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Faculty of Multimedia Communications

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An Investigation into Shoe Style for Prevention of Heel Pain

Author: **MgA. Ing. Naveed Anwar**

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Supervisor: doc. MgA. Petr Stanický, M.F.A.

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Abstract

In a digitally changing world, where the boundaries between traditional commerce and ecommerce are merging, the need for cutting edge technologies and innovations is essential.

The shoes we wear are very important for the health of our feet. In particular, the choice of shoes and the materials has a significant influence on the protection of feet according to multiple experimental studies. Use of appropriate footwear among diabetics and those with foot problems has been well documented to play a vital role in the prevention and treatment of established foot diseases.

The incidence and prevalence rates of heel pain problems in the world are increasing and foot complications are rising parallel. This is related to the lifestyle of the people which is changing including diet. There is however lack of adequate knowledge about the role of footwear in the management of foot related problems among heel pain patients in the world. This study is the first of its kind to be done with an aim to develop a framework that would help to identify appropriate footwear material and design for people suffering with heel pain. The studies are experimental studies with repeated measures data. A total of 25 individual participants' heel pain patients were involved.

To achieve this, data were collected through questionnaire and interview surveys, shoe upper style, materials, foot analysis and foot measurements included foot pressure measurements through Classic MatScan by Tekscan software and hardware. However, several systems for measuring plantar pressure in the foot are currently available. Among those are the E-med, Pedobarographs, F-Scan/Mat-Scan*, and Piezoelectric insoles. For this study, the Mat-Scan was utilized to perform pressure analysis of the foot. For evaluation, a study was conducted collecting barefoot Mat-Scan data of 25 individual participants' heel pain patients while standing and walking positions to be assessed in order to provide them with the most appropriate footwear design for their condition to reduce the heel pain. Pressure sensors within the mat can detect increased foot pressure and whether this pressure is evenly distributed, or concentrated in certain anatomical areas of the foot. Contact pressure on the plantar aspect of the foot generates forces in the subsurface tissue, and causes it to deform. The "breakdown" develops when the contact pressure load leads to a permanent distortion of the tissue and to the formation of localized tissue damage.

In addition, Product Design Specification (PDS) and design framework were formulated. And functional footwear prototypes was designed, constructed and assessed.

The data from the questionnaire survey indicate that up to 75% of the foot problem subjects have not received information about the type of footwear they should wear most often. The study revealed that the patients have very poor knowledge about heel pain and its complications, foot care, and the use of appropriate footwear. It was discovered that up to 53% female and 37% male of the patients were wearing slippers so called open shoes most often. Similarly, the findings from the medical doctors interviewed show that up to 66% of the patients were wearing slippers/ slip-on (with no fastening mechanism) most often. The research revealed that financial constraint was a key factor to use of appropriate footwear by the patients. Many use cheap footwear regardless whether they provide the required protection and comfort to their feet or not. It was found out that specialist knowledge among foot doctors so called podiatrist regarding foot care and provision of special footwear like orthopaedic and diabetic footwear to patients was very low.

The shoe upper materials analyses demonstrated that leather and stretch materials has good physical properties required for making footwear for heel pain relief. Data from the measurement of feet indicated that no individual's feet are exactly the same even as people wearing the same shoe size might not have the same foot dimensions. It was concluded that these differences could have considerable effects on the shoe wearer. From the measured values, the tolerable allowance was found to be 3.4mm and 3.5mm for male and female subjects respectively. The fitting and comfort assessment of the prototypes have shown that some parts of the last used to make the prototypes would require amendments in order to accommodate minor foot deformities properly.

The findings from the research were used to develop PDS and a research framework which could be used as a guide for footwear design and construction to reduce the heel pain. Finally, the contributions of this research to knowledge and critical areas that would require further investigations were outlined.

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1 CHAPTER “Introduction”

1.1 Introduction / Overview

In recent years footwear sales have shown significant growth and the variation of footwear available in the market today is increasing parallel to quantity. In addition to quantity and these variation the perceptions of style has grown. Product performance on the other hand, should broadly base on its function, form, and fit that mean the interaction with the foot. It is well known that fit or product compatibility is necessary for a person to experience comfort, safety and satisfaction during use and improve the performance. However, compatibility is not so well known for all types of interaction between people and equipment. For example, form and aesthetics has been the dominating factor in the sale of footwear over the last few decades. Even though technology enhancements are thought to improve the functioning of footwear, some of them are simply ornaments to enhance form rather than functional elements that protect people's feet. Given the tremendous flexibility of the foot, it is important that the foot be accommodated in a way that allows a foot to function as "designed". Ergonomics dictates good posture and many other specialized human engineering areas can be reasonably should be well integrated into the design and development of footwear.

The concept of human and product interface becoming increasingly important parameter for designing any product for the reason that the interaction between them may cause some disorders, injury, pain or discomfort. Pressure at the human-product interface is unavoidable, at has received considerable attention over the years. There is wide range of product variety, but among them the footwear has a very special feature. It is a kind of product that;

- Nearly all people use it,
- Nearly all the time except sleeping they wear it.
- It covers the human feet, carry the body and mechanically they work together.

There are various categories of footwear - those made from leather, synthetic materials and other fibres. Since all humans are different in size and taste, shoe designers and manufacturers need to keep in mind different needs and wants - shoes for men, women, children, formal shoes, casual shoes, trekking shoes, sports shoes and so on; the list of different styles of shoes is endless. But, footwear is the source of feet disorders if it is not designed well. Major issues such as structural fatigue, slipper bumps, hammer toes, bunions, blisters, abrasions, ingrown nails, calluses, fungus, hallus valgus, achilles tendon inflammation, back problems, body column chance, knee discomforts, sprains and ligament injuries, heel spur etc.. (Which will be later discussed in this chapter) are all side-effects of footwear on the market designed for the fashion concepts disregarding the human- footwear interface and interaction. In recent years designers and consumers have started to look beyond appearance and aesthetical requirements. As the most of the product, footwear has a social and sexual expressing role. The form and its aesthetical characteristic was the unique factor for self-expressing by using its semiotic point of view. In the history, especially women had wearer too small, high heeled, pointed or platform shoes which had caused foot disorders. This indicates that apart from social expressing role of footwear, even though the functionality is more an important parameter for designing footwear. Footwear design should concentrate; controlling rear-foot movement, shock attention, weight bearing, and body balance and comfort factors (involves several different factors). Comfort and functionality are features increasingly demanded by the consumers. Footwear comfort is the result of a complex interaction of several factors that affect the foot function during human activity. They are the factors of human engineering which lead to us to find the footwear design criteria.

The design strategies have to work for human-footwear interfaces with respect to human engineering for the reason that product and human interaction is the basic factor to design good products. The main factor is to study the human feet, biomechanics and the human body in motion. Trying to understand the design and construction of good shoes would be difficult without the knowledge of what goes inside or above them. Hence the comprehensive knowledge of human anatomy is a key for human engineering. So, shoe design requires the efforts of several academic fields.

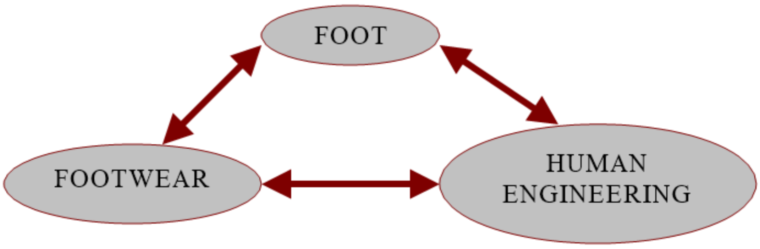


Figure 1.1 Foot-footwear and human engineering

Footwear design is a complex process that involves the collaboration of a variety of individuals, designers, craftsmen, technicians, scientists and foot doctors/ podiatrist. Designers have a crucial role to develop the footwear and consequently to improve of the human performance.

What should be the designer's role?

Designers are designing something that causes the some disorders which may or may not be their fault. For example, the premise for many product liability cases is that the actions of the person were normal and predictable and that the manufacturer of the product should have foreseen the behaviour and provided the appropriate safety features (design and/or warning). This is a human engineering problem and is far more complex than the passive biomechanics problem. It involves knowledge of how the various body systems function along with their contribution to action or activity. Fortunately, all human performance/action patterns are performed using a similar information processing procedure that is dependent upon past experiences of the individuals.

Today, apart from bespoke shoes, shoes do not show much customization (adaptation) in general. Foot length and width are the most common dimensions by which shoes are manufactured and fitted. Yet every foot is so different in size and shape that 'fitting the foot into the shoe is bound to cause painful feet. In addition to the foot shape itself, its change throughout life is equally important, as well as a person's medical condition. Therefore, as a designer I see a necessity for footwear that will be 'fitted on the foot' and that takes account of the individual foot shape, provides the required comfort considering the human engineering. This shoe will be much more customized than one can find today. The objective is to extend the bespoke shoe into a larger user market for the average people while integrating human factors engineering to the footwear design, and at the same time trying to respond to the shoe's social role.

Future work will involve the use of evolutionary computation to aid in the development of footwear segments that articulate to provide the necessary motion for intimate coupling with the foot. Evolutionary computation holds the potential for making significant contributions to product design, particularly in the field of functional products that enhance human performance.

- Right shape for human feet
- Well-constructed
- In the correct size

Finally, when considering the products that interact with the human body and affect the human performance, the industrial design field has a great demand of responsibility to prevent the negative consequences of the products. From this point of view, especially footwear is the most important product because of its characteristics. Thus, designers should concentrate to interface design and aim to create better design solutions based on the comprehensive knowledge of human engineering.
Overall, there is still lack of adequate knowledge about the role of footwear for the management of heel pain related foot problems among patients and health care providers in the world leading to further foot complications among patients in the region. But it has been discovered that proper footwear can have a significant influence on the well-being of heel pain patients. Therefore, this study focuses on footwear style selection and overall design that could provide the relief of heel pain and probably support other developing countries with appropriate footwear for maintenance or improvement of foot health.

All the research activities and outcome are put together in this thesis which consists of five major sections. The first section (chapter 1) would focus on general introduction, background, motivation, aim/ objectives, methodology, time management and the research structure. Following the introduction section is the literature review (chapter 2) of the subject matter. Another section dealing with the surveys and experimental analysis (chapter 3-4), development of the trial prototypes and evaluation (chapter 5) would form a substantial part of this research thesis. The results obtained from the surveys and experimental analysis would be discussed in a separate section (chapter 6). And a final section on conclusion, and recommendations (chapter 7) for further research work would be outlined.

1.2 Background

Definition of the problem

Foot pain is very common. About 75% of people in the United States have foot pain at some time in their lives. Most foot pain is caused by shoes that do not fit properly or that force the feet into unnatural shapes (Kevin, Weaks., 2011. May, 19-25 Labor Tribune/ Your Health pp8). In the UK, it is thought that 75 to 80 per cent of the adult population has some form of foot problems, and over 90 per cent will suffer from a foot problem at some point in their lives. Many people put up with foot pain believing it to be normal (The society of chiropodists and podiatrist, chapter 4 working feet). Strangely enough, it is as unusual to find a doctor wearing a pair of properly shaped shoes as it is to find a businessman or any type of white collar worker in shoes conducive to foot health. What then can doctors advise their patients concerning the proper kind of footwear for their health and comfort? The answer is very little, for the medical profession, as a whole, knows very little about foot weakness, its causes, its cure, or its close relationship to the kind of shoes we wear. Why? (A new approach to foot health by Thomas Hale, Jr., Director, Albany Hospital Albany, N.Y). Dr. William A. Rossi, a leading chiropodist and an editor of the Boot and Shoe Recorder, stated in the October 1958 issue of the Journal of the American Podiatry Association: "Absence of scientific standards are the missing links in fields of foot health and footwear. Physicians, orthopedists, chiropodists, shoe fitters, shoe manufacturers, all have individualized approaches to foot health, with the result that no one knows what is a 'normal foot,' a 'good shoe,' or how to evaluate a foot."

Definition of the problem is based on general background of foot anatomy. This part also follows the structure and growth of feet and common foot health problems. Our feet bear an enormous burden of daily living. As well as carrying the weight of our body, feet must also twist and flex with increased impact and strain when we move around. Even through simple day-to-day activities such as standing and walking, our feet can be injured if not properly supported. Shoes play a vital role in this, as well as protecting our feet from external dangers.

From time to time voices have been raised protesting that the shape of the shoe is almost invariably the causative factor in producing weak and disabled feet. As early as 1905, Dr. Peter Hoffman, an orthopaedic surgeon, contended that most foot trouble was caused by compressing the feet into poorly shaped shoes which did not conform to the shape of the foot. There is no such thing as the one perfect shoe. Feet come in all shapes and sizes. Men, women, children, athletes and older people all have different shoe requirements, and these vary considerably from activity to activity.

From a biomechanical /functional point of view, shoes serve at least three main functions: they provide protection from the environment; they improve the connection with the ground thus providing a stable foundation for movement; and they improve foot comfort when standing or walking. However, in recent years new footwear that seems to contradict the second of these paradigms has become popular: instead of providing a stable foundation, these types of shoes try to create specific forms of instability. Each year, consumers spend hundreds of millions of dollars for "walking shoes" promising to help the wearer walk "right" or more comfortably.

1.3 Motivation

I was motivated to carry out a study on comfort footwear because of the following reasons:

- Foot patients' satisfaction with prescribed footwear is reported to be low (Waaijman et. al. 2013; Williams & Meacher 2001).

- It is understood from the literature (Williams & Nester 2006) that the current stock footwear design has been developed through technological advancements, results of research on clinical need and perspectives. However, in addition to these, the design and manufacture of comfort footwear based on an understanding of patients' expectations and perceptions of footwear is not often considered.

- Currently, 285 million people are affected with foot problems worldwide and the number is expected to grow to 438 million by 2030. And the largest age group currently affected by diabetes is between 40-59 years old (World Health Organization 2010; International Diabetes Federation 2009; and World Footwear 2008). It therefore means that comfort footwear has become a growth market.

- Foot problems are a threat to everyone with diabetes (Bakker 2008; Edmonds1987). Their foot problems often required prolonged and costly hospital stays and eventually leading to amputation of a toe, foot, or the lower limb completely. And according to Leung and Wong (2008), for patients with special need in their footwear that cannot be answered by commercial shoe, input from a professional is needed. This is important as improper footwear has been shown to be a common culprit for causing foot ulcer in diabetes.

- In addition, footwear can prevent or increase foot problems (Caselli 2011). Furthermore, Torreguitart (2009) pointed out that the use of inappropriate footwear is the most common cause of foot problems.

Indeed, the role of footwear in the management of foot problems requires urgent attention because data from investigators (Reiber 1994; Edmonds et al. 1986; Apelqvis et al. 1993) show that 39-76% amputations in foot problems population were initiated by ill-fitting footwear.

- There is paucity of research in the area of comfort footwear (Ogrin 2007; Cavanagh 2004) and a comprehensive concept of technical requirements for comfort footwear is lacking (Dahmen et al. 2001). Therefore, there is a great challenge for footwear designers and health professionals to work together to solve the problem.

- Health professionals advocate for a multidisciplinary approach to management of foot problems and its complications (Tyrrell & Carter 2009; Pedrisa 2006; Edmonds et al. 2006; Connor1987; Nigg1986; Edmonds, & Foster 2005). Therefore, those in the field of footwear design have a stake in solving this problem faced by every society in the world today, and can make significant contributions to knowledge that could provide solution to this global challenge.

- Most research on designing footwear for people has concentrated on comparing different shoes or materials rather than comparing the basic physical characteristics of the materials that are used (Goonetillete 2003). It is therefore believe that there is wide range of materials with variety of properties that could be explored to make suitable footwear for numerous foot conditions.

- The need for research to collect data on heel pain complications and the appropriate preventative measures have been pointed out (International Diabetes Federation (IDF) and International Working Group on the Diabetic Foot (IWGDF), (2005). Therefore, Inputs from footwear designers are required to solve or at least reduce foot problems by designing appropriate footwear.

The above mentioned issues captured my attention and provided me with areas for this research. A reflection on my M.A dissertation in 2001 and discussions with my major supervisor after my M.A Programme, further strengthens my desire to explore this problem area. More importantly, the focus of this present work is to discover the potential solutions that will contribute to providing or improving hell pain patients' foot health condition through the provision of appropriate footwear. I believe this work has the potential for contributing to positive foot health benefits for people suffering with heel pain.

1.4 Research Aims and Objectives

The purpose of this research is to achieve the role of footwear in the prevention of heel pain. To formulate a framework that would identify appropriate materials and suitable design style for comfort and arch support particularly for people suffering with heel pain.

The Objective of the proposed research is to provide patients with the most appropriate footwear with arch support design style for their condition to reduce the heel pain. The foot and footwear interaction and explore ways of improving the footwear design, the fit of the shoe on the foot from the view point of human factors engineering.
The objectives of this thesis based on:

- To attempt to explain scientifically the footwear design parameters according to human engineering.
- To search and review the relevant literature regarding the subject area.
- To source for relevant information from heel pain patients using questionnaire survey.
- To source for information from health professionals on the important factors to be considered for designing footwear to reduce heel pain.
- To study appropriate footwear materials and design(s) solution for people suffering with heel pain.
- Evaluate and improve technical knowledge for designing of footwear by comparing of performance values of various footwear.
- Improve the basis for an alternative design method instead of the present standard determining the human engineering properties.
- Investigate for a scientific design theory which will improve high tech foot care styles those will be safe, comfortable and stylish which will fulfil the heel pain patient's requirement as per podiatrist and pedorthist specifications and guidelines in the health care pedagogy.

1.5 Scope of the Research

This study focuses on the role of footwear in the management of foot problems, appropriate footwear materials and design(s) for people suffering with heel pain particularly in Czech and other developing countries.

1.5.1 Research Structure

The research structure presented below (fig. 1.2) was used to carry out this research. The PhD journey started with a critical thinking of the research area/ topic, formulation of the aim/ objectives and the research methodology. Basically, the research structure is categorized into three data sets as follows:

- Data set involving research participants: This includes information gathered through the pilot study, questionnaire and interview surveys, foot measurement through the Mat Scan and prototypes assessment.

- Experimental analysis data set: This set of data was based on shoe upper materials analysis.

Data set based on previous literature: Information gathered from the background study and literature review constituted this data set.

In summary, the structure for this study was developed based on established secondary and primary research methods identified in previous literature. For effective gathering of information and validation, it was agreed that relevant and related data should be collected both from heel pain patients and health care providers. Consequently, structured interviews and questionnaire were developed for collection of data from heel pain patients and medical doctors respectively. However, to complement the findings from the two methods mentioned above, two additional studies (footwear materials analysis and foot measurement) were designed. It was anticipated that the experimental analysis would provide information about suitable materials for comfort footwear manufacture; whereas the foot measurement would provide data on foot dimensions that could help to determine proper footwear fitting.

