



UNIVERSITI PUTRA MALAYSIA

***EFFECTS OF HEEL HEIGHTS AND SHOE INSERTS ON STEP
COUNTS AND PERCEIVED COMFORT AMONG FEMALE
UNDERGRADUATES IN FACULTY OF MEDICINE AND HEALTH
SCIENCES, UPM***

**BY
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ABSTRACT

EFFECTS OF HEEL HEIGHTS AND SHOE INSERTS ON STEP COUNT
AND PERCEIVED COMFORT AMONG FEMALE UNDERGRADUATES IN
FMHS, UPM

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Introduction: Heeled-shoes could contribute to occupational ergonomic problems such as consequent musculoskeletal discomfort, sprained ankles, and lower back pain. Studying effects of heeled shoes and shoe inserts on step counts and perceived comfort may advance shoe design and minimize adverse effects on human musculoskeletal system. **Objective:** To determine whether increasing heel height and use of shoe inserts change step counts and perceived comfort among female undergraduates. **Methods:** Through stratified random sampling method and group comparison sample calculation, 32 healthy female undergraduates from experienced group and 32 from non-experienced group were included in this experimental study based on heeled-shoes wearing experience. The heel heights used were 2.0 cm (flat), 4.0 cm (low), and 6.0 cm (high). The shoe-insert conditions used were shoe only, heel cup, arch support, and total contact insert (TCI). Respondents walked on treadmill for each experimental condition. Foot anthropometric data were taken by anthropometer; step counts by OMRON pedometer, and perceived discomfort rating by VAS scale. Reliability of instrumentation was proven and Chronbach's alpha values for VAS scale were in average 0.818. **Results:** With overall response rate of 87.5%, there was significant difference between average steps count per minute for flat, low, and high heel heights among both experienced ($p=0.004$) and non-experienced group ($p=0.001$). Significant differences were found for flat ($p=0.026$), low ($p=0.003$), high-heeled shoes ($p<0.0001$) with different shoe insert conditions for experienced group. However, no significant difference was found for heel heights and shoe insert conditions with step counts when compared between 2 groups. For perceived discomfort rating, there were significant differences between low ($t=2.570$, $p=0.013$), high ($t=2.398$, $p=0.020$), total contact insert (TCI) at low ($t=2.232$, $p=0.029$) and total contact insert (TCI) at high ($t=2.354$, $p=0.022$) heeled-shoes between experienced and non-experienced groups. **Conclusion:** Experienced group of female undergraduates with previous wearing experience, flat heeled-shoes, and total contact insert offered lowest number of step counts, and lowest perceived discomfort rating when compared to other heel heights and insert condition.

Keywords: *Heel heights, Shoe inserts, Step count, Perceived comfort*

ABSTRAK

KESAN KASUT TUMIT DAN INSOLIA KEPADA PENGIRAAN LANGKAH DAN TANGGAPAN KESELESAAN DI KALANGAN MAHASISWI DI FAKULTI PERUBATAN DAN SAINS KESIHATAN, UPM

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Pengenalan: Kasut tumit boleh menyumbang kepada masalah ergonomik pekerjaan seperti ketidakselesaan otot skeletal, pergelangan kaki terseliah, dan sakit belakang bawah. Mengkaji kesan kasut tumit dan insolia kepada pengiraan langkah dan tanggapan keselesaan boleh memajukan reka bentuk kasut dan meminimumkan kesan buruk pada sistem otot skeletal manusia. **Objektif:** Untuk menentukan sama ada tumit kasut yang bertambah ketinggiannya dan penggunaan insolia menukar pengiraan langkah dan tanggapan keselesaan di kalangan mahasiswi. **Metodologi:** Melalui kaedah persampelan rawak berstrata dan pengiraan sampel kumpulan perbandingan, 32 mahasiswi yang sihat dari kumpulan yang berpengalaman dan 32 dari kumpulan yang tidak berpengalaman telah dipilih dalam kajian eksperimen ini berdasarkan pengalaman pemakaian kasut tumit. Ketinggian tumit yang digunakan adalah 2.0 cm (rata), 4.0 cm (rendah), dan 6.0 cm (tinggi). Insolia kasut yang digunakan adalah cawan tumit, sokongan gerbang, dan sokongan penuh (TCI). Responden berjalan di atas mesin larian bagi setiap keadaan eksperimen. Data antropometri kaki diukur oleh antropometer; pengiraan langkah oleh alat pengukur langkah OMRON; dan tahap tanggapan ketidakselesaan oleh skala VAS. Instrumen telah ditentukan dan nilai-nilai alfa Chronbach untuk skala VAS berada dalam purata 0.818. **Keputusan:** Dengan kadar respons keseluruhan 87.5%, terdapat perbezaan yang signifikan antara kiraan langkah purata seminit untuk ketinggian tumit rata, rendah, dan tinggi di kalangan kedua-dua kumpulan yang berpengalaman ($p=0.004$) dan tidak berpengalaman ($p=0.001$). Terdapat perbezaan yang signifikan untuk kasut tumit rata ($p=0.026$), rendah ($p=0.003$), dan tinggi ($p<0.0001$) dengan jenis insolia kasut yang berbeza untuk kumpulan yang berpengalaman. Walau bagaimanapun, tiada perbezaan ketara yang dijumpai untuk ketinggian tumit dan insolia kasut dengan kiraan langkah purata seminit apabila dibandingkan antara 2 kumpulan. Untuk tahap tanggapan ketidakselesaan, terdapat perbezaan yang signifikan di antara kasut tumit rendah ($t=2.570$, $p=0.013$), tinggi ($t=2.398$, $p=0.020$), insolia sokongan penuh (TCI) pada tumit rendah ($t=2.232$, $p=0.029$) dan insolia sokongan penuh (TCI) pada tumit tinggi ($t=2.354$, $p=0.022$) antara kumpulan-kumpulan yang berpengalaman dan tidak berpengalaman. **Kesimpulan:** Kumpulan mahasiswi yang berpengalaman memakai kasut tumit, jenis kasut tumit rata, dan insolia sokongan penuh menunjukkan bilangan kiraan langkah dan tahap ketidakselesaan yang berkurang apabila dibandingkan dengan ketinggian tumit dan jenis insolia lain.

Kekunci: Ketinggian tumit, Insolia kasut, Kiraan langkah, Tanggapan keselesaan

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LIST OF ABBREVIATIONS

=	Equal to
<	Less than
%	Percentage
χ^2	Chi-square
BMI	Body Mass Index
<i>et al.</i>	And colleagues
FMHS	Faculty of Medicine and Health Sciences
MOH	Ministry of Health, Malaysia
SD	Standard Deviation
SPSS	Statistical Package for Social Science
UPM	Universiti Putra Malaysia
VAS	Visual Analogue Scale
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Introduction

In history, the origin of the high heel goes back many centuries. In a tomb of Tebas in Old Egypt, and date from 1000 BC, the first precursors of stiletto heels were discovered. These heels indicated a high social status to them (Nigel, 2005). Females started to wear high-heeled shoes in order to satisfy their desire to be more beautiful. For 250 years, medical scientists have talked about the health hazards of high-heeled shoes, which originated four centuries ago. Millions of females continue to wear high-heeled shoes despite these warnings. In fact, high heels have also been linked to ergonomic issues such as overworked or injured leg muscles, osteoarthritis of the knee and low back pain (Lee C. M. et al, 2001).

Sarah et al. (2010) studied on step counts taken during flat, medium and high heel conditions. Also, this study reported increased in step counts when heel heights increased. Some previous studies investigated on increased in step counts when heel heights increased due to gait angular changes (Lee CM et al., 2001; Kerrigan DC et al., 2005).

A modification in shoe heights and application of shoe inserts could improve the perceived comfort in different regions of foot. Mündermann et al. (2001) reported a higher perceived comfort score in subjects with the use of elastic and soft insert material rather than viscous and hard materials. Also, Lee et al. (2005) studied the effects of shoe inserts and heel height on perceived comfort during walking. These studies addressed the effects of heel heights and shoe inserts on perceived comfort.

Perceived comfort of high heels is defined as processes that organize information in the sensory image and interpret it as a state of physical ease and freedom from foot pain or constraint due to high heels wearing. It is produced by properties of objects or events in the external and three-dimensional world (Gerrig, Richard J., 2002).

1.2 Problem Statement

In Malaysia, studies on effects of wearing high-heeled shoes are limited. However, a study in Taiwan reported that surveys of shoe choice showing 53% of females in average wear high-heeled shoes between 1 and 8 hours per day on a daily basis. The reasons for wearing this style of footwear vary greatly with many women stating that they feel more confident and glamorous from the extra height gained (Lee et al., 2005).

Previous study by Sarah et al. (2010) shows that there was an increase in the step counts taken during medium and high heel conditions compared to flat heel condition. An increase in heel height is considered to plantarflex the foot, and flexes the hip and knee. These angular changes therefore result in a shorter stride length (Lee CM et al., 2001; Kerrigan DC et al., 2005). Comparisons between the high and orthoses condition also showed significant differences with fewer step counts taken for the shoe inserts conditions. Taking more steps however may be a negative factor since more steps may result in higher sagittal and varus knee torques 30-32 which in turn leads to joint damage (Sarah et al., 2010).

Oversea studies also show that a prevalence of 83% of foot problems in females wearing high-heeled shoes. Women have about 90% of the nearly 800,000 annual surgeries for neuromas, bunions, and hammer toes (Dawson et al., 2002). Lee et al. (2001) surveyed 200 females who regularly wore high-heeled shoes, and found 58% of this population experienced perceived discomfort whilst wearing the shoes. As a result, foot discomfort produce a substantial cost to health system and industrial productivity, with treatment and missed time from work in North America alone estimated to cost more than US \$100 billion per year (Sahar et al., 2007).

A study showed the effect of high-heeled shoes on lumbar lordosis. Also, low back pain and the wearing of high heeled-shoes are common. Women complain of low back pain that they believe is due to wearing high-heeled shoes, and clinicians seem to think the reason is that high-heeled shoes cause increased lumbar lordosis (Brent S. Russell DC, 2010).

Perceived discomfort could contribute to ergonomic problems such as consequent musculoskeletal discomfort, sprained ankles, lower back pain, due to increased spinal curvature, and leg pain, due to added weight placed on the toes (Lee et al., 2005). Female occupational workers may experience additional biomechanical stresses placed on them by fashion demands such as high heels. All these effects can significantly increase discomfort levels in those wearing high heels.

1.3 Research Justification

Today, high heels are more typically worn by females if compared to males, with heights varying from a kitten heel to a stiletto heel (or spike heel) or more. In order to show good image and to be more beautiful in formal places such as university, female undergraduates tend to wear high heels. Statistics serves as an important database in predicting trend, designing model as well as forecasting through correct analysis and interpretation to identify, study and solve many complex problems. The study aims to investigate a young homogenous asymptomatic population. Therefore recruitment will be limited to female participants due to potential morphological, kinematic, and neuromuscular differences between sexes. Female undergraduates will be chosen as it is thought that they are more likely to wear perceived voluntary with increased heel height (eg. high-heeled shoes), and they haven't stepped into real working environments which may require they wear high-heels involuntary during working hours such as office ladies, models, promoters, and stewardess. Therefore any findings may also have applications to regular their future female foot-wears on selecting appropriate heel heights and shoe inserts before it is too late.

The significance of this study is not merely to provide more statistics, data and information but also collectively to serve as an indicator for future development

in addressing step counts and perceived discomfort due to heel heights. The outcome of this study may recommend a best heel height and best shoe insert to minimize the perceived discomfort and adverse effects on the human musculoskeletal system.

Previous studies demonstrated the effects of inserts on step counts and perceived comfort in flat or running shoes. Only few studies in overseas attempted to investigate the effectiveness of inserts in high heel shoes. Hence, the purpose of this study is to determine whether increasing heel height and use of shoe inserts change step counts and perceived comfort during walking. Also, this study is to compare the different heel heights and shoe insert conditions with step counts and perceived comfort between experienced and inexperienced wearers of female undergraduates.

1.4 Conceptual Framework

Figure 1.1 showed the conceptual framework for this study. This conceptual framework was used to describe the effects of heel heights and shoe inserts on step counts and perceived comfort among female undergraduates in Faculty of Medicine and Health Sciences, UPM. Female undergraduates were divided into experienced group and non-experienced group based on their wearing experience of heeled-shoes (Alessandra et al., 2010). There were few factors of shoes involved in step counts

and perceived comfort among female undergraduates. The factors of shoes other than heel heights include foot shape, shoe fit, material properties, skeletal alignment, colour and fashion (Witana et al., 2004; Emily Yim et al., 2007).

Heel heights were classified into flat, low and high-heeled shoes (Lee et al., 2005). Shoe inserts that may improve perceived discomfort rating were total contact inserts, heel cup, arch support, and metatarsal pad (Chen et al. 2003; Lee et al., 2005). Effects of heel heights and shoe inserts may affect foot pressure, impact force, step counts, perceived comfort, musculoskeletal disorder, and walking gait (Lee et al., 2005; Sarah et al., 2010; Munermann et al., 2002; Dawson et al., 2002; Esenyel et al., 2003). Visual analogue scale (VAS) is a tool used for analyzing the perceived comfort among female undergraduates (Munermann et al., 2002). Individual characteristics of respondents were determined. Foot anthropometry, age, ethnicity, and BMI were constitutional confounding variables to step counts and perceived comfort. In addition, personal hobbies or physical activities or lifestyles were behavioural confounding variables to perceived comfort.

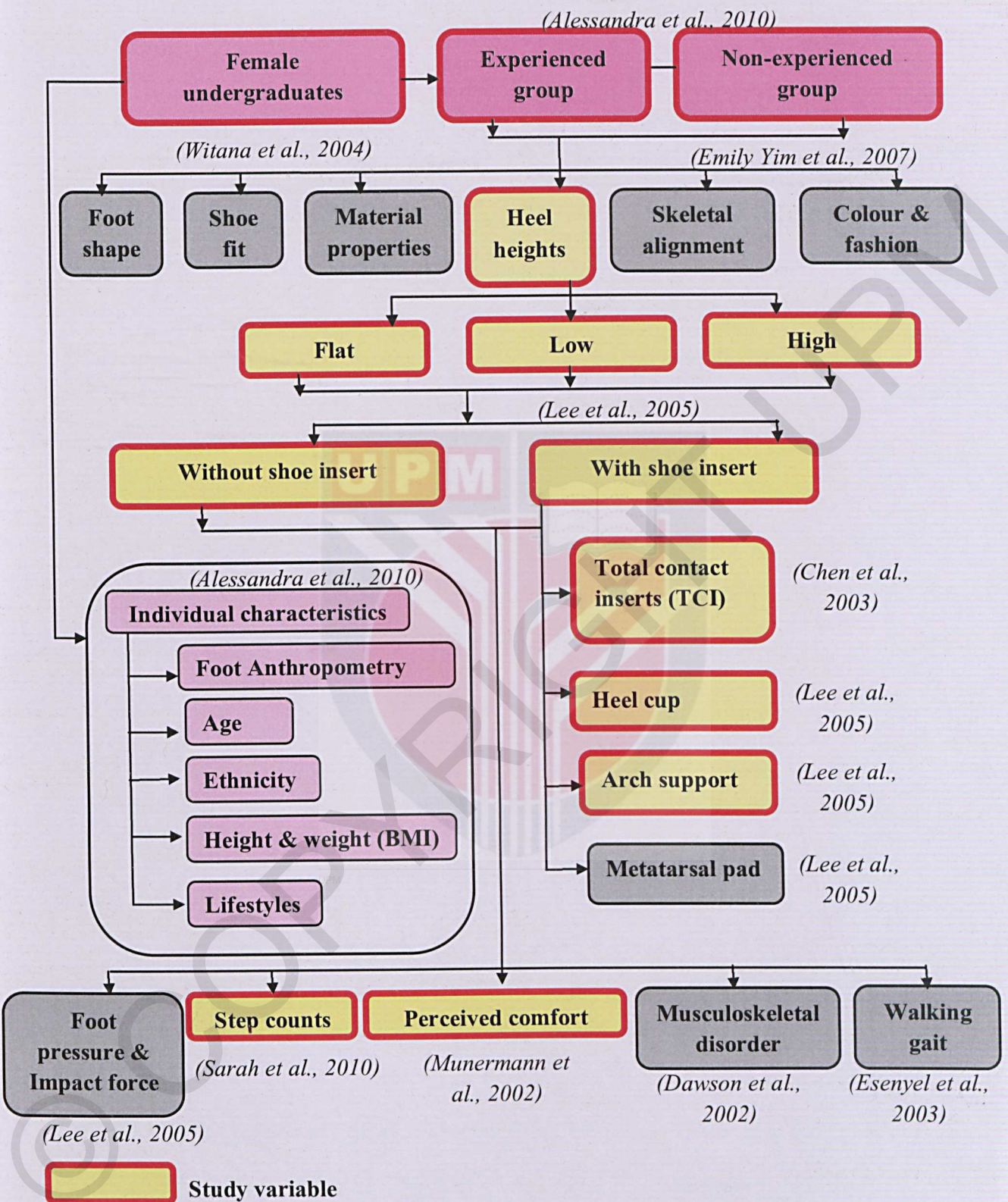


Figure 1.1: Conceptual framework

1.5 Research Definitions

1.5.1 Conceptual Definition

i. Heel heights

Heel heights are length of perceived heel that raises the wearer's foot significantly higher than the toes. High-heeled shoes come in a wide variety of styles, and the heels are found in many different shapes, including stiletto, pump (court shoe), block, tapered, blade, and wedge. (Glossary of Terms for Women's Shoe Styles, 2006)

ii. Shoe inserts

Shoe inserts are extra strips of materials put inside a shoe or high heels for comfort or protection. It can also be called innersole of a shoe or high heels. (American Heritage® Dictionary, 2009)

iii. Step counts

Step counts are beat, rate, or measure of rhythmic walking movement when moving foot; to advance or recede by raising and moving one of feet to another resting place, or by moving both feet in succession. (American Heritage® Dictionary, 2009)

iv. Perceived comfort

Perceived comfort is defined as processes that organize information in the sensory image and interpret it as a state of physical ease and freedom from foot pain or constraint. It is produced by properties of perceived in the external and three-dimensional world. (Gerrig, Richard J., 2002)

iv. Body Mass Index (BMI)

BMI is defined as a number that calculated from a person's weight and height which provide reliable indicator for body fatness. According to Standard guideline by World Health Organization, body weight and height are classified according to formula below: (WHO, 2006)

$$\text{Body Mass Index (BMI)} = \text{Weight (kg)} / [\text{Height (m)} \times \text{Height (m)}]$$

1.5.2 Operational Definition

i. Heel heights

A "flat heel" is considered as flat heels less than 2.0 centimeters, while heel more than 2.0 centimeters and less than 5.0 centimeters is considered as "low heel", and anything over that is considered as "high heel". (Lee and Hong, 2005)

ii. Shoe inserts

Four shoe inserts conditions were selected in this study, which were arch support, heel cup, total contact insert (TCI), and shoe only. (Lee and Hong, 2005)

iii. Step counts

Step counts were measured by the Omron Digital Pedometer HJ-105 in the study. Number of steps was counted in unit of steps per minute.

iv. Perceived comfort

Perceived comfort was rated under Visual Analogue Scale (VAS). The VAS can be used to rate the perceived discomfort rating for each heel heights and shoe insert conditions. (Munermann et al., 2002)

iv. Body Mass Index (BMI)

Body Mass Index was calculated by dividing weight (kg) with height (m^2). Then the readings were classified according to WHO, 2006 (Table 1.1):

Table 1.1: International classification of adult underweight, normal range, overweight and obesity according to BMI

Classification	BMI(kg/m ²)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	18.50 - 24.99	18.50 - 22.99
		23.00 - 24.99
Overweight	≥25.00	≥25.00
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	≥30.00	≥30.00
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

1.6 Research Objectives

1.6.1 General Objective

To determine effects of heel heights and shoe inserts on step counts and perceived comfort among female undergraduates in Faculty of Medicine and Health Sciences, UPM

1.6.2 Specific Objectives

- a. To determine the socio-demographic data among female undergraduates
- b. To determine the foot anthropometric data among female undergraduates
- c. To compare the different heel heights and shoe insert conditions with step counts among female undergraduates
- d. To compare the different heel heights and shoe insert conditions with step counts between experienced and non-experienced groups of female undergraduates
- e. To compare the different heel heights and shoe insert conditions with perceived discomfort rating among female undergraduates
- f. To compare the different heel heights and shoe insert conditions with perceived discomfort rating between experienced and non-experienced groups of female undergraduates

- g. To determine individual preference among the three different heel heights and four different shoe insert conditions

1.7 Research Hypothesis

- a. There is a significant difference between heel heights and shoe insert conditions with step counts among female undergraduates.
- b. There is a significant difference for heel heights and shoe insert conditions with step counts between experienced and non-experienced groups of female undergraduates.
- c. There is a significant difference between heel heights and shoe insert conditions with perceived discomfort rating among female undergraduates.
- d. There is a significant difference for heel heights and shoe insert conditions with perceived discomfort rating between experienced and non-experienced groups of female undergraduates.

