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SAFETY SHOES WEARER'S COMFORT PERCEPTION AND EFFECTS AMONG MANUFACTURING EMPLOYEES

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ABSTRACT

This study investigates ergonomic problems faced by manufacturing employees due to wearing inappropriate safety shoes. A total of 30 survey respondents was recruited based on the shoes they wear. Pedar-X was used in the experiment to measure the pressure that acts on the wearer' feet. Survey results showed the wearer' experienced the highest pain with the frequency of 80% for right and 83.33% for the left heel for wearing safety shoes two to three times a week. Meanwhile, Pedar-X recorded average peak pressure, force and surface area: Amporlo, 90.53 kPa, 259.57 N, and 67.74 cm2; Land Master, 75.07 kPa, 273.79 N and 72.65 cm2; Jack Parcell ordinary flat, 67.85 kPa, 170.68 N and 52.08 cm2 respectively. It was found strain on the front and middle of the feet were lowest. Meanwhile, the back foot, which locates the heel recorded the highest pressure value of 185 kPa as a result of wearing inappropriate safety shoes.

Keywords: Peak pressure, force, surface area, foot, comfort

1. INTRODUCTION

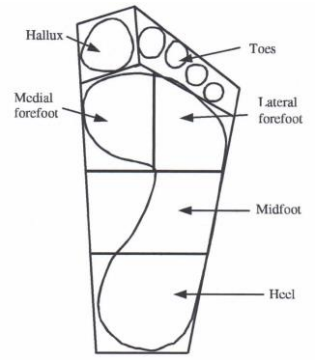
There is a wide range of safety shoes designed and used in the workplace depending on the existing hazard. It can be divided into three categories, such as safety, protective and occupational shoes. Safety shoes are made of various materials and are equipped with a special internal protection element, such as toecap, metatarsal anti-stress, ankle protector and anti-penetration are installed in the safety shoes (Irzmańska, 2014; ISO 20344, 2012) for foot protection from impact and pressure. These protective elements are made from different materials, which includes steel, aluminum, plastic and composite (Koradecka and Konarska, 2002).

2. LITERATURE REVIEW

The foot is primarily supported by the plantar surface. Figure 1 shows the definition of the six plantar surface regions. For example, when a person is standing (i.e. the inside of a shoe), there will be interaction between the plantar surface of the foot and the surface on which the person stands. The interaction between the plantar surface, dorsal surface of the foot and the load-bearing surface, the whole body posture contributes to foot and surface deformations and hence to perceived comfort, discomfort, pain or fatigue (Witana et al. 2009; Cham and Redfern, 2001; Kelaher et al. 2000; King, 2002). High plantar pressures have been linked to foot pain and discomfort (Gardner et al. 1988; Hodge et al. 1999). Other factors that could contribute towards comfort are firmness, anthropometric features and pressure distributions (Na et al. 2005).

In manufacturing industries, safety shoes are specially designed for employees to wear to protect their foot from workplace hazards such as rolling, falling or sharp objects. The basic functions of safety shoes are to provide protection the foot against hazards present at the workplace (Irzmańska, 2014; Koradecka (2010). There are various types of safety shoes have been specially designed for use in factories and in other industries. Safety shoes have a wide variety of designs and each type of safety shoes manufactured has its own advantages and disadvantages. In addition, the design of appropriate safety shoes for various industrial sectors, professions, and work positions need to meet all requirements with respect to ergonomic and protective properties, durability, hygiene, comfort for use and functionality to avoid the occurrence of foot pain and injury in the workplace (Dobson et al. 2017; Koradecka, 2012).

Figure 1: Definition of the Six Plantar Surface Regions (Hong et al. 2005).



On average, the majority of employees working in the manufacturing industries spent a total of eight hours per day or more. While working, for example, an operator in semiconductors or in the automotive manufacturing factory, employees usually work in prolonged sitting and standing postures. Wearing inappropriate safety shoes will negatively affect the comfort level of an employee. Thus, the two main objectives of this study are to review and evaluate the overall effects of wearing of safety shoes to employees.

3. DATA AND METHODOLOGY

3.1 Respondents

The study population is employees from manufacturing industry itself. They were selected due to their positions, such as the factory managers, executives, engineers, safety officers and supervisors from the plant.

3.2 Data Collection

The survey questionnaire comprised of three parts; socioeconomic status, risk factors, and prevalence of pain in the lower part of the body. A survey questionnaire was given to selected respondents in the manufacturing industries. Every respondent was given the explanation and guidance on how to complete the survey questionnaire.

3.3 Pedar-X System

Pedar-X system data collection method was used to determine the shoe pressure. This method used an insole or a liner attached with a sensor that can measure the amount of pressure in a shoe. In this study, data was collected while the subject is standing in the upright position only (Ramanathan et al. 2010). During the experiment, subjects were asked to wear three different types of shoes. The main purpose of this experiment was to measure and determine data distribution experienced by the wearer of the shoes.

Parameters considered in this method are contacted area, contact time, maximum force, pressure-time integral, force-time integral, peak pressure, mean force and mean area. However, to simplify the data collection in this study, only a few parameters were taken, which include peak pressure, force and mean area. Having done that, comparisons were made for all the three types of shoes selected. Figure 2 shows the experimental set-up preparation for Pedar-X System.