In addition, the research structure was designed in such a way that data collected from the secondary and primary research would be analysed, interpreted and used to make trial prototypes that was assessed in real life situation (see later chapter). The structure also provided a section for general discussion on the key findings from the study.
This section gives clear understanding of all the issues and ideas that were discovered from each aspect of the study by linking or comparing them one to another. And finally, conclusion and recommendations for further research were outlined based on the outcomes of both the primary and secondary research and the assessment of the trial prototypes.

1.5.2 The structure of the thesis

Figure 1.3 gives the structure of the thesis. It is grouped into four sections namely; (1) introduction and review of the relevant literature, (2) data collection and presentation of results, (3) prototyping and design framework, and (4) general discussion and conclusion.

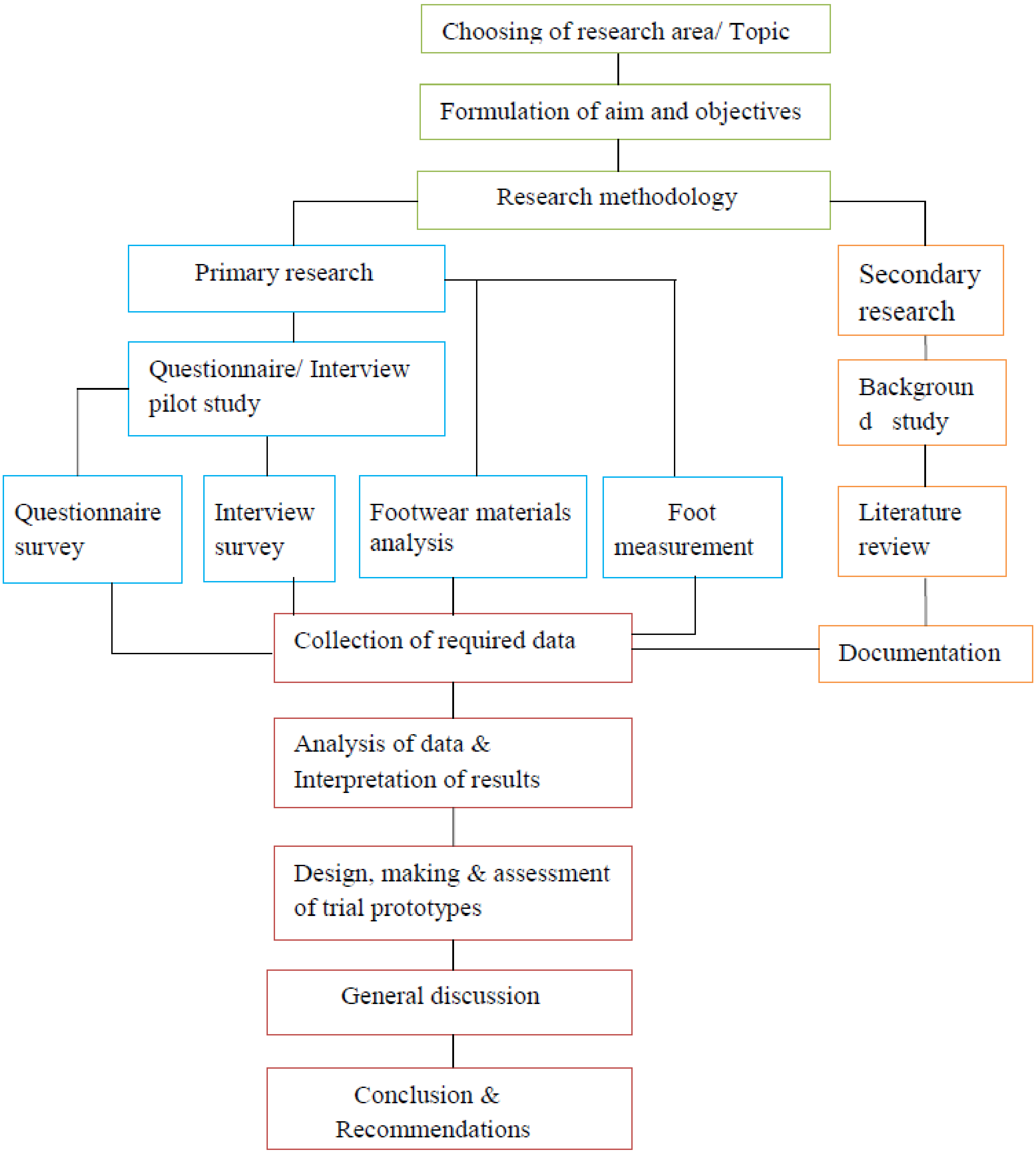


Figure 1.2 Research Structure

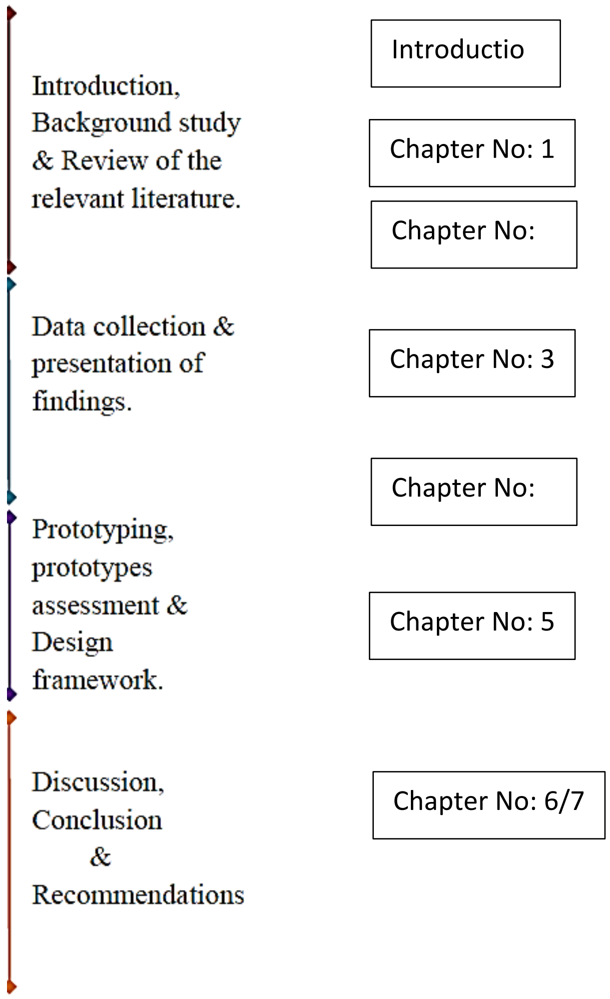


Figure 1.3 Structure of the thesis

1.6 Methodology

Research methodology is the tools for doing research and obtaining useful information. Clough and Nutbrown (2007) define research as "the investigation of an idea, subject or topic for a purpose. It enables the research to extend knowledge or explore theory. It offers the opportunity to investigate an area of interest from a particular perspective". And according to Adams and Schvaneveldt (1985, p. 50), "Research methodology applies a systematic approach to problem solving and data collection to ensure that one has useful data, that the results can be understood by others, and that the procedures can be carried out by someone else at a later time. With data gathered in research, we can explain, predict, describe, and eventually relate current studies with other research".

Key methodological components that cut across quantitative and qualitative methodologies were used in this study (see sub-sections 3.4, 4.4, 5.4 & 6.4).

This research was undertaken based on established research processes as shown in figure1.4 Research process in this sense is seen as cyclical. The process is shown as going through a number of cycles, the outcome of each one influencing upon the way in which successive cycles are approached.

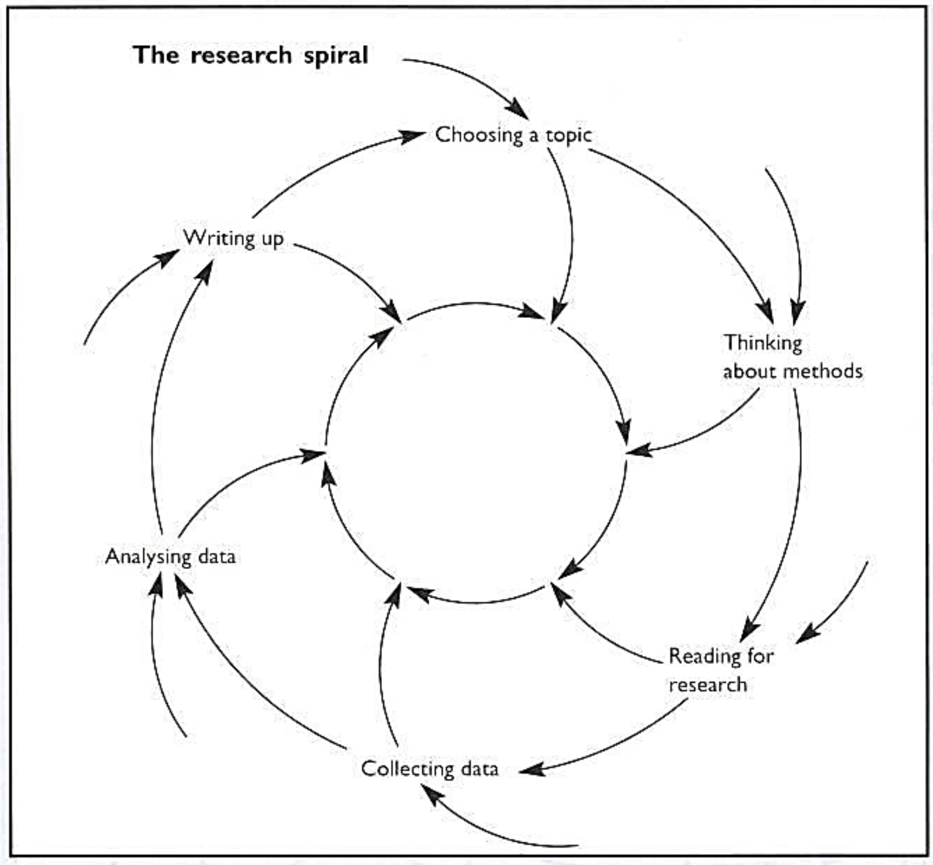


Figure 1.4 The Research Spiral (Blaxter et al. 2010. p. 9).

There are two main approaches for gathering information or data in any structured research work. The first approach is from secondary sources, whereas sources used in the second approach are called primary sources (Ranjit 1999). The two methods are briefly explained below.

1.6.1 Secondary Research

This information and/ or data are gathered from second hand sources: reference books, journals, and government statistics, internet, etc., which supply information on wide range of issues (Wall et al. 1996).

The published literature was used by the author in order to:

- provide an academic basis to the research carried out,
- to clarify ideas and findings,
- to find data and research methods to be adopted.

Using the published literature is a core part of the academic communication process. It connects the work someone has done to the great scholarly chain of knowledge, and in more immediate terms it demonstrates someone understanding and puts the work he has done in a wider context (Library Services, Tomas Bata University, Zlin). Therefore, I used secondary research tool to put my work in the right perspective (see chapter 2).

1.6.2 Primary research

The aim of the primary research was to gather first-hand information on different aspects of the subject investigated through interview survey, questionnaires and laboratory analysis of footwear materials and designs.

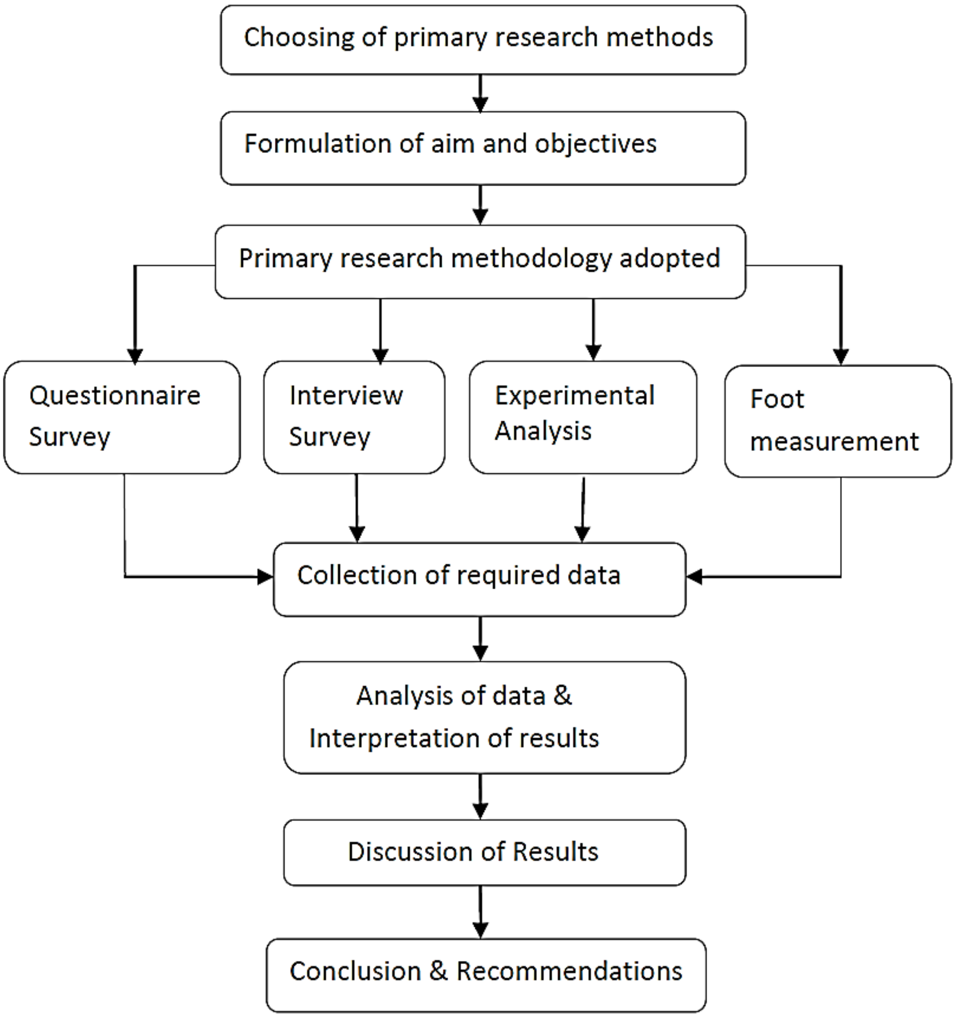


Figure 1.5 Primary Research Structure

There are various vehicles that are used for collecting primary research data which can broadly be categorised into two types namely: qualitative and quantitative. Qualitative method of research seeks out the ‘why’ not the ‘how’ of its topic through the analysis of unstructured information-things like interview transcripts, e-mail, etc. It does not just rely on statistics or numbers, which are the domain of quantitative method of research (QSR International, 2007). On the other hand, quantitative research is used to measure the 'how' of its topic through analysis. This type of research is very effective when measuring for example, how many people feel, think, or act in a particular way. Quantitative surveys tend to include large samples, for example structured questionnaires can be used incorporating mainly closed questions. But closed questions have a limited set of responses (Research Portals 2009).

In this project, both methods of research mentioned above were explored to obtain the required data (see fig. 1.5).

I utilized quantitative research method by designing a detailed questionnaire which included personal profile of the respondents, Information on foot heel pain and foot problems, foot problems developed as a result of using inappropriate footwear, and footwear fitting/ features. The required information was gathered from people living with foot problems from a developing society. The outcome and explanation of the data obtained from the questionnaire survey are provided in chapter 3.

I equally used interview survey to achieve the aim and objectives of my study. According to Patton (1980), interview is a process of obtaining information via questioning conducted face-to-face or over a telephone. I interview foot doctors so called podiatrist, pedorthist and their views on key aspects of the research are presented in chapter 4.

In addition to the questionnaire, interview approach, it was also necessary to carry out experimental analysis of footwear design and material in order to understand materials that would be more suitable for making the final product.

These research methods were used because a range of research methods would allow the development of multiple viewpoints; it also allows inductive and deductive reasoning, ensuring that all aspects of the research question are being investigated.

1.7 Research and Time Management

1.7.1 Research Management

Time management is defined "as systematic, priority-based structuring of time allocation and distribution among competing demands" (The Business Dictionary 2010). To help manage time and to be able to complete the project on the target time, the main research areas were identified and split up to develop a monthly plan (and some tasks were further broke down into weekly plan). From the research breakdown, a Gantt chart (look at details in appendix) was drawn up to demonstrate the research activities against the time schedule.

The Gantt chart was a useful tool for analysing and planning of all the research tasks. Using the tools provided by ‘Mind Tools’ (2010), I identified the activities that were dependent (or sequential) on other activities being completed first. These dependent (see details in appendix) activities were completed in a sequence, with each stage being more-or-less completed before the following activity began. Other activities that were not dependent (parallel tasks) on completion of any other tasks were also identified. These tasks were done at any time before or after particular stage were reached. The Gantt chart was drawn by following the following steps:

a. All the project activities were listed and for each task, the estimated length of time required to complete the task was recorded.

b. A chart was used to indicate the months (s) through to completion.

c. The tasks were plotted onto a chart, showing the starting date or month and the month of completing each task.

1.7.2 Time Management

The research was the individual responsibility to carry out careful planning of the research activities. First and foremost, the research title, aim and objectives were set out after negotiating with the supervisor. To achieve the aim and objectives of the project, the project was divided into several main sections. The main sections were further sub-divided into small research activities in order to get a clear research structure (see fig. 1.2).

A list of research activities (see appendix) was then formulated from the research framework. After establishing the research activities, a project plan in the form of a chart (See details in appendix) was drawn to achieve the research aim and objectives. In addition, progress reports (at least monthly) of discussions held between the experts and supervisor was kept as evidence of regular progress meetings via “Skype” throughout the period of the study. An example of the researcher’s progress report is given at the end of each semester.

The literature search, citation and review (secondary research) activities were based on study of books, journals, magazines and articles from internet sources. Most of the articles used for the research were collected from the University’s Library. Information from the secondary research was explored to meet the objectives of the project.

The primary research was carried out mainly in Czech. It was difficult to stay on schedule with some of the activities, such as interview and questionnaire surveys. However, language translation and regular discussions with the supervisor helped me to manage the project within the overall time scheduled.