1.8 Research Limitations

- I. Data collection was limited to a laboratory setting and all the tasks were performed over a 2 hours and a half period for every respondent. In a realistic work environment, the individual may be standing for much of the work day. It may fail to capture daily setting.
- II. The study may fail to capture the everyday setting such as fatigue often experienced by women at the end of a day.
- III. The study may have been limited to the immediate effects of various heel heights and shoe inserts on step counts and perceived comfort.
- IV. Recall bias may have occurred when respondents were unable to recall wearing experience and provided answers that did not accurately characterize their wearing experience of heeled-shoes.

CHAPTER 2

LITERATURE REVIEW

2.1 Heel Heights

Previous studies have demonstrated that wearing high-heeled shoes modifies gait kinematics and kinetics. Walking in high-heeled shoes alters lower-extremity joint function. Also, it raises the peak pressure in the forefoot and shifts peak pressures from the third, fourth and fifth metatarsal heads to the first and second and thus reduced the perceived comfort (Esenyel et al., 2003).

In addition, wearing high-heeled shoes for walking generates a force spike at initial ground contact (i.e., impact force) and the force is then transmitted up to the skeleton as a 'shock wave'. This shock wave appeared to damage soft tissues, which may result in perceived discomfort of leg and back-pain complaints and eventually

lead to degenerative joint disorders (Dawson et al., 2002). Moreover, heel height also has an effect on the foot pressure distribution and vertical impact force. Reports indicated that high heel height generates greater vertical impact force, whereas flat shoes tend to produce lower impact force (Min and Mao, 2007).

2.2 Shoe Inserts

Engineering efforts may reduce foot loading caused by peak pressure and impact force, and to improve shoe comfort, involved designing shoe inserts with different shapes. The use of inserts is effective in redistributing pressure beneath foot and absorbing energy in terms of reducing impact force. Various inert designs demonstrate different kinetic modification during gait (Lee et al., 2005).

Previous studies by Lee et al. (2005) show that a heel pad is effective in reducing heel pressure and the magnitude of the heelstrike impact. An arch support was designed to resist depression of foot arch during weight bearing through skeletal support, thereby decreasing tension in the plantar aponeurosis. A metatarsal pad has been found to reduce forefoot pressure and transfer weight bearing to the longitudinal and metatarsal arches. The use of a metatarsal pad increased pressure of the midfoot region, but did not significantly reduce pressure of the medial forefoot

and impact force. The pad was not effective in improving perceived comfort during high-heeled walking. It was possible that the pad was not customized for each participant and it was also not so easy to install in a definite position compared with other inserts. Also, the metatarsal pad did not provide either pressure relief or comfort. Last but not least, a total contact insert (TCI) provided pressure relief in the heel and forefoot regions (Chen et al., 2003).

These studies, however, focused on inserts in flat or running shoes. Very limited study, in so far as examined, attempted to identify insert effectiveness in high heels. The types of shoe inserts used in this study included heel cup, arch support, and total contact inserts (TCI).

Table 2.1: Previous studies of heel heights and shoe inserts on step counts and perceived comfort

By	Place	Sample	Heel Heights	Shoe Insert(s)	Results/Comment
Sarah et al. (2010)	United Kingdom	10 females	Flat (1.5cm), Low (4.5cm), High (7.0cm)	McConnell orthosis, Insolia orthosis	Step counts were significantly increased and lower comfort for high condition compared to flat and low conditions; and reducing step counts but increasing comfort between high and shoe inserts conditions.

Lee et al. (2005)	Taiwan	10 females	Flat (2.0cm), Low (4.0cm), High (6.0cm)	Heel cup, arch support, metatarsal pad, total contact insert (TCI)	Increasing heel height increases the perceived discomfort significantly during walking. Heel cup, arch support and TCI significantly offered better comfort.
Mündermann et al. (2001)	Canada	4 females & 5 males	---	Soft, medial wedge, hard insert	Soft insert was rated significantly higher in comfort than medial wedge and hard insert.
Caroline et al. (2005)	Holland	10 females	High(5.91±1.03cm), Low(1.95±1.06cm)	---	Low-heeled shoes were rated significantly higher in comfort than high-heeled shoes.
Min-Chi et al. (2007)	Taiwan	20 females	---	Arch support	Wearing shoe insert significantly improved perceived comfort when compared to without shoe insert condition.
Caleb et al. (2008)	Australia	6 females & 16 males	---	Total contact insert (TCI)	Total contact insert was rated significantly higher in comfort than non-insert condition.

2.3 Musculoskeletal discomfort

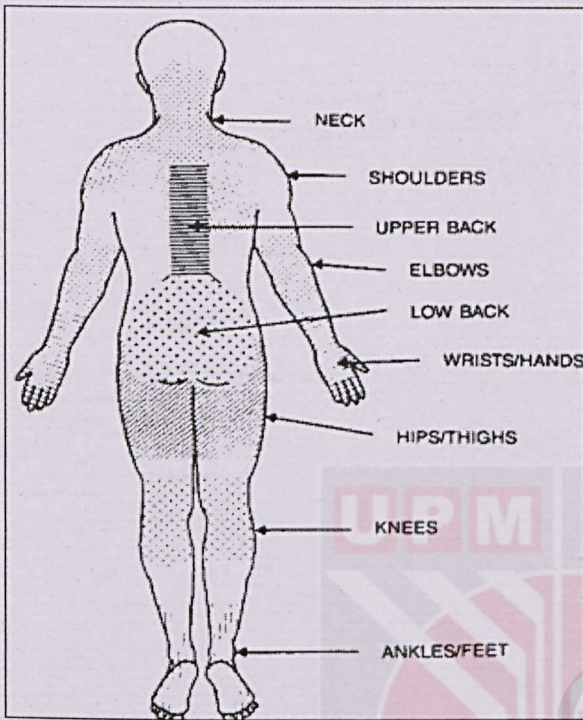


Figure 2.1: Musculoskeletal body part

Figure 2.1 shows the human musculoskeletal body part. Musculoskeletal system is a system that gives the ability to move using the muscular and skeletal systems. The musculoskeletal system provides form, support, stability, and movement to the body. Musculoskeletal discomfort involves the bones, cartilage, tendons, ligaments, and other connective tissues that support and bind tissues and organ together. The main function includes supporting the body, allowing motion, and protecting vital organs. Bones provide the stability to the body in analog to iron rod in concrete construction. Muscles play a role in movement of the bones (Manfio, et al., 2001).

2.4 Step counts

According to Ministry of Health Malaysia (2007), the distance recommended for keeping good shape is 6,000 steps a day, while for weight loss we should be doing about 10,000 steps a day. Also, recent public health recommendations for step frequency over a given time frame (steps min^{-1}) associated with moderate-intensity physical activity (MPA) have been developed. The recommendation suggests 100steps min^{-1} (Michael et al., 2010).

2.5 Perceived Comfort

Comfort is an important factor for perceived in recreational physical activities. Most people can quickly identify comfortable or non-comfortable perceived situations (Munermann et. al., 2002). Subjective perceptions of comfort are quantifiable; and comfortable and uncomfortable shoes have distinct perceptions (Emily and Ravindra, 2006).

2.6 Pedometer for measurement of step counts

Pedometer is a relatively simple motion sensor and electronic devices that record the acceleration and deceleration of movement in one direction. It is normally use to estimate mileage walked and/or steps taken over a period of time (Michael et al., 2010). Previous study by Katrien et al. (2012) investigated on validity and reliability of the Omron HJ pedometer. The pedometer showed acceptable accuracy for all wearing positions during stairs walking and treadmill walking at higher speeds; but limited accuracy during free-living conditions when worn at non-traditional wearing positions (necklace and pants pocket). Reliability was acceptable during treadmill walking at higher speeds and free-living conditions.

2.7 Visual Analogue Scale (VAS) for Analysis of Perceived Comfort

It is proposed that perceived comfort should be measured using a continuous scale. Visual analogue scales (VASs), for example, have been proven to be a reliable measure to assess subjective pain. VAS responses are very easy to obtain from patients and normal volunteers and require little instruction (Munermann et. al., 2002). Despite concerns regarding their adverse effects on human musculoskeletal system, employment criteria and/or fashion customs encouraged the continuous use

of high-heeled shoes. Studying the effects of heel heights and shoe inserts on perceived comfort among female undergraduates provide a basis for shoe heels and inserts selection that minimizes adverse effects.

2.8 Step Counts and Perceived Comfort with Foot Anthropometry

Previous study done by Michael et. al (2010) shows that there was significant difference between foot anthropometry changes and step counts. As leg length increased, estimated steps min^{-1} decreased by $-1.15 \text{ steps min}^{-1}$. Based on leg length for individuals 5ft to 6ft 6 in, steps min^{-1} ranged from 111 to 85, respectively. Improper shoe size is a cause of foot injury, pain and deformity. Poorly fitting shoes can lead to foot ulceration and perceived discomfort. Proper shoes could provide foot protection and stability, absorb excessive force, and prevent falls. The basic foot anthropometric variables were foot length, width, and height as described by Manfio (2001). A study of foot anthropometric data among Thai women showed that most women had foot length between shoes size 22.5 cm and 24.5 cm. These foot data are essential for fitting proper shoes for women, in order to provide foot ergonomics and prevent perceived discomfort (Chaiwanichsiri D et al., 2008). Anthropometric measurement is defined as the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of human body. The uses of anthropometry include evaluations of postures and

distances to reach controls, specification of clearances separating the body from hazards such as surrounding equipment; identification of objects or elements that constrict movement; and assistance in the biomechanical analysis of forces and torques (Thomas G McPoil et al., 2009).

2.9 Step Counts and Perceived Comfort with Age

Ten healthy females (age range 21 – 34 years) who were regular high heel wearers volunteered for the study by Sarah et al. (2010). The participants had a mean age of 26.3 years (standard deviation [SD] 5.4, range 21 – 34 years). Perceived can also be a source of discomfort. With age, the width and height of the forefoot increases to a greater extent than the width and height of the hind foot, making it difficult to find appropriate shoes. Especially in older age, wearing inadequate shoes limits mobility and consequently impairs health, independence and quality of life and thus increased perceived discomfort (Lee, Y.H. et al., 2005; Tencer, A.F. et al., 2004). It seems prudent that older women may avoid wearing high-heeled shoes, which reduces the support base and consequently changes the weight distribution on the plantar surface of the foot (Alessandra et al., 2010).

2.10 Step Counts and Perceived Comfort with Ethnicity

A study by Hawes MR et al. (2001) showed that there were racial differences in foot anatomy. They studied 708 second generation Caucasian North American and 513 Japanese and Korean male subjects. It was conducted to determine normative data with respect to forefoot shape and dimension. Substantial differences were noted in the incidence of step counts and digital patterning. It leads to the conclusion that the shape of the Japanese and Korean forefoot differs from that of the Caucasian North American, with the implication that unique shoe lasts for both populations are required for optimal step counts and perceived comfort.

CHAPTER 3

STUDY METHODOLOGY

3.1 Study Design

This was an experimental study. This study was designed to determine whether heel heights and shoe inserts has effect on perceived comfort among female undergraduates. Wearing flat-heeled shoes act as control condition of this study. This experimental study includes pre-post test design, control and treatment conditions, and random assignment of study participants.

3.2 Study Location

This study was conducted in Health & Nutrition Assessment Laboratory, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang.



Figure 3.1: Health & Nutrition Assessment Laboratory, UPM

3.3 Sampling Population and Sampling Method

3.3.1 Sampling Population

The sampling population was the female undergraduates from the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang.

3.3.2 Study Sample

The study sample consisted of two groups of female undergraduates who were:-

- i. Experienced group: had worn low or high-heeled shoes at or more than one time per week for at least 1 year (Alessandra et al., 2010)
- ii. Non-experienced group: had no or less than 1 year experience in wearing low or high-heeled shoes (Alessandra et al., 2010)

The study samples were examined with three heel heights: “flat” at less than 2.0 cm, “low” at or more than 2.0cm but less than 5.1cm, and “high” at or more than 5.1cm (Lee and Hong, 2005).

3.3.3 Sampling Frame

Sampling frame included the name list of female undergraduates studying at the faculty which was obtained from the faculty management.

3.3.4 Sampling Unit

Sampling unit was an individual female undergraduate.

3.3.5 Sampling Method

Stratified random sampling was used to obtain the respondents of this study. The sampling frame included the name list of female undergraduates studying at the

faculty which was obtained from the faculty management. The female undergraduates were divided into strata according to the ethnicity in the faculty. The respondents were randomly selected from each stratum. The respondents were then explained briefly about the objective and purpose of the study. This was to ensure that the respondents who were willing to participate in this study also fulfilled the inclusion and exclusion criterias.

They were selected based on the inclusion and exclusion criteria:

Inclusion criteria:

- i. female undergraduate aged between 18 and 26
- ii. normal BMI (18.50 – 24.99)
- iii. had no physical disability or foot discomfort problem

Exclusion criteria

- i. suffered an injury to the lower body part during the preceding year
- ii. use of bandages or orthoses that would prevent direct contact of the shoe inserts with the skin
- iii. pregnant female

3.4 Sample Size

Group comparison (2 groups) sample calculation was used.

$$n = \frac{2\alpha^2 (Z_{1-\alpha/2} + Z_{1-\beta})}{(\mu_1 - \mu_2)^2}$$

(Lemeshow et al., 1990: Adequacy of sample size in health studies)

where α = estimated standard deviation (assumed to be equal to each group)

μ_1 = estimated mean (larger)

μ_2 = estimated mean (smaller)

$Z_{1-\alpha}$ = standard error associated with confidential interval (choose 95% confidential interval = 1.96)

$Z_{1-\beta}$ = standard error associated with power (choose 95% of power = 1.645)

Thus, to test the hypothesis about my study on the studied population, based on the literature review, the following estimations were made:

Where α = estimated standard deviation = 10.0

μ_1 = estimated mean (larger) = 11.8

μ_2 = estimated mean (smaller) = 7.6

(Sarah A. Curran, 2010)

Computing the mean and standard deviation as well as setting standard error, the total sample required in this study was only 30 people. However, in order to ensure statistical significance, and to take into consideration of the non-responsive sample result, the required respondent was increased 5% bringing up the figure to approximately 32 respondents. Hence, 32 respondents for experienced group, and another 32 respondents for non-experienced group were required (total 64 respondents). Thus, 32 female undergraduates who had worn low or high-heeled shoes at or more than one time per week for at least 1 year (experienced group), and 32 female undergraduates who had no or less than 1 year experience in wearing low or high-heeled shoes (non-experienced group) were included for the study.

3.5 Instrumentation

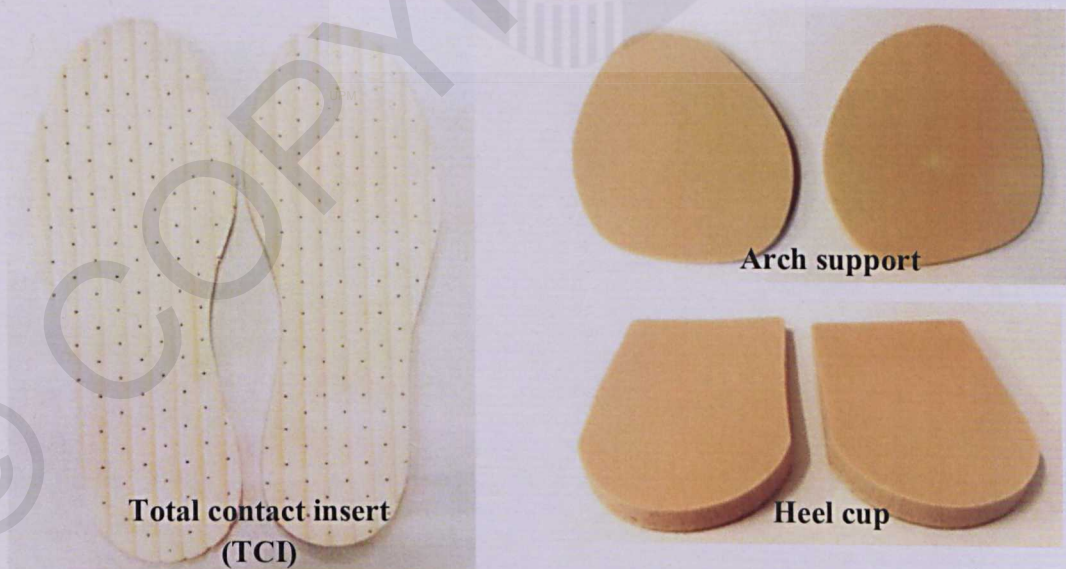
3.5.1 Heeled-shoes and Shoe Inserts

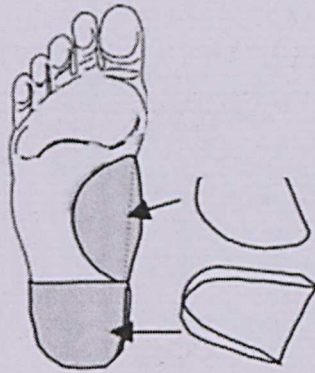
The shoes used in this study were commercially available items and were selected based on the similarity of construction such as foot contact points, supports, and pump style. The main difference among these shoes was the height of the heel: a flat (2.0 cm), a low (4.0 cm) and a high heel (6.0 cm) (Figure 3.1).

Each participant received four insert conditions: (1) shoe only; (2) heel cup; (3) arch support; and, (4) Total Contact Insert (TCI) (Figure 3.2). The inserts were commercially available items and were fabricated semi-rigidly from Multiform polyethylene molded materials. The density of multiform provides good support as well as cushioning. To avoid slipping around the inside of the shoe, the inserts were adjusted to appropriate position and then attached inside the shoe while being worn.



Figure 3.2: The shoes of 3 different heel heights are used in this study. From left to right: a flat (2.0cm), a low (4.0cm) and a high heel (6.0cm).





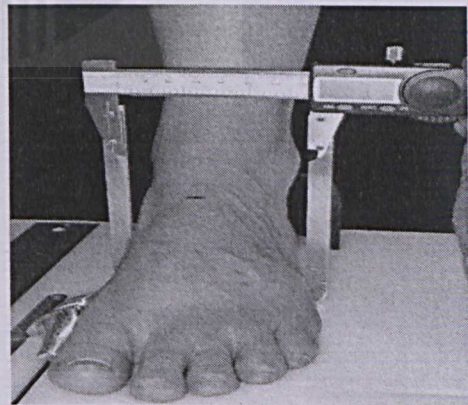
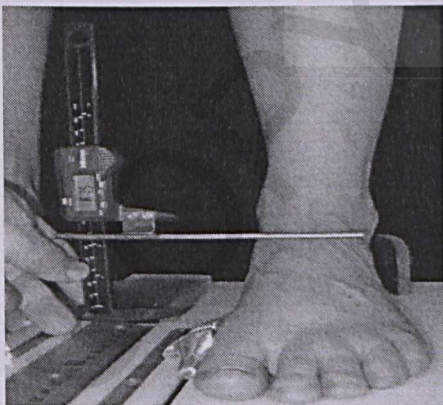
Arch support

Heel cup

Figure 3.3: The shoe inserts and their support positions.

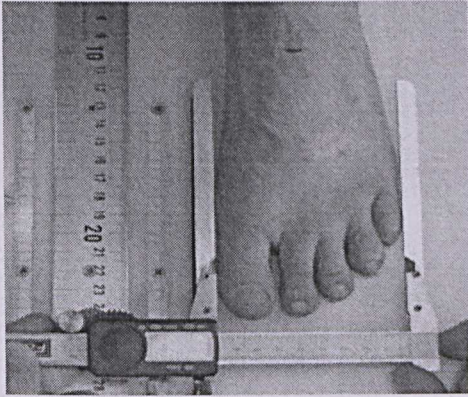
3.5.2 Weight Bearing Arch Height Gauge and Caliper

Foot length and width were measured in centimetre (cm) using a 30-cm analog caliper with 1 mm resolution. Dorsal arch height was measured by sliding metal rod of the weight bearing height gauge.

