Research Article

Guidelines for Selecting the Appropriate Heel Insoles on Ladies Flat Shoes with Walking Activity

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Abstract
The interviewed 150 ladies from the central provinces of Thailand prefer to wear flat shoes for performing daily activities. A 54% of the interviewed group prefers to apply heel insoles for releasing stress occurred during the day; especially the ladies who are members of an aircrew or a flight attendant. Some insoles or heel inserts are available in the market without clear product instructions or descriptions, only the trained brand ambassadors have introduced and suggested the specific characteristics of their products. Cost of inserts is depended upon the reliability, the brand designers or the materials of the product. Providing product description clearly on the package can help the customers avoid any confusion and eliminate issue about having trouble getting comfortable when they are wearing shoes with inserts. Applying the technical applications proposed in this research can help to select the appropriate insoles with a reasonable price for minimizing foot pain or extending the walking period tolerance of daily activities where the same or favorite shoes still be applied.

Keywords: Heel insoles, Customer's requirement, Reverse Engineering (RE), Virtual model, Contact data acquisition, Insert materials

1 Introduction

Nearly a million ladies who decided to purchase products in the last five years were influenced by various sources such as internet, social media, offline-magazines, and direct conversations. Among those factors, they prefer to consult friends and family for making a purchase, and they finally judge the quality and reliability of the product by using the emphasized face-to-face conversations. For needs, they can be classified into five main types: self actualization needs, esteem needs, social needs, safety needs, and physiological or basic needs [1]. The products purchased by ladies, in general, are grouped as integrated social-basic needs such as fashionable shoes, bags or clothes. The purchasing decisions of social basic needs are influenced by online (e.g., internet) and offline (e.g., magazines) social medias where the prices of the fashionable things are depended upon shapes, designs, designers, colors, and materials. Recently, ladies have spent a lot of money for buying the shoes that can represent the sense of personal identity and inspire the special characteristics for making a person unique [2]. The eight-hour workday is ineffective approach to work when a pair of insufficient shoes is applied. For ladies who prefer to wear the same shoes for a whole day, they decide to add the extra comfortable inserts onto their beloved or favorite shoes since the heel area or the part of the sole will suitably raise the rear of the shoes in relation to the front. The commercial materials applied for inserts are advertised in various sources. The brand ambassador

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(i.e., a salesperson or other company representative) drives the ladies to make a quick purchasing-decision. Some materials of the inserts are suitable for just standing position or a few movements; some designs of the inserts are perfectly fitted to the shoes that provide enough space around the heel area. For an eight-hour outing or walking activity, ladies prefer the shoes that contain a design offering high arch support with a wide toe box leaving plenty of room for comfort; however, they need the extra textured bottom or heel inserts for keeping foot in place and keeping them from misaligning their bodies. Different foot characteristics, structures, and different everyday activities cause different foot's problems. Selecting the appropriate types of heel inserts can help the ladies feel more comfortable during a long walking activity, bring them to be more productive, active, and provide health benefits.

These have led to the proposed approach where the walking simulation has been applied on various types of the heel inserts, and the flat shoe designed with a rubber sole is selected as the reference shoes for this research. The proper design of heel inserts for supporting walking activity will be guided and discussed where the purchasing characteristics of ladies on foot inserts have been studied and analyzed through the questionnaires during initial stage of the research.

2 Related Works

Recently, the manufacturers have applied various types of material for making inserts: foam rubber, cellular polymers (e.g., polypropylene, polyethylene, ethylene vinyl acetate, polyurethane and segmented polyetherurethane) [3], [4], plastic material (PVC), natural materials (leather), and the composite material. These kinds of material have different characteristics and properties, for example, if the odor is emphasized on heel insole, the foam rubber has poor ventilation and heat retaining that is not suitable for making heel insole. Moreover, a non-slip technology of PU gel can help to stay firmly in place of the heel while walking [5].