1.8 Chapter Summary

This chapter gives the general introduction, the background of the study and the structure of the research/ thesis. The background has shown that heel pain often leads to foot problems and that the manifestations of the foot problems often require specially designed or adapted footwear style. I was motivated to carry out this work based on the fact that foot problems are a threat to everyone with heel pain and that footwear can prevent or increase foot ulceration or problems. Related research work conducted by individuals and group of researchers in this area have shown that a comprehensive conceptual approach for the management of the various aspects of heel pain is still lacking. Therefore, I aimed in this study to find out the possible design style solution for comfortable footwear particularly for people suffering with the heel pain disease in developed and non-developed societies. Secondary research (literature review) and primary research (questionnaire and interview surveys, experimental analysis and foot measurement scan data) were the main research tools used to conduct the study and a Gantt chart was used to successfully manage the project.

The next chapter is a critical review of the literature of the research area; that is heel pain and foot complications, the role of footwear in heel pain foot management, footwear materials and design styles, etc.

2 CHAPTER “Literature Review of Research Areas”

2.1 Introduction

Literature reviews according to Gregorio (2000) are a common feature of all dissertations, regardless of discipline or subject matter. The main goal to achieve in literature review is to gather information or to develop a knowledge and understanding about a particular topic from many different but relevant sources on previous work or activity and in regard to the topic been searched. The information can be used for a variety of purposes, including identifying of gaps in research literature, to uncovers all relevant knowledge and research method related to the topic, linking ideas from different articles, identifying contradictions in agreement, comparing dissimilarities in articles, building one’s own argument and identifying areas for further study (Gregorio 2000; Timmins & Mccabe 2005; Blaxter et al. 2006).

Furthermore, Philips and Pugh (2005) point out that literature review allows the researcher to demonstrate that he has professional grasp of the background theory of the subject. It also enables the researcher to evaluate the contributions of others, and to identify areas of theoretical and empirical weakness.
Based on `this, the literature review helped me to have an appraisal of the current developments in prevention of heel pain footwear and gave him an insight on what to focus on in this present work. In other words, the literature review enabled me to develop a knowledge and understanding of the previous works in regard to the research topic.

Timmins and Mccabe (2005) suggested that a systematic, organized search of the literature that uses wide range and available resources effectively is more likely to produce quality work. Therefore, to develop a meaningful discussion and argument on the research topic, I carried out the task of searching, selecting, and reviewing of the relevant literature throughout the period of the study to inform and guide each stage of the research process.

2.2 Aim/ Objectives of this Chapter

2.2.1 Aim

To review the relevant literature in order to discover the reason of common foot problems and what other researchers have done concerning this subject matter and their opinion or suggestions for further work on comfort footwear and to use findings and suggestions to develop this present work.

2.2.2 Objectives

- To plan when, where and what information to search.
- To collect books, journal articles and other sources of information.
- To review and analyse the relevant literature.
- To cite the literature and develop conclusion on common foot problems.

2.3 Foot Complications

Here are some most common foot problems discussed in this chapter

2.3.1 Corns and Calluses

Friction causes the thick, hardened, dead skin of corns and calluses, which form to protect sensitive skin. Appearing cone–shaped, corns point into the skin, and usually occur on areas that bear little weight. Calluses may appear anywhere there's friction, and are more diffuse. Both may be caused by ill–fitting shoes and will fade when friction stops. Mole skin pad scan help relieve a corn; calluses scan be trimmed or surgically corrected.

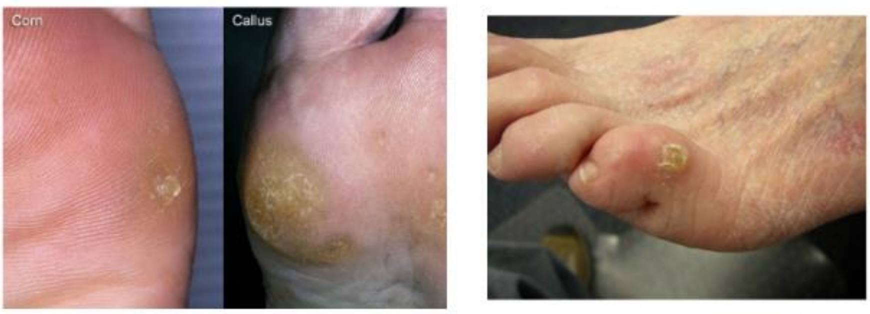


Figure 2.1 Corns and Calluses

2.3.2 Fungal Infection

A fungal infection that can cause peeling, redness, itching, burning, and sometimes blisters and sores, athlete's foot is mildly contagious, passed by direct contact or by walking barefoot in areas such as locker rooms, or near pools. The fungi then grow in shoes, especially tight ones without air circulation. Athlete's foot is usually treated with topical antifungal lotions or oral medications for more severe cases.

Figure 2.2 Fungal Infection

2.3.3 Bunion

A bony bump at the base of the big toe, a bunion causes that toe to deviate toward the others. Throwing foot bones out of alignment and producing the characteristic bump at the joint's base, a bunion can be very painful due to pressure or arthritis, and may also lead to corns.

Pain relievers, pads to cushion the bunion, custom shoe inserts, or surgery may help, as will wear roomy shoes and avoiding high heels.

Figure 2.3 Bunion

2.3.4 Hammertoe

When toe muscles get out of balance, they can cause painful toe problems. While some people are prone to hammertoe, other risks include tight footwear. Hammertoe generally causes the middle joint of the toe to bend downward, with toes appearing raised near the foot. Well–fitted footwear with the correct amount of space in the toe box, shoe supports, and surgery may offer relief.

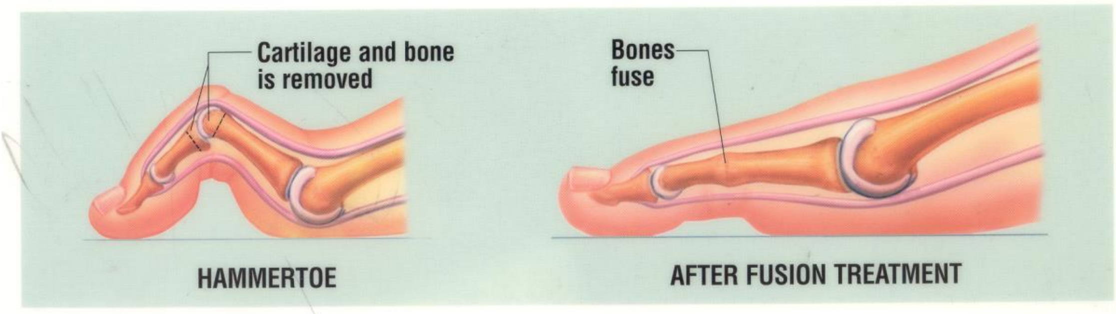


Figure 2.4 Hammertoe

2.3.5 Ingrown Toenail

A toenail that has grown into the skin, an ingrown toenail can result in pain, redness, swelling, even infection. Cutting nails too short or not straight across, injury to the toenail, and wearing tight shoes are culprits. For mild cases, soak the foot in warm water, keep it clean, and wedge a small piece of cotton under the corner of the ingrown nail to lift it off the skin. Minor surgery can remove all or part of the nail.

Figure 2.5 Ingrown Toenail

2.3.6 Itchy Feet

Itchy, scaly skin may be athlete’s foot, a fungal infection that's common in men

Figure 2.6 Itchy Feet

between the ages of 20 and 40. A reaction to chemicals or skin care products --called contact dermatitis --can cause itching, too, along with redness and dry patches. If the skin on your itchy feet is thick and pimple-like, it may be psoriasis, an over-reaction of the immune system. Medicated creams can relieve the symptoms.

2.3.7 Fungal Nail Infection

Occurring when microscopic fungi enter through a break in the nail, a fungal infection can make your nails thick, discoloured and brittle. If left untreated, the nail infection won't go away --and can be hard to treat. Thriving in warm, wet places, the fungi can be spread from person to person.

Figure 2.7 Fungal Nail Infection

Topical creams may help mild cases but antifungal pills are your best chance of curing a severe infection.

2.3.8 Flat Foot

Flatfoot is characterized by the sole of the foot coming into complete or near–complete contact with the ground. It may be inherited, caused by an injury, or by a condition, such as rheumatoid arthritis. Flatfoot symptoms are rare, though weight gain, ill–fitting shoes, or excessive standing may cause pain. Treatment includes foot–strengthening exercises, and shoes with good arch support or orthotics.

Figure 2.8 Flat Foot

2.3.9 Swollen Feet

This is usually a temporary nuisance caused by standing too long or a long flight --especially if you are pregnant. In contrast, feet that stay swollen can be a sign of a serious medical condition. The cause may be poor circulation, a problem with the lymphatic system, or a blood clot. A kidney disorder or underactive thyroid can also cause swelling. If you have persistent swelling of your feet, see a physician.

Figure 2.9 Swollen Feet

2.3.10 Heel Pain

The most common cause of heel pain is plantar fasciitis, inflammation where this long ligament attaches to the heel bone. The pain may be sharpest when you first wake up and put pressure on the foot. Arthritis, excessive exercise, and poorly fitting shoes also can cause heel pain, as can tendonitis. Less common causes include a bone spur on the bottom of the heel, a bone infection, tumour, and or fracture.

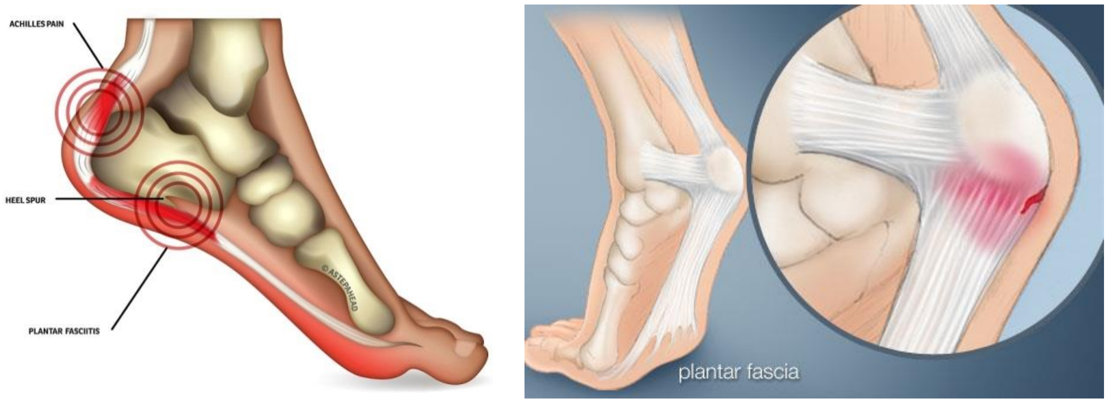


Figure 2.10 Heel pain

2.4 The Human Foot

2.4.1 The Anatomy of the Foot

Shoemakers' from ancient times until the end of the 18th century, concentrated exclusively on the external shape of the foot for which they were to provide a protective covering, ignoring completely what lay beneath. But in the 19th century, shoemakers realize that a shoemaker simply cannot do without knowledge of anatomy (a study of the characteristics of the bone structure, the joints, the tendons and the skin of the foot). This knowledge is important because taking of measurement of the feet for shoe construction is based on anatomical fixed points. These points can easily be recognized and they manifest only small variations when measurements are taken repeatedly (Vass 2006).

Ling and his colleagues (2008) has revealed that the foot is a complex structure with 26 bones, 33 joints and more than 100 muscles, ligaments and tendons. It is also consists of an intricate network of blood vessels and nerves. Of the 208-214 bones in the skeleton, the ones to be found in the most mobile parts of the body, the hands and the feet are among the smallest. These researchers further explained that on the surface, the foot is closely similar to the hand, but on detailed study, the foot is markedly different anatomically, biomechanically and functionally from the hand. The surface anatomy of the foot consists of medial side and sole of the foot, lateral side and dorsum of the foot (look at fig. 2.4). Vass (2006) explains that the bones, muscles, joints, and tendons of the foot jointly constitute the most complex mechanical structure in the human body.

The bones form the foot's load-bearing structure whereas the muscles, which are attached to the bones with tendons, carry out the function of movements. The bottom area of the feet approximately on arrange size 8/42 length of 270mm width 9.5 which must reliably bear an average body weight (for men) of between 70-120kg on standing.

The foot is therefore seen as a complex anatomical and biomechanical structure. Therefore, a thorough understanding of the structure of the foot is essential for designing comfort footwear in order to avoid the consequences of nerve injury, poor wound healing and disrupted function (Edward & James 2011). Anatomically the foot consists of three sections namely; tarsus, metatarsus, and phalanges (Chen 1993; Ahonen 2008; & Donatteli 1990).

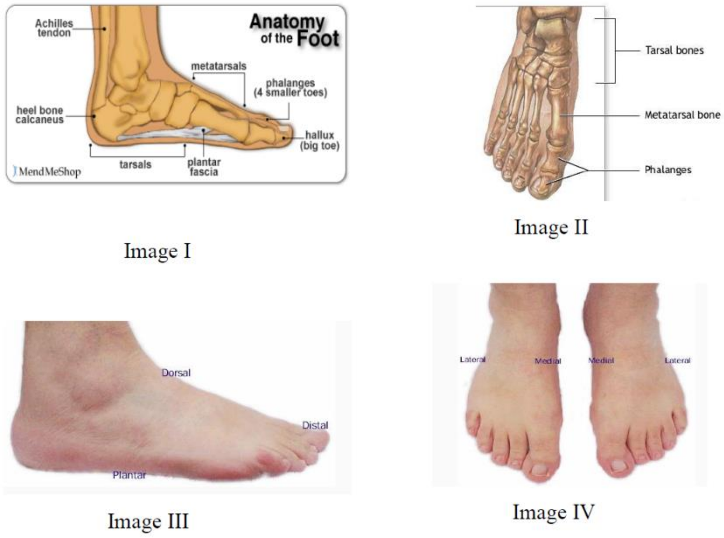


Figure 2.11 Different views of the anatomy of the foot

It should be therefore noted that footwear acts as the interface between the body and the ground during gait, in addition to protecting the feet from potentially harmful environmental factors. Footwear can be modified to alter mechanical loads on the lower extremity generally during the stance phase of gait and whenever special footwear is provided, the supplier should make sure that it fits properly and allow the toes a wiggle room (around 10mm or 1cm gap between the longest toe and the end of the shoes).

Gait adaptation to footwear modifications can be divided into three phases according to Mundermann (2004) namely: Short-term, medium-term, and long-term adaptation. Short-term adaptation may be considered as immediate adjustment of the body’s gait mechanics to a modification in footwear. The medium-term adaptation is described as adaptation to footwear modifications that occurs within a few days of using a new footwear modification. During long-term adaptation phase, the body “fine tunes” its gait mechanics, possibly to minimize energy and improve gait efficiency.

A research work on the effects of common footwear on joint loading in osteoarthritis of the knee by Shakoor and his colleagues (2010) has shown that the entire lower extremity is considered to be an interrelated functional and mechanical unit, and alterations at one aspect of the lower extremity (e.g. the foot) can have serious impact on distant areas such as the knee. Therefore, they concluded that footwear design and several aspects of footwear may substantially affect the loading patterns of the entire lower body. They pointed out that the heel lifts and heel height in walking shoes may affect loading. The ‘stiffness’ imposed by shoe soles is another characteristics of footwear likely to affect joint loading. And Mueller and his co-researchers (2006) reported that therapeutic footwear and orthotic devices are capable of protecting the foot from excessive plantar pressures during walking.

Previous studies (D'Ambrogi et al. 2005) have pointed out that peripheral neuropathy is responsible for remarkable changes of both structure and function of the foot in diabetic patients. They also observed alterations in plantar pressure distribution in heel pain patients with and without neuropathy, thus suggesting that functional changes may occur before neuropathy becomes evident.

Human walking analysis (Versluys 2009) has shown that during walking, there are periods when only one foot is on the ground (single support) and a period when both feet are on the ground (double support). Versluys (2009) analysed that double limb support occurs for two periods of 12% of the gait cycle and single limb support occurs for two periods of 38% of the gait cycle (in intact walking).

From biomechanics point of view, the main goal of footwear is to redistribute force over a large area (that is, to reduce pressure), thereby cushioning foci of elevated pressure. Normally, an insole that conformed to all curvatures of the foot can be used to redistribute the pressure throughout the surface of the foot. But it is important to identify how much the patients use their feet and in what activities. This knowledge about both the amount and type of use of the feet is critical because, for example, much greater forces are transmitted through the planter tissues from running than walking. And a patient who is chair or bed bound might not need sophisticated footwear to protect the feet, whereas a very athletic patient who has significant foot problems might have to consider changing or altering his or her behaviour as well as footwear (Bowker & Pfeifer 2008)

The result of a research work carried out by De Castro and his colleagues (2010) show that wearing inappropriate shoes can cause biomechanical in balance, foot problems, pain and induce falls. The outcome of their work indicate that the percentage of the participant wearing shoe sizes bigger than their foot length was 69.2% for the men and 48.5% for the women.

The method to design comfort footwear is based on characterization of the biomechanical variables appropriate to footwear design. "Of most importance for a heel pain foot are the high pressures under the 1st MTP (metatarsophalangeal) joint. High pressures under the 1st MTP joint (metatarsophalangeal joint) are known to be associated with foot problem" (Bernabeu et al. 2013, p. 977).

2.5 Footwear Materials

Footwear materials are described as “natural and synthetic materials which are suitable for footwear manufacture or repair and have adequate wear properties as upper or sole materials” (British Standard, 2007 p. 4). There can be few solid materials in the world which at some time or the other have not been used for footwear (Thornton 1970). Materials like, leather, stretch fabric, wood, brass, glass, iron, etc., are among the numerous materials that have been used or are used for footwear manufacture. But the choice of any of the materials mentioned above for shoe making would be a factor of its availability and suitability.

2.5.1 Shoe Upper Materials

Footwear upper materials are manufacture from a wide range of materials. The material which must have the necessary properties for making shoe uppers may be leather, woven, non-woven or knitted stretch fabrics in natural and synthetic fibres, or polymers (Larcombe 1975). Leather stands out as the most suitable material for footwear manufacture, but stretch synthetic alternatives have been invented. The stretch synthetic alternatives are mostly used in making ladies’ fashion footwear, mainly because the cost to produce them is lower than that of natural leather products (Covington 2009).

“The elegance and durability of a shoe depend to a crucial extent on the quality of the materials used. In consequence, the first rule of shoe making is to exercise great care when selecting the leather for the upper and sole of the shoe” (Vass, 2006 p.96).

Therefore, leather and stretch synthetic is seen as the most effective materials for shoe upper because of its properties of plasticity and elasticity (Tyrrell & Carter 2009).