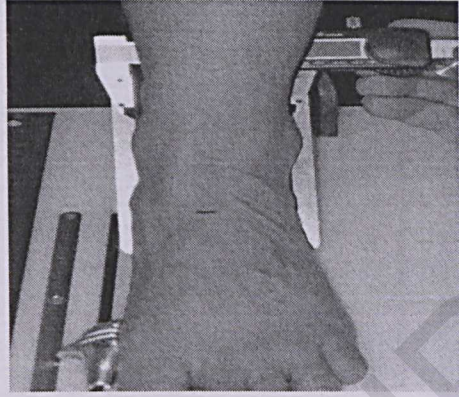


a) Measure dorsal arch height by gauge

b) Measure midfoot width by caliper



c) Measure forefoot width by caliper



d) Measure heel width by caliper

Figure 3.4: Measurement of foot anthropometric data by gauge and caliper

Based on literature review, the validity and reliability of the measurement techniques used in the study was acceptable and that further analysis of the results could be performed (Thomas G McPoil et al., 2009). To verify the reliability, Alessandra et. al. (2010) calculated the indexes of footprint and found out the repeatability value of 0.122, indicating that it was a good measurement technique.

3.5.3 Measuring Tape and Weighing Scale

Both the body meter and weighing scale were used to measure the height and weight of the respondents involved in the study. The purpose was to measure the height and weight by calculating their Body Mass Index (BMI). Measuring tape used was SECA body meter with accuracy of ± 0.001 meter while the weighing scale used was DETECTO weighing scale with ± 0.1 kg accuracy.



Figure 3.5: DETECTO weighing scale



Figure 3.6: SECA body meter

3.5.4 Digital Pedometer

The Omron Digital Pedometer HJ-105 was used to display step count in the study. The pedometer is a great motivational tool to track step count. The dual display functions shows both the time and the step count simultaneously. The accuracy of Omron Digital Pedometer HJ-105 was adjusted at $\pm 5\%$ (the differential of 5 steps more or less against 100 steps), in a normal condition where the user walks straight on level ground. Study by Katrien et al. (2012) shows that intra-instrument reliability was proven for controlled tests (ICC = 0.14–0.96).



Figure 3.7: Omron digital pedometer HJ-105

3.5.5 Treadmill

The NordicTrack Apex 4600 treadmill was used to make walking steps systematically. It can be adjusted the speed and incline of the treadmill during workout with the single touch of a button instead of having to tediously scroll through options. The treadmill helped the respondents of the study stay in the target speed and incline during walking using different heel heights and shoe inserts. The NordicTrack Apex 4600 treadmill has 0-12 MPH 1-Touch™ speed control, 0-12% 1-Touch™ Power Incline® capability, and adjustable DuraSoft™ cushioning system which provides a more comfortable walking surface while also reducing impact on joints of respondents.



Figure 3.8: NordicTrack Apex 4600 treadmill

3.5.6 Questionnaires

The questionnaire was divided into six parts:

- A. Socio-demographic Data
- B. Personal Lifestyles
- C. Health Status Information
- D. Usage Of Heeled-shoes & Shoe Insert(s)
- E. Body Measurements
- F. Visual Analogue Scale (VAS)

The Visual Analogue Scale (VAS) was used to rate perceived comfort for each experimental condition. VASs that most clearly delineate extremes (e.g. the best condition imaginable, the worst condition) and were 100–150 mm in length have been shown to have the greatest sensitivity and were the least vulnerable to distortions or biases in ratings. It has been suggested that giving specific instructions to subjects will increase the reliability of VASs. Muñermann et al. (2002) found an inter-test correlation coefficient of 0.970 for a 150mm VAS and specific instructions. Also, intraclass correlation coefficients (ICCs) between comfort ratings for repeated conditions were high (ICC=0.799). The results from the study showed that VASs provide a reliable measure to assess perceived comfort (Muñermann et al., 2002).

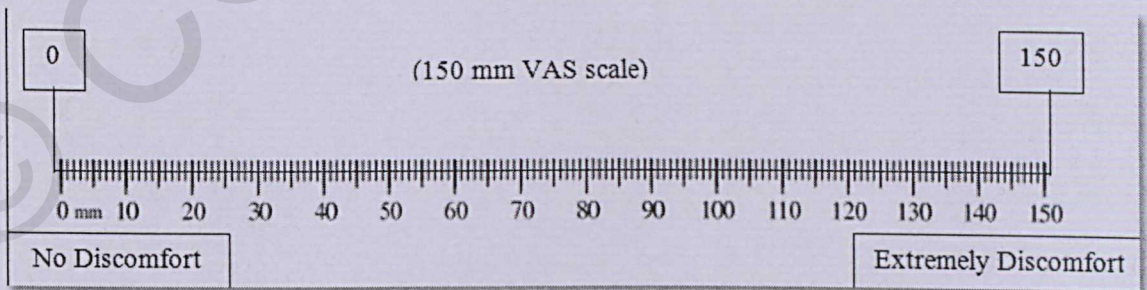


Figure 3.9: 150mm Visual Analogue Scale (VAS)

3.6 Study Techniques

3.6.1 Heel Heights and Shoe Inserts

Female undergraduates who had fulfilled the inclusion and exclusion criteria were briefed about this study on the purpose. After briefing, female undergraduates were asked to fill up the consent form which stated that they were willing to participate in this study.

Female undergraduates were then asked to complete the questionnaires. Once they complete the questionnaire, their weight and height were measured using SECA body meter and DETECTO weighing scale. Also, at the beginning of the experiment, foot anthropometric data was taken from each participant.

In the study, all participants walked on a treadmill. Firstly, each participant walked on a treadmill for 5 min at 130 cm/s to become habituated to each heel height and walking speed. The speed of 130 cm/s was used because the comfortable speeds reported in previous studies about high heels ranged from 122 to 140 cm/s (Esenyel et al., 2003).

Firstly, a heel height was randomly assigned to the participant to minimise potential sequencing effects. For the same heel height, the order of inserts was then randomly selected. To prevent slippage within the shoe, a new piece of double sided adhesive tape was applied to each prefabricated insert before each trial. Each participant took a 5-min rest in between to prevent fatigue. Based on previous studies (Lee and Hong, 2005; Caleb Wegener, 2008) participants were fitted with appropriate shoe size and given 5-minute acclimatization period for each perceived condition where participants were able to walk or run. A total of 768 trials (64 subjects x 3 heel heights x 4 insert conditions) were obtained for data analysis.



Figure 3.10: Respondents with 3 different heel heights: from left to right: a flat (2.0cm), a low (4.0cm) and a high heel (6.0cm).



Figure 3.11: Respondent walked on treadmill for each heel height and shoe insert condition.



Figure 3.12: Chair for respondent to take 5-min rest in between

3.6.2 Foot Anthropometric Data

The anthropometric variables studied were: foot length, width, and height as described by Manfio (2001). Foot length is the distance between the most prominent point in the calcaneal tuberosity region and the tip of the longest toe, along the longitudinal axis of the foot (heel–second toe). They were all measured in cm.

- **Total foot length** was first measured by placing the sliding bar on the centered metal ruler and moving the bar to just touch the longest toe of each foot.
- To measure **midfoot width**, the digital caliper was positioned so that the arms of the caliper were aligned laterally and medially to the 50% length point marked on the dorsum of the foot.
- To measure **heel width**, the digital width caliper was then placed behind each heel with the metal arms of the caliper placed at a 45° angle. The arms were then moved together until they just made contact with the skin on the lateral and medial sides of the heel.
- To measure **forefoot width**, the edges of the two metal arms attached to the caliper were positioned so that they were parallel to the centered metal ruler.
- To measure **dorsal arch height**, the sliding metal rod of the weight bearing height gauge was then positioned over the 50% length mark and the vertical height to the dorsum of each foot was measured.

3.6.3 Digital Pedometer

The Omron Digital Pedometer HJ-105 was attached to the belt or the top of waistband of respondents. The unit must be positioned horizontal with the ground for the unit to function correctly. The case should be closed during use. The case was opened only to see readings. After completed setting the pedometer, the unit may display step count.

3.6.4 Perceived Comfort

The visual analogue scale (VAS) is a reliable measure to assess perceived comfort. The VAS was used to rate the perceived comfort for each experimental condition in this study. Comfort was rated by a ruler that consisted of a 150mm VAS with the left end of the scale labeled 'not comfortable at all' (0 comfort point) and the right end labeled 'the most comfortable condition imaginable' (15 comfort points). To perceive uniform comfortable experiences, we required participants to comfortably fit into the size and advised them not to take the effects of shoe cosmetics and styles into comfort rating (Munermann et. al., 2002).

3.7 Quality Control Assurance

3.7.1 Pre Test of Questionnaires

The visual analogue scale (VAS) questionnaire (Munermann et al., 2002) was used. Pre-test for the whole experimental protocol and questionnaire were done on 10% of the total number of respondents. Also, for visual analogue scale (VAS) questionnaire (Munermann et al., 2002), participants were advised not to take the effects of shoe cosmetics and styles into comfort rating to perceive uniform comfortable experiences.

3.7.2 Standard Operating Procedure for Using Pedometer

- i. Press the RESET Button for 2 seconds to reset the data to zero.
- ii. Close the case and attach the pedometer to belt or waistband.
- iii. Walk 100 steps to confirm the pedometer counts number of steps correctly.

Note: If a discrepancy between the number of steps walked and the number of steps displayed on the unit is found adjust the sensitivity switch.

- iv. Start walking.

The pedometer can be adjusted to a $\pm 5\%$ accuracy rate ($\pm 5\%$ steps against 100 steps) when used on a level surface at a consistent walking pace, and before data began the step number was cleared.

- i. Attach the unit to belt or waistband and walk 100 steps.
- ii. Reading is 105 steps or more: Switch to the (-) direction.
- iii. Reading is 95 steps or less: Switch to the (+) plus direction.

NOTE: May need to adjust the Sensitivity Switch if change walking speed.

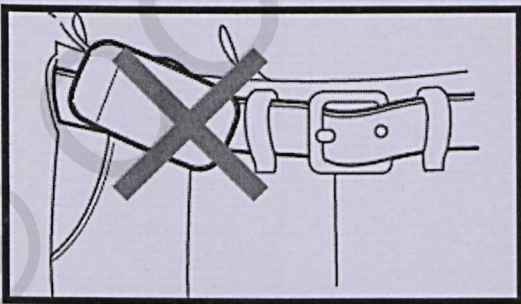


Figure 3.13: The pedometer must be positioned horizontal with the ground for the unit to function correctly.

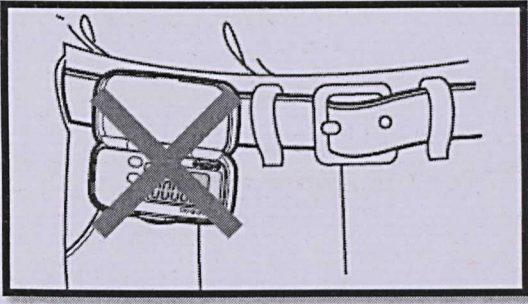


Figure 3.14: The case should be closed during use. Open only to see readings.

3.7.3 Standard Operating Procedure to Measure Height and Weight

Height was taken using SECA body meter and measurement was done twice to get a more accurate data. Weight measurement was done using DETECTO scale. The measurement was repeated twice too to get an average value.

SOP for Height Measurement:

- i. Heavy outer clothing (coats, jackets, vest) shoes and hair accessories on top of head should be removed.
- ii. Heels, buttocks and upper back should touch the stadiometer. Feet should be together and arms must be hanging in relax position by the sides of body.
- iii. Look straight ahead with the vision parallel to floor.
- iv. Move the adjustable headboard on the stadiometer down to the uppermost position of the head, compressing the hair and respondents are asked to step away. The headboard is hold in place by researcher.
- v. The height is read on the vertical board and recorded immediately.
- vi. Step ii to v are repeated to get a mean value.

SOP for Weight Measurement:

- i. Scale must be placed on a level, uncarpeted surface.
- ii. Before each measurement, make sure the scale reads zero.
- iii. Respondents must remove everything from their pockets.
- iv. Respondents should stand motionless in the middle of the scale platform with the feet slightly apart and the body weight distributed equally on both feet.
Arms should be relaxed and hanging down loosely at the sides of the body.
- v. The reading must be recorded immediately.
- vi. Step ii to v are repeated to get a mean value.

3.8 Data Collection Procedures

Figure 3.15 demonstrates the data collection procedures in this study. Female undergraduates were recruited based on the name list provided in administrative office in FMHS, UPM. Female undergraduates were given pre-survey questionnaires and were interviewed to obtain the permission to participate in the study. Consent forms were given to the respondents who fulfill the inclusion criteria and voluntary to participate in this study. Direct measurement of weight and height were carried out. Foot anthropometric measurement were done prior collected socio-demographic data, health status data, lifestyles data, heeled-shoes and shoe inserts usage through filling up the questionnaires. After each experimental condition, the respondents were given

VAS scale to rate perceived discomfort rating. Step counts were measured by pedometer. All the data were then analyzed and evaluated.

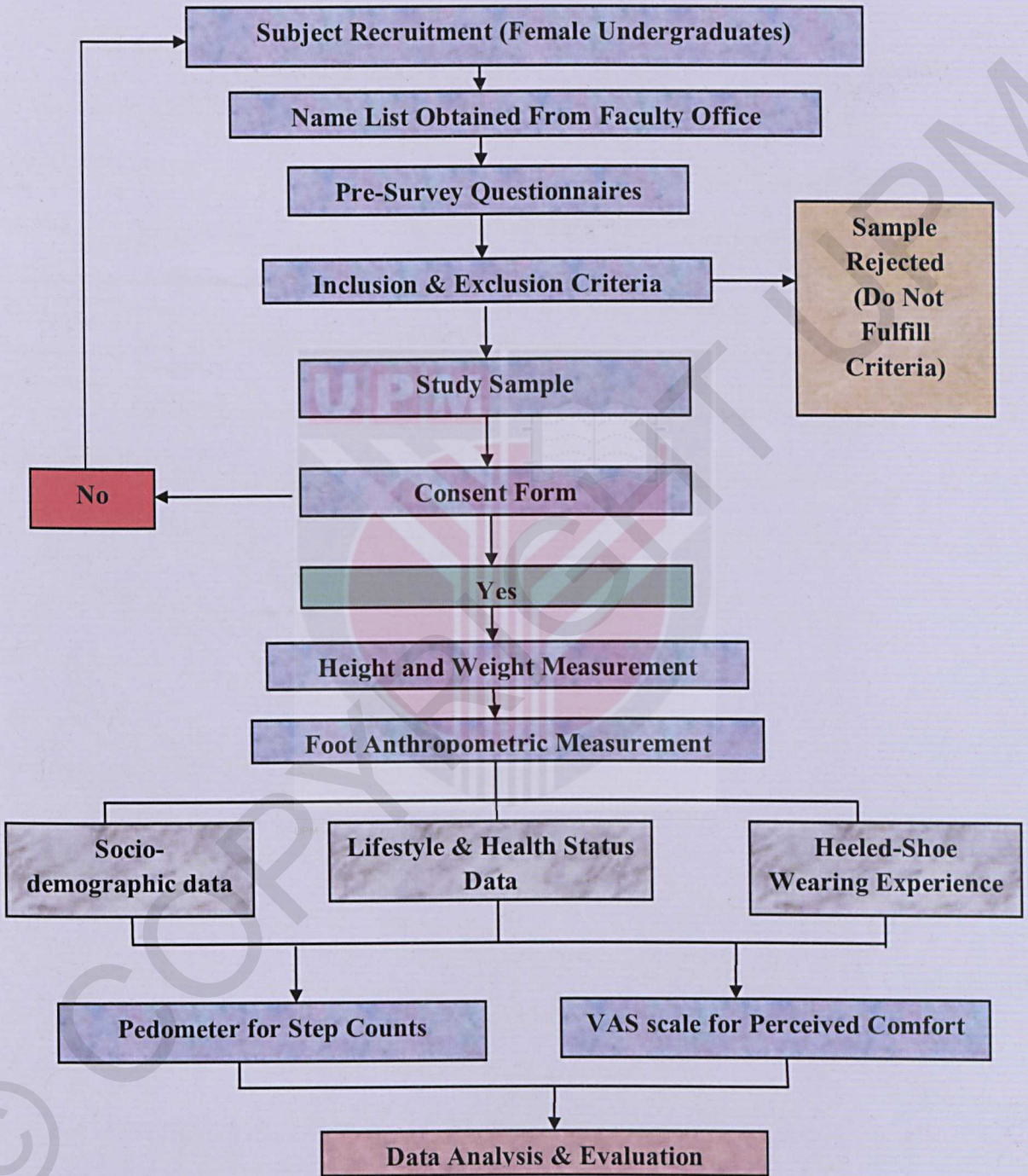


Figure 3.15: Data collection procedure flowchart

3.9 Ethical Clearance

Permission from Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia was required prior before data collection (ethical letter reference number: UPM/FPSK/PADS/T7-MJKEtikaPer/F01 JKK(U)_Dis(11)10). All the respondents were given detailed description about the purpose and procedure of the study. Respondents who were willing to participate in this study were asked to sign a consent letter. Respondents were free to withdraw themselves anytime during the study duration if they felt uncomfortable participating in the study. All information obtained from this study was kept in confidentiality. The respondents were notified regarding the findings of this research.

3.10 Data and Statistical Analysis

Data collected was divided into univariate and bivariate. IBM SPSS (Statistical Package for Social Science) Version 19.0 was used to analyze the variables. The types of statistical test used depend on the study objectives and hypothesis. The step counts and perceived discomfort rating of the respondents were recorded before analyzed by the SPSS. Normality of data distribution was tested by Shapiro-Wilk normality test. Univariate data were presented as frequencies and

percentages or mean and standard deviation value. For bivariate analysis, repeated-measures analysis of variance (ANOVA) was employed to study the effects of heel height and shoe insert on step counts and perceived comfort, whilst paired-samples t test post hoc analysis was used to identify where the differences occurred. Independent samples T-test was used to compare the mean difference of study variables, whilst Fisher's exact test compares frequencies between experienced and non-experienced groups of female undergraduates. Chi-Square test was used to compare personal lifestyle factors and usage of heeled-shoes and shoe inserts between experienced and non-experienced group. This study was conducted using 95% confidence level and the level of significance was set at 0.05 for all tests.

3.10.1 Determination of Data Distribution

Shapiro-Wilk normality test was used to determine the normality distribution of each variable studied before any statistical analysis was carried out on the variables. The result showed normal distribution in step counts and VAS perceived discomfort rating.

Table 3.1: Statistical Test based on Objective/ Hypothesis

Objectives/ Hypothesis	Data Analysis	
To determine the socio-demographic data among female undergraduates	Descriptive analysis	
To determine the foot anthropometric data among female undergraduates	Descriptive analysis	
To determine individual preference among the three different heel heights and four different shoe insert conditions	Descriptive analysis	
Shapiro-Wilk normality test	Parametric data	Non-parametric data
There is a significant difference between heel heights and shoe insert conditions with step counts among female undergraduates. (Post hoc analysis)	Repeated-measures ANOVA Test Paired samples T-test	Friedman Statistic Test Wilcoxon signed-rank test
There is a significant difference for heel heights and shoe insert conditions with step counts between experienced and non-experienced groups of female undergraduates.	Independent samples T-test	Mann-whitney U Test
There is a significant difference between heel heights and shoe insert conditions with perceived discomfort rating among female undergraduates. (Post hoc analysis)	Repeated-measures ANOVA Test Paired samples T-test	Friedman Statistic Test Wilcoxon signed-rank test
There is a significant difference for heel heights and shoe insert conditions with perceived discomfort rating between experienced and non-experienced groups of female undergraduates.	Independent samples T-test	Mann-whitney U Test

CHAPTER 4

RESULTS

4.1 Response rate and socio-demographic data

The study was conducted among female undergraduates from Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. A total of 64 respondents were selected from stratified random sampling by ethnicity. Approximately 3.1% of respondents suffered from elbows and hands injury within past 1 year. Those who had body injury within past 1 year were excluded from the study. About 9.4% of respondents did not fulfill the inclusion criteria of normal BMI thus were excluded from the study. The overall study response rate was 87.5%.

Table 4.1 shows the distribution of experienced and non-experienced group among female undergraduates by socio-demographic characteristics. The variables

include age, ethnicity, height, weight, and BMI index. Results show that all of the female undergraduates are aged between 20 to 24 years old. The means for Body Mass Index (BMI) among experienced and non-experienced group are classified as normal range, which is between 18.5 to 24.9. The participants with wearing experience had a mean age of 21.59 years, mean weight of 55.83kg, and mean height of 1.58m. For non-experienced wearers, the participants had a mean age of 21.81 years, mean weight of 54.00kg, and mean height of 1.59m. For experienced group, majority of the respondents are Malays (59.4%), and the rest are Chinese, Indians, and others. For non-experienced group, majority of the respondents are Malays too (65.6%). The Fisher's exact test and independent-samples t test for homogeneity shows that the experienced and non-experienced groups are homogeneous by socio-demographic characteristics ($p > 0.05$). There was no significant difference for age, ethnicity, height, weight, and body mass index between experienced and non-experienced group.