Figure 2: Preparation for Pedar-X System Device

4. FINDINGS AND DISCUSSIONS

4.1 Survey Questionnaire Results

Based on Cornell analysis found in the survey questionnaire, the impact of safety shoe application showed pain commonly occurs at the left and right heel with a total average prevalence of 81.67% and pain occurs as a result of their standing work posture. Part of the calf showed the relatively high average prevalence of pain at 51.67%. Meanwhile, the hips showed the lower average prevalence of pain at 26.67% compared to other body parts. Other parts of the body, such as the neck, shoulders, back, arms, hips, wrists, buttocks, hips, and knees are not affected with the wearing of safety shoes.

The survey result shows that when the work is done while standing, the pressure of the shoes will be higher than the pressure on the shoes while sitting. This is the main cause why parts of the heel have a high percentage of the pain after wearing safety shoes. Employees at this automotive car body assembler work at different workstations. Each worker has to install different car components, where he or she has to stand upright while installing each component in the vehicle.

4.2 Pedar-X System Analysis

Data analysis using the Pedar-X system was conducted on three different types of shoes, two of them were safety shoes (i.e. Amporlo and Land Master) and the third one is ordinary flat shoes (i.e. Jack Parcell). Normal data distribution from the Pedar-X system for Amporlo safety shoes shows that the peak pressure was 82.5 kPa, the force of 243.77 N and surface area 67.33 cm^2. For Land Master safety shoes, the peak pressure was 67.5 kPa, the force of 224.363 N and surface area 72.17 cm^2. Jack Parcell the flat shoes indicate the peak pressure of 60kPa, force 163.193 N and surface area 48.67 cm^2.

Experimental results as shown in Figure 3, when the subject was wearing Amporlo safety shoes, the pressure distribution data recorded at foot front was 88kPa, at the middle part of the foot was 15kPa, and at the back of the foot (i.e. heel) was 185kPa. Meanwhile, for Land Master safety shoes as shown in Figure 4, the pressure distribution data recorded at the foot front was 88kPa, at the middle part of the foot was 15kPa, and at the back foot (i.e. heel) was 160 kPa. For Jack Parcell normal flat shoes as shown in Figure 5 the pressure distribution data readings recorded at the front of the foot was 50 kPa; at the middle part of the foot was 15kPa, and at the back foot (i.e. heel) was 83 kPa.

Figure 3: Pressure Distribution Recorded on the Subject's Foot When Wearing Amporlo Safety Shoes

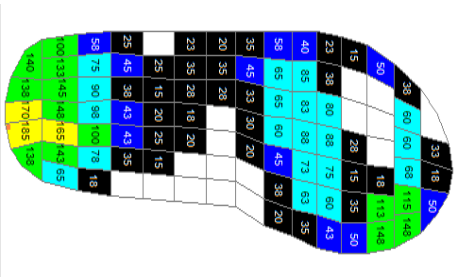


Figure 4: Pressure Distribution Recorded on the Subject's Foot When Wearing Land Master Safey Shoes

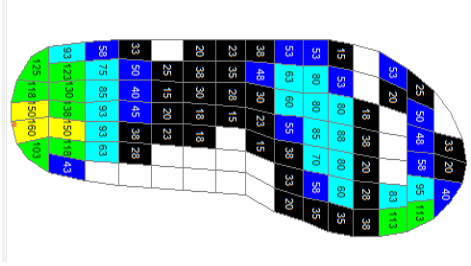
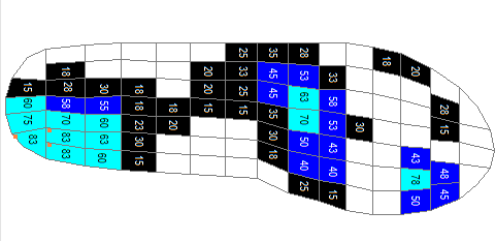


Figure 5: Pressure Distribution Recorded on the Subject's Foot When Wearing Ordinary Flat Shoes



5. CONCLUSION

Based on the data found in the survey conducted, the impact of wearing safety shoes resulted in pain at left and right heel with a total average prevalence of 81.67% due to their standing work posture. The heel recorded the highest pressure distribution data when wearing all the three shoe types: Amporlo safety shoes, 185kPa; Land Master safety shoes, 160 kPa; and Jack Parcell normal flat shoes, 83 kPa. Meanwhile, the pressure distribution data recorded at the foot front when wearing: Amporlo safety shoes, 88kPa; Land Master safety shoes, 88 kPa; and Jack Parcell normal flat shoes, 50 kPa. The pressure distribution recorded at middle of the foot when wearing both safety shoes and ordinary flat shoes were the lowest and all three different shoes recorded the same value, which is at 15kPa. When compared with data from the Pedar-x system, proved that the strain on the front and middle of the feet are the lowest and when compared with data from the Pedar-x system, also proved that the pressure on the back of the legs which is the heel, highest with the value of 185kPa.

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