2.5.2 Shoe Insoles and Inserts

The reduction of high plantar pressure in heel pain foot with peripheral neuropathy using appropriate insole or the shape of insole is mandatory for prevention of ulcers and amputations. An orthotic is used to provide an interface between the foot and the shoe. Therefore, it is expected that the upper surface of the orthotic must match the anatomical profile of the foot, with adaptations as required, and the under surface must always match the innersole of the shoe. When prescribing orthotic to heel pain patient, it is important to consider if the footwear has sufficient length, width, and depth to accommodate the orthotic.

There should be enough room within the shoe to fit the foot and the orthotic. If the footwear is inadequate, the therapeutic will fail (Tyrrell 2009; Pataky et al. 2010).

Bonnie and his colleague (2004) revelation on the 'effectiveness of insoles on plantar pressure redistribution' show that the use of insoles could reduce local peak pressure and increase the contact area significantly. They show that contoured insoles are significantly better than flat insoles in respect to the insole functions in reducing local peak pressures. A recent study (Kari 2010) indicates that increased plantar foot pressure is a leading cause of ulceration in the heel pain population. To help prevent ulcer formation in high-risk diabetic patients, Reiber (1994) recommended wearing appropriately fitted custom-made shoes with accommodative inserts.

Many foams and viscoelastic materials are used in shoes as insoles. Porous polyurethane sheets of 3-10mm thickness can be used based on the patient's specific need. The required mechanical and cushioning properties of insole or orthotic material for individual patient can be achieved by developing material with required thickness and density by changing the polymer content, polymer concentration and solvent volume (Saraswathy et al. 2009).

Foot orthotic is a device that is placed inside footwear that acts as an interface between the footwear and the weight bearing surface off the foot with the goal of correcting foot problem through providing support for the foot during weight bearing (Muogboh 2000). Pressure from wearing normal shoes and minor traumas are more likely to lead to ulcers. Hence, in 1993, the U. S Congress passed The Therapeutic Shoe Bill (TSB), that defined the benefits of wearing preventative footwear and so cleared the way for government and private insurance to contribute 80% of the cost of such footwear up to a maximum of $330 (World Footwear 2003). The study also outlined the different orthotics used in diabetic footwear. It shows that foot orthotics fall into two general categories-functional and accommodative. Orthotic for diabetic footwear fall into the latter category (also called sock-liners, inserts or inlays), which are fitted into the foot-bed of the shoe. They treat common foot ailments such as heel pain, metatarsal pain, tendonitis, painful lesions, arthritis, as well as the diabetic 'at risk' foot. The article further explains that the orthotics used in diabetic footwear may be custom- moulded or pre-moulded, as long as they are made from a suitable dual or multi-density material and are moulded to be in total contact with the plantar surface of the foot. In contrast to the above mentioned study which emphasis was on orthotics for diabetic foot, the present study would only investigate comfort footwear material choices and design.

2.6 Footwear Fitting and Fastening

Proper fitting of shoe according to Goonetilleke (2003) involves understanding feet, shoes, and the selection of shoes to achieve a required fit. Vernon and his colleagues categorically state that “while ill-fitting footwear may cause superficial yet painful problems, such as corns and callus in the healthy population, more serious problems, including foot ulceration can arise in the at-risk population”.

Therefore Litzelman (1997) reported that a properly fitted shoe which has been manufactured from soft materials with a sole designed to absorb shock, is sufficient to protect sensate feet, even in diabetes patients.

Shoe fitting is best accomplished according to White, J. (2010) The Medicare Therapeutic Shoe Programme: New Challenges, New Opportunities. Podiatry Management. Available at: www.podiatrym.com . (Accessed on 5/3/2014) by having the patient try on shoes from a fitting inventory. Such an approach allows the fitter to best determine the footwear size to order, and to allow the patient to see and feel how the shoes will fit at the time of dispensing. It is recommended that patients who cannot be satisfactorily fit in depth shoes must be fit with custom-moulded shoes.

In order to avoid the tendency of therapeutic shoes harming patients, they must be fitted by experience person or supplier. It is recommended that shoes should be fitted only by practitioners trained in fitting shoes to the diabetic foot and to ensure good fit, suppliers should have a large stock of depth-inlay shoes in different styles and brands (Wooldridge et al. 1998). Normally, when trying on the shoe, the wearer must be certain there is enough room for the toes at the sides and front, as well at the top, so that these parts of the shoe do not put pressure on his toes. To make sure you have enough room in front of your toes, Gilmore (1981) recommended that the thumb should be pressed across the tip of the shoe; the fit is correct if the thumb does not overlap the longest toe. In other words, the shape of the footwear must match the shape of the foot (see fig. 2.12). Chen (1993) pointed out that most complaints that relate to pains in the forefoot such as hallux valgus and on top of toes might be caused by continually wearing a pair of shoes with insufficient width and lack of enough accommodation at the forepart region.

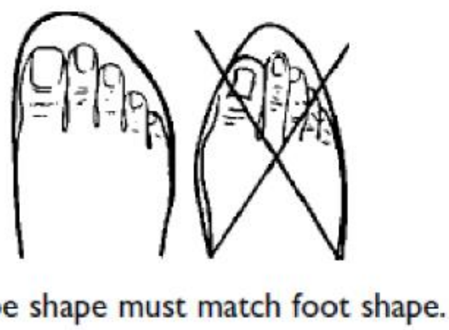


Figure 2.12 Foot Shape and Shoe Shape

Pezza (2011) in explaining the importance of footwear in podiatry practice, outlined 4Cs of shoe fitting which are “Care, Convenience, Compliance, and Cash”. She pointed out that podiatrist would be able to help their patients to reap the benefits of therapeutic shoes program if they follow all the rules, and ensure that patients have everything they need to maintain good foot health.
It is generally believed that product performance can be broadly evaluated based on its function, form and fit. Product compatibility or fit is necessary for someone to experience comfort, safety and satisfaction during use. It is observed that manufacturers attempt to design and develop footwear so that they provide a covering for the foot while exhibit fashion or style. But the design and development of footwear must cater for the varied perceptions of fashion and style while taking into high consideration the product compatibility (Goonetilleke 2003). A study conducted by Silvester and other researchers (2010) on ‘choosing shoes’ has shown that although fit and comfort are perceived by patients to be important factors in choosing footwear, current footwear choices are always inappropriate. Their work has pointed out the need for good footwear and the need to improve both practitioner and patient knowledge of footwear. According to Sandrey and his colleagues (1996), properly fitting shoes are important in the prevention of injuries. They pointed out that foot length should not be the only consideration used to determine proper shoe fitting. Static and dynamic measurements for the right or left foot, as well as metatarsal width, fifth metatarsal length, and heel width should also be included. Proper fitting of footwear (Janisse 1992) can be achieved as follows:

- Measure and fit shoes at the end of the day rather than at the beginning due to deformation and swelling.
- Fit shoes to the longer foot with a toe clearance of 9-12mm at the longest toe.

It should be noted (Goonetilleke 2003) that proper shoe fitting should consider heel-to-toe length of the foot as well as the arch length. If differences exist, the correct shoe size is determined using the larger of the two measures, arch length or overall heel-toe length. If the arch length is larger than heel-to length, the shoe size is chosen to correspond to the arch length. Similarly, if the heel-toe length is larger than the arch length, the shoe size is supposed to correspond to the heel-toe length as otherwise the shoe will be too short. The principle of fitted footwear for diabetic patients was looked into by Jeffcoate and Macfarlane in 1995. They explained in their research paper that the principle of fitted footwear is to provide a shoe which is deep enough and broad enough, but floppy. They point out that the materials for making the shoe, especially the upper should be soft, and there should be good instep support.

It is recommended (Tyrrell and Carter 2009) that both modular and bespoke footwear should be made to fitting stage- without permanent soles and heels attached. At this point, alterations to length, width, and girth can easily be made. To ensure that the shoe fits well, it is advisable to have subsequent fittings, because the moment the sole and heel have been permanently attached, the footwear cannot be altered.

Another important consideration in the choice of shoe style for heel pain feet is in the area of how to manage shoe fastenings. Some people find it difficult or impossible to fasten their shoes for a variety of reasons. They may be physically incapable of reaching their feet because of obesity, paralysis, arthritis, may be unable to see sufficiently well; they may have lost one or more fingers, or they may have lost a hand or an arm; or lack of co-ordination, and many other reasons too many to mention here. One obvious solution to the problem of fastening shoes is the use of 'slip-on' shoes but, they are not wholly satisfactory. They are limited to certain types and ages of people and to certain occasions (England 1973).

Some of the common footwear fasteners used are; Zip fasteners, laces, a transverse strap and buckle, Velcro. Velcro, which looks like two opposing strips of coarse velvet and adheres on impact, may be used by people living with diabetes. One of the great advantages of using Velcro is that it can be made to work without any precision of touch, even by means of the pressure of one foot upon the other (England 1973).

2.7 Chapter Summary

The literature on heel pain and comfort footwear as reviewed and analysed above has provided an extensive range of information concerning heel pain, and the particular foot problems associated with diabetes. The assessment of the literature has also revealed the need for heel pain patients to use or wear special footwear that will serve the important purpose of protection and support allowing for individuals to perform their activities of daily living. The basic information required to design and construct footwear that fits heel pain foot appropriately was also developed as a consequence of analysing research evidence presented in the literature review.

3 CHAPTER “Data Collection With Questionaire”

3.1 Introduction

There is evidence that lack of patient knowledge about foot care, unmanaged heel pain and the use of improper footwear are key factors contributing to most devastating preventable foot complications. However, the design and manufacture of comfort footwear based on an understanding of patients’ expectations and perceptions of footwear are not often considered. Therefore, for a complete view of the role of comfort footwear in the prevention or management of foot complications, the opinions of people suffering with the disease was sought in this study through a questionnaire/ interview survey.
Information on the outcome of the questionnaire survey carried out among diabetic foot and heel pain patients is provided in this chapter. The survey was designed to access a range of data from people with heel pain that provided me with the useful information for developing design concept for heel pain relief footwear. The research participants shared their thoughts and experiences on factors that would affect the design and construction of footwear. Therefore, this chapter provides key information on foot problems and the important factors to consider for designing heel pain relief footwear from the viewpoint of people suffering with the disease. The chapter ends with an analysis and discussion of the outcome of the survey.

3.2 Aim/ Objectives of this Chapter

3.2.1 Aim

The aim of this empirical research was to gather information from heel pain patients mainly about foot problems, foot care and their preferred type of footwear in order to develop an appropriate pain relief footwear design frame.

3.2.2 Objectives

- To understand the nature of heel pain and foot problems.
- To investigate the type and feature of footwear often used by diabetes and heel pain patients.
- To study diabetes and heel pain patients’ preferred footwear styles.

- To generate data for developing appropriate footwear design(s) for people suffering with heel pain.
- To identify areas that would require further investigation.

3.3 Protocol for the survey

Figure 3.1 gives a summary of the protocol followed to carry out the questionnaire survey.

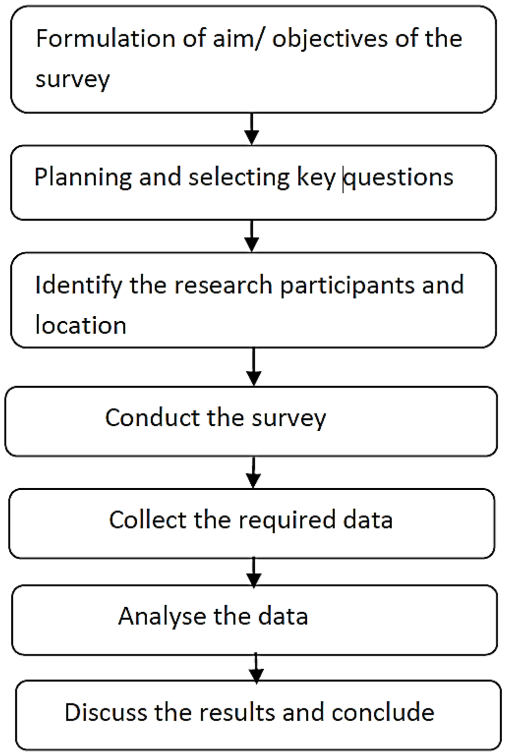


Figure 3.1 Protocol for Questionnaire Survey

3.4 Method

In this study, a questionnaire was formulated based on key objectives of the study. Questionnaires are considered to be one of the most widely used primary data gathering techniques. It is a research tool through which people are asked to respond to the same set of questions in a predetermined order (Gray 2004). It is also a technique that is used to seek views and perspectives of respondents. Data collected by questionnaire may be either qualitative or quantitative. However, questionnaires do lend themselves more to quantitative forms of analysis because they are designed to collect mostly discrete items of information, either numbers or words which can be coded and represented as numbers (Blaxter et al. 2010). It has been pointed out that surveys and experiments are probably the main vehicles of quantitative research (Bryman 1996). The data gathered in this chapter are mainly quantitative. Nonetheless, to ensure that other vital information not mentioned in the questionnaire would be identified, certain qualitative data were also gathered and interpreted. This approach was used in order to have a better understanding of different areas of the study. Moreover, it has been reported that much research uses a combination of methods for data collection to strengthen a study by providing different types of data (Crouch & Pearce 2012; Flick, et al. 2004; Black 1999).

During the formulation of the questionnaire, it was agreed that a multiple-choice questionnaire would be the simplest and quickest way of getting the main information required due to the different language barriers. In some cases, however, respondents were requested to rank certain elements or features based on their preference, and only one or two questions were open-ended (the detailed questionnaire is provided at the end in appendix). To ensure that the research questionnaire was well structured and that important items were included in the survey tool, the questionnaire was divided into four sections. The first section explores the background information of the respondents. The second section evaluates heel pain problems and foot care services available to the respondents. The third section examines foot problems and the role of footwear among people suffering with heel pain. In the fourth section, information on footwear fitting/ features is gathered. The design of the questionnaire was in accordance with the literature (Burns 2000) that suggests a good questionnaire should have four sections: The introduction, warm-up questions, the body of the study, and demography questions. The literature further explains that many researchers find it most appropriate to place demographic questions, concerning the sex of the respondent, socioeconomic status, age and so on, at the beginning of the questionnaire. The reason for this is that while one of the warm-up questions might upset the respondent and lead to negative response or to discontinue participation in the study, demographic questions do not usually upset and lead the respondent well into the questionnaire.

For validation of the questionnaire, it was decided that a pilot survey should be carried out prior to the actual study (see sub-section 3.4.3).

3.4.1 Research Participants

The survey was carried out at different clinics around the State, Czech from December 2013 to March 2014. Myself along with my colleague as language translator and the clinic assistants approached each patient in the waiting room and been asked questions to complete the questionnaire while waiting to see the foot doctor/ podiatrist, or foot expert so called pedorthist. An oral explanation of the research was given to each participant in addition to a written explanation that accompanied the questionnaire. Questionnaires were not given to patients who refused. In most cases, completed questionnaires were returned to me immediately. Overall, 180 questionnaires were given out to people living with foot problems and 164 were collected back, but few were rejected or excluded from the analysis because they were not properly completed. Therefore, 156 (75 male and 81 female) filled questionnaires were analysed and the results are presented in sub-section 3.5.

3.4.2 Ethical consideration and Standard Operating Procedure (SOP)

Ethical approval and my Czech Podiatry Association membership for this study was obtained from Czech Podiatry Association MUDr.Marie Souckova CPA Prezident and Jaroslav Fesar (Ceska podologicka spolecnost, z.s Praha Czech Republic), MUDr. Jaroslav Lux (Atlas Care, Ostrava Czech Republic), Ing. Ludmila Maluchova (Medicia, Ostrava Czech Republic). Participants at the beginning of the study were given information on the nature of the survey, the anonymity and confidentiality of personal data and the participants' right to withdraw from the study at any time. Hence, the participants entered into the research voluntarily and with adequate information. No one was subtly coerced or unduly influenced to participate in the research. A Standard Operating Procedure (SOP) was designed for the study (see details in appendix). It consisted of structured questions that helped the researcher to identify the locations of the research participants. In addition, it was also used to guide the researcher in step by step conducting of the survey.

3.4.3 Pilot study

The pilot study was carried out to ensure that the survey tools could determine the research area of interest reliably and validly when used for the real survey. The specific objectives are:

- To obtain professional feedback about the initial version of the survey materials
- To collect preliminary information from the proposed research participants
- To identify ways to improve the survey items

- To identify ways to administer the actual survey to participants effectively.

An initial investigation or pilot survey is an important step to determine the next step of the survey process that should be undertaken prior to administering an actual survey to the research participants. It is described as a mini piece of research that is used to ensure that the questions set could be easily answered and the tools to be used actually work (Etchegaray & Fischer 2011; www.wiki.aswers.comm 2013). A pilot survey is a great deal of work, but if it is done properly, many complications often not considered are handled at this stage and makes the following research much easier. Even though the specifics of the pilot survey vary among researchers, the goal is the same: that is, to ensure that the items can measure the area of interest reliably when used in real situations. In this work, a structured questionnaire for heel pain patients was prepared and administered at some clinics where the actual survey was planned to be conducted in order to see whether the questions would be appropriate to get the responses the researcher was aiming at receiving. The initial investigations helped the researcher to make changes to the survey items. The key changes that were made were:

1. One view of the initial foot image (see details in appendix) that was used for the pilot survey was considered inadequate to be used to gather the required data from the respondents about their foot problems. Therefore, the foot image was re-presented in 3 views during the full survey (as given in fig. 3.3, 3.5 & 3.7).

2. The questionnaire was not initially divided into sub-sections, but it was observed during the pilot study that the respondents did not find it interesting to fill in. So, the final questionnaire was divided into sub-sections (see details in appendix) to make it easier for the respondents to complete and for the researcher to analyse.

3.5 Results

The individual outcomes of the questionnaire survey were coded, analysed and the findings are presented in this section mainly in the form of tables and charts.

Table 3.1. Participants' personal information.

*NA-Not Applicable

Enquiry		Males % (n=75)	Females % (n=81)	Overall % (n=156)
1. Sex		48	52	100
2. Age (years)	≤ 20	0	0	0
	21-35	08	05	06
	36-50	24	42	33
	51-65	49	38	44
	≥ 66	19	15	17
	Mean	55.3	52.9	54.1
3. Occupation	Employed	34	28	31
	Own business	23	31	27
	Unemployed	03	03	03
	Retired	23	05	14
	Student	0	0	0
	Farmer	15	0	07
	housewife	NA*	33	18
4. Residency	Rural	16	22	19
	Urban	84	78	81
5. Type of diabetes	type 1	07	04	05
	type 2	36	20	28
	Do not know	57	76	67
6. Duration of living with diabetics	≤5yrs	45	38	41
	6-10yrs	25	38	32
	11-15yrs	15	15	15
	16-20yrs	10	06	08
	≥21yrs	05	03	04
	mean	7.7	9.0	7.5

Table 3.1 Participants’ Personal Information

The background information about the research participants presented in table 3.1 has provided data on the participants’ sex, age group, and occupation, and residency, type of foot problem and duration of living with the disease.