Table 4.1 Distribution of experienced and non-experienced group among female undergraduates by socio-demographic characteristics

Socio-demographic Characteristics	Experienced Group (N=32)			Non-experienced Group (N=32)			t	x ²	P-value
	N (%)	Range	Mean ± SD	N (%)	Range	Mean ± SD			
Age		20 - 24	21.59 ± 0.88		20 - 24	21.81 ± 1.12	0.871	-	0.387 ^a
Ethnicity									
Malay	19 (59.4)			21 (65.6)					
Chinese	11 (34.4)			9 (28.1)					
Indian	1 (3.1)			1 (3.1)					0.944 ^b
Others	1 (3.1)			1 (3.1)					
Height (m)		1.48 - 1.68	1.58 ± 0.05		1.50 - 1.75	1.59 ± 0.06	0.857	-	0.395 ^a
Weight (kg)		41.0 - 71.0	55.83 ± 8.17		40.0 - 70.0	54.00 ± 6.96	-0.964	-	0.339 ^a
Body Mass Index, BMI (kg/m²)			22.53 ± 3.37			21.48 ± 2.67	-1.385	-	0.171 ^a

*Significant at P < 0.05

a Independent-Samples T Test

b Fisher's Exact Test

4.2 Lifestyle

For the lifestyle factors listed in the Table 4.2, all respondents from experienced and non-experienced group do not have smoking habits. Around 12.5% of respondents from experienced and non-experienced group carried out the community service/ voluntary activity, 59.4% for the outdoor activity/ exercise. Only 15.6% of respondents from experienced group and 3.1% from non-experienced group are involved in part-time job. The mean hours of last night sleeping time (the day before experiment) was more than 6 hours. The Chi-square test and independent-samples t test for homogeneity shows that the experienced and non-experienced groups are homogeneous by lifestyle factors ($p > 0.05$). There was no significant difference for smoking, voluntary activity, outdoor exercise, part time job, and hours slept last night between experienced and non-experienced group.

4.3 Usage of heeled-shoes and shoe inserts

Table 4.3 highlights the usage of heeled shoes and shoe inserts among experienced and non-experienced group. Experienced group of female undergraduates are those who had worn low or high-heeled shoes at or more than one time per week for at least 1 year. Non-experienced group of female undergraduates

are those who had no or very limited experience in wearing low or high-heeled shoes. All respondents from experienced and non-experienced group have ever worn flat-heeled shoes. The results show that non-experienced group have worn flat-heeled shoes for longer duration of years, days, and hours compared to experienced group. 93.8% of respondents from experienced group have ever worn low-heeled shoes and 50.0% of them have ever worn high-heeled shoes. Only 6.3% of respondents from experienced group have ever used total contact insert (TCI) and heel cup while wearing heeled-shoes. Only 3.1% of them have ever used arch support. For non-experienced group, only 6.3% of respondents have ever used heel cup, while nearly 3.1% of them have ever used total contact insert (TCI) and arch support. The independent-samples t test for homogeneity shows that the experienced and non-experienced groups are homogeneous by previous usage of flat-heeled shoes and shoe inserts ($p > 0.05$). None of the respondents from non-experienced group has ever worn low or high-heeled shoes. Chi-square test demonstrates that there were significant differences for previous usage of low ($\chi^2 = 56.471, p < 0.0001$) and high-heeled shoes ($\chi^2 = 21.333, p < 0.0001$) between experienced and non-experienced group.

Table 4.2 Distribution of experienced and non-experienced group among female undergraduates by personal lifestyle factors

Personal Lifestyle Factors	Frequency (%)						t	x ²	P-value
	Experienced Group (N=32)			Non-experienced Group (N=32)					
	Yes	No	Mean ± SD	Yes	No	Mean ± SD			
Smoking	0	32 (100.0)		0	32 (100.0)		-	-	-
Community Service/Voluntary Activity	4 (12.5)	28 (87.5)		4 (12.5)	28 (87.5)		-	0.000	1.000 ^a
Outdoor Activity/Exercise	19 (59.4)	13 (40.6)		19 (59.4)	13 (40.6)		-	0.000	1.000 ^a
Part-time Job	5 (15.6)	27 (84.4)		1 (3.1)	31 (96.9)		-	2.943	0.086 ^a
Hours Slept Last Night			6.77 ± 1.32			6.41 ± 1.29	-1.117	-	0.268 ^b

*Significant at P < 0.05

a Chi-Square Test

b Independent-Samples T Test

Table 4.3 Distribution of experienced and non-experienced group among female undergraduates by usage of heeled-shoes & shoe inserts

Usage of Heeled-Shoes & Shoe Insert(s)	Experienced Group (N=32)			Non-experienced Group (N=32)			t	x ²	p
	Frequency (%)		Mean ± SD	Frequency (%)		Mean ± SD			
	Yes	No		Yes	No				
Flat-heeled	32 (100.0)	0		32 (100.0)	0		-	-	-
Year(s)			14.41 ± 6.42			14.78 ± 5.90	0.243	-	0.809 ^a
Day(s) per week			5.94 ± 1.52			6.00 ± 1.44	0.169	-	0.866 ^a
Hour(s) per day			7.22 ± 3.08			7.84 ± 4.39	0.659	-	0.512 ^a
Low-heeled	30 (93.8)	2 (6.3)		0	32 (100.0)		-	56.471	<0.0001 ^{b*}
Year(s)			4.53 ± 4.77						
Day(s) per week			2.13 ± 1.83						
Hour(s) per day			4.80 ± 3.04						
High-heeled	16 (50.0)	16 (50.0)		0	32 (100.0)		-	21.333	<0.0001 ^{b*}
Year(s)			3.63 ± 2.25						
Day(s) per week			1.31 ± 0.60						
Hour(s) per day			2.94 ± 1.12						
Shoe Insert(s)									
TCI	2 (6.3)	30 (93.8)		1 (3.1)	31 (96.9)		-	0.350	0.554 ^b
Arch support	1 (3.1)	31 (96.9)		1 (3.1)	31 (96.9)		-	0.000	1.000 ^b
Heel cup	2 (6.3)	30 (93.8)		2 (6.3)	30 (93.8)		-	0.000	1.000 ^b

*Significant at P < 0.05

a Independent-Samples T Test

b Chi-Square Test

4.4 Feeling after wearing heeled-shoes

Table 4.4 tabulates the feeling of respondents after wearing different heights of heeled-shoes. About 53.1% from respondents of experienced group and 68.8% from non-experienced group feel very comfortable while wearing flat heeled-shoes. Among the 30 respondents from experienced group who have ever worn low-heeled shoes, 40% of them feel uncomfortable and 60% of them feel comfortable while wearing it. For the 16 respondents from experienced group who have ever worn high-heeled shoes, 18.8% of them feel very uncomfortable while half of them feel uncomfortable while wearing it. Fisher's exact test shows that there was a significant difference among experienced group by feeling after wearing low and high-heeled shoes ($p = 0.0178$).

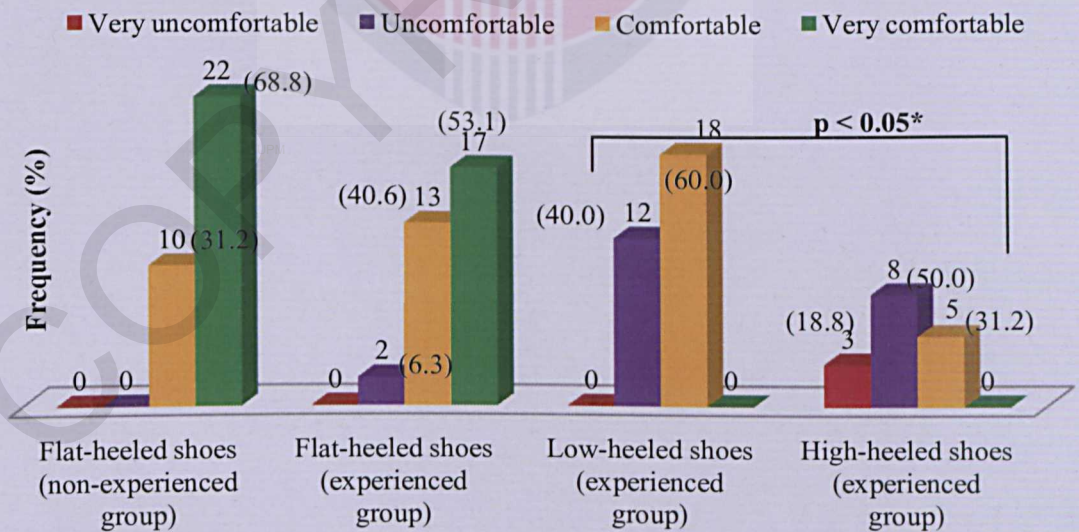


Figure 4.1 Distribution of experienced and non-experienced group among female undergraduates by feeling after wearing heeled-shoes

4.5 Discomfort body part after wearing heeled-shoes

Discomfort body part after wearing heeled-shoes was demonstrated in Figure 5. Among the 2 respondents who feel uncomfortable while wearing flat heeled-shoes, they experienced knees and ankles/feet discomfort. For 12 respondents who feel uncomfortable while wearing low heeled-shoes, 66.7% of them feel ankles/ feet discomfort and 16.7% of them experienced low back discomfort. All of the respondents feel uncomfortable at ankles/feet and 45.5% of them experienced knee pain among 11 respondents who feel uncomfortable while wearing high heeled-shoes.

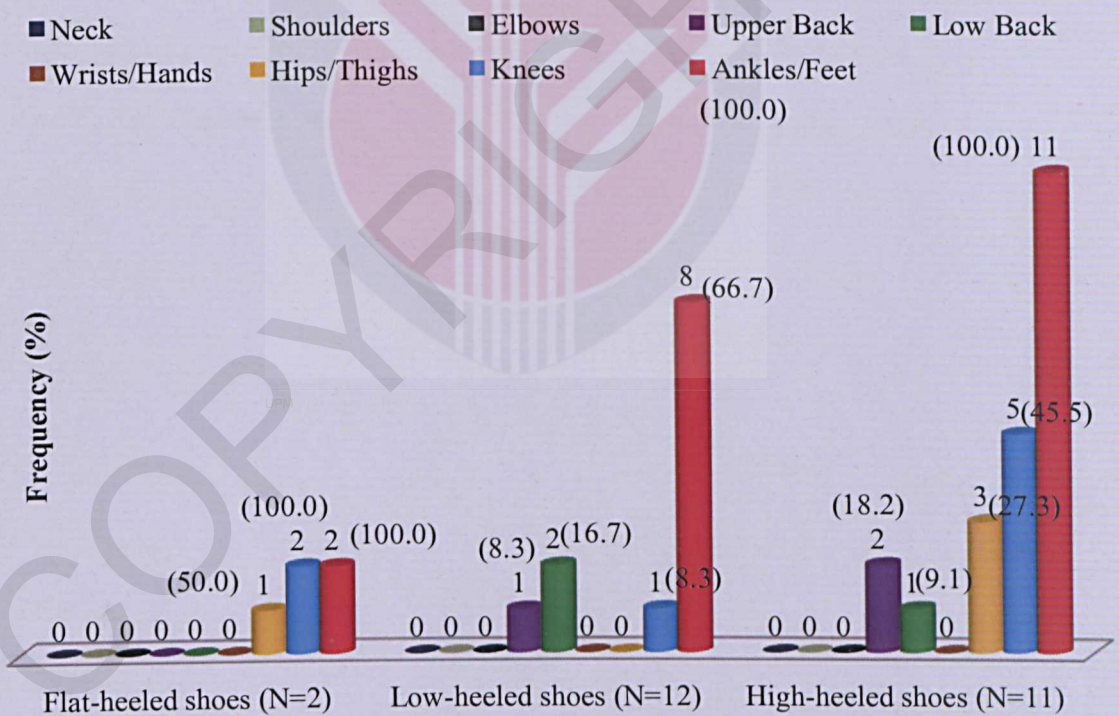


Figure 4.2 Distribution of experienced and non-experienced group among female undergraduates by discomfort body part after wearing heeled-shoes

4.6 Foot anthropometric measurements

Table 4.4 shows the distribution of respondents by foot anthropometric measurements. Total foot length mean of right foot for experienced group (22.51cm) was slightly smaller than non-experienced group (22.60cm). Non-experienced group of respondents were having smaller mean of left foot length (22.58cm) compared to experienced group (22.61cm). Respondents from experienced group were having larger mean of midfoot width, forefoot width and dorsal arch height for both right and left foot compared to non-experienced group. The only exemption was heel width, in which experienced group was having smaller heel width mean of right foot (5.10cm) compared to non-experienced group (5.13cm). The independent-samples t test for homogeneity shows that the experienced and non experienced wearers groups are homogeneous by foot anthropometric measurements ($p > 0.05$). There was no significant difference for total foot length, midfoot width, heel width, forefoot width, and dorsal arch height among experienced and non-experienced group.

Table 4.4 Distribution of experienced and non-experienced group among female undergraduates by foot anthropometric measurements

Foot Anthropometric Measurements (cm)	Experienced Group (N=32)		Non-experienced Group (N=32)		Right Foot		Left Foot	
	Mean ± SD		Mean ± SD		t	p	t	p
	Right Foot	Left Foot	Right Foot	Left Foot				
Total Foot Length	22.51 ± 0.80	22.61 ± 1.03	22.60 ± 0.98	22.58 ± 0.99	0.406	0.686	-0.114	0.910
Midfoot Width	6.64 ± 0.55	6.70 ± 0.51	6.42 ± 0.71	6.47 ± 0.75	-1.389	0.170	-1.527	0.132
Heel Width	5.10 ± 0.50	5.17 ± 0.44	5.13 ± 0.49	5.12 ± 0.50	0.271	0.787	-0.447	0.656
Forefoot Width	8.37 ± 0.42	8.41 ± 0.43	8.18 ± 0.51	8.28 ± 0.54	-1.601	0.114	-1.075	0.287
Dorsal Arch Height	6.53 ± 0.70	6.62 ± 0.72	6.30 ± 0.65	6.48 ± 0.66	-1.349	0.182	-0.822	0.414

a Independent-Samples T Test

4.7 Average step counts (steps) per minute for different heel heights and shoe insert conditions

Table 4.5 demonstrates the result of average step counts (steps) per minute for heel heights & shoe insert condition. Repeated-measures ANOVA test shows that there were significant differences between average step counts (steps) per minute for flat, low, and high heel heights among both experienced ($p = 0.001$) and non-experienced group ($p = 0.004$). For shoe insert conditions, results show that there were significant difference between average step counts (steps) per minute for flat ($p = 0.026$), low ($p = 0.003$), high ($p < 0.0001$) with different shoe insert conditions for experienced group. For non-experienced group, results present that there were significant difference between average step counts (steps) per minute for high ($p = 0.014$) with different shoe insert conditions. Paired-samples T test post hoc analysis for experienced group demonstrated significant differences for step counts between all 3 heights ($p < 0.0001$) and 4 shoe insert conditions ($p < 0.05$) except for flat shoe only with arch support ($p = 0.725$), flat arch support with TCI ($p = 0.056$), flat heel cup with TCI ($p = 0.941$), low shoe only with TCI ($p = 0.611$), and low arch support with heel cup ($p = 0.971$). Also, paired-samples T test post hoc analysis for non-experienced group has shown significant differences for step counts between all 3 heights ($p < 0.05$) and 4 shoe insert conditions for high-heeled shoes ($p < 0.05$) except for high shoe only with TCI ($p = 0.055$), high arch support with TCI ($p = 0.055$), and high heel cup with TCI ($p = 0.613$).

Table 4.5 Repeated-measures ANOVA test to compare the difference of average step counts (steps) per minute for heel heights and shoe insert conditions

Heel Heights & Shoe Inserts	Non-experienced Group (N=32)			Experienced Group (N=32)		
	Mean ± SD	F (df)	P-value	Mean ± SD	F (df)	p-value
Shoe only						
Flat	154.31 ± 20.60	13.918	0.001*	155.97 ± 12.47	9.712	0.004*
Low	156.34 ± 20.53	(1.004)		158.66 ± 12.17	(1.015)	
High	164.69 ± 23.88			171.88 ± 24.35		
Flat-heeled Shoes						
Shoe Only	154.31 ± 20.60	0.844	0.467	155.97 ± 12.47	3.475	0.026*
Arch Support	153.53 ± 18.81	(2.810)		156.28 ± 16.48	(2.518)	
Heel Cup	149.19 ± 16.99			154.91 ± 16.43		
TCI	149.06 ± 18.93			153.38 ± 14.40		
Low-heeled Shoes						
Shoe Only	156.34 ± 20.53	2.113	0.109	158.66 ± 12.17	5.625	0.003*
Arch Support	155.19 ± 17.92	(2.793)		157.19 ± 16.50	(2.559)	
Heel Cup	149.63 ± 16.58			155.34 ± 15.98		
TCI	149.56 ± 18.88			153.88 ± 14.37		
High-heeled Shoes						
Shoe Only	164.69 ± 23.88	4.668	0.014*	171.88 ± 24.35	17.582	<0.0001*
Arch Support	163.59 ± 15.52	(1.927)		164.81 ± 15.67	(1.494)	
Heel Cup	157.56 ± 18.35			164.34 ± 21.01		
TCI	159.03 ± 19.90			160.06 ± 18.90		

*Significant at P < 0.05

4.8 Average step counts (steps) per minute for different heel heights and shoe insert conditions between experienced and non-experienced groups

Table 4.6 presents the result of average step counts (steps) per minute for heel heights & shoe insert condition between experienced and non-experienced groups. For flat, low and high-heeled shoes, independent samples t-test shows that there was no significant difference for heel heights and average step counts (steps) per minute between experienced and non-experienced groups. However, experienced group took increased number of average step counts per minute for flat (1.1%), low-heeled shoes (1.5%), and high-heeled shoes (4.2%) compared to non-experienced group. Also, there was no significant difference for shoe insert conditions (arch support, heel cup and total contact insert) and average step counts (steps) per minute when compared experienced to non-experienced groups. Flat-heeled shoes with total contact insert among non-experienced group achieved lowest number of average step counts per minute, and marked reduced steps (2.9%) compared to experienced group.

Table 4.6 Independent samples t-test to compare the difference of average step counts (steps) per minute for heel heights and shoe insert conditions between experienced and non-experienced groups

Heel Heights & Shoe Inserts	Mean \pm SD		t	p-value	95% CI
	Non-experienced Group (N=32)	Experienced Group (N=32)			
Flat-heeled					
Shoes					
Shoe Only	154.31 \pm 20.60	155.97 \pm 12.47	-0.389	0.699	-10.203 – 6.890
Arch Support	153.53 \pm 18.81	156.28 \pm 16.48	-0.622	0.536	-11.588 – 6.088
Heel Cup	149.19 \pm 16.99	154.91 \pm 16.43	-1.369	0.176	-14.071 – 2.634
TCI	149.06 \pm 18.93	153.38 \pm 14.40	-1.026	0.309	-12.717 – 4.092
Low-heeled					
Shoes					
Shoe Only	156.34 \pm 20.53	158.66 \pm 12.17	-0.548	0.586	-10.745 – 6.120
Arch Support	155.19 \pm 17.92	157.19 \pm 16.50	-0.464	0.644	-10.607 – 6.607
Heel Cup	149.63 \pm 16.58	155.34 \pm 15.98	-1.405	0.165	-13.857 – 2.419
TCI	149.56 \pm 18.88	153.88 \pm 14.37	-1.028	0.308	-12.698 – 4.073
High-heeled					
Shoes					
Shoe Only	164.69 \pm 23.88	171.88 \pm 24.35	-1.192	0.238	-19.240 – 4.865
Arch Support	163.59 \pm 15.52	164.81 \pm 15.67	-0.313	0.756	-9.012 – 6.574
Heel Cup	157.56 \pm 18.35	164.34 \pm 21.01	-1.375	0.174	-16.640 – 3.078
TCI	159.03 \pm 19.90	160.06 \pm 18.90	-0.213	0.832	-10.729 – 8.666

*Significant at P < 0.05

4.9 Perceived discomfort rating for different heel heights and shoe insert conditions

Table 4.7 demonstrates the result of VAS perceived discomfort rating for different heel heights and shoe insert conditions. There was highly significant difference for all heel heights ($p < 0.0001$), together with low ($p < 0.0001$) and high-heeled ($p < 0.0001$) shoe insert conditions among experienced and non-experienced groups with perceived discomfort rating. There was lowest VAS perceived discomfort rating for flat heeled-shoes, followed by low-heeled shoes, while high-heeled shoes achieved highest VAS perceived discomfort rating. All heel heights with total contact inserts (TCI) marked lowest perceived discomfort rating. Post hoc analysis demonstrated significant differences for perceived discomfort rating among non-experienced group between all 3 heights ($p < 0.0001$) and certain shoe insert conditions such as low shoe only with TCI ($p < 0.0001$), heel cup ($p = 0.004$); low shoe TCI with arch support ($p = 0.025$); and high shoe only with TCI, heel cup, and arch support ($p < 0.0001$). For experienced group, there were significant differences for perceived discomfort rating between all 3 heights ($p < 0.0001$) and certain shoe insert conditions such as low shoe only with TCI ($p < 0.0001$), low shoe TCI with heel cup ($p = 0.004$), low shoe TCI with arch support ($p < 0.0001$); and high shoe only with TCI, heel cup, and arch support ($p < 0.0001$).