According to the suitable structural and cushioning properties cellular polymer, they are recommended to use as heel insoles effectively [6]. The important characteristics of heel insole materials

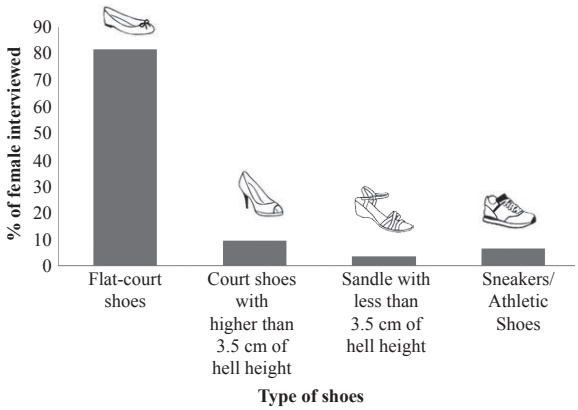


Figure 1: Results of the interviews: shoes selections from ladies.

are biocompatibility, ease of use, ease of fabrication, availability, and durability [7]. The simulation of mechanical properties of soft tissue, and subjective comfort and cost are also analyzed for the dynamic activities [8]. Walking activity, even it is good for health, may cause the feet disorders such as knee pain [9], osteoarthritis [10], and plantar heel pain [11]. There are many shapes, material types, and price of heel insoles available in the market for absorbing pressure during walking and relieving pain on feet [6].

3 Research Concepts

In order to observe ladies' behaviors for purchasing shoes, the surveys were conducted where 150 ladies between the ages of 20 and 35 years were asked for filling the questionnaires which were considered as self-administered questionnaires. Shoes shops in shopping malls around the central provinces of Thailand (i.e., Bangkok metropolitan region, Sumutprakarn, and Nonthaburi provinces) were the sample locations used for observing the purchasing behaviors. To accomplish the aim of the proposed approach, details of shoes style, problems occurred on wearing shoes, experiences on using the heel insoles, satisfactions/expectations of applying inserts, types/materials of the used inserts, and prices of the inserts, were considered and analyzed. As the results, there is 90% of those ladies have more than 5 shoes for supporting daily activity. A majority of ladies (i.e., 85%) has decided to buy flat shoes where the heel height of the shoes is less than 3.5 cm. [12] (as shown in Figure 1).

In order to accomplish the proposed approach, the appropriate guidelines for the ladies who would like to select the heel insoles for walking activity have been created by using the concept of product design and development [13]. The concept development phase will be emphasized and researched. The overall steps required for accomplishing the proposed are presented in Figure 2.

In world business community, the proportion of ladies of working age is increasing while the relative number of the retired is decreasing. In general, the ladies spend their entire week for doing various outdoor activities. For focusing on the customers who have been influenced by social media, friends, culture, self-motivation and decisions, and perceptions, ladies between the ages of 20 and 35 years have been researched as the target group. The other characteristics of a specific target group are presented below;

- *Ladies between the ages of 20 and 35 years*: This is because ladies between the ages of 20 and 35 years have been influenced by the external factors such as fashions, culture, designs or friends [14]. They always change and buy the shoes every few weeks, and they are very active for dynamic activities.
- *Heel height*: According to a person in the age range of 20 to 35, wearing flat shoes (i.e., with 3.5 cm-heel height) is very popular since the majority of shoes type available for ladies in many department stores is flat-shoe-type.
- *Average weight*: The weight range of Asian ladies is around 50–57 kg [15]. Therefore, the sample who is asked for demonstrating the proposed approach should weigh around that considered range.
- *Normal feet*: This research focuses only on the normal feet because the expected results should be analyzed and obtained without any hidden factors as happened in the flat or high arch feet.
- *The participant has no serious accident affected the nerve on lower limb*: If this characteristic is not specified, the results from the experiment may be not reliable. Even through some people recover the pain from the accidents, they are sensitive affected the nerve on their foot and legs rather than usual people. Moreover, they should also do not have any feet disorder previously.

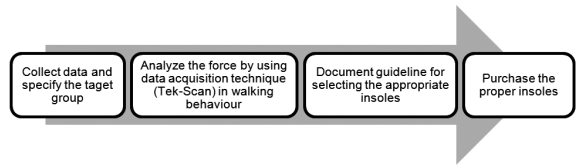
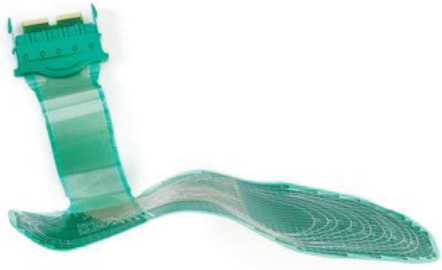


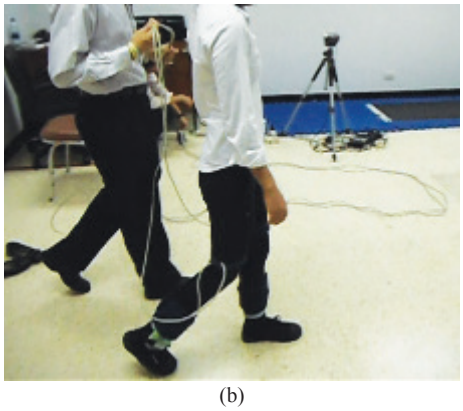
Figure 2: The steps of proposed research.