The findings are shown as percentages with n=156 for both males (48%) and females (52%) participants. The findings indicate a wide spectrum of different age groups who are suffering with the disease. Half of the participants are 51-65 years and those that are between 36 years and 50 years accounts for 31% of the respondents. Therefore, eighty one percent of the participants are less than 65 years of age. When the patients were asked how long they have been living with the disease, 41% indicated that they have been living with foot problem for less than 5 years and 32% state that they have being suffering with the disease for 6-10 years. Only 4% of those that participated in the study reported that they have lived with foot problems for over 20 years. The mean age of the duration of living with the disease for both male and female participants was found to be 7.5 years.

Table 3.1 has also shown that up to 31% of the respondents were employed and 27% are engaged in their own businesses. Eighteen percent of those that participated in the study were housewives. The majority (81%) of the patients involved in the survey live in towns, whereas only 19% live in rural areas. This is because most of the survey was carried out in urban clinics.

When patients were questioned about type of foot problems they were suffering with, up to 67% reported that they did not know, while 28% state that they were suffering with type foot pain and only 5% reported that they have type foot problem.

Enquiry	Males (n=75)		Females (n=81)		Overall (n=156)	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
1. Feet have been checked by health professional	70	30	71	29	70	30
2. Ever reported numbness or pain in the feet to a doctor	59	41	62	38	61	39
3. Suffering with foot problems like ulcer,	44	66	35	65	40	60

Table 3.2 Foot Problems and Foot care

It was discovered from the survey that the patients' feet are not checked ordinarily by the foot doctors except if they have complained of pain or any other foot problem. Table 3.2 gives some insight into the level of foot problems diabetes patients' experience. The results in the table shows that 70%, 61% and 40% at one time or another had their feet checked by a health professional, reported pain in the feet, and suffered with foot problems like ulcers, respectively.

Figures 3.2 to 3.7 provide findings on the areas or parts of the foot patients mostly experience foot problems. Three views (plantar or the sole, dorsal/ lateral and dorsal/ medial) of the foot were presented to the research participants to indicate the particular area or location they have foot problems like pains, wound, ulcers, gangrene etc., if they have any.

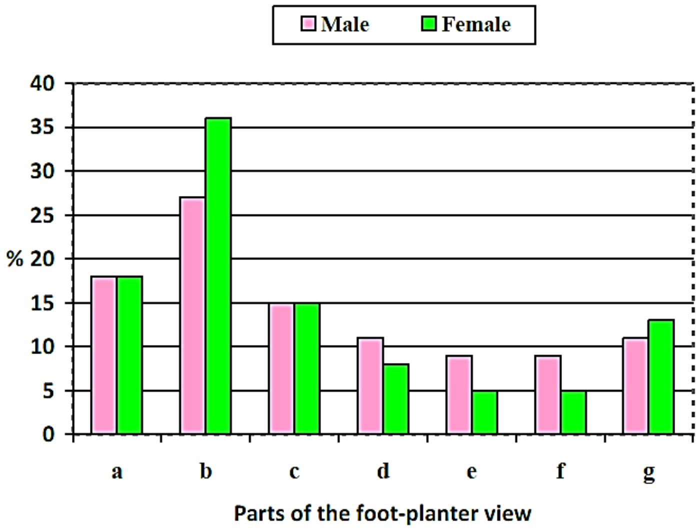
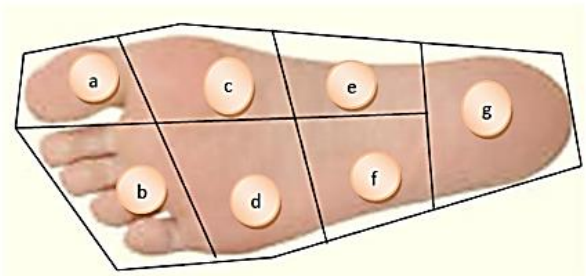


Figure 3.3 Foot Problems Located on the Plantar “Refer to fig. 3.3



Note:
(a) Big toe
(b) phalanges (c) 1st MTP joint
(d) 2nd -5th MTP joint
(e) Plantar/ medial (In-between heel & MTP location)
(f) Plantar/ lateral (In-between heel & MTP location)
(g) heel

Figure 3.2 Plantar Views of the Human Foot

Figure 3.3 shows that foot problems located at sole or plantar part of the foot occurred mostly at location ‘b’ with percentages up to 36% for females and 27% for males. The second location with very significant percentage of foot problems is location ‘a’ which is up to 18% for both males and females. Locations ‘a’ and ‘b’ are the distal part of the foot or the phalanges.

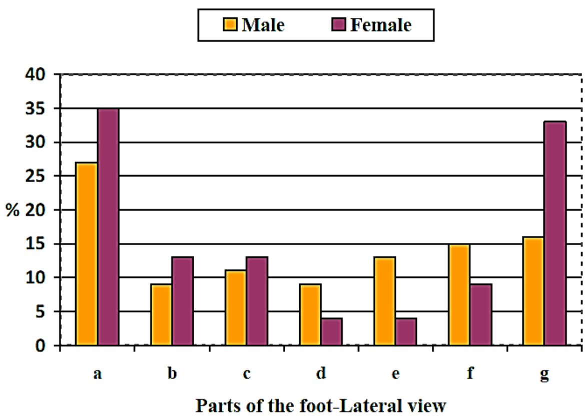
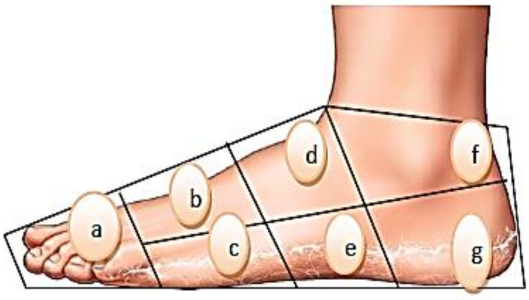


Figure 3.4 Foot problems located at the lateral part of the foot (refer to fig.3.5)



Note: **(a)** Toes **(b)** MTP joint (dorsal) **(c)**MTP joint **(d)** In-step **(e)** Lateral (location between heel & MTP **(f)** Ball joint **g.** heel.

Figure 3.5 Lateral View of a Human

The top two locations of the foot in regards to the dorsal/ lateral view mostly affected with foot problems are locations ‘a’ and ‘g’. Location ‘a’ with 35% and 27% foot problems for both female and male respectively represents the entire phalanges. Secondly, 22% foot problems among female participants were located at the heel, while 16% of males indicated that they experience foot problems at the heel.

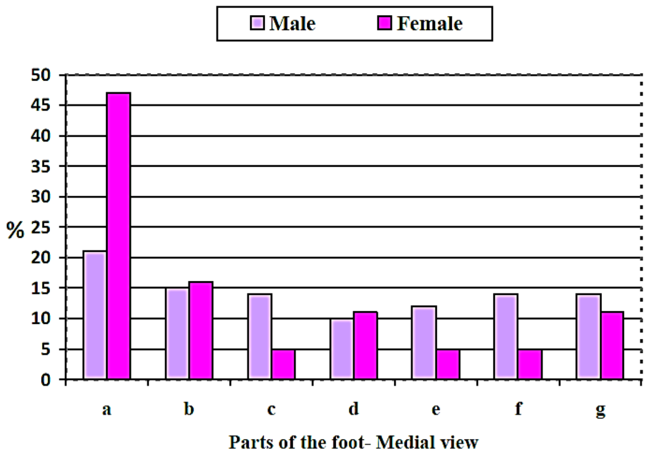
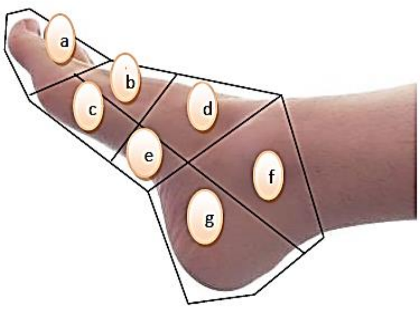


Figure 3.7 Location of foot problems on the dorsal/medial side (refer to fig. 3.7)



Note: **(a)** Big toe/ other toes **(b)** MTP joint **(c)** MTP **(d)** In-step **(e)** Medial (location between heel & MTP joint **(f)** Ball joint **(g)** Heel.

Figure 3.6 Medial View of a Human Foot

This survey also provided information on foot problems located at the dorsal/ medial view of the foot. Figure 3.6 clearly shows that the highest percentage of the problems occurred at the phalanges. Almost half (47%) of the foot problems experienced by the female subjects were experienced at the phalanges and up to 21% of the problems were experienced at the same location by the male participants.

Table 3.3. Areas of the foot with particular sensitivity or pain caused by the use of inappropriate footwear (refer to fig. 3.3, 3.5 & 3.7 to view the different foot locations).

Foot Location	Plantar View	Lateral View	Medial View
	Male (Female)	Male (Female)	Male (Female)
a (%)	16 (11)	22 (17)	26 (15)
b (%)	23 (26)	08 (15)	10 (14)
c (%)	15 (14)	08 (15)	13 (15)
d (%)	08 (12)	19 (13)	13 (14)
e (%)	14 (14)	08 (12)	09 (14)
f (%)	08 (09)	16 (15)	13 (13)
g (%)	16 (14)	13 (16)	16 (15)

Table 3.3 Areas of the foot with particular sensitivity or pain caused by the use of inappropriate footwear

The highest values (26% & 23% for female and male respectively) in table 3.3 are found at the plantar (at location ‘b’). Looking at data for the dorsal/ lateral view, location ‘a’ gives the highest percentages (22% and 17%) for both male and female participants respectively. Location ‘f’ with values up to 16% for male and 15% for female is another location that should be noted. For the dorsal/ medial part of the foot that most of the discomfort or pains were experienced by the male participants, location ‘a’ has the highest value (26%). The values from one location to another did not vary significantly.

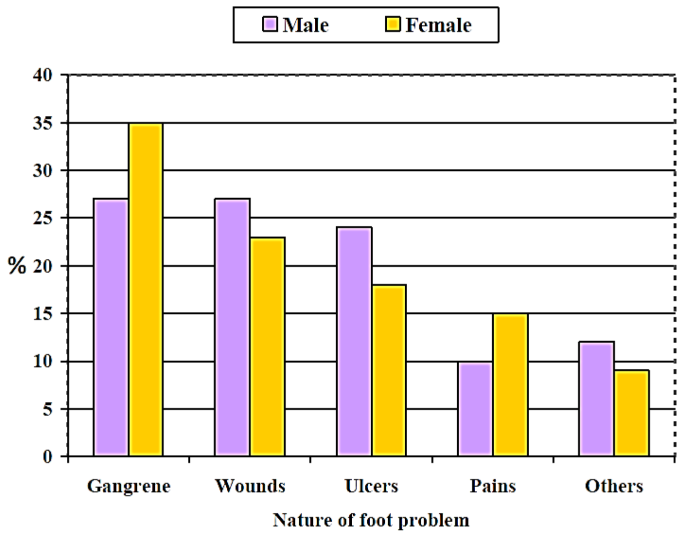


Figure 3.8 Nature of foot problems among diabetic patients

Most of the participants that reported of foot problems indicated that they had at least one of the conditions mentioned in figure 3.8 above. However, the presence of wounds ranked highest at 31% for females participants, whereas wound and gangrene ranked highest at 27% among males participants. Twenty four percent of both male and female participants reported that they had foot ulcers. Gangrene was found to be more prominent among female patients with up to 35% reported cases. On the other hand, the cases of severe pains at the foot were more common among the male participants.

a. Shoes are too tight; b. Shoes are rubbing feet; c. Shoes are pinching feet

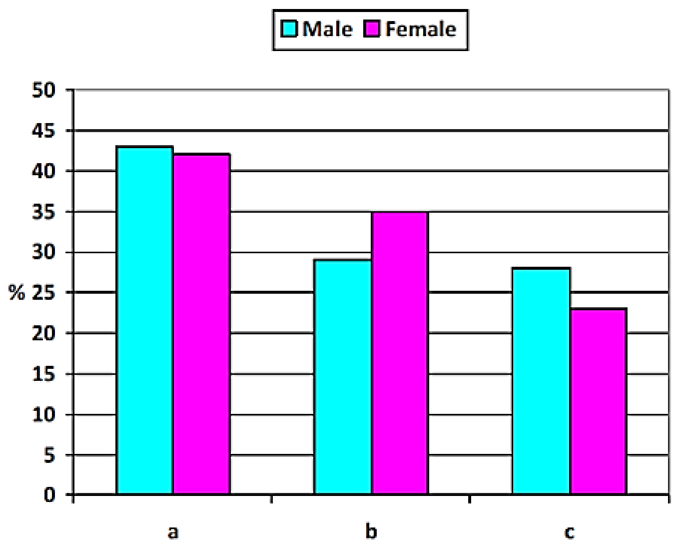


Figure 3.9 Causes of pain/ injury as a result of wearing inappropriate footwear

Interestingly, figure 3.9 gives vital information about causes of pain/ injury for patients as a result of wearing inappropriate footwear. The findings indicate that almost half (43% & 42% for males and females respectively) of the cause of pain or foot injury for participants was as a result of wearing shoes that are too tight. Other reasons with significant impact for causing foot pain and injury due to using footwear were be attributed to shoes rubbing feet (up to 35% for females and 29% for males) or pinching (28% and 23% for males and females respectively) the feet of the wearer.

Enquiry	Male		Female		Overall	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
1. Regular shoes not able to accommodate patients' feet due to foot problems	38	62	30	70	34	66
2. Shoes need modification in order to accommodate feet well	28	72	34	66	31	69
3. Patient walk without shoes or barefoot sometimes	35	65	42	58	38	62
4. Find it difficult to put on shoes or to take off shoes	31	69	28	72	29	71
5. Wear shoes without socks	66	34	75	25	70	30
6. Comfortable with own shoes	76	24	86	14	81	19
7. Patient knows his/her correct shoe size	92	08	92	08	92	08
8. Patient needs different sizes of shoes for left and right feet	12	88	06	94	09	91
9. Receive information about type of footwear to wear most often	25	75	34	66	25	75
10. Willing to use footwear with extra insert materials as insoles	78	22	83	17	81	19
11. Willing to buy footwear that could cost double the amount usually spent on shoes, if recommended by a doctor.	88	12	80	20	84	16

Table 3.4 Footwear Fitting/ Features

The aim of this section was to investigate the experience of patients on the use of their footwear in terms of fitting and their willingness to use extra inserts materials. Secondly, it was to find out if they received information about the type of footwear they should use often and their willingness to use or buy shoes that may be recommended to them by their health care providers.

The first item in table 3.4 gives information on participants that regular shoes are unable to accommodate their feet due to foot problems. It can be observed from the findings that 34% of those that participated in the study cannot wear regular shoes. When asked the reason why they could not use regular footwear, one of the respondents said; “My foot problem caused by diabetes has deprived me from wearing any type of shoes I like.” The second item on the need to modify patients’ footwear in order to accommodate their feet well gives a very similar percentage (31%) to item one (those that reported that regular shoes cannot accommodate their feet).

Looking at item 3 in the table above, a significant number of patients (38%) sometimes walk without shoes or barefoot, a situation that is not recommended for diabetic patients because their feet need to be protected always. When asked if they find it difficult to put on shoes or take off their shoes, 29% of those that participated in the survey reported that they find it very difficult to put on or take off their shoes.

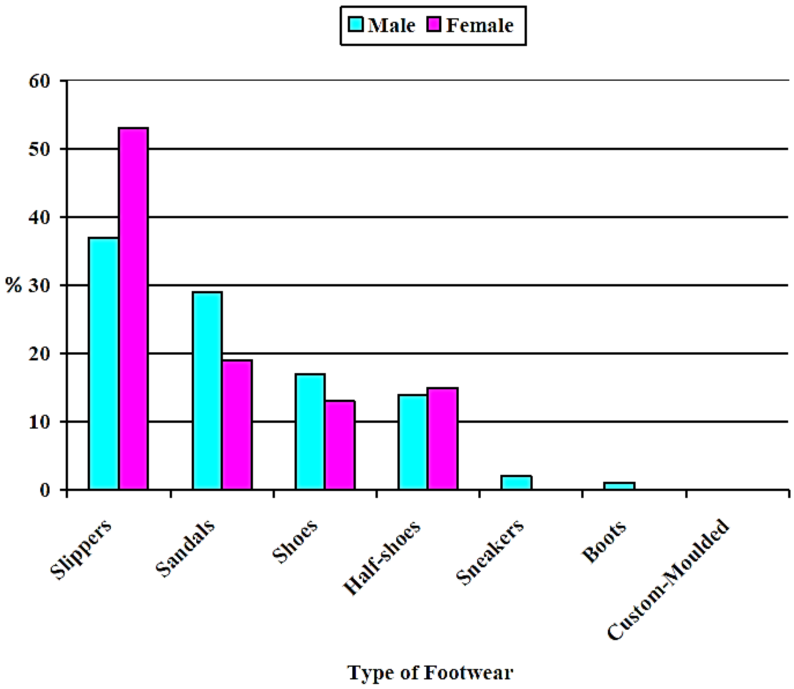


Figure 3.10 Type of footwear most often used by participants

It has been recommended that foot patients wear clean cotton socks every day that are soft and that do not have thick seams, creases, or holes that could rub the skin (Carmel & Edelman 2005). It can be observed from the findings shown in table 3.4 that only 30% of the responded reported that they wear shoes with socks, whereas the majority (70%) do not wear socks at all.

The survey also investigated the knowledge of foot patients about their shoe size. The findings indicate that 8% did not know their correct shoe sizes and 9% reported that they needed different sizes of shoes for their right and left feet.

It has been discovered from this study that only 25% of the respondents receive information about the type of footwear they should wear most often while up to 75% do not receive information on the issue. Another interesting finding presented in table 3 is willingness of the patients to buy shoes that would cost them double the amount they usually spend on footwear if recommended by a foot doctor/ podiatrist. Eighty four percent of the respondents would be willing to buy footwear prescribed to them by a foot doctor/ podiatrist.

Information gathered by the researcher through the questionnaire survey and presented in figure 3.10 has shown the top two footwear worn by the female respondents are slippers (53%) and sandals (19%). For the male participants, up to 37% wear slippers most often and 29% use sandals most times. None of the patients used custom-moulded footwear. Only 17% male and 13% female respondents wear shoes. This is seen as a very poor result because diabetic patients are expected to use footwear that gives good instep support.