Table 4.7 Repeated-measures ANOVA to compare the difference of perceived discomfort rating for heel heights and shoe insert conditions

Heel Heights & Shoe Inserts	Non-experienced Group (N=32)			Experienced Group (N=32)		
	Mean ± SD	F(df)	p-value	Mean ± SD	F (df)	p-value
Shoe Only						
Flat	18.16 ± 17.90	116.314	<0.0001*	18.33 ± 16.09	64.364	<0.0001*
Low	70.14 ± 20.59	(1.513)		58.69 ± 14.56	(1.395)	
High	105.63 ± 38.68			82.03 ± 40.03		
Flat-heeled Shoes						
Shoe Only	18.16 ± 17.90	3.160	0.055	18.33 ± 16.09	2.881	0.060
Arch Support	27.66 ± 29.00	(1.790)		19.50 ± 15.49	(2.134)	
Heel Cup	26.31 ± 29.92			23.02 ± 24.74		
TCI	15.34 ± 18.77			12.00 ± 12.05		
Low-heeled Shoes						
Shoe Only	70.14 ± 20.59	8.032	<0.0001*	58.69 ± 14.56	9.796	<0.0001*
Arch Support	59.69 ± 25.35	(3.000)		50.88 ± 26.94	(2.505)	
Heel Cup	55.34 ± 17.30			49.97 ± 24.69		
TCI	47.03 ± 16.26			36.76 ± 20.35		
High-heeled Shoes						
Shoe Only	105.63 ± 38.68	13.262	<0.0001*	82.03 ± 40.03	15.027	<0.0001*
Arch Support	65.18 ± 31.95	(1.788)		55.53 ± 32.60	(2.245)	
Heel Cup	69.48 ± 28.10			59.76 ± 34.23		
TCI	67.52 ± 31.71			49.09 ± 30.90		

*Significant at P < 0.05

4.10 Perceived discomfort rating for different heel heights and shoe insert conditions between experienced and non-experienced groups

Table 4.8 demonstrates the result of VAS perceived discomfort rating between experienced and non-experienced groups. For low and high-heeled shoe only, there was significant difference for heel heights with perceived discomfort rating between experienced and non-experienced groups ($p = 0.013$; $p = 0.020$). There was lowest VAS perceived discomfort rating for flat, followed by low, while high-heeled shoes achieved highest VAS perceived discomfort rating for both experienced and non-experienced group of respondents. In addition, there was significant difference between perceived discomfort rating for low and high-heeled shoes with total contact insert between experienced and non-experienced groups ($p = 0.029$; $p = 0.022$). However for flat heeled-shoes, there was no significant difference for perceived discomfort rating and heel heights together with all shoe insert conditions between experienced and non-experienced groups. As shown in table, non-experienced group perceived higher strength of discomfort compared to experienced group in low and high-heeled shoes, while experienced group experienced slightly higher strength of discomfort in flat-heeled shoes compared to non-experienced group. There was lowest score of perceived discomfort rating for flat, low and high heeled-shoes with total contact insert. High-heeled shoes with heel cup achieved highest score of perceived discomfort rating while flat-heeled shoes with total contact insert marked lowest score of perceived discomfort rating.

Table 4.8 Independent samples t-test to compare the difference of perceived discomfort rating for heel heights and shoe insert conditions between experienced and non-experienced groups

Shoe Insert Conditions	Mean ± SD		t	p-value	95% CI
	Non- experienced Group (N=32)	Experienced Group (N=32)			
Flat-heeled					
Shoes					
Shoe Only	18.16 ± 17.90	18.33 ± 16.09	-0.038	0.970	-8.668 – 8.343
Arch Support	27.66 ± 29.00	19.50 ± 15.49	1.404	0.165	-3.4569 – 19.782
Heel Cup	26.31 ± 29.92	23.02 ± 24.74	0.479	0.633	-10.428 – 17.010
TCI	15.34 ± 18.77	12.00 ± 12.05	0.847	0.401	-4.544 – 11.219
Low-heeled					
Shoes					
Shoe Only	70.14 ± 20.59	58.69 ± 14.56	2.570	0.013*	2.542 – 20.368
Arch Support	59.69 ± 25.35	50.88 ± 26.94	1.349	0.182	-4.254 – 21.891
Heel Cup	55.34 ± 17.30	49.97 ± 24.69	1.008	0.318	-5.305 – 16.048
TCI	47.03 ± 16.26	36.76 ± 20.35	2.232	0.029*	1.072 – 19.478
High-heeled					
Shoes					
Shoe Only	105.63 ± 38.68	82.03 ± 40.03	2.398	0.020*	3.927 – 43.266
Arch Support	65.18 ± 31.95	55.53 ± 32.60	1.195	0.236	-6.484 – 25.777
Heel Cup	69.48 ± 28.10	59.76 ± 34.23	1.242	0.219	-5.927 – 25.371
TCI	67.52 ± 31.71	49.09 ± 30.90	2.354	0.022*	2.782 – 34.074

*Significant at P < 0.05

4.11 Individual preference on heel heights and shoe insert conditions

Figure 4.3 demonstrates individual preference among the three different heel heights and four different shoes insert conditions. 96.9% from non-experienced group and 87.5% from experienced group selected flat heel as their most preferable heel height. Only 3.1% from experienced group preferred high-heeled shoes. When the respondents were asked about preferable shoe insert conditions, 56.3% from non-experienced group and 71.9% from experienced group chose total contact insert as their most preferable shoe insert. It was then followed by arch support (21.9% for non-experienced group; 18.7% for experienced group), heel cup (15.6% for non-experienced group; 6.3% for experienced group), and shoe only (6.2% for non-experienced group; 3.1% for experienced group). According to table 4.9, the Fisher's exact test for homogeneity shows that the experienced and non experienced wearers groups are homogeneous by individual preference ($p > 0.05$). There was no significant difference for the individual preference between experienced and non-experienced group.

Table 4.9 To determine individual preference among the three different heel heights and four different shoe insert conditions

Heel Heights & Shoe Insert Conditions	Frequency (%)		χ^2	p-value
	Non-experienced Group (N=32)	Experienced Group (N=32)		
Heel Heights				
Flat	31 (96.9)	28 (87.5)	-	0.234 ^a
Low	1 (3.1)	3 (9.4)		
High	0	1 (3.1)		
Shoe Insert Conditions				
Shoe Only	2 (6.2)	1 (3.1)	-	0.550 ^a
Arch Support	7 (21.9)	6 (18.7)		
Heel Cup	5 (15.6)	2 (6.3)		
Total Contact Insert	18 (56.3)	23 (71.9)		

^a Fisher's Exact Test

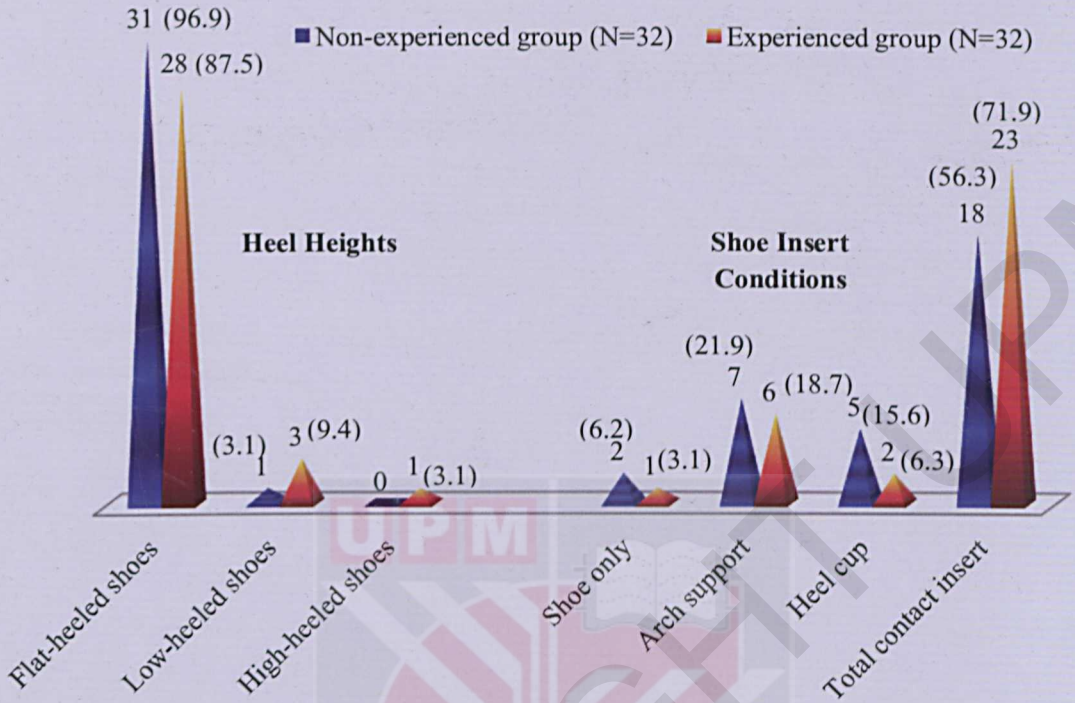


Figure 4.3 To determine individual preference among the three different heel heights and four different shoe insert conditions

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

This study sought to establish the influence of heel heights and shoe inserts on step counts and perceived comfort. The results of this study demonstrated clear links between an increase in step counts and perceived discomfort rating as heel height increased. This link was reversed upon implementation of 3 types of shoe inserts, which showed a decrease in step counts and perceived discomfort rating. However, there was no significant difference found for step counts when compared between experienced and non experienced group.

5.1.1 Usage of heeled-shoes & shoe inserts

All respondents from experienced and non-experienced group have ever worn flat-heeled shoes. The results show that non-experienced group have worn flat-heeled shoes for longer duration of years, days, and hours compared to experienced group. Majority of respondents from experienced group have ever worn low-heeled shoes and half of them have ever worn high-heeled shoes. Very few respondents have ever used arch support, total contact insert (TCI) and heel cup while wearing heeled-shoes.

In Malaysia, studies on effects of wearing high-heeled shoes are limited. However, a study in Taiwan reported that surveys of shoe choice showing 37–69% of females wear high-heeled shoes between 1 and 8 hours on a daily basis (Lee et al., 2005). The wearing percentage shown by Taiwan study was higher than our study (25% of our respondents wear high-heeled shoes between 1 and 8 hours on a daily basis). Many women stated that they feel more confident and glamorous from the extra height gained.

5.1.2 Feeling and discomfort body part after wearing heeled-shoes

Majority respondents of experienced group and non-experienced group feel very comfortable while wearing flat heeled-shoes. Among respondents from experienced group who have ever worn low-heeled shoes, some of them feel uncomfortable and more than half of them feel comfortable while wearing it. For respondents from experienced group who have ever worn high-heeled shoes, few of them feel very uncomfortable while half of them feel uncomfortable while wearing it.

Previous studies have demonstrated that wearing high-heeled shoes modifies gait kinematics and kinetics. Walking in high-heeled shoes alters lower-extremity joint function. Also, it raises the peak pressure in the forefoot and shifts peak pressures from the third, fourth and fifth metatarsal heads to the first and second and thus reduced the perceived comfort (Esenyel et al., 2003). Wearing high heeled-shoes without shoe inserts may lose natural ability to attenuate the shock waves and increase risk of degenerative joint disorders (Kerrigan et al., 2005).

Results of this experimental study indicate that none of the respondents from experienced and non-experienced group suffered from lower body part injury within past 1 year (exclusion criteria). Oversea studies show that a prevalence of 83% of

foot problems in females wearing high-heeled shoes (Dawson et al., 2002). Lee et al. (2001) surveyed 200 females who regularly wore high-heeled shoes, and found 58% of this population experienced perceived discomfort whilst wearing the shoes. As a result, wearing high heeled-shoes produces a substantial cost to health system and industrial productivity (Sahar et al., 2007). Perceived discomfort could contribute to ergonomic problems such as consequent musculoskeletal discomfort, sprained ankles, lower back pain, due to increased spinal curvature, and leg pain, due to added weight placed on the toes (Lee at al., 2005). Especially in older age, wearing inadequate shoes limits mobility and consequently impairs health, independence and quality of life. With age increases, the width and height of the forefoot increases to a greater extent than the width and height of the hind foot, making it difficult to find appropriate shoes (Lee, Y.H. et al., 2005; Tencer, A.F. et al., 2004). Older women may avoid wearing high-heeled shoes, which reduces support base and consequently changes weight distribution on plantar surface of foot (Alessandra et al., 2010).

5.1.3 Foot anthropometric measurements

The basic foot anthropometric variables were foot length, width, and height as described by Manfio (2001). A study of foot anthropometric data among Thai women showed that most women had foot length between shoes size 22.5 cm and 24.5 cm. In this study, foot measurements in weight bearing position using Chula

foot calipers. Those who had a past history of neurological disorders, spinal or lower extremity injury, or had been diagnosed as having inflammatory joint disease were excluded in the Thai study. Foot length, foot width, arch length, toe depth, heel width, upper ball, upper arch, ball girth, waist girth, instep girth, short heel girth, ankle circumference, and ankle height were recorded in centimeters (Chaiwanichsiri D et al., 2008). The Thai study is consistent with the results of our study with mean of foot length 22.51cm to 22.61cm. These foot data are essential for fitting proper shoes for women, in order to provide foot ergonomics and prevent perceived discomfort. Proper foot anthropometric measurements are important because proper shoes could provide foot protection and stability, absorb excessive force, and prevent falls. Improper shoe size and poorly fitting shoes can lead to foot ulceration and perceived discomfort.

5.1.4 Average step counts (steps) per minute for different heel heights & shoe insert conditions

A study done by Sarah et al. (2010) presents that there was an increase in step counts during the medium (13.6%) and high (17.8%) conditions compared to the flat condition. In the study, ten healthy females (age range 21 – 34 years) who were regular high heel wearers participated for the study. Five footwear conditions were randomly assigned: heel height of 15mm (flat), 45mm (low), 70mm (high), high with

McConnell shoe insert and high with Insolia shoe insert. Comparisons between the high and shoe insert condition also showed significant differences with fewer step counts taken for McConnell® (10.8%) and Insolia® (13.7%) shoe insert. The findings are consistent with results of our study, which is increase in step counts during the low and high conditions compared to the flat condition.

Also, previous study by Noel Lythgo (2009) shows that on average, participants took 165.0 ± 51.5 steps in the barefoot condition and 155.0 ± 52.0 steps per minute when wearing shoes. However, participants of the study wore athletic shoes or runners commonly used for walking, and without shoe inserts. Limited studies so far, have examined the effects of heel heights & shoe insert conditions on step counts. An increase in heel height plantarflexes foot, flexes hip and knee. These angular changes result in shorter stride length. Since speed was kept constant throughout all conditions by treadmill, step counts during high condition had to increase (Kerrigan DC et al., 2005; Lee CM et al., 2001). Taking more steps in high-heeled shoes however may be a negative factor since more steps may result in higher sagittal and varus knee torques which in turn leads to joint damage. Moreover, longer activation times of rectus femoris and cocontraction of other lower limb muscles may also be linked to longer stride patterns (Esenyel et al., 2003; Lee YH et al., 2005).

According to Ministry of Health Malaysia (2007), the distance recommended for keeping good shape is 6,000 steps a day, while for weight loss we should be doing about 10,000 steps a day. Public health recommendations suggest 100steps min^{-1} (Michael et al., 2010). The results of our study demonstrated more than 100steps min^{-1} for all heel heights and shoe insert conditions.

5.1.5 Perceived discomfort rating for different heel heights

In this study, majority of respondents feel very comfortable while wearing flat heeled-shoes. Among respondents who have ever worn high-heeled shoes, more than half of them feel uncomfortable while wearing it. Previous studies by Kerrigan DC et al. (2005) and Esenyel et al. (2003) demonstrated that wearing high-heeled shoes modifies gait kinematics and kinetics. Walking in high-heeled shoes alters lower-extremity joint function, raises peak pressure in forefoot, and shifts peak pressures from third, fourth and fifth metatarsal heads to first and second, and thus reduced the perceived comfort.

Our study results in lowest VAS perceived discomfort rating for flat, followed by low-heeled shoes, while high-heeled shoes achieved highest VAS perceived discomfort rating for both experienced and non-experienced group. Our

study is consistent with the study done by Lee YH et al. (2005), in which the mean comfort rating in flat shoe was 7.6 and reduced to 2.6 in high heels. Lee YH et al. (2005) study was done in Taiwan, in which 10 females participated in that study with flat, low, and high heel. However, comfort was rated by a ruler that consisted of a 100mm VAS with the left end of the scale labelled 'not comfortable at all' (0 comfort point) and the right end labelled 'the most comfortable condition imaginable' (10 comfort points). This is different with our study, in which we used more reliable 150mm VAS (Munermann et al, 2002). In the Taiwan study, the shoes used were commercially available items and were selected based on the similarity of construction such as foot contact points, supports, and pump style. The main difference among these shoes was the height of the heel: a flat, a low and a high heel. The study shows that increasing heel height increases the perceived discomfort significantly during walking. The mean comfort rating in the study indicates that higher heel lift might lead to more discomfort.

Also, another study done by Sarah et al. (2010) has presented mean overall comfort rating was 11 for flat condition but reduced to 7.8 for high heel condition. The footwear used in that study was commercially available and were selected based on the similarity of construction such as forefoot width (D fitting) with a strap style and foot contact points. The key difference among this footwear was the height of the heel: a flat (15mm), a low (45mm), and a high heel (70mm). The comfort level was rated by 150mm VAS Footwear Comfort Scale, which is the same scale with our

study. Wearing high-heeled shoes for walking generates a force spike at initial ground contact (i.e., impact force) and the force is then transmitted up to the skeleton as a 'shock wave'. This shock wave appeared to damage soft tissues, which may result in perceived discomfort of leg and back-pain complaints and eventually lead to degenerative joint disorders (Dawson et al., 2002). Moreover, heel height also has an effect on the foot pressure distribution and vertical impact force. Reports indicated that high heel height generates greater vertical impact force with lower perceived comfort, whereas flat shoes tend to produce lower impact force thus have higher perceived comfort (Min and Mao, 2007).

5.1.6 Perceived discomfort rating for different shoe insert conditions

The types of shoe inserts used in this study included heel cup, arch support, and total contact inserts (TCI). The results show that there was lowest score of perceived discomfort rating for flat, low and high heeled-shoes with total contact insert. Flat-heeled shoes with total contact insert marked lowest score of perceived discomfort rating. This is consistent with study done by Sarah et al. (2010), in which comfort rating were improved with use of the McConnell® (mean 11.8) and Insolia® (mean 11.0) shoe insert. In that study, the foot orthoses used were commercially available prefabricated products.

Previous studies by Lee et al. (2005) show that a heel cup is effective in reducing heel pressure and the magnitude of the heelstrike impact thus reduced perceived discomfort rating. An arch support was designed to resist depression of foot arch during weight bearing through skeletal support, thereby decreasing tension in the plantar aponeurosis and improved comfort level. Last but not least, a total contact insert (TCI) provided total pressure relief in the heel and forefoot regions (Chen et al., 2003). The use of inserts is effective in redistributing pressure beneath foot and absorbing energy in terms of reducing impact force and then improving perceived comfort level. Various inert designs demonstrate different kinetic modification during gait (Lee et al., 2005).

A metatarsal pad has been found to reduce forefoot pressure and transfer weight bearing to the longitudinal and metatarsal arches. However, it was not used in our study. The use of a metatarsal pad increased pressure of the midfoot region, but did not significantly reduce pressure of the medial forefoot and impact force. The pad was not effective in improving perceived comfort during high-heeled walking. It was possible that the pad was not customized for each participant and it was also not so easy to install in a definite position compared with other inserts. Also, the metatarsal pad did not provide either pressure relief or comfort (Chen et al., 2003). Many studies, however, focused on inserts in flat or running shoes. Very limited study, in so far as examined, attempted to identify insert effectiveness in high heels.

