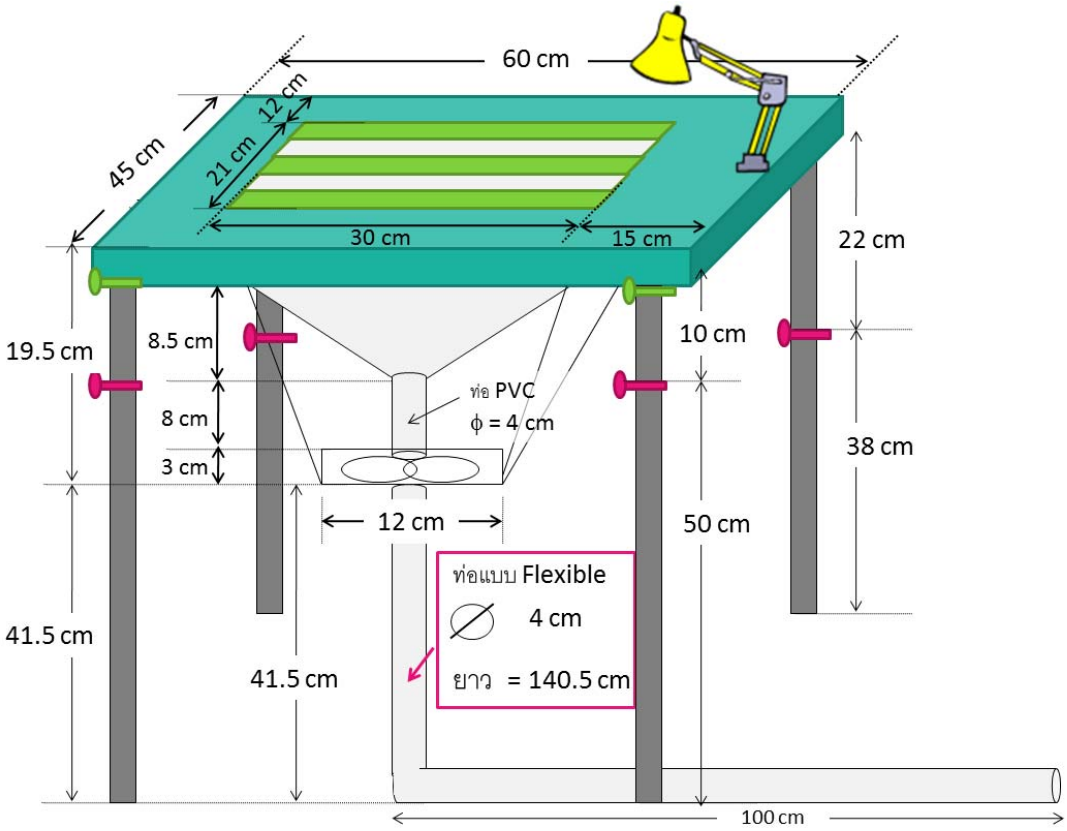
ลงนาม .....
(รองศาสตราจารย์พิพัฒน์ ลักษมีจรัสกุล)
ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์

ลงนาม .....
(รองศาสตราจารย์พิทยา จารุพูนผล)
คณบดีคณะสาธารณสุขศาสตร์

วันที่รับรอง : 15 มกราคม 2553
วันที่เอกสารรับรองหมดอายุ : 14 มกราคม 2554

APPENDIX D

THE DRAWING AND CALCULATION OF TABLE NAIL



The drawing of table nail (local ventilation for nail salon)

The calculation of table nail

1	หมายเลขช่วงท่อและฮูด				a - b	c - d
2	อัตราการไหลอากาศที่ต้องการ			m^3/s	0.01455	0.01455
3	ความเร็วต่ำสุด			m/s	10	10
4	ขนาดท่อใหญ่สุด			mm	43	43
5	ขนาดท่อที่เลือกใช้			mm	40	40
6	พื้นที่หน้าตัดของท่อ			m^2	0.0013	0.0013
7	ความเร็วลมในท่อ			m/s	11.58	11.58
8	ความดันเคลื่อนที่ในท่อ			Pa	80.85	80.85
9	ความดันสถิตที่ฮูดและความดันเคลื่อนที่ในท่อ	คำนวณความดันสถิตที่สล็อต	พื้นที่สูงสุดของสล็อต	m^2	0.0378	0
10			ขนาดพื้นที่ของสล็อตที่เลือกใช้	m^2	0.0378	0
11			ความเร็วลมในสล็อต	m/s	0.385	0
12			ความดันเคลื่อนที่ในสล็อต	Pa	0.089	0
13			สัมประสิทธิ์การสูญเสียที่สล็อต	(0 หรือ 1)	1	0
14			แฟคเตอร์ความสูญเสียจากการเร่งความเร็ว		1.78	0
15			ความสูญเสียที่สล็อต/VP	(13+14)	2.78	0
16			ความดันสถิตที่สล็อต	(12x15)	0.247	0
17		สัมประสิทธิ์ความสูญเสียเมื่ออากาศเข้าสู่ฮูด		ภาพที่ 7.17	0.25	0
18		แฟคเตอร์ความสูญเสียจากการเร่งความเร็ว		(0 หรือ 1)	1	0
19		ความสูญเสียที่ฮูด/ VP		(17+18)	1.25	0
20		ความสูญเสียที่ฮูด		(8x19) Pa	101.0625	0
21		ความสูญเสียอื่นๆ		Pa	0	0
22		ความดันสถิตที่ฮูด		(16+20+21) Pa	100.972	0
23	ความยาวท่อตรง			m	0.08	1.405
24	แฟคเตอร์ความเสียดทาน (Hf)				0.6477	1.068
25	ความสูญเสียจากการเสียดทาน/ VP			(23x24)	0.051816	1.50054
26	จำนวนท่อโค้ง 90°				0	1
27	สัมประสิทธิ์ความสูญเสียที่ท่อโค้ง				0.13	0.13
28	ความสูญเสียที่ท่อโค้ง/ VP			(26x27)	0	0.13
29	จำนวนท่อสาขา			(0 หรือ 1)	0	0
30	สัมประสิทธิ์ความสูญเสียที่ท่อสาขา				0	0
31	ความสูญเสียที่ท่อสาขา/ VP			(29x30)	0	0
32	สัมประสิทธิ์ความสูญเสียที่ท่อลักษณะพิเศษ				0	0

The calculation of table nail (Cont.)

33	ความสูญเสียที่ท่อ/ VP	(25+28+31+32)	0.051816	1.63054
34	ความสูญเสียในท่อ	(33x8) Pa	4.1753	131.3889
35	ความดันสถิตในช่วงท่อ	(22+34) Pa	105.1473	131.3889
36	ความสูญเสียอื่นๆ	(เช่น VP3 - VPr) Pa	0	0
37	ความดันสถิตสะสม	Pa	-105.1473	+131.3889
38	ความดันสถิตที่มีค่าสูงเมื่อท่อมาพบกัน	(gov, SP)		
39	อัตรการไหลอากาศที่ปรับแล้ว	m^3/s		
40	ค่าความเร็วลมที่ปรับแล้ว			
41	ความดันเคลื่อนที่ที่ปรับแล้ว	Pa		
42	ความดันเคลื่อนที่ซึ่งเกิดจากท่อ 1 และท่อ 2 มาพบกัน	(VPr)		

BIOGRAPHY

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