Figure 3: Six types of heel insoles: (a) specimen 1 (gel and rubber with cloth on top), (b) specimen 2 (natural latex foam), (c) specimen 3 (silicone gel), (d) specimen 4 (gel with cloth on top), (e) specimen 5 (soft foam), (f) specimen 6 (invisible gel).

In order to measure and analyze the force, area and pressure by using the flexible, actual simulation called Tek-Scan [16] has been applied. Six insert types [ranging from Figure 3(a) to (f)]; gel and rubber with cloth on top, natural latex foam, silicone gel, gel with cloth on top, soft foam, and invisible gel, will be named as specimen 1 to 6 and they are located on the foot bed around heel position. Then the ultra-thin load cell with sensors [Figure 4(a)] is later placed onto the inserts. Before inserting the load cell, it needs to be cut into the desire shape to nearly fit the shoes of the participant. When a load (body weight) is applied on the load cell, the pressure and force distributed on the feet and inserts can be immediately recorded up to 8 seconds or 400-snapshot frames [Figure 4(b)]. The software will report the forces, contact areas and contact pressures of all frames taken as the graphs and numeric values of a period oscillation.



(a)



(b)

Figure 4: Tek-Scan simulation: (a) Flexible, thin-in shoe load cell, (b) The experimental conducting for walking.

In order to conduct the experiment to determine the force and pressure acting on the feet and inserts, a participant (lady who has the normal feet and her weight is around 53 kg) is asked for walking slowly and naturally. During the walking activity, Tek-Scan records up to 6–7 walking steps of each foot side within 8 seconds and provides the detail information about the forces, areas and the pressures.

After applying Tek-Scan for actual simulation, the best characteristic of shape and material of heel insoles that has the lowest pressure can be determined. The pressures that are used to analyzed come from the average of pressure of both foot sides (left and right) for all five steps. The value of first step of walking is not used because during the experiment, it might occur the error from the beginning of walking (may come from feeling nervous by participant while conducting the experiment). To document guidelines for selecting the appropriate heel insoles for walking, the results from Tek-Scan obtaining the best characteristic of shape and material used to produce heel insoles for long-walking people is made.

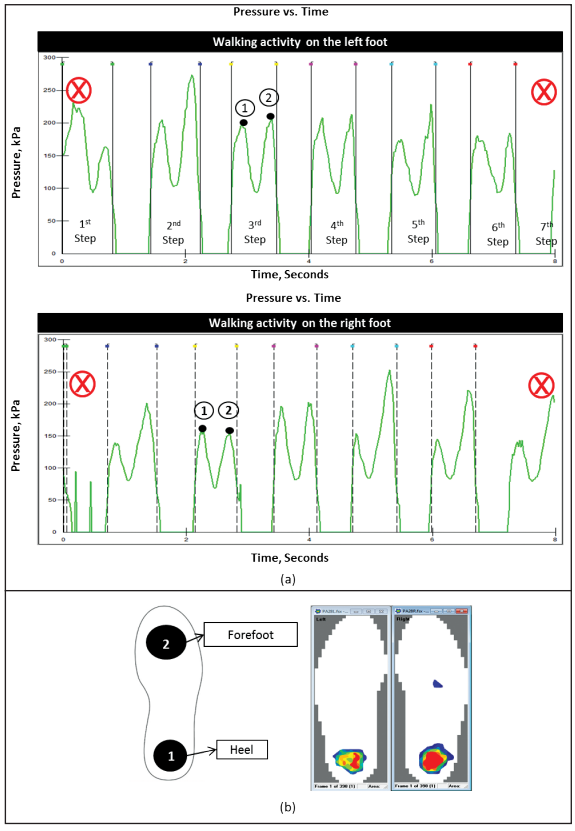


Figure 5: Testing results: (a) Graphs of walking activity on left and right foot, (b) Pressure distributed on left and right foot.