5.2 Conclusion

This study indicates that more than half of the respondents felt uncomfortable while wearing high-heeled shoes. Different heel heights and shoe insert conditions have significant effects to step counts and perceived discomfort rating. Majority of respondents selected flat heel as their most preferable heel height, and total contact insert as their most preferable shoe insert. Increasing heel height increases step counts and increases perceived discomfort rating during walking. Usage of 3 types of shoe inserts showed a decrease in step counts and perceived discomfort rating. A total contact insert (TCI) combined with heel-cup and arch-support mechanism for high-heeled shoes would be effective for an improvement in footwear comfort. Experienced group of female undergraduates with previous wearing experience, flat heeled-shoes, and total contact insert offered lowest number of step counts, and lowest perceived discomfort rating when compared to other heel heights and insert condition.

To summarize,

- a. Significant differences were found for different heel heights (flat, low, and high) and shoe insert conditions with step counts among female undergraduates.

- b. No significant differences were found for different heel heights and shoe insert conditions with step counts between experienced and non-experienced groups of female undergraduates.
- c. Significant differences were found for different heel heights (flat, low, and high) and shoe insert conditions with perceived discomfort rating among female undergraduates.
- d. Significant differences were found for low and high heel heights and Total Contact Insert (TCI) condition with step counts between experienced and non-experienced groups of female undergraduates.
- e. Majority respondents from non-experienced and experienced group selected flat heel as their most preferable heel height, and total contact insert as their most preferable shoe insert.

5.3 Recommendations

This is an experimental study, which was laboratory-based and the tasks were performed over a 2 hours and a half period for every respondent. In a realistic work environment, the individual may be standing for much of the work day. An experiment of longer duration may provide better insight into the behavioural and physical adaptations of each individual and reflect the effects found in real work

environments. Also, future research should include data collection at the beginning and end of the day to establish the role of fatigue.

Increasing heel height increases perceived discomfort during walking. A custom-made insert with a heel-cup or an arch-support mechanism for high-heeled shoes would be effective for an improvement in footwear comfort. In particular, a TCI, combined with a heel-cup and an arch-support mechanism, could offer better comfort when compared to not wearing an insert. It is suggested that these inserts may contribute to relieve foot pressure, reduced impact force, and more comfort at work for women wearing high-heeled shoes. Information gained from additional studies can help to document effects of heeled-shoes and to optimize the design and selection of shoe inserts.

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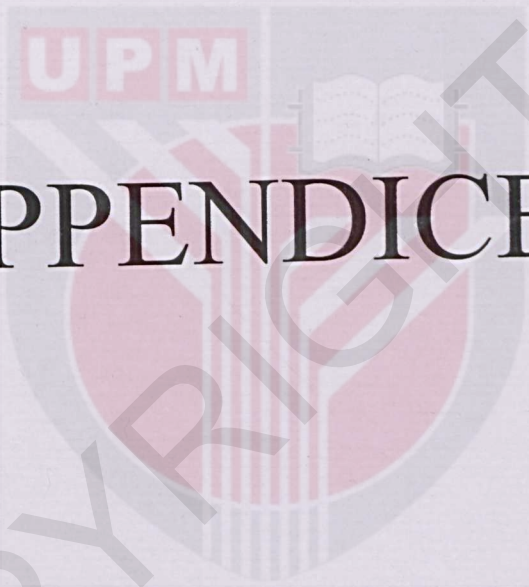
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APPENDICES



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Appendix 1
Questionnaires & VAS Scales



For researcher
use

A1

A2

A3

B1

B2i

B2ii

B2iii

SECTION A: SOCIO-DEMOGRAPHIC DATA

Please answer all parts of the questions and tick (✓) for questions with options.

1. Age : years-old
2. Ethnicity : 1. Malay 2. Chinese 3. Indian 4. Others
3. Programme : 1. Doctor of Medicine 2. Biomedical Science
3. Nutrition & Community Health
4. Environmental & Occupational Health
5. Dietetic 6. Nursing

SECTION B: PERSONAL LIFESTYLES

1. Do you smoke?

0. No 1. Yes

If yes, please state how many cigarette(s) per day you smoke: _____ cigarette(s) per day

2. Are you involved in the activities stated below?

i. Community service/ voluntary activity

0. No 1. Yes

If yes, please state the type of activity: _____

And how many hour(s) per week are you involved with? _____ hour(s) per *week/month/year

ii. Outdoor activity/ exercise

0. No 1. Yes

If yes, please state the type of activity: _____

And how many hour(s) per week are you involved with? _____ hour(s) per *week/month/year

iii. Part-time job

0. No 1. Yes

If yes, please state the type of activity: _____

And how many hour(s) per week are you involved with? _____ hour(s) per *week/month/year

(*Circle which is appropriate)

SECTION C: HEALTH STATUS INFORMATION

1. Do you have any history of body part injury within the past one year?

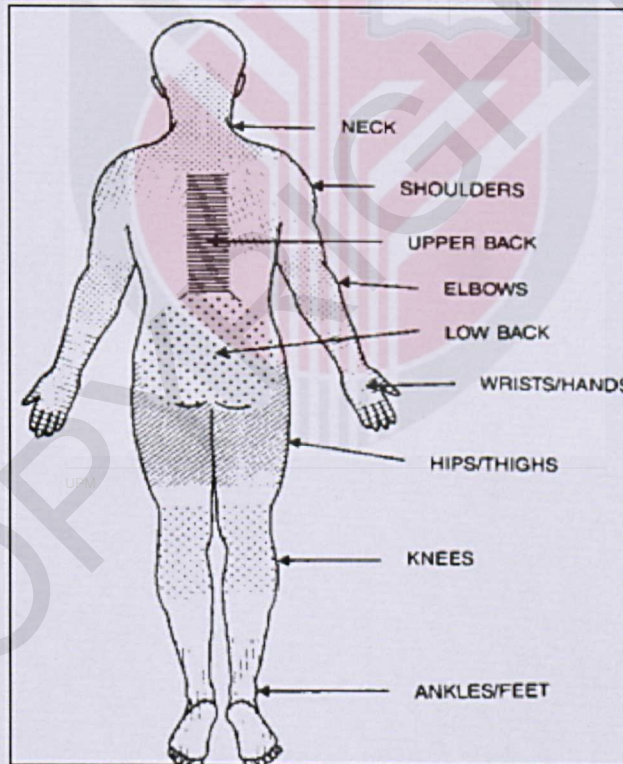
C1

0. No 1. Yes

i. If yes, please tick (✓) for which body part(s) involved (may choose more than one):

C1i

- | | | |
|--|---|------------------------------------|
| 1. <input type="checkbox"/> Neck | 2. <input type="checkbox"/> Shoulders | 3. <input type="checkbox"/> Elbows |
| 4. <input type="checkbox"/> Upper Back | 5. <input type="checkbox"/> Low Back | |
| 6. <input type="checkbox"/> Wrists/Hands | 7. <input type="checkbox"/> Hips/Thighs | |
| 8. <input type="checkbox"/> Knees | 9. <input type="checkbox"/> Ankles/Feet | |



2. Are you pregnant now?

0. No 1. Yes

C2

3. How many hour(s) did you sleep last night? hour(s) minutes

C3

SECTION D: INFORMATION RELATED TO USAGE OF HEELED-SHOES & SHOE INSERT(S)

1. Have you ever worn the heeled-shoe(s) stated below?

- | | 0. No | 1. Yes | |
|-------------------------------------|--------------------------|--------------------------|--------|
| i. Flat-heeled shoe (< 2.0cm) | <input type="checkbox"/> | <input type="checkbox"/> | D1 i |
| ii. Low-heeled shoe (2.0cm - 5.0cm) | <input type="checkbox"/> | <input type="checkbox"/> | D1 ii |
| iii. High-heeled shoe (> 5.1cm) | <input type="checkbox"/> | <input type="checkbox"/> | D1 iii |



Flat-heeled (< 2.0cm)



Low-heeled (2.0cm - 5.0cm)



High-heeled (> 5.1cm)

2. Please answer this question if you have chosen yes (✓) for **flat-heeled shoes** in question 1:

- | | | |
|--|---|--------|
| i. How many year(s) have you been wearing flat-heeled shoe? | <input type="text"/> <input type="text"/> year(s) | D2 i |
| ii. How many day(s) per week do you wear flat-heeled shoe? | <input type="text"/> <input type="text"/> day(s)/week | D2 ii |
| iii. How many hour(s) per day do you wear flat-heeled shoe? | <input type="text"/> <input type="text"/> hour(s)/day | D2 iii |
| iv. How do you feel after wearing flat-heeled-shoes ? | | D2 iv |
| 1. <input type="checkbox"/> Very uncomfortable | 2. <input type="checkbox"/> Uncomfortable | |
| 3. <input type="checkbox"/> Comfortable | 4. <input type="checkbox"/> Very comfortable | |

3. Please answer this question if you have chosen yes (✓) for **low-heeled shoes** in question 1:

- | | | |
|---|---|--------|
| i. How many year(s) have you been wearing low-heeled shoe? | <input type="text"/> <input type="text"/> year(s) | D3 i |
| ii. How many day(s) per week do you wear low-heeled shoe? | <input type="text"/> <input type="text"/> day(s)/week | D3 ii |
| iii. How many hour(s) per day do you wear low-heeled shoe? | <input type="text"/> <input type="text"/> hour(s)/day | D3 iii |
| iv. How do you feel after wearing low-heeled-shoes ? | | D3 iv |
| 1. <input type="checkbox"/> Very uncomfortable | 2. <input type="checkbox"/> Uncomfortable | |
| 3. <input type="checkbox"/> Comfortable | 4. <input type="checkbox"/> Very comfortable | |

4. Please answer this question if you have chosen yes (✓) for **high-heeled shoes** in question 1:

- i. How many year(s) have you been wearing high-heeled shoe? year(s) D4 i
- ii. How many day(s) per week do you wear high-heeled shoe? day(s)/week D4 ii
- iii. How many hour(s) per day do you wear high-heeled shoe? hour(s)/day D4 iii
- iv. How do you feel after wearing **high-heeled shoes**? D4 iv
 - 1. Very uncomfortable
 - 2. Uncomfortable
 - 3. Comfortable
 - 4. Very comfortable

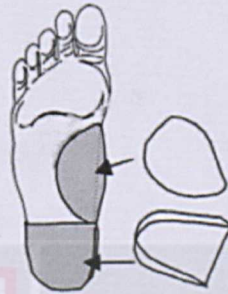
5. If you choose **very uncomfortable** or **uncomfortable** as your answer in any question 2 - 4, please mark appropriate body part(s) which is/are **very uncomfortable** or **uncomfortable** with "X" on the following body diagram (may mark more than one)

- i. NECK D5 i
- ii. SHOULDERS D5 ii
- iii. UPPER BACK D5 iii
- iv. ELBOWS D5 iv
- v. LOW BACK D5 v
- vi. WRISTS/HANDS D5 vi
- vii. HIPS/THIGHS D5 vii
- viii. KNEES D5 viii
- ix. ANKLES/FEET D5 ix

6. Have you ever used shoe insert(s) while wearing heeled-shoes?

0. No 1. Yes

i. If yes, please tick (✓) for shoe insert(s) which you use: (may choose more than one)



Arch support

Heel cup

1. Total contact insert (TCI) 2. Arch support 3. Heel cup

D6

D6i

SECTION E: THIS SECTION WILL BE FILLED IN BY RESEARCHER.

1. Height . m

2. Weight . kg

3. BMI .

*The respondent is **(qualified/ not qualified)** to participate in this study.

4. Foot Anthropometric Data

Right Foot (cm)

Left Foot (cm)

i. Total Foot Length

.

.

ii. Midfoot Width

.

.

iii. Heel Width

.

.

iv. Forefoot Width

.

.

v. Dorsal Arch Height

.

.

E1

E2

E3

a,b

E4i

E4ii

E4iii

E4iv

E4v

SECTION F: AVERAGE STEP COUNT & DISTANCE WALKED
THIS SECTION WILL BE FILLED IN BY RESEARCHER

Heel Heights/ Shoe Insert Conditions	Total step count in 5 minutes (step)			Average steps min ⁻¹		
	Flat- heeled - 2.0cm	Low- heeled - 4.0cm	High- heeled - 6.0cm	Flat- heeled - 2.0cm	Low- heeled - 4.0cm	High- heeled - 6.0cm
Shoe Only						
Arch Support						
Heel Cup						
Total Contact Insert						

i, ii, iii

F1

F2

F3

F4

Heel Heights/ Shoe Insert Conditions	Total distance walked in 5 minutes (m)			Average distance walked min ⁻¹		
	Flat- heeled - 2.0cm	Low- heeled - 4.0cm	High- heeled - 6.0cm	Flat- heeled - 2.0cm	Low- heeled - 4.0cm	High- heeled - 6.0cm
Shoe Only						
Arch Support						
Heel Cup						
Total Contact Insert						

F5

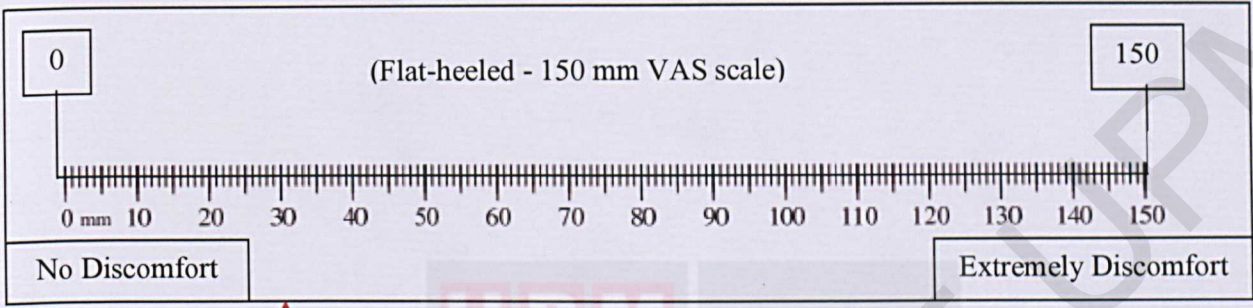
F6

F7

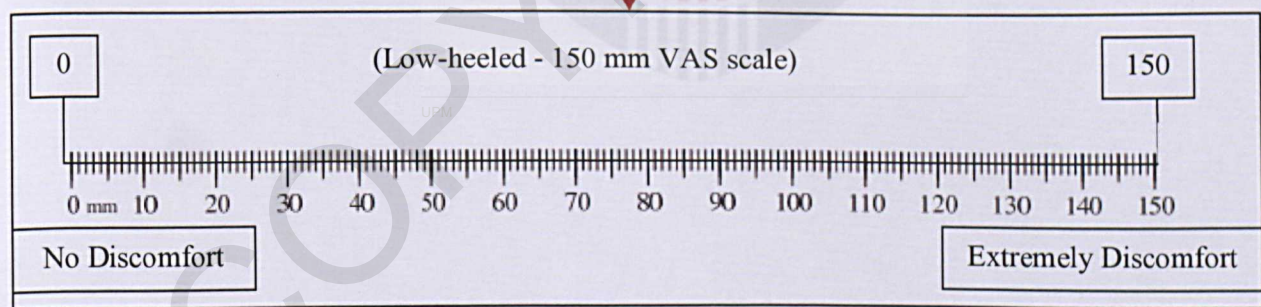
F8

SECTION G: VISUAL ANALOGUE DISCOMFORT SCALE (VAS)

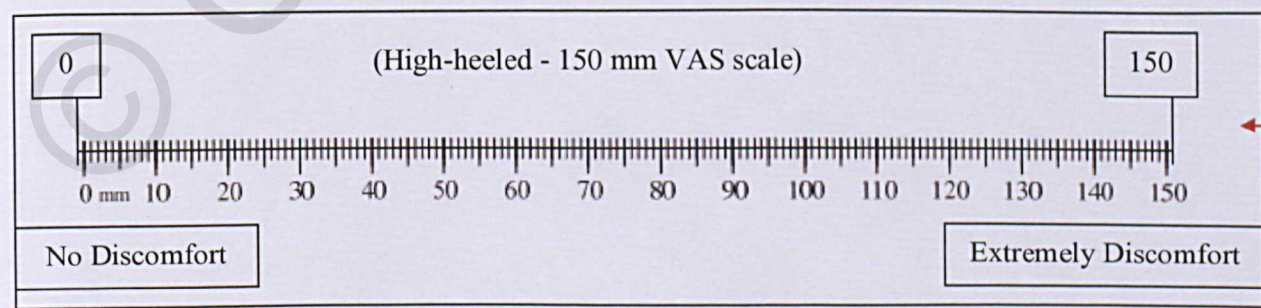
1. 150mm Visual Analogue Scale (VAS) – **HEELED SHOES ONLY WITHOUT SHOE INSERT**
 Please mark (X) on a VAS scale for the level you feel discomfort of body part(s) after practical session.



Gli



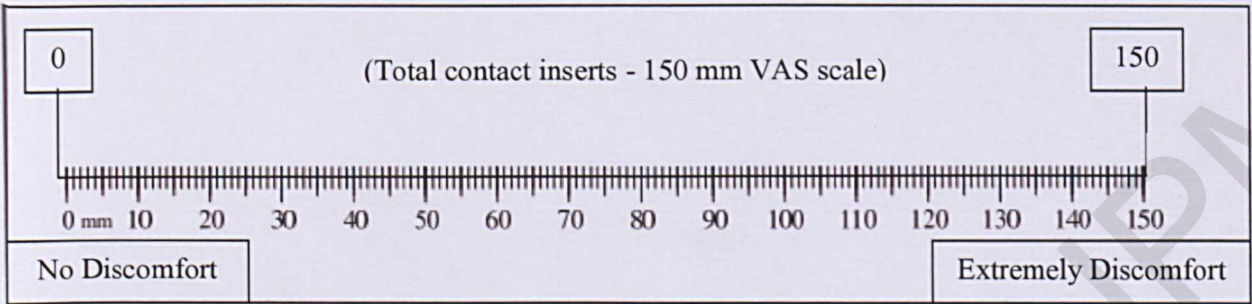
Glii



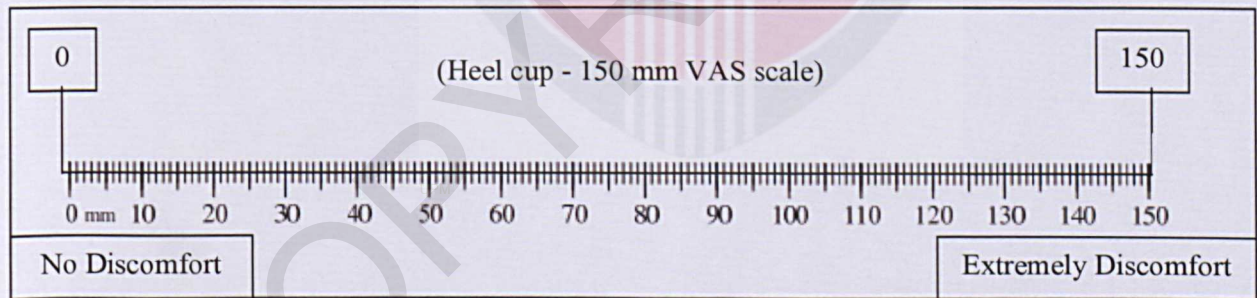
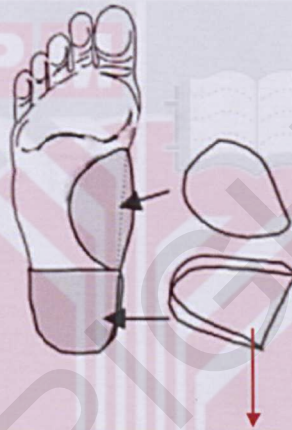
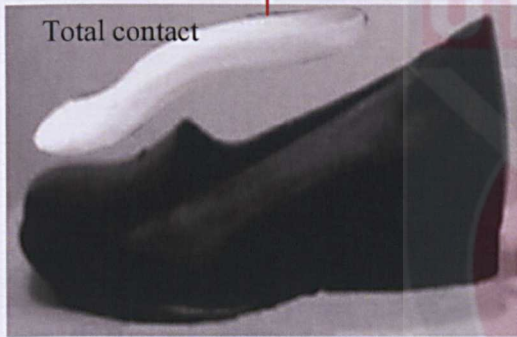
Gliii

2. 150mm Visual Analogue Scale (VAS) – **FLAT-HEELED SHOES WITH SHOE INSERT**

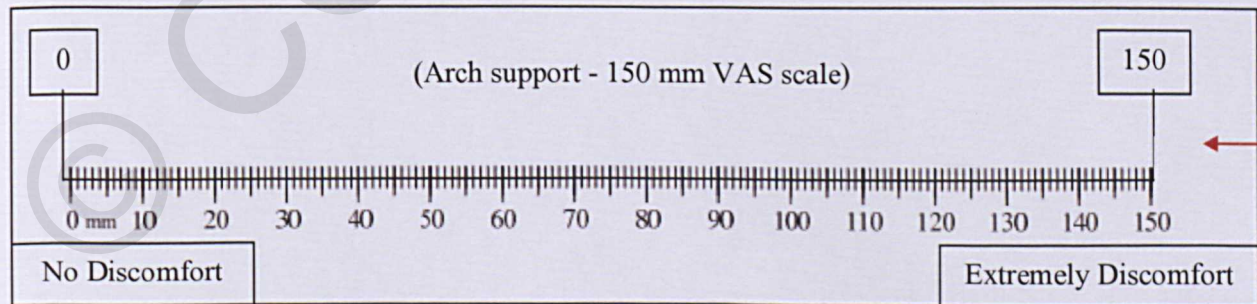
Please mark (X) on a VAS scale for the level you feel discomfort of body part(s) after practical session.