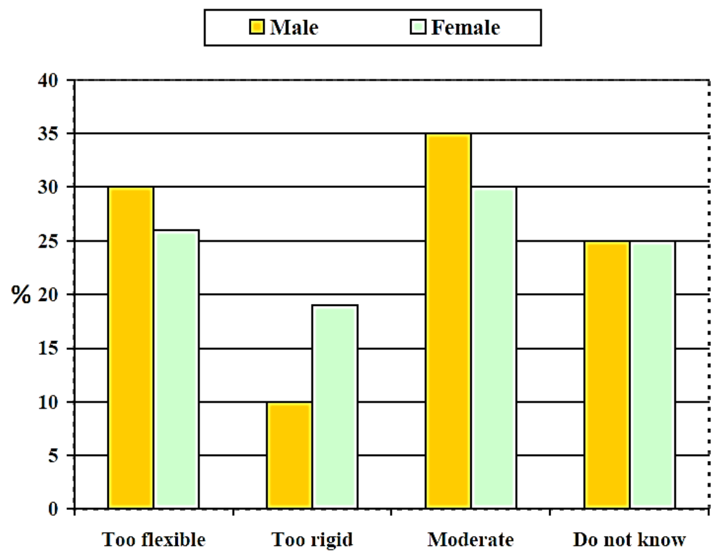


Figure 3.11 Participants' view on the out-soles of their footwear

In this study, the nature of out-sole often used by foot patients was investigated. Figure 3.11 presented above indicates that 35% male and 30% female respondents' out-sole of their footwear were neither too rigid nor too flexible (i.e moderate). The percentages of patients wearing footwear with flexible soles were 30% (male) and 26% (female). A quarter of the participants could not describe the nature of out-sole of the footwear. Nineteen percent of the male respondents indicated that out-soles of their footwear were too rigid, but only 10% of the female patients reported that out-sole of the footwear were too rigid.

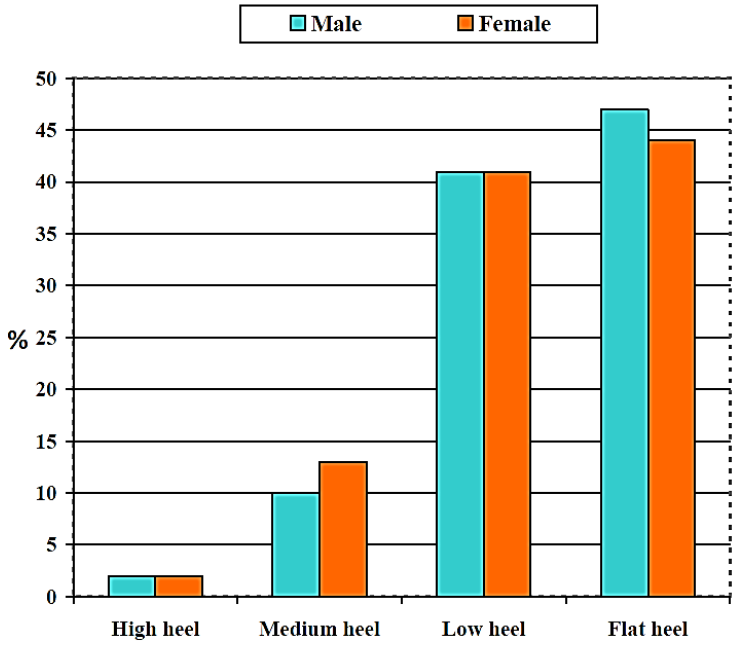


Figure 3.12 Preferred Sole Heel Construction Height

Figure 3.12 clearly shows that the majority of the male patients preferred footwear that has low sole height (41%) and flat sole heel height (47%). Similarly, 44% and 41% female patients preferred footwear made with flat and low heels respectively. A significant percentage of the patients would prefer medium heel footwear. But a very low percentage (2%) of both male and female like wearing footwear that have high bottom sole heel height.

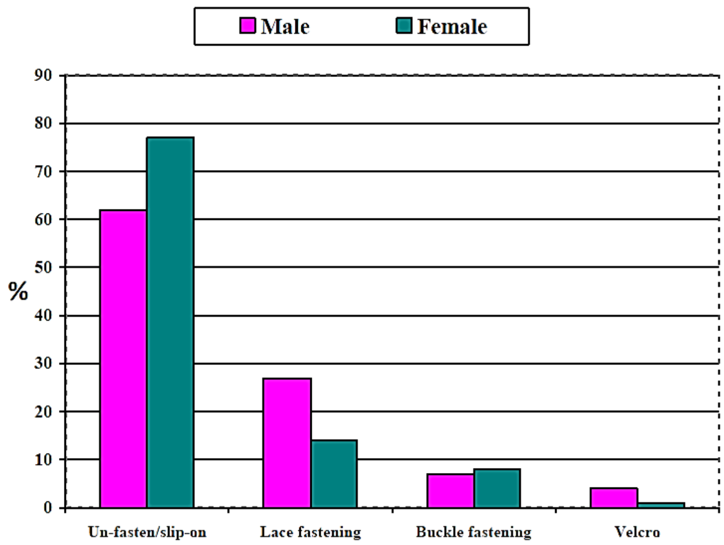


Figure 3.13 Style of footwear used most often

In regards to shoe fastening, figure 3.13 provides information on the preference for the different types of shoe fastenings or otherwise. The findings indicate that up to 77% females and 62% respondents used footwear that do not have any form of fastening or are slip-on footwear. Lace-up shoes were used by 28% of the male participants and only 12% of female patients used a similar type of footwear. Footwear with buckle and Velcro fastening were the least popular type of footwear used by the research subjects.

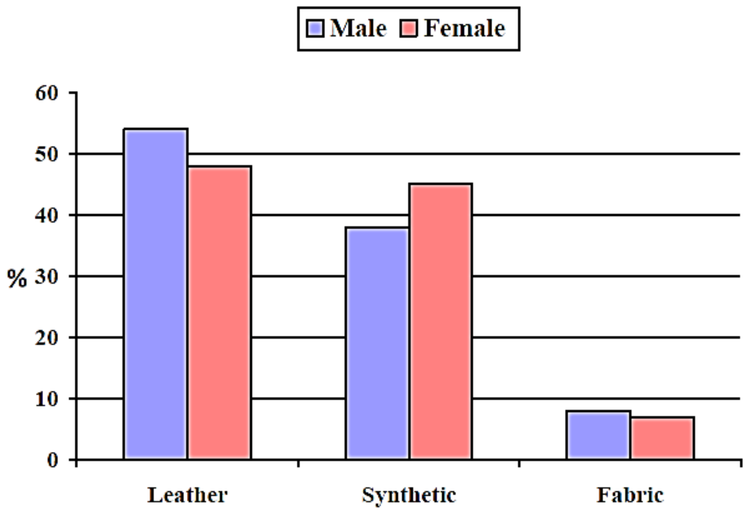


Figure 3.14 Preferred Upper Material

Responded were asked to indicate their preferred shoe upper material and as shown in figure 3.14, more than half (54%) of the male respondents preferred leather and approximately half (48%) of the female subjects also preferred leather for their shoe upper. However, the percentage of the female participants that indicated that they preferred synthetic materials as shoe upper is also high (45%). Based on this survey, fabrics are the least preferred upper.

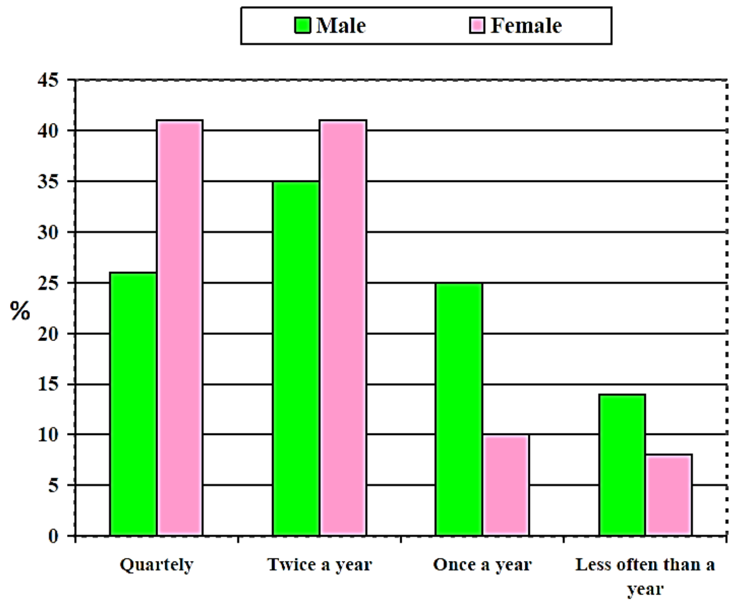


Figure 3.15 Frequency of Purchasing Footwear

The frequency of purchasing footwear by the respondents is shown in figure 3.15. The frequency of buying shoes is highest among female subjects. 41% of the females indicated that they buy footwear quarterly, whereas 26% of the males reported that they buy footwear within that period of time. Looking at the chart above, male patients buy footwear less often than female patients.

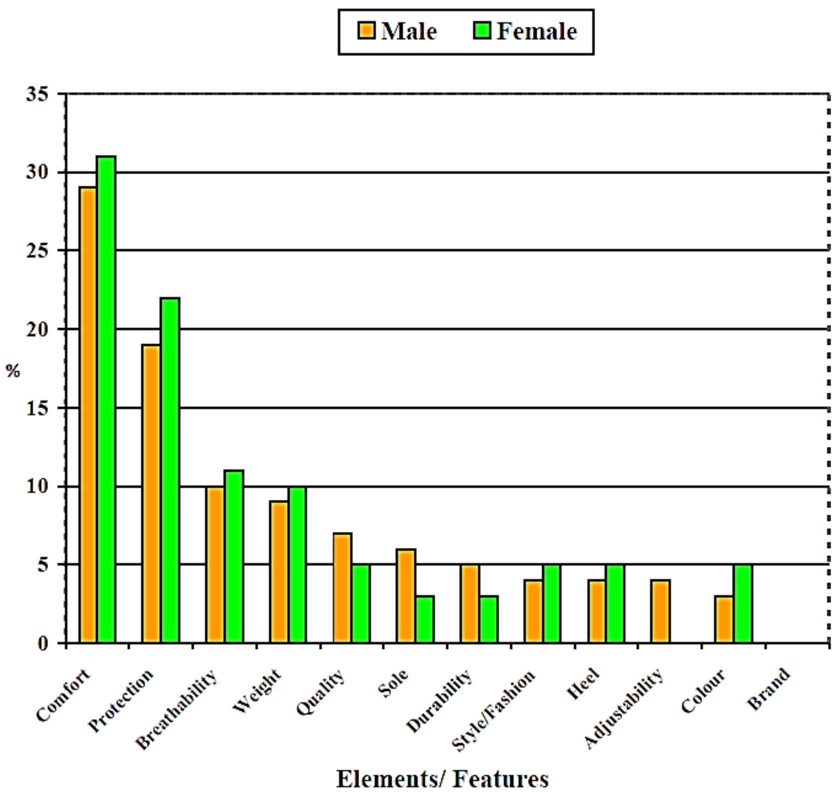
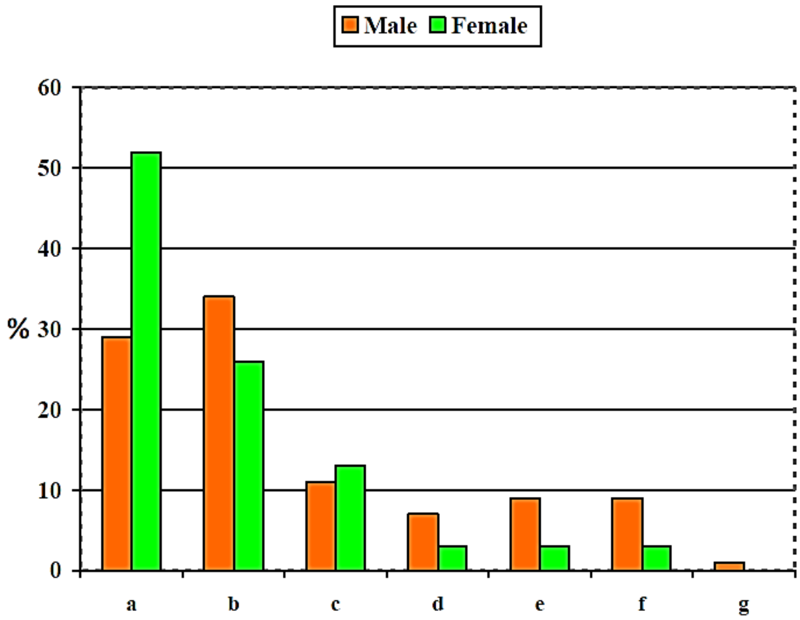


Figure 3.16 Preferred Footwear Elements

The questionnaire was partly designed to understand the elements respondents considered very important when purchasing shoes. The top four most preferred footwear elements from the result presented in figure 3.16 are comfort, protection, breathability and weight with values 28%, 18%, 10%, 8% and 31%, 22%, 11% & 10% for males and females respectively. Note that the outcome of this survey indicates that female patients (5%) give more preference to colour than male patients (3%). Whereas male took into account the adjustability of their footwear, female patients completely did not consider it as an important element when purchasing footwear. But both male and female reported that they were not bothered about the brand of the product (footwear) they buy.



(a) (€ 40-60) **(b)** (€60-80) **(c)** (€80-90)
(d) (€100) **(e)** (€120) **(f)** (€140)
(g) (€150)

Figure 3.17 Amount willing to spend on a pair of footwear

Figure 3.17 gives the outcome of the amount the patients were willing to spend on a pair of footwear. The result shows that the majority (52%) of the female respondents were not willing to spend more than € 40-60. Based on the data presented above, the tendency for foot care patients in this part of the world to buy a pair of footwear that will cost up to €60-80) and above is very low (1% for male & 0% for female).

3.6 Selected Comments Made by the Participants

Selected comments made by the research participants during the questionnaire survey are given below.

Foot problems and the role of footwear

The simple comment I have is that, at times one foot may be bigger than the other due to swollen, so something like elastic grip can be considered on slip on shoes.

Sometimes I walk barefooted without knowing because my shoes can go off my feet and I will not know.

I use slippers and even the slippers go off my feet without knowing that they have gone off my feet

If I am to trek from the hospital clinic to the gate, I have to rest 4 to 5 times before getting to the hospital gate and my slippers can go out from my feet without my knowledge.

My foot became too bad (rotten) due to diabetics, and so I cannot wear shoes, afterward I had to undergo amputation (on my left leg).

I am comfortable with wearing any type of shoe despite my condition.

The blisters due to diabetes is not yet severe to stop me from wearing my shoes.

My ulcered foot caused by diabetes has deprived me from wearing any type of shoes I like.

Diabetes have spoiled my legs (more to the left) and now I can't wear shoes

The condition resulted to the unhealing of my foot injuring I had rendered me unable to wear shoes.

My condition has made me scared of wearing shoes, less my feet get blistered and wounds.

I was using a half shoe with socks, which latter resulted to the injury on my left toe.

Prolong putting on of shoes with for 4 days made me have blisters, and subsequently complications. Now I cannot put on shoes.

Comfortable footwear should be made for diabetics. Diabetes patients should be given free treatment just like HIV and TB patients, because it is not all patients that can afford buying the drugs.

Initially, the little blister makes me uncomfortable, but now I can wear any type of shoe I want.

The pains I feel on my toes prevent me from wearing shoes comfortably.

The gangrene on my right big toe and the swollen condition of my right foot as a result of diabetes has prevented me from using shoes as I would.

Because of the wound on my left foot, I find it difficult to put on shoes.

Awareness

I have diabetics and I would like to be enlighten the more about the type of shoes to use.

I received information from the clinic about the type of shoes I should use but I did not buy them.
I will be happy to wear any shoe so long as it will be good for my diabetic foot.
Preferred type of footwear
Comfortable footwear will be appreciated by me.
The footwear should be moderate and light.

3.7 Discussion

The findings presented in this chapter are discussed under the following sub-headings: subjects' gender and age, diabetics and foot problems, knowledge of foot care and footwear, footwear fitting/ features, footwear materials and components, preference for special footwear and cost.

3.7.1 Gender and Age

According to the results of the survey, the percentage of female participants (52%) was slightly more than that of the male (48%). However, Krentz and Bailey (2001) reported that the relative prevalence of foot problem among the sexes varies from population to population and no clear view has emerged.
Of the 156 studied foot patients, 50% were found to be in the age group 51-65 years and up to 31% were in the age bracket of 36-50 years. Those suffering with the disease that were 66 years and above accounted for 12% of the respondents. The mean age is 54.1 years old. The result obtained is at variance with the findings of Anselmo et al (2010) whose studies on the 'effectiveness of educational practice in foot problems.

3.7.2 Heel pain and Foot Problems

Heel pain and diabetic foot disease with its related morbidity and mortality have become a serious global burden. Boulton et al. (2005) argue that most foot problems are preventable. And it has been pointed out (Wild et al 2004; Beran & Yudkin 2006) that the greatest rise in the prevalence of type 2 diabetes is likely to be in developing countries. Table 3.1 shows that 28% of the foot patients that participated in the survey have type of foot pain. The literature (see sub-section 2.4.0) also reported that the risk of developing foot problems differs according to ethnic group.
This survey has given a clear picture of the percentage of people suffering with foot problems and how long they have being living with the disease. It was discovered that just 27% (refer to fig.3.5) of the patients have being living with the disease for over 10 years. However, a similar survey (Tagang 2010) revealed that people in the developed societies (U. K) live with foot problems

for longer period of time compared with people with the condition in the developing societies.
In this study, it was discovered that up to 40% of the patients were suffering with foot problems like pains, ulcers, blisters, wounds, etc. Research has also shown that the prevalence rates of the foot disease are increasing and foot complications are rising parallel (Abbas & Archibald 2007).
Mansour and Dahyak (2008) state that "foot problems are common in patients with diabetes, often requiring prolonged and costly hospital stays and eventually leading to lower extremity amputation". They found out from their study that 36.2% patients with diabetes in Basrah, Iraq had prominent foot abnormalities. In this study, it was discovered that the majority of the foot problems among the patients that participated in the study occurred at the toes (see fig.3.2-3.7). The result of this research is in agreement with a work published by Benn et al (2005) which reported that foot ulcers in diabetic subjects occur in the forefoot. With the understanding of the fact that forefoot pressure is higher than rear foot pressure, there is need for forefoot off-loading. Data from literature (U. S National Institutes of Health, 2011) also shows that almost 30% of people with diabetes aged 40 years or older have impaired sensation in the feet (that is, at least one area that lacks feeling).