4 Results and Discussions

The results are presented as the graph [shown in Figure 5(a)] and simulation on load cell [shown in Figure 5(b)]. From the graphs of walking activity on left and right foot [Figure 5(a)], two peaks in each step are the positions of foot contacting the floor; the first position (i.e., the 1st peak) is the pressure on the heel happened when the participant starts walking in which the heel is the first area contacting to the floor. The second position (i.e., the 2nd peak) presents the forefoot region that is later touched the floor to fulfil the completion of one walking step. The obtained values of pressure can be used to determine the trend of insert type which provides the best result for relieving pain on the feet during walking activity.

During the test, from 8-second walking activity, the participant was allowed to walk only 7 steps. In

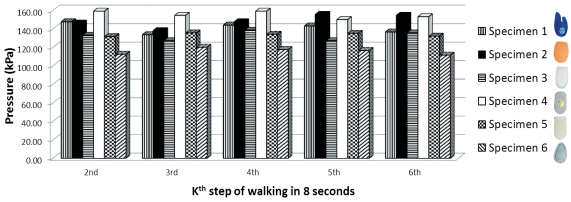


Figure 6: Graph showing results of pressure from Tek-Scan.

order to obtain the accurate results, the 1st and the 7th steps were cut off since the force, pressure were not stable. Therefore, the consideration periods were considered and analyzed from the 2nd to the 6th step (as shown in Figure 6. and Table 1).

After considering the values of average pressure on both left and right foot of all six specimens, the lower pressure indicates that the inserts can potentially absorb the pressures distributed on the forefoot region and the heel areas. The best absorber is presented at specimen 6 which is invisible gel. Hence, for supporting the one who would like to increase the performance of a long period or eight-hour workday such as an aircrew or a flight attendant, applying the heel inserts with invisible gel onto the flat shoe is recommended.

5 Conclusions and Recommendations

After accomplishing the simulations, the obtained results can be used as the guidelines for the ladies who perform as aircrew duties or spend a long period for walking activity to select the appropriate insert. From the experiment, it was suspected that the invisible gel provides the best result for relieving some pains around the heel, and making the ladies feel more comfortable when walking activity attempts since the pressure distributed on the area of the foot is minimum comparing to the other materials of the heel inserts. Moreover, having the shape and the textures similarly to the specimen 6 (Figure 7) provides increased stability, and keeps the shoes from slipping out of their feet while walking.

Table 1: Results of pressure from Tek-Scan

Insert Type	K^{th} step of walking in 8 seconds	Average Pressure [kPa]		Average Pressure [kPa] (5 Steps)	
		Left	Right	Left	Right
Specimen 1 (Gel and rubber with cloth)	2	169.00	126.00	150.60	131.20
	3	151.00	116.00		
	4	151.00	137.00		
	5	143.00	143.00		
	6	139.00	134.00		
Specimen 2 (Latex foam)	2	161.00	131.00	164.20	132.40
	3	148.00	128.00		
	4	157.00	138.00		
	5	179.00	132.00		
	6	176.00	133.00		
Specimen 3 (Silicone gel)	2	142.00	124.00	147.40	117.00
	3	144.00	110.00		
	4	153.00	124.00		
	5	138.00	116.00		
	6	160.00	111.00		
Specimen 4 (Gel with cloth)	2	162.00	156.00	153.40	156.80
	3	159.00	150.00		
	4	161.00	157.00		
	5	133.00	167.00		
	6	152.00	154.00		
Specimen 5 (Soft foam)	2	137.00	126.00	140.80	126.40
	3	151.00	120.00		
	4	144.00	124.00		
	5	143.00	127.00		
	6	129.00	135.00		
Specimen 6 (Invisible gel)	2	126.00	99.00	130.00	101.20
	3	136.00	104.00		
	4	129.00	106.00		
	5	138.00	95.00		
	6	121.00	102.00		

Figure 7: Specimen 6 (Invisible gel).

Figure 8: Specimen 5 (Soft foam).

For eight-hour workday, a lady may perform standing activity for a long period to do some tasks; the specimen 5 (Figure 8) made from a soft foam is recommended [12], since it can provide more flexible to form the heel insoles into the shape of heel area instantly. The recommendation of this proposed approach is about compromising between standing and walking activity for selecting foot inserts, the specimen 5 seems to be the best among the rest since it provides the second place for supporting pressure from the body during walking inferior to the specimen 6.

Selecting the material as soft foam and the shape as specimen 5 can help a lady feeling more comfortable for doing various activities; however, the rough cashmere or texture cloth is required on the topmost surface of the soft form insert for better and easily positioning the foot on without slipping during walking attempts.

Acknowledgments

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