G2i



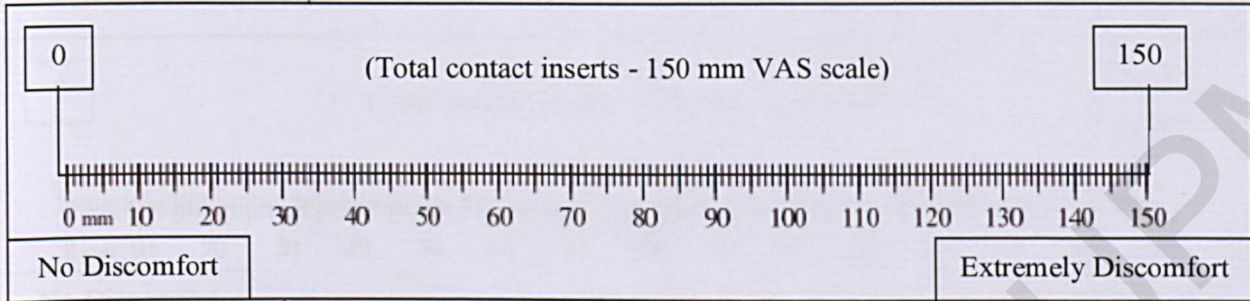
G2ii



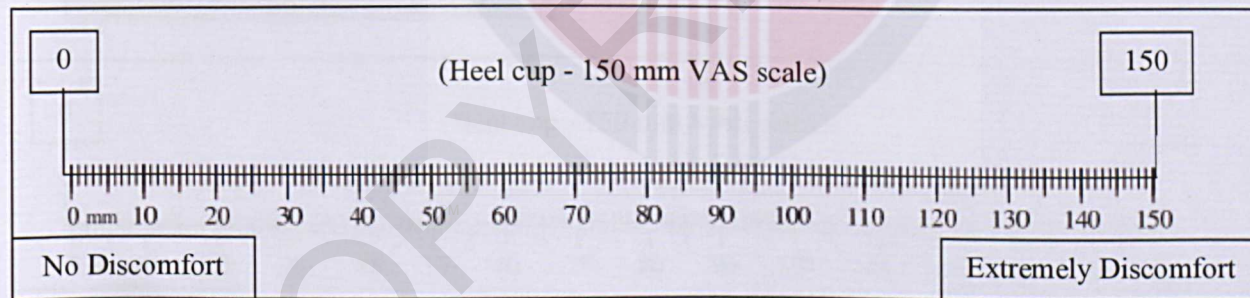
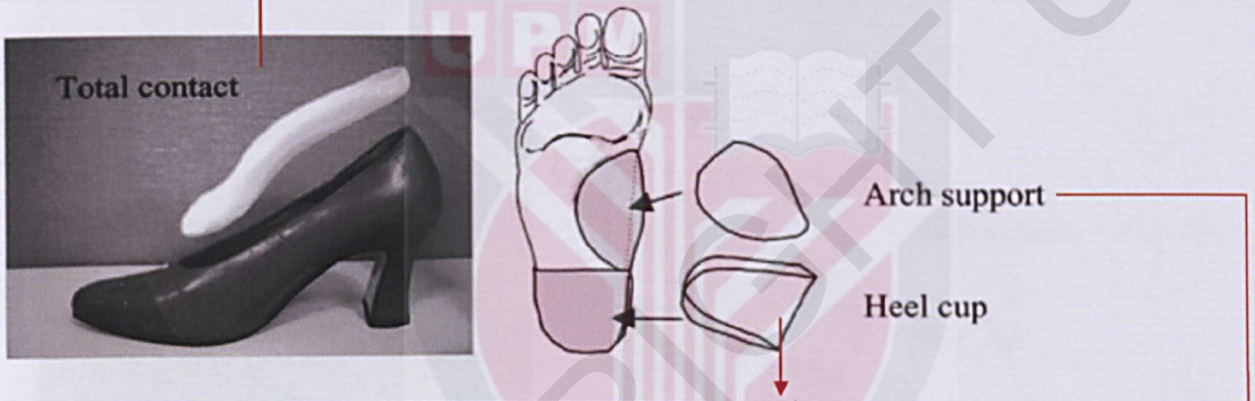
G2iii

3. 150mm Visual Analogue Scale (VAS) – **LOW-HEELLED SHOES WITH SHOE INSERT**

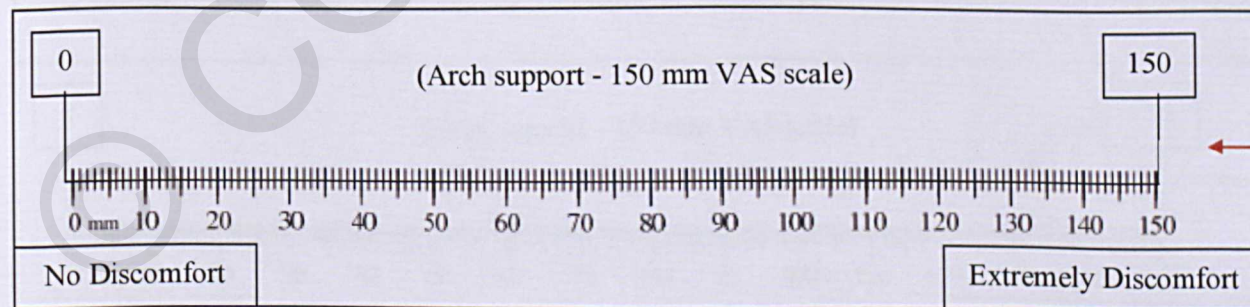
Please mark (X) on a VAS scale for the level you feel discomfort of body part(s) after practical session.



G3i



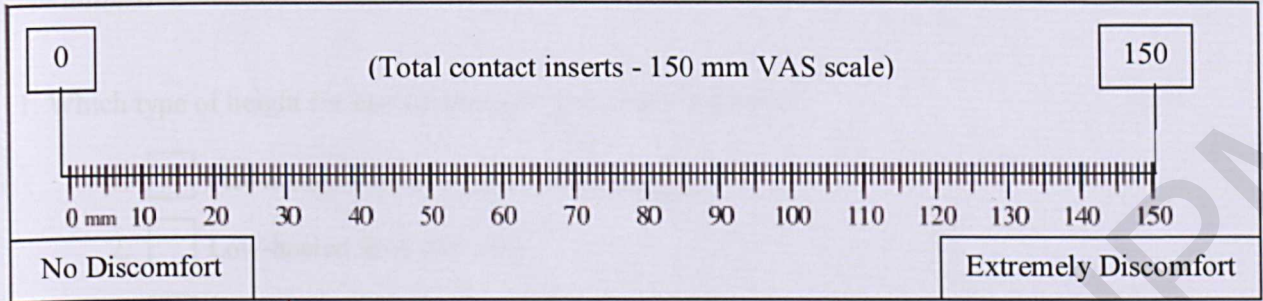
G3ii



G3iii

4. 150mm Visual Analogue Scale (VAS) – **HIGH-HEELED SHOES WITH SHOE INSERT**

Please mark (X) on a VAS scale for the level you feel discomfort of body part(s) after practical session.

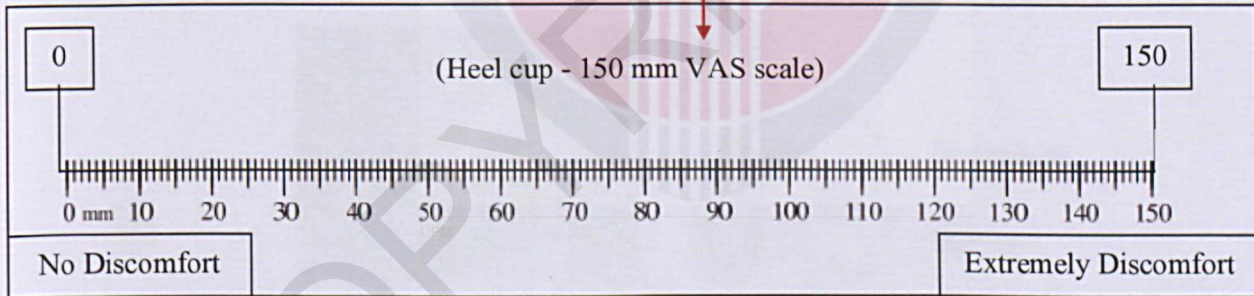


G4i

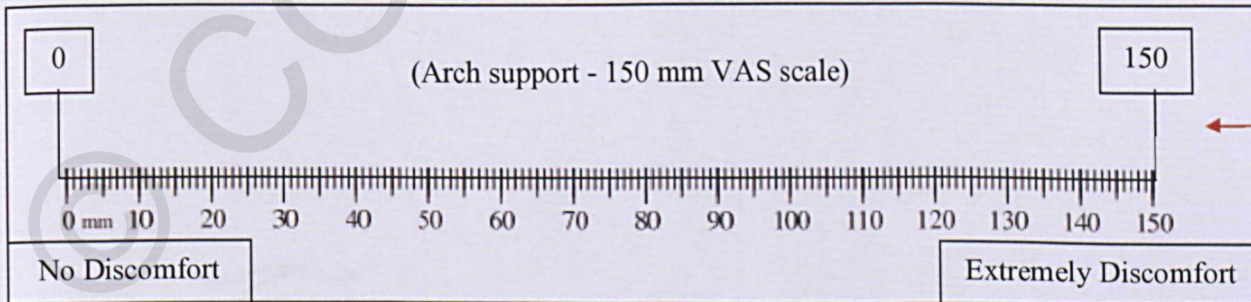


Arch support

Heel cup



G4ii



G4iii

SECTION H: INDIVIDUAL PREFERENCE

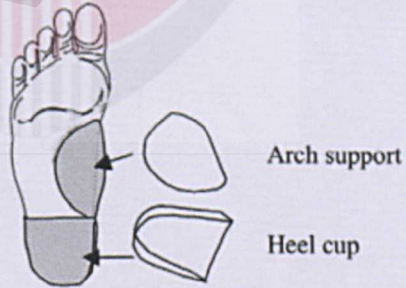
**The following questions are to be answered only if you have completed tasks for all experimental conditions.*

1. Which type of height for heeled-shoes do you prefer the most?

- 1. Flat-heeled shoe (2.0 cm)
- 2. Low-heeled shoe (4.0 cm)
- 3. High-heeled shoe (6.0 cm)

2. Which type of shoe insert condition do you prefer the most?

- 1. Total contact insert (TCI)
- 2. Arch support
- 3. Heel cup
- 4. Shoe only



H1

H2



End of questionnaires. Thank you for your participation!

The logo of Universiti Pendidikan Malaysia (UPM) is a shield-shaped emblem. It features a red and white striped background. At the top left, the letters 'UPM' are written in white on a red rectangular background. In the center, there is a white open book. The shield is surrounded by a grey border.

Appendix 2
Consent Letter



CONSENT FORM (RESPONDENT)

**RESEARCH TITLE: EFFECTS OF HEEL HEIGHTS AND SHOE INSERTS ON
 STEP COUNTS AND PERCEIVED COMFORT AMONG FEMALE
 UNDERGRADUATES IN FMHS, UPM**

RESEARCHER : LEE YOON YEE (148691)

I Identity Card No.
 address.....

.....hereby voluntarily agree to take part in the clinical
 research and questionnaire study specified above.

I have been informed about the nature of the clinical research in terms of methodology, possible
 adverse effects and complications (refer to Information Sheet). I understand that I have the right to
 withdraw from this clinical research at any time without assigning any reason whatsoever. I also
 understand that this study is confidential and all information provided with regards to my identity will
 remain private and confidential.

I wish to *know/don't wish to know the results of the tests performed on my sample.

* delete where necessary

Signature
 (Respondent)

Signature
 (Witness)

Date :.....

Name :.....

I/C No. :.....

I confirm that I have explained to the respondent the nature and purpose of the above –mentioned
 clinical research.

Date

Signature
 (Researcher)



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Appendix 3
Explanation for Respondents

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RESPONDENT'S INFORMATION SHEET

Please read the following information carefully, do not hesitate to discuss any questions you may have with your researcher.

STUDY TITLE

"Effects of Heel Heights and Shoe Inserts on Step Counts and Perceived Comfort among Female Undergraduates in FMHS, UPM"

INTRODUCTION

Today, high heels are more typically worn by females if compared to males, with heights varying from a kitten heel to a stiletto heel (or spike heel) or more. In order to show good image and to be more beautiful in formal places such as university, female undergraduates tend to wear high heels. Oversea studies also show that a prevalence of 83% of foot problems in females wearing high-heeled shoes. Perceived discomfort could contribute to ergonomic problems such as consequent musculoskeletal discomfort, sprained ankles, lower back pain, due to increased spinal curvature, and leg pain, due to added weight placed on the toes. Female undergraduates will be chosen as it is thought that they are more likely to wear perceived voluntary with increased heel height (eg. high-heeled shoes), and they haven't stepped into real working environments which may require they wear high-heels involuntary during working hours such as office ladies, models, promoters, and stewardess. Therefore any findings may also have applications to regular their future female foot-wears on selecting appropriate heel heights and shoe inserts before it is too late. The purpose of this study is to determine whether increasing heel height and use of shoe inserts change step counts and perceived comfort during walking.

WHAT WILL YOU HAVE TO DO?

You should first sign the participant letter to show that you are interested to participate in this research study. You will then be asked to complete the questionnaires (socio-demographic data, health status, and high heels wearing experience). Once you complete the questionnaire, your weight and height will be measured using SECA body meter and DETECTO weighing scale. Also, at the beginning of the experiment, your foot anthropometric data will be taken. In the study, you have to walk on a treadmill for 5 min at 130 cm/s to become habituated to each heel height and walking speed. To prevent fatigue, you will be given a 5-min rest in between. A total of 12 trials (3 heel heights x 4 insert conditions) will be obtained for data analysis. Then, you have to fill in the VAS scale to rate the perceived comfort for each experimental condition in this study. The whole test will take approximately 2 hours to finish, in order completing all heel heights and shoe inserts experiments.

WHO SHOULD NOT ENTER THE STUDY?

Those who had physical disability or foot discomfort problem, suffered an injury to the foot or lower extremity during the preceding year, use of foot bandages or orthoses, and pregnant female should

not enter the study.

WHAT WILL BE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

You may identify a best heel height and best shoe insert to minimize the perceived discomfort and adverse effects on your musculoskeletal system.

b) TO THE INVESTIGATOR?

The significance of this study is not merely to provide more statistics, data and information but also collectively to serve as an indicator for future development in addressing step counts and perceived discomfort due to heel heights. The outcome of this study may recommend a best heel height and best shoe insert to advance the shoe design, minimize the perceived discomfort and adverse effects on the human musculoskeletal system.

ARE THERE ANY RISKS?

This study may cause little psychological risk since the height, weight, foot anthropometric will be taken. Some participants may feel embarrassed. There is no social risk since all the information gathered from the respondent will be treated very confidentially.

WHAT ARE THE POSSIBLE DRAWBACKS?

It may require physical energy consumption of the human body. Every participant will walk on a treadmill for 5 min at 130 cm/s to each heel height and walking speed. However, to prevent fatigue, each participant will take a 5-min rest in between.

WILL THE INFORMATION AND MY IDENTITY REMAIN CONFIDENTIAL?

The data from each individual will remain private and confidential. The results obtained will be reported in a collective manner. Therefore, there will be no reference to a specific individual and names will not be revealed in any report or publications at the end of the study. Only upon request, you will be notified regarding the findings of this research.

WHO SHOULD I CONTACT IF I HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If there is any question or need for clarification, please contact the following person:



FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

Lee Yoon Yee (Undergraduate Student)

Environmental and Occupational Health
Faculty of Medicine and Health Sciences
University Putra Malaysia
43400 UPM
Serdang, Selangor.
Email: yoonyee88@hotmail.com
Tel: 017-2259030

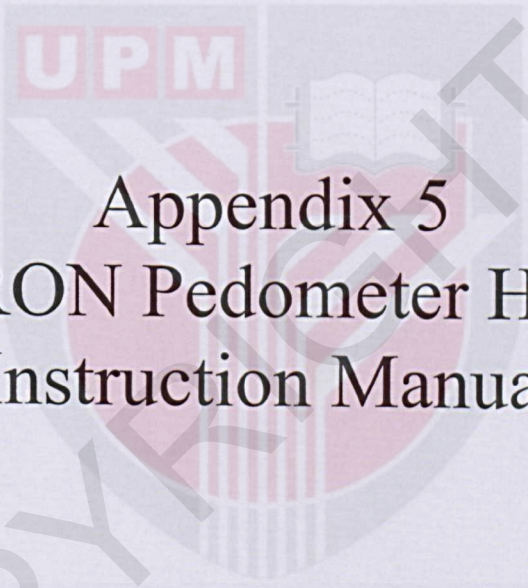
Dr. Anita Binti Abd Rahman (Supervisor)

Department of Community Health
Faculty of Medicine and Health Sciences
University Putra Malaysia
43400 UPM
Serdang, Selangor.
Email: anitaar@medic.upm.edu.my
Tel: 03-8947240



The image features a large, faint watermark of the Universiti Putra Malaysia (UPM) logo in the background. The logo is a shield-shaped emblem with a red and white design, including a book and a sun. The letters 'UPM' are prominently displayed in a red box at the top of the shield.

Appendix 4
Approval Letter from Ethic
Committee



Appendix 5
OMRON Pedometer HJ 105
Instruction Manual



UPM

OMRON®

INSTRUCTION MANUAL

OMRON Pedometer

Model **HJ-105**

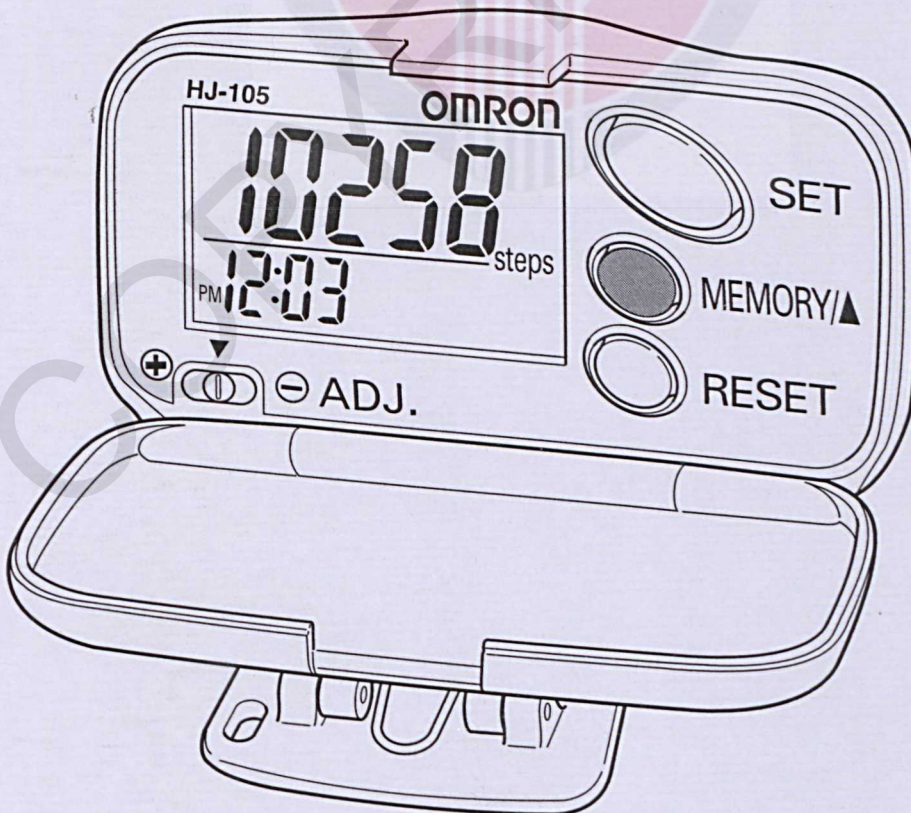


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INTRODUCTION

Thank you for purchasing the Omron HJ-105 Pedometer.