3.7.3 Knowledge of Foot Care and Footwear

According to Boulton and Jude (2004), footwear is probably one of the major reasons for the lack of progress in reducing foot ulceration and amputation rates. In agreement with their assumption, up to 75% of the diabetic subjects that participated in this study reported that they have not received information about the type of footwear they should wear most often. Some comments (see sub-section 3.6) indicate that footwear cause and/ or complicate their foot problems.
An important finding of this study is the nature or type of footwear worn by patients in this part of the world. Our data give a very poor choice of footwear by people suffering with pain (see fig. 3.10). Poor knowledge of the foot complications, and lack of knowledge of the management of the disease are seen as the major reasons for the high percentage of patients experiencing foot complications in this part of the world. Therefore it has been advocated that patients' education on avoidable complications of foot problems and awareness of appropriate footwear for maintenance of good foot health should be emphasised by health care providers (Chandalia et al. 2008).

3.7.4 Footwear Fitting/ Features

Serious foot problems including foot ulceration can arise in the at-risk population due to ill-fitting footwear. Proper fitting footwear is therefore very important in the prevention of injuries. It has been pointed out that proper fitting footwear involves an understanding of feet, footwear and the correct selection of footwear to achieve a required fit (Goonetilleke 2003). It has also been suggested that footwear should be fitted only by practitioners trained in fitting footwear for diabetic foot (Wooldridge et al. 1998).

The data provided in this chapter (in table 3.4) shows that up to 29% of the subjects found it very difficult to put on shoes or to take off shoes and 31% agreed that their footwear needed modification in order to accommodate their feet well. My argues that this percentage could have been higher if not for the fact that the majority of the subjects were wearing slippers as it had shown that most of the patients worn slippers (straps without back support) and sandals (see fig. 3.10 and appendix IX) and just 17% and 13% male and female subjects respectively worn shoes. On this issue of type of footwear worn by the patients, one of the subjects states that “I use slippers and even the slippers go off my feet without knowing that they have gone off my feet”. Generally, the majority of foot problem people wear open footwear.

This finding points to the fact that a significant number of foot patients are wearing footwear that do not fit properly and lack the basic knowledge of proper fitting of footwear. They also do not have access to practitioners trained in fitting footwear for diabetic foot. It is believed that patients’ foot care education, particularly in regards to footwear, will significantly improve the poor choice of footwear by both male and female patients in this part of the world. Health care providers have a big role to play in this by making extra emphasis on good foot care practices and by giving patients information on avoidable complications and prevention. Whereas slippers and shoes are widely used in and other countries like India (Chandalia, et al. 2008), shoes are found (Tagang 2010) to be the most widely worn type of footwear used in the UK and other Western countries.

One important consideration in footwear fitting for foot patients is in the choice of footwear style and shoe fasteners. Figure 3.10 clearly shows that majority of those that participated in the research worn improper footwear (i.e. wrong styles of footwear and without shoe fasteners).

Footwear is much more that a material that covers the foot. It serves many roles like protection, comfort, fashion, performance in sport and improved foot health (Tyrrell & Carter 2009). In regards to some of these important elements, it was discovered from this study that foot patients ranked comfort, protection and breathability very high. Another element considered very important by the patients is the weight of the footwear.

Most of them preferred their footwear to be very light. This is a very positive outcome because in the prescription of therapeutic diabetic footwear, based on the International Diabetes Federation (IDF) Guidelines (Nather & Singh 2008), it states that: Footwear should be light, preferably less than 700g per pair and that the heel of the shoe should be under 5cm high to avoid weigh being thrown forward onto the metatarsal heads.

This shows that when designing shoes for diabetic foot, a range of factors that would improve comfort, protection, breathability and lightweight should be highly considered. Materials that cause discomfort should therefore be avoided or eliminated completely. Thorstensen (1993) explains that shoe comfort is related more to the take-up of liquid moisture and evaporation than to the passage of air or water vapour. He further explained that porosity and good air permeability do not necessarily imply comfort and good cooling of the foot. Information from the internet (http://hubpages.com/hub/walkfit-reviews) points out that most discomforts in the foot when shoes are worn are associated with improper cushioning in the shoes and it has been suggested that that desired cushioning can be provided by using extra inserts insole. Although cushion (extra inserts) insoles can give the patients an immense relief, certain precautions like wearing of loose shoes should be taken.

3.7.5 Footwear Materials and Components

The analysis of the questionnaire indicated that both males and females preferred to wear shoes that are made with leather. This finding is in agreement with a research conducted in Singapore on “footwear habits in diabetics with and without foot problems” by Nather and other researchers (2008). But while the preference for fabric materials for shoe upper is very low (less than 10%), the female subjects that reported that they preferred synthetic materials are reasonably high (45%).

In this survey, the nature of the sole was another consideration. According to Dahmen et al. (2001), out-sole designed for comfort footwear can have different degrees of flexibility: stiff, toughened, or supple. A stiff outsole is necessary for the reduction of pressure in one particular area of the foot, correction of the foot shape, and immobilisation of the foot in the shoe. In addition, this inflexibility is needed to facilitate the distribution of forces exerted on the foot. But the outcome of this study indicates that 35% male and 30% female subjects wear footwear in which out-soles were neither too flexible nor too rigid (i.e. moderate out-sole).

The heel is another important component of comfort footwear. It was found out that the majority (47% males and 44% female) of the participants preferred to wear shoes that do not have a heel or have a flat heel and up to 41% of the subjects preferred to wear shoes that have low heel. It is important to note here that very few (2%) people living with diabetes that participated in the survey like wearing high heel shoes. Research has shown that the heel of the comfort shoe should be between 2cm and 3cm high and have a wide base to avoid instability. This will also help to avoid weight being thrown forward onto the metatarsal heads (Torreguiart 2009; Nather & Singh 2008; Meadows 2006).

3.7.6 Preference for Special Footwear

Since compliance with wearing footwear designed for foot by people living with the condition is a major problem (Boulton & Jude 2004), the opinion of diabetic patients in regards to their willingness to use prescriptive footwear was sought. It was discovered that up to 84% subjects were willing to buy footwear that could cost double the amount they usually spend on footwear, if it is recommended by a foot doctors/ podiatrist. Some reported that they would rather buy medicine for diabetes than buy footwear that would cost them double the amount they would normally spend on shoes. With comments like this, patient education on the role of footwear in the management and/ or prevention of foot problems must be seen as an urgent issue.

3.7.7 Cost

The cost of a footwear product is an important factor of consideration particularly for foot patients in western countries. This study has revealed that only 9% of male and 3% of female subjects would be willing to spend up to 60-80 Euros on a pair of footwear, while the majority (52%) of the female participants would not be able to spend more than €60 on a pair of footwear. 62% of the research participants would not be able to spend more than €60-80 on a pair of footwear (see fig. 3.17). When data presented in figure 3.17 are compared with the result in figure 3.16, it can be clearly seen that females buy shoes more frequently than men, but it was also observed that the male's patients buy more high quality and costly footwear than their female counterparts. The prices are converted from Czech koruna into euros.

3.8 Chapter Summary

In summary, the key issues presented in this chapter are based on foot patients' viewpoint. The patients gave valuable information on a number of issues including their level of knowledge in regards to footwear, foot problems, foot care, footwear materials and components, etc. Generally, the patients' knowledge about foot problems and its complications, foot care, the use of appropriate footwear, etc. was found to be very poor. In addition, the study also gives insight on the subjects' preferred shoe upper materials, heel height, footwear style/ features, etc. Inevitably, the amount the patients spent on footwear or would be willing to spend on prescriptive footwear was researched, because every manufacturer must take this into consideration. The next chapter investigates foot measurement and determination of tolerable allowance issues studied in this chapter.

4 CHAPTER "Foot Measurement and Determination of Tolerable Allowance

4.1 Introduction

The relation between foot shape and shoe shape is considered a cause of discomfort, foot problems, or even injury because an individual's shoe size and foot size can differ significantly. Also, foot morphology differs appreciably based on geographic area of an individual origin (Olivato et al. 2007; Hawes 1994; Goonetilleke 2003). Therefore, to be able to make shoes to an individual's correct shoe size and to eliminate guess work, accurate measurement of the foot is required.

Many people assume they know their correct shoe size, but previous studies show that a careful consideration of the relationship that exists between the foot shape and the lasts is required in order to be able to make comfortable shoes for the wearer. Furthermore, to provide the best fit of footwear for the population with foot problems, correct measurement of their feet before they buy shoes must be carried out (Olivato 2007; Goonetilleke 2003).

With this understanding, the present study was undertaken in to provide me with the data that would be useful for the construction and assessment of heel pain relief comfort footwear prototypes (refer to the next chapter). In addition, the results of the foot survey would provide the footwear and last makers with important information that would allow them to make model sizes of lasts on which the desired standard comfort heel pain relief footwear could be made. Therefore, this chapter provides information on materials and devices used for foot measurement, results of measurements taken at crucial positions of the foot and the implications of the variations that exist in the dimensions of an individual's feet.

4.2 Aim and objectives of this chapter

4.2.1 Aim

The aim of this chapter is to carry out foot survey using simple measuring techniques in order to determine tolerable allowance of normal feet.

4.2.2 Objectives

The objectives of the study presented in this chapter are:

- To study human foot shape, foot pressures and dimensions.
- To measure the feet of research participants in order to determine their footwear tolerable allowance.
- To use the findings for effective explanation of the concept of proper footwear fitting in the next chapter.
- To provide recommendations for acceptable foot tolerable allowance for heel pain patients.
- To identify areas that would require further research.

4.3 Protocol for foot measurement

Figure 4.1 provides a summary of the protocol followed to collect the required information presented in this chapter.

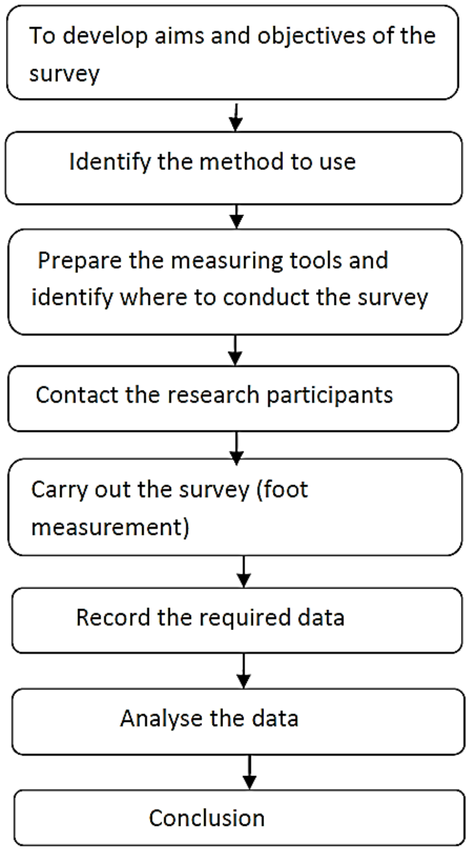


Figure 4.1 Protocol for foot measurement

4.4 Materials and Method

4.4.1 Materials

As pointed out in chapter 2 (sub-section 2.10.1) there are many devices that could be used to measure the foot for last/ footwear design and fitting. These devices range from simple measuring tape to sophisticated equipment's like laser scanning devices that can record thousands of measurements of the whole foot. The different devices or tools are designed to take accurate and specific measurements of important positions of the foot. It has been shown that "taking foot measurement could be as simple as using a last maker's tape measure, or as complex as the hand-drawn chart for a bespoke item or the use of the latest computer-aided design/ computer-aided manufacturing (CAD/CAM) scanning system that records hundreds of measurements in a split second to reproduce a three-dimensional image on the computer screen" (Tyrrell & Carter 2009, p.76/77). In this survey, the following simple materials and tools were used to carry out the foot measurement.

- Pencil
- Ruler
- Measuring tape
- White sheets of paper (A4)
- Tekscan Pressure Measurement System (Software & Hardware) as shown in fig.4.2

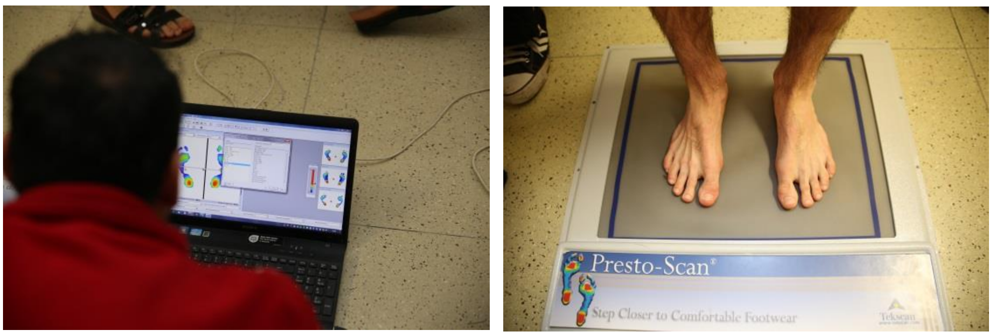


Figure 4.2 Presto-Scan by Tekscan Pressure Measurement System

4.4.2 Method or Procedure

This research was carried out with simple but accurate tools and procedures. In general, there are two kinds of approaches for measuring the foot shape. One is the measurement of static foot shape, and the other is about the motion dynamics of the foot. It has been pointed out that static foot shape is needed to design appropriate footwear (Kimura et al. 2009). Therefore, in this study, the approach that was adopted is the static foot measurement and the steps followed are hereby outlined.

Step 1

In a standing position, the participant placed his or her foot on a clean white A4 sheet of paper. Taking the foot measurement while the subject stands up allows the foot to be measured at its maximum length and width. For correct measurement to be obtained, it was ensured that the feet of the subjects were placed on the paper at 90o to the leg. This position is considered semi-weight bearing, which means that there is some pressure through the foot (Broussard 2002).

Step 2

A pencil was used to trace around the foot of the participant gently and ensuring that the pencil remained in constant contact with the foot during the process. To ensure that the measurement carried out would allow for foot comfort and ample room, it was done in the afternoon/ evening because some people's feet swell, especially after standing for long periods of time.

Step 3

The positions of the inner and outer ball joint (1st and 5th metatarsals) were marked. Also, the position of the longest toe was marked with a pencil.

Step 4

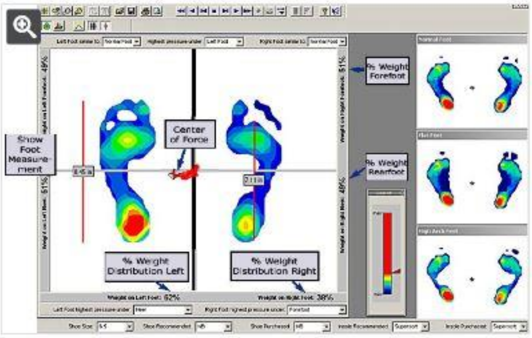
The circumference of the foot at the in-step was measured with a measuring tape. Two measurements were made at this point. Firstly, the circumference of the foot was accurately measured, and afterward, the second reading was taken after the tape was pulled and the subject indicated that it was too tight. This is a very important measurement as it was used to determine the tolerable allowance of the research subjects by subtracting the second reading of the in-step measurement from the first.

Step 5

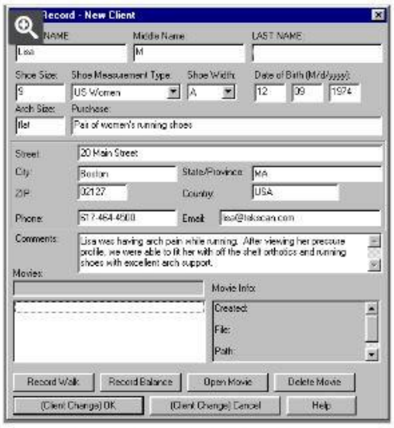
To find the overall length, the distance between the two longest points on the tracing was measured. Similarly, the width was found by measuring the distance between the two widest points (usually at the 1st/ 5th MTP joint) on the tracing using a ruler that was clearly calibrated in millimetres. Each measurement was recorded immediately on a prepared sheet of paper.

Step 6

To find patients foot pressure and measurement foot scanner take a major part to analyzed data. Presto-scan software and hardware was used to collect and analyzed data as shown fig. 4.3



Software display foot measurements, weight distributiorn & center of force.



Store customer information in the software database for easy access.

Figure 4.3 Presto-Scan by Tekscan Pressure Measurement System

Here are some important Presto-Scan Software and hardware features.

The Presto-Scan system has the ability to measure foot pressure distribution while walking or standing. Display 2D & 3D pressure profiles in real-time or record and save for later use and review. Display Center of Force progression while walking.

Provide foot patients with a printout of their pressure profiles & purchasing choices. Print reports with their pressure profiles. Drop-down menus to record foot type, foot and regions with highest pressure. Show percentage of weight distribution while standing:

- Left foot vs. right foot
- Forefoot vs. rear foot
- Left side vs. right side

Educate customers about their foot type and appropriate footwear to optimize function and comfort. Capture patients' attention with high-tech foot pressure mapping displays. Identify the foot type, foot function and weight distribution. Recommend appropriate foot wear, insoles or orthotics based on objective data.

This system pinpoints problem area instantly foot type and foot function.

Immediately view high plantar pressure points and the weight distribution.

Show foot measurement. Display pressure profiles of normal, flat, and high arch feet for comparison. Analyze patient's history at any time.

4.5 Results of foot measurements

In this survey, 280 normal adult volunteer subjects were involved. Of this number, 186 (66%) were male and 94 (34%) female (see table 4.13 and 4.14).

While tables 4.1 to 4.6 provide detailed results of the male participants, tables 4.7 to 4.12 give the full results of the female subjects. The data gathered from the subjects were grouped based on their shoe size. For instance, men wearing shoe size 40 were coded MA and female wearing shoe size 36 were coded FA.

Male Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
M_A01	55	252	250	97	102	245	242	3
M_A02	37	242	237	104	98	246	244	2
M_A03	46	249	246	93	95	235	230	5
M_A04	32	245	242	89	90	233	231	2
M_A05	*DNM	255	254	98	98	234	232	2
M_A06	22	238	239	88	86	210	207	3
M_A07	23	254	253	102	100	240	235	5
M_A08	47	254	255	103	103	263	258	5
M_A09	29	251	254	100	98	238	235	3
M_A10	25	249	248	95	95	229	226	3
M_A11	32	246	250	110	108	248	245	3
M_A12	40	244	246	96	96	265	263	2
M_A13	75	245	237	104	100	255	252	3
M_A14	40	242	247	86	95	257	253	4
M_A15	45	245	239	95	102	245	241	4
M_A16	18	250	248	88	83	220	215	5
M_A17	23	247	247	93	93	242	239	3
M_A18	30	241	245	83	85	230	228	2
Mean age (yrs	**36.4**							
Avg (mm		247.1	247.5	95.7	95.9	240.8	237.5	**3.3**

Table 4.1 Results of foot measurement: Men wearing shoe size 40

*DNM - Do not want to mention.