Fill-in for future reference

DATE PURCHASED: _____

Staple your purchase receipt here.

A pedometer is a great motivational tool to track your distance, the number of steps you take and how many calories you burn. The convenient memory function supports the management of daily walking. The dual display function shows both the time and the number of steps simultaneously. You can easily set and reach your daily goals.

Your HJ-105 comes with the following components:

- Main Unit
- LR43 Battery (installed)
- Instruction Manual

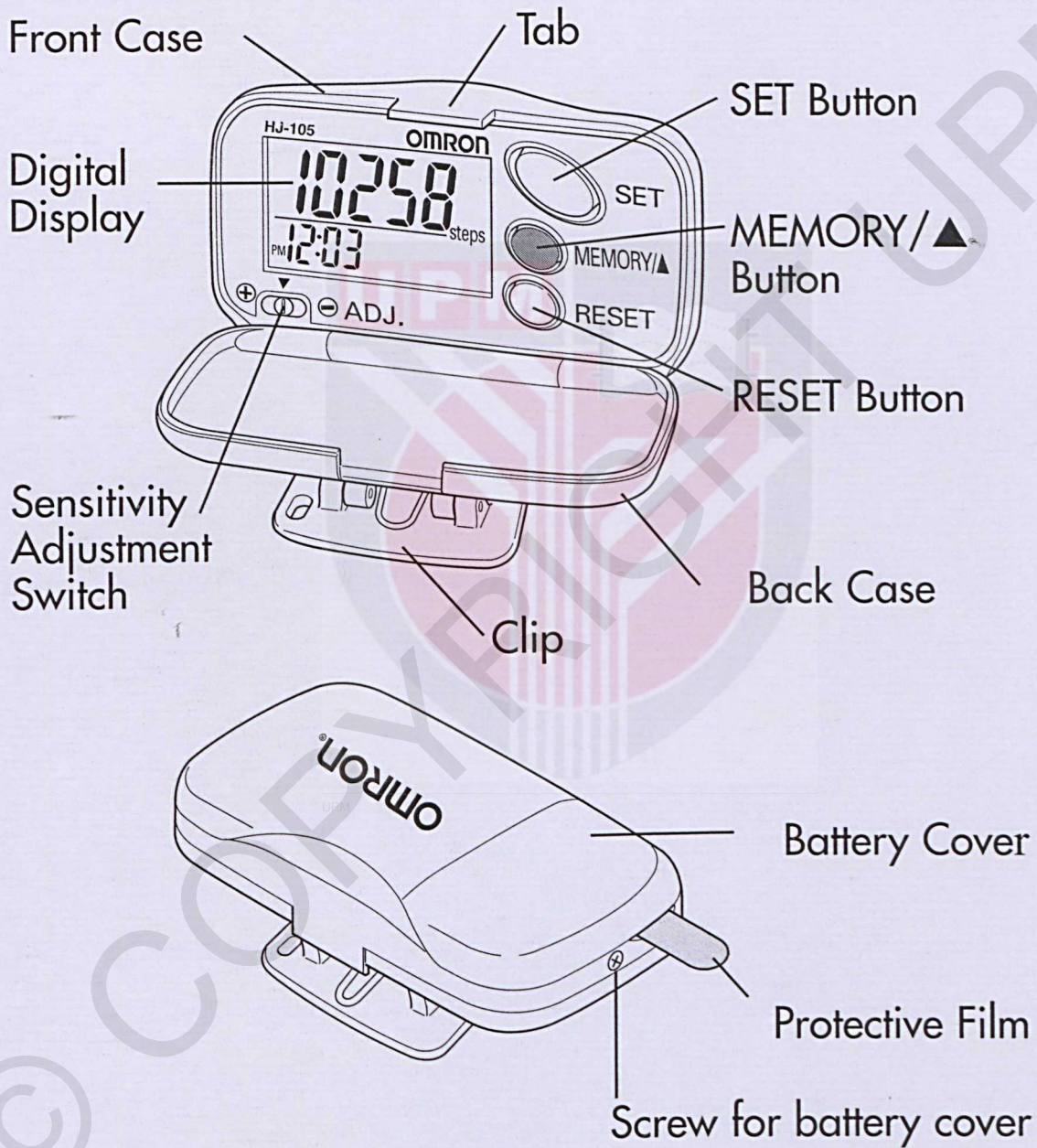
Save These Instructions

IMPORTANT SAFETY NOTES

To assure the correct use of the product basic safety measures should always be followed including the precautions listed below:

- Read all information in the instruction book and any other literature included in the box before using the unit.
- Operate the unit only as intended. Do not use for any other purpose.
- Keep the unit out of reach of young children. If a young child swallows the battery, battery cover, or screw immediately consult with a doctor.
- Properly dispose of used battery. Do not throw the battery into fire. The battery may explode.
- Do not disassemble or modify the unit. Changes or modifications not approved by Omron Healthcare will void the user warranty.
- Consult your physician or healthcare provider before beginning an exercise program.

KNOW YOUR UNIT



AEROBIC STEP FUNCTION

Helpful for building your health, the unit can measure the number of aerobic steps that can be considered an effective exercise to improve cardiovascular fitness.

The number of “aerobic steps” indicates the number of steps that can be considered as effective aerobic exercise.

The unit displays the total number of steps in a day, which satisfies the following two conditions:

1. Walk more that 60 steps per minute
2. Walk for more that 10 minutes continuously

The total duration you walked as the number of aerobic steps is also displayed in minutes.

Example: If you walk for 20 minutes at the speed of 120 steps per minute, the number of aerobic steps is 2400.



NOTE: Taking a rest for less than 1 minute during continuous walking for more than 10 minutes is considered as continuous walking.

CALORIE/AMOUNT OF FAT BURNED

The amount of fat burned is displayed in grams simultaneously with the amount of calories consumed.

This information can be used for diet planning.

The calorie/amount of fat burned display indicates the estimated calories consumed by walking calculated from the weight, stride distance, number of steps, and walking speed.

The actual calories/amount of fat burned varies with age and gender. To improve the accuracy of the calculation, multiply the displayed calorie/amount of fat burned by the coefficient in the table shown below.

Correction coefficient for calorie display

Example of correction:

For a woman in her 50's with the calorie display of 300, the consumed calorie is calculated as follows.

$$300 \times 0.95 = 285 \text{ kcal}$$

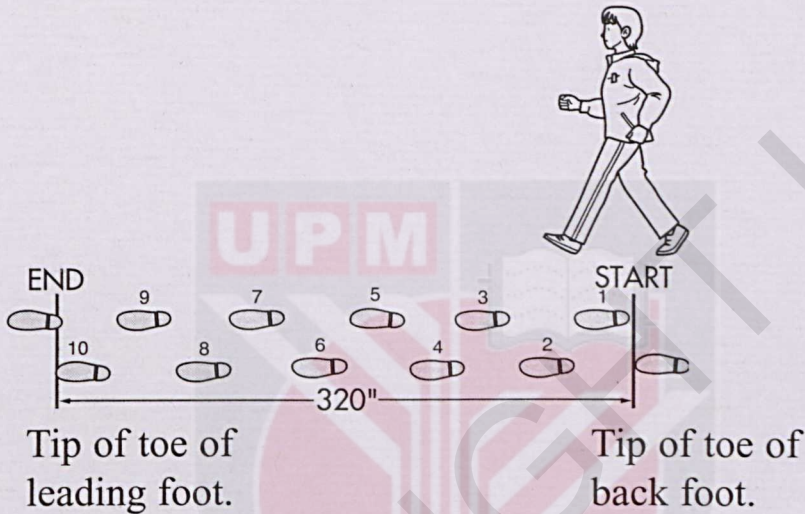
	Man	Woman
20's	1.10	1.07
30's	1.05	1.01
40's	1.02	0.97
50's	1.01	0.95
60's	1.00	0.95
70's	0.98	0.96
80's	0.95	0.95

STRIDE LENGTH MEASUREMENT

Measure your stride length before beginning to set the pedometer.

1. How to measure your stride length

Walk 10 steps with your normal stride as illustrated below.



2. Measure the distance from START to END in inches.
3. Calculate your stride length by dividing the total distance by 10.
4. Convert your stride length to feet and inches. You will set the stride length using feet and inches.

Example:

Total Distance from START to END = 320" (inches)

$320'' \div 10 = 32''$ (inches)

$32'' = 2' 8''$ (2 feet 8 inches)

Conversion Chart

12" inches = 1' foot

24" inches = 2' feet

36" inches = 3' feet

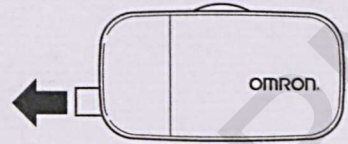
48" inches = 4' feet

ACTIVATING THE BATTERY

Open the unit and remove the protective film from the face of the display.

The pedometer will not draw power from the battery until the insulation film is removed.

Pull the tab in the direction of the arrow as illustrated.



All displays will turn on for approximately 2 seconds. The unit will proceed to the setting mode.



SETTING THE TIME

1. Press and hold the SET Button.
Hour Display Blinking

Example: To set the time to 2:30 p.m.

2. Press the MEMORY Button to adjust the hour.



NOTE: Press and hold the RESET Button for 2 seconds to reset the hour to 12AM.

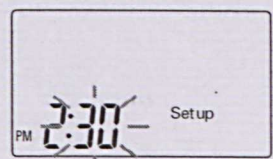
Press the SET Button
Minute Display Blinking



3. Press the MEMORY Button to adjust the minute. Press and hold the MEMORY Button to advance in 10-minute increments.

NOTE: Press and hold the RESET Button for 2 seconds to reset the minute to 00.

Press the SET Button.
The time is set.



Weight Display Blinking

SETTING THE WEIGHT

Set weight within the range of 70 to 300 pounds

Weight Display Blinking

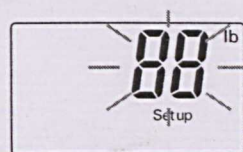
1. Press the MEMORY Button to adjust the weight. Press and hold the MEMORY Button to advance in 10-pound increments.

NOTE: *Press and hold the RESET Button for 2 seconds to reset the weight to 88 pounds.*

Press the SET Button.

The weight is set.

Stride Display Blinking



Example: To set the weight to 145 lbs



SETTING THE STRIDE LENGTH

Set stride length between 1'00" and 4'00".

1. Press the MEMORY Button to adjust the stride length. When the stride length reaches 4'00" the display will return to 1'00".

Example: To set the stride distance to 1'10"

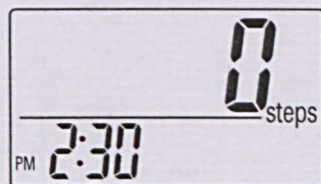


NOTE: *Press and hold the RESET Button for 2 seconds to reset the stride length to 1'08".*

Press the SET Button.

The stride length is set. The screen will display the number of steps and the time.

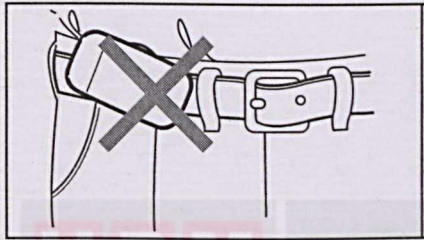
NOTE: If the Set Button is not pressed for 5 minutes without setting the time, weight, or stride length the screen will display the number of steps and time. Go to Setting the Time begin to set the unit.



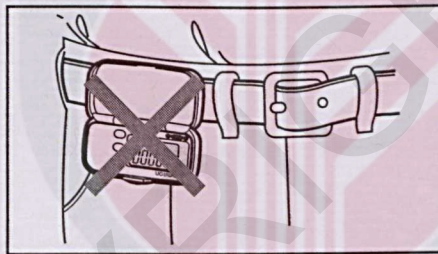
ATTACHING THE PEDOMETER

Clip the pedometer to your belt or the top of your waistband.

The unit must be positioned horizontal with the ground for the unit to function correctly.



The case should be closed during use. Open only to see readings. The unit will not count steps if the case is open.



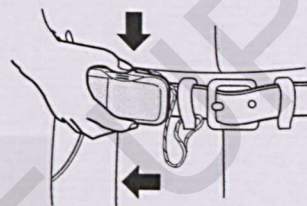
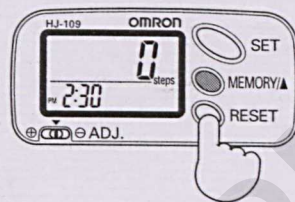
NOTE: The unit may not count steps correctly in the following conditions:

1. When the unit is being set
2. When you walk at an inconsistent pace
 - When you shuffle or wear sandals
 - When you fail to walk consistently in a crowded place
3. When you use the unit in a place where up and down movements take place
 - Standing up and/or sitting down
 - Playing sports other than walking
 - Ascending or descending movement on stairs or steep slopes
 - Vertical or horizontal vibration in a moving vehicle such as a bicycle, automobile, train or bus

USING THE PEDOMETER

After you have completed setting the pedometer the unit may display steps, number of aerobic steps, calories and distance.

1. Press the RESET Button for 2 seconds to reset the data to zero.
2. Close the case and attach the unit to your belt or waistband.
3. Walk 100 steps to confirm the unit counts your number of steps correctly.



Note: If a discrepancy between the number of steps walked and the number of steps displayed on the unit is found adjust the sensitivity switch.

4. Start walking.

ADJUSTING THE SENSITIVITY SWITCH

The unit can be adjusted to a $\pm 5\%$ accuracy rate ($\pm 5\%$ steps against 100 steps) when used on a level surface at a consistent walking pace.

Attach the unit to your belt or waistband and walk 100 steps.

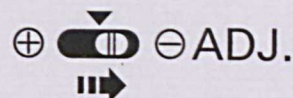
- **Reading is 105 steps or more**

Slide the ADJ. Switch to the

⊖ minus direction.

- **Reading is 95 steps or less**

Slide the ADJ. Switch to the ⊕ plus direction.



NOTE: You may need to adjust the Sensitivity Switch if you change your walking speed.

USING THE MEMORY FUNCTION

This unit can store up to seven days of data for the number of steps, number of aerobic steps with minutes for aerobic steps, calorie with amount of fat burned, and distance.

The current day data is automatically stored in memory when the time reaches 12:00 AM. The display will return to zero.

You do not need to press the RESET Button every day.

NOTE: The time must be correctly set in the unit.

How to view data stored in the memory

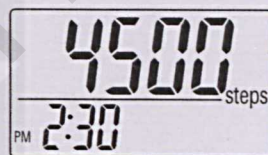
Press the SET Button until the data you want to see is displayed:

Steps

Aerobic Steps / Aerobic Time

Calories Consumes / Fat Grams Burned

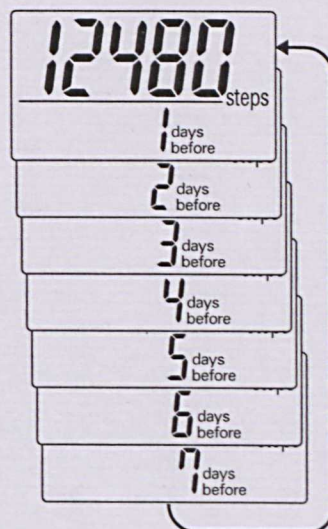
Distance



Press the MEMORY Button.

The previous day data is displayed.

Continue to press the MEMORY Button until all seven days of stored data is displayed.



NOTE: The time is not displayed when using the memory function.

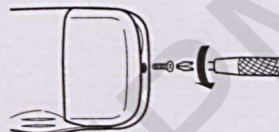
TROUBLESHOOTING

Problem	Probable Cause	How to Correct
The battery indicator blinks.	The battery is low or worn.	Replace the battery with a new LR43.
Nothing is displayed.	The polarities of the battery (+ and -) are aligned in the wrong direction.	Insert the battery in the correct alignment.
	The battery is worn.	Replace the battery with a new LR43.
The displayed values are incorrect.	<p>The unit is positioned incorrectly.</p> <p>Case open during use.</p> <p>Up and down movement.</p> <p>Inconsistent pace.</p>	Refer to “Attaching the Pedometer” on Page 11.
	The set values are wrong.	Check the weight and stride length settings.
	Change in walking speed.	Adjust the sensitivity control switch.

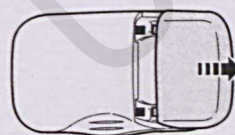
BATTERY INSTALLATION

When the battery is removed from the unit the settings will return to the default values. All data stored in the memory will be erased.

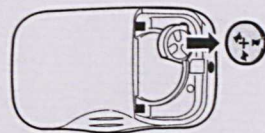
1. Remove the screw from the battery cover.
Use a Phillips screwdriver.



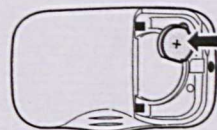
2. Open the battery cover.



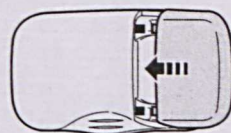
3. Replace the battery with a new LR43 battery.



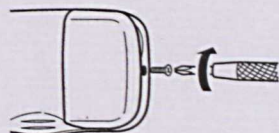
Face the positive (+) side of the new battery upwards. Insert the battery in the direction of an arrow.



4. Close the battery cover.



5. Tighten the screw on the battery cover.



NOTE: After installing the new battery set time of day, weight and stride length.

CARE AND MAINTENANCE

Clean the unit with a soft dry cloth.

- Do not use any abrasive or volatile cleaners.
- The unit is not waterproof. Do not wash it or touch it with wet hands.
- Never immerse the unit in water.
- Be careful so water does not get into the unit.

Store the unit in a safe and dry location.

- Avoid the unit being exposed to direct sunlight, high temperatures, high humidity, water and/or dust.

Do not subject the unit to strong shock, drop, or step on the unit.

Use the unit consistent with the instruction provided in this manual.

SPECIFICATIONS

Model:	Omron Pedometer HJ-105	
Power Supply:	1.5 VDC (one LR43 battery)	
Measurement Range:	Number of steps:	0 to 99,999 steps
	Number of aerobic steps:	0 to 99,999 steps
	Duration of aerobic walk:	0 to 1440 minutes
	Calorie:	0 to 99,999 kcal
	Amount of burned fat:	0.0 to 199.9 g
	Distance:	0.00 to 999.99 miles
	Time:	12:00 AM to 11:59 PM
Memory:	Number of steps:	previous 7 days
	Number of aerobic steps:	previous 7 days
	Duration of aerobic walk:	previous 7 days
	Calorie:	previous 7 days
	Amount of burned fat:	previous 7 days
	Distance:	previous 7 days
Setting Range:	Time:	12:00 AM to 11:59 PM (12 hour display)
	Weight:	70 to 300 lbs (in increments of 1 lb.)
	Stride Length:	1'00" to 4'00" (in increments of 1")
Operating Temperature:	14°F to 104°F (-10°C to +40°C)	
Precision of		
Step Counting:	Within +/- 5% (by vibration testing machine)	
Time Precision:	Within +/- 90 seconds of the average monthly deviation (under normal temperature)	
Battery Life:	Approx. 3 months. Varies depending on usage	
External Dimensions:	Approx. 2 1/2" x 1 1/2" x 1"	
Weight:	Approx. 0.85 oz (including the battery)	
Contents:	1 Pedometer, 1 Battery (LR43 installed) and 1 Instruction Manual	

- Specifications are subject to change without notice.

WARRANTY INFORMATION

LIMITED WARRANTIES

Your HJ-105 Pedometer, excluding the battery, is warranted to be free from defects in materials and workmanship appearing within 1 year, when used in accordance with the instructions provided with the monitor. The above warranties extend only to the original retail purchaser.

We will, at our option, repair or replace without charge the monitor covered by the above warranties. Repair or replacement is our only responsibility and your only remedy under the above warranties.

To obtain warranty service, ship the monitor and all of the components, together with proof of purchase and a note explaining the problem with \$5.00 for return shipping and insurance to:

Omron Healthcare, Inc.
Attn: Repair Department
300 Lakeview Parkway
Vernon Hills, IL 60061

Be sure to include the model number, your name and your phone number on the enclosed note and any other correspondence.

ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THE APPLICABLE WRITTEN WARRANTY ABOVE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

OMRON SHALL NOT BE LIABLE FOR LOSS OF USE OR ANY OTHER INCIDENTAL, CONSEQUENTIAL OR INDIRECT COSTS, EXPENSES OR DAMAGES. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which may vary from state to state.

FOR CUSTOMER SERVICE (US & Canada)

Visit our web site at:

www.omronhealthcare.com

Call toll free:

1-800-634-4350



Manufactured by: OMRON

Distributed by:

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300 Lakeview Parkway

Vernon Hills, Illinois 60061

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HJ-105INST Rev A