Male Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
M_B01	35	258	260	102	100	240	237	3
M_B02	53	259	258	100	103	265	261	4
M_B03	35	264	255	99	104	260	255	5
M_B04	54	266	265	102	100	270	266	4
M_B05	25	256	261	95	97	260	255	5
M_B06	27	259	254	100	96	260	253	7
M_B07	25	250	250	92	85	242	240	2
M_B08	23	258	255	98	98	236	233	3
M_B09	43	265	265	95	94	260	256	4
M_B10	23	256	262	102	102	253	248	5
M_B11	67	259	255	98	95	250	248	2
M_B12	25	254	253	103	99	250	245	5
M_B13	26	258	262	102	100	248	245	3
M_B14	23	250	255	97	95	251	248	3
M_B15	57	263	271	99	103	240	238	2
M_B16	52	255	248	98	96	252	249	3
M_B17	75	260	251	104	106	258	255	3
M_B18	DNM	255	254	96	99	255	253	2
M_B19	64	250	246	96	96	230	225	5
M_B20	DNM	265	268	97	92	241	236	5
M_B21	62	257	256	95	96	240	238	2
M_B22	67	260	254	90	92	235	230	5
M_B23	52	265	260	103	98	242	238	4
M_B24	55	262	262	102	101	246	242	4
Mean age (yrs)	**44.0**							
Avg (mm)		258	257.4	99	98.4	249.3	245.6	**3.7**

Table 4.2 Results of foot measurement: Men wearing shoe size 41

Male Subjects	Age (years)	Foot length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
Mc01	57	260	267	107	106	258	256	2
Mc02	48	269	269	100	99	260	258	2
Mc03	23	267	266	103	103	240	235	5
Mc04	22	270	273	100	101	240	237	3
Mc05	20	260	255	95	96	230	225	5
Mc06	34	260	261	99	100	240	237	3
Mc07	29	260	258	100	100	253	248	5
Mc08	45	272	270	99	105	249	246	3
Mc09	25	265	270	102	96	257	254	3
Mc10	42	265	265	110	110	290	285	5
Mc11	32	259	260	110	109	275	270	5
Mc12	27	256	257	94	94	270	268	2
Mc13	21	266	267	105	103	257	254	3
Mc14	47	277	276	106	105	276	270	6
Mc15	33	280	279	106	104	258	256	2
Mc16	53	272	269	102	97	265	263	2
Mc17	44	270	274	107	109	268	265	3
Mc18	44	262	256	104	99	265	262	3
Mc19	29	277	267	102	100	245	240	5
Mc20	25	266	270	96	96	252	249	3
Mc21	37	268	267	95	95	260	255	5
Mc22	23	262	265	102	98	260	255	5
Mc23	30	275	271	98	100	255	252	3
Mc24	23	277	277	92	95	255	253	2
Mc25	43	261	263	100	99	257	254	3

Mc26	47	264	265	100	101	261	258	3
Mc27	26	267	268	104	104	242	239	3
Mc28	32	268	268	105	105	250	245	5
Mc29	20	265	266	104	99	253	249	4
Mc30	45	280	285	109	108	280	275	5
Mc31	20	272	268	102	105	270	265	5
Mc32	40	265	265	100	100	245	240	5
Mc33	25	269	261	100	97	240	235	5
Mc34	24	260	263	94	95	230	228	2
Mc35	38	269	270	100	97	260	258	2
Mc36	25	267	272	110	108	251	248	3
Mc37	58	269	267	105	107	288	285	3
Mc38	18	280	280	120	115	270	266	4
Mc39	25	266	266	98	100	243	240	3
Mc40	23	262	258	92	90	225	222	3
Mc41	22	273	275	103	100	242	240	2
Mc42	22	277	272	105	110	235	233	2
Mc43	22	278	280	98	95	240	237	3
Mc44	23	280	280	115	114	262	257	5
Mc45	22	275	277	116	110	270	267	3
Mc46	21	285	288	104	107	252	248	4
Mc47	30	269	269	98	98	240	237	3
Mc48	21	267	266	93	96	270	267	3
Mc49	20	258	264	103	98	271	268	3
Mc50	30	268	266	87	87	241	237	4
Mc51	20	262	259	99	95	250	247	3
Mc52	50	260	258	96	91	253	250	3
Mc53	60	268	264	92	93	232	228	4
Mc54	71	268	273	106	107	265	262	3
Mc55	53	271	267	100	103	280	277	3
Mc56	54	264	266	106	105	262	259	3

M_C57	48	265	246	101	96	270	267	3
M_C58	80	265	273	107	103	272	268	4
M_C59	23	274	271	102	108	260	255	5
M_C60	76	257	257	91	92	235	231	4
M_C61	75	254	258	89	86	235	232	3
M_C62	62	274	270	107	109	263	259	4
M_C63	63	265	266	108	103	261	258	3
Mean age (yrs)	**36.3**							
Avg (mm)		267.873	267.6	98.2	97.5	255.6	252.1	**3.5**

Table 4.3 Results of foot measurement: Men wearing shoe size 42

Male Subjects	**Age (yrs)**	**Foot Length (mm)**		**Foot Width (mm)**		**In-step Girth (mm)**		**Tolerable Allowance (mm)**
		Right	Left	Right	Left	1st	2nd	
M_D01	25	273	273	102	101	250	245	5
M_D02	40	280	278	108	110	287	284	3
M_D03	30	272	275	105	107	266	263	3
M_D04	41	279	277	108	113	295	290	5
M_D05	33	268	274	108	108	281	277	4
M_D06	23	278	276	108	110	271	268	3
M_D07	45	275	280	107	105	270	266	4
M_D08	33	288	287	105	102	270	265	5
M_D09	38	282	283	106	103	270	265	5
M_D10	33	288	285	102	106	280	278	2
M_D11	43	282	280	108	102	272	269	3
M_D12	40	267	261	99	98	265	250	15
M_D13	22	267	267	98	98	267	260	7
M_D14	37	285	283	96	97	250	247	3

M_D15	28	267	267	109	109	300	296	4
M_D16	24	282	278	105	104	270	263	7
M_D17	46	275	280	96	98	280	278	2
M_D18	38	288	284	109	109	268	266	2
M_D19	29	278	273	100	97	255	252	3
M_D20	30	277	278	107	104	270	268	2
M_D21	41	272	272	101	102	267	265	2
M_D22	29	275	277	102	104	265	262	3
M_D23	42	275	276	110	111	280	275	5
M_D24	30	277	271	101	95	240	235	5
M_D25	27	285	285	105	105	275	272	3
M_D26	30	273	278	110	112	271	267	4
M_D27	50	277	277	115	115	295	290	5
M_D28	22	279	285	103	105	265	261	4
M_D29	21	268	263	90	94	250	248	2
M_D30	24	273	274	106	110	275	273	2
M_D31	27	274	270	106	108	255	251	4
M_D32	36	272	265	104	97	268	264	4
M_D33	34	270	270	93	94	251	247	4
M_D34	24	289	285	114	115	270	268	2
M_D35	38	273	280	105	110	270	267	3
M_D36	28	285	280	107	102	268	266	2
M_D37	19	280	285	115	110	267	265	2
M_D38	32	285	283	115	111	270	264	6
M_D39	41	292	286	116	117	300	294	6
M_D40	36	265	272	100	100	255	250	5
M_D41	27	263	264	93	94	260	257	3
M_D42	31	281	280	104	103	270	265	5
M_D43	45	275	280	113	106	261	257	4
M_D44	65	262	260	101	101	252	248	4
Mean age (yrs)	**33.6**							
Avg (mm)		276.6	276.3	104.9	104.6	269.0	265.0	**4**

Table 4.4 Results of foot measurement: Men wearing shoe size 43

Male Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
M_E01	24	282	283	103	105	280	278	2
M_E02	42	290	290	110	110	290	288	2
M_E03	46	286	286	120	112	285	281	4
M_E04	34	285	283	111	105	279	276	3
M_E05	31	288	291	105	108	272	269	3
M_E06	47	293	293	110	109	273	270	3
M_E07	51	285	288	108	110	283	280	3
M_E08	40	300	301	113	105	285	281	4
M_E09	29	272	276	103	103	251	247	4
M_E10	40	275	275	114	116	280	277	3
M_E11	33	288	287	110	111	255	253	2
M_E12	35	285	285	119	119	282	279	3
M_E13	30	290	291	117	117	300	295	5
M_E14	40	275	278	110	111	290	287	3
M_E15	23	272	271	95	94	271	268	3
M_E16	25	298	300	130	122	295	292	3
M_E17	26	265	265	93	100	265	261	4
M_E18	39	285	285	114	106	265	261	4
M_E19	27	271	277	104	100	267	265	2
M_E20	23	286	265	96	96	250	246	4
M_E21	26	277	276	98	100	260	257	3
M_E22	28	278	281	90	102	254	252	2
M_E23	40	261	265	95	97	282	279	3
M_E24	45	286	281	107	109	268	264	4
M_E25	53	271	280	100	100	273	270	3

M_E26	27	270	267	101	101	269	267	2
M_E27	52	275	261	103	108	275	271	4
M_E28	70	286	282	117	113	274	271	3
M_E29	47	290	284	104	106	268	266	2
Mean age (yrs)	**37.0**							
Avg (mm)		281.6	280.9	106.9	106.7	273.8	270.7	**3.1**

Table 4.5 Results of foot measurement: Men wearing shoe size 44

Male Subjects	**Age (yrs)**	**Foot Length (mm)**		**Foot Width (mm)**		**In-step Girth (mm)**		**Tolerable Allowance (mm)**
		Right	Left	Right	Left	1st	2nd	
M_F01	26	297	296	108	105	280	277	3
M_F02	37	292	295	110	103	282	278	4
M_F03	36	291	300	113	112	290	288	2
M_F04	24	300	295	108	105	300	297	3
M_F05	37	297	297	110	105	281	278	3
M_F06	39	287	287	115	116	275	272	3
M_F07	21	315	318	120	122	302	299	3
M_F08	58	286	291	112	110	292	290	2
Mean age (yrs)	**34.7**							
Avg (mm)		295.6	297.4	112	109.8	287.8	284.9	**2.9**

Table 4.6 Results of foot measurement: Men wearing shoe size 45/46

Female Subjects	**Age (yrs)**	**Foot Length (mm)**		**Foot Width (mm)**		**In-step Girth (mm)**		**Tolerable Allowance (mm)**
		Right	Left	Right	Left	1st	2nd	
F_A01	50	238	232	93	92	210	205	5
F_A02	29	211	244	92	90	228	225	3
F_A03	32	238	238	93	93	225	220	5
F_A04	60	245	240	87	85	210	205	5
F_A05	20	230	228	95	92	220	215	5
F_A06	20	236	237	85	87	230	227	3
F_A07	23	238	240	96	98	231	228	3
F_A08	19	249	254	96	95	240	238	2
F_A09	18	240	244	85	87	230	227	3
F_A10	16	244	246	93	97	238	233	5
F_A11	23	232	225	80	74	220	216	4
F_A12	35	242	247	100	94	240	235	5
F_A13	25	234	234	86	86	231	226	5
F_A14	22	230	225	82	80	220	217	3
F_A15	26	240	240	84	84	240	237	3
F_A16	20	232	237	85	82	230	226	4
F_A17	25	254	251	90	93	223	220	3
Mean age (yrs)	**27.3**							
Avg (mm)		237.24	238.9	89.5	88.8	227.4	223.5	**3.9**

Table 4.7 Results of foot measurement: Women wearing shoe size 37

Female Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
F_B01	21	242	246	88	86	240	237	3
F_B02	21	249	256	98	96	235	230	5
F_B03	17	234	235	80	86	215	205	10
F_B04	19	252	254	79	81	220	215	5
F_B05	18	246	231	88	85	235	230	5
F_B06	33	247	250	98	103	230	228	2
F_B07	29	249	244	90	91	217	214	3
F_B08	30	238	242	89	92	221	218	3
F_B09	32	246	248	93	87	244	240	4
F_B10	60	246	247	88	88	242	238	4
F_B11	22	247	254	102	100	240	237	**3**
F_B12	35	244	244	110	108	240	235	5
F_B13	25	242	245	100	100	238	233	5
F_B14	22	248	254	88	90	236	231	5
F_B15	16	240	240	83	88	240	237	3
F_B16	20	242	239	88	84	250	246	4
F_B17	28	240	245	98	95	271	268	3
F_B18	25	241	245	99	95	240	234	6
F_B19	22	250	252	85	90	242	238	4
F_B20	24	244	245	79	79	241	239	2
F_B21	23	237	238	91	88	243	240	3
F_B22	24	248	247	95	94	235	232	3
F_B23	25	235	233	94	94	234	230	4
Mean age (yrs)	**25.6**							
Avg (mm)		243.7	244.9	91.4	91.3	236.8	232.8	**4**

Table 4.8 Results of foot measurement: Women wearing shoe size 38

Female Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
Fc01	26	263	260	92	92	242	238	4
Fc02	21	260	267	102	99	245	241	4
Fc03	24	242	240	88	84	240	238	2
Fc04	30	263	257	95	100	230	227	3
Fc05	23	248	250	88	87	243	240	3
Fc06	19	250	253	97	92	230	228	2
Fc07	18	248	248	91	90	225	223	2
Fc08	55	246	253	88	97	235	230	5
Fc09	20	249	243	88	80	237	235	2
Fc10	21	241	242	90	91	250	248	2
Fc11	22	260	260	96	97	238	234	4
Fc12	21	248	250	96	92	251	248	3
Fc13	20	248	237	91	88	230	228	2
Fc14	23	249	244	91	93	237	234	3
Fc15	18	255	255	95	95	243	238	5
Mean age (yrs)	**24.0**							
Avg. (mm)		251.3	250.6	92.5	91.8	238.3	235.3	**3**

Table 4.9 Results of foot measurement: Women wearing shoe size 39

Female Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
F_D01	32	268	261	88	88	251	248	3
F_D02	23	253	250	85	78	234	230	4
F_D03	32	268	267	104	96	256	253	3
F_D04	23	261	260	100	100	238	235	3
F_D05	38	275	272	112	112	270	265	5
F_D06	DNM	256	251	88	93	235	232	3
F_D07	48	240	267	100	103	244	240	4
F_D08	43	267	265	100	95	240	237	3
F_D09	DNM	253	249	95	91	242	238	4
F_D10	DNM	258	265	95	98	250	247	3
F_D11	DNM	253	249	96	95	252	250	2
F_D12	DNM	245	243	90	83	260	257	3
F_D13	25	256	256	91	91	242	238	4
F_D14	26	265	263	95	89	250	246	4
F_D15	47	258	264	113	110	230	225	5
F_D16	23	262	262	104	105	265	260	5
F_D17	DNM	246	242	88	83	251	249	2
F_D18	23	257	260	101	100	239	236	3
F_D19	DNM	254	248	88	87	250	246	4
Mean age (yrs)	**31.9**							
Avg (mm)		257.6	257.5	96.4	94.5	247.2	243.7	**3.5**

Table 4.10 Results of foot measurement: Women wearing shoe size 40

Female Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
F_E01	21	251	235	97	88	243	240	3
F_E02	61	261	258	90	94	251	248	3
F_E03	25	245	237	89	86	234	230	4
F_E04	21	268	271	108	105	247	243	4
F_E05	24	260	260	95	86	260	256	4
F_E06	DNM	250	256	97	95	261	259	2
F_E07	20	273	270	104	100	255	252	3
F_E08	27	260	260	100	98	241	238	3
F_E09	24	252	252	90	88	250	247	3
F_E10	27	256	255	104	102	262	259	3
F_E11	24	250	254	100	96	242	238	4
Mean age (yrs)	**27.4**							
Avg (mm)		256.9	255.2	97.6	94.3	249.5	246.3	**3.2**

Table 4.11 Results of foot measurement: Women wearing shoe size 41

Female Subjects	Age (yrs)	Foot Length (mm)		Foot Width (mm)		In-step Girth (mm)		Tolerable Allowance (mm)
		Right	Left	Right	Left	1st	2nd	
F_F01	21	262	259	90	87	261	258	3
F_F02	22	265	265	95	91	260	257	3
F_F03	25	259	258	88	90	263	260	3
F_F04	DNM	260	261	97	96	260	258	2
F_F05	DNM	252	245	96	92	264	260	4
F_F06	29	258	262	91	90	225	220	5
F_F07	26	278	278	97	104	252	249	3
F_F08	DNM	247	245	88	96	290	287	3
F_F09	29	265	272	105	102	257	254	3
Mean age (yrs)	**25.3**							
Avg (mm)		260.6	260.5	94.1	94.2	259.1	255.9	**3.2**

Table 4.13 Results of foot measurement: Women wearing shoe size 42

Subjects (Shoe sizes)	Mean age (years)	No	%	In-step Girth (mm)		Tolerable Allowance (mm)
				1st reading	2nd reading	
M_A (40)	36.4	18	10	240.8	237.5	3.3
M_B (41)	44.0	24	13	249.3	245.6	3.7
M_C (42)	36.3	63	34	255.6	252.1	3.5
M_D (43)	33.6	44	24	269.0	265.0	4.0
M_E (44)	37.0	29	15	273.8	270.7	3.1
M_F (45/46$^1/_2$)	34.7	08	4	287.8	284.9	2.9
Avg (mm)				**262.7**	**259.3**	**3.4**

Table 4.12 Summary of Outcome of foot measurements (Male Subjects)

Subjects (Shoe Size)	Mean age (years)	No	%	In-step Girth (mm)		Tolerable Allowance (mm)
				1st reading	2nd reading	
F_A (37)	27.3	17	18	227.4	223.5	3.9
F_B (38)	25.6	23	24	236.8	232.8	4.0
F_C (39)	24.0	15	16	238.3	235.3	3.0
F_D (40)	31.9	19	20	247.2	243.7	3.5
F_E (41)	27.4	11	12	249.5	246.3	3.2
F_F (42)	25.3	9	10	259.1	255.9	3.2
Avg (mm)				**243.0**	**239.5**	**3.5**

Table 4.14 Table 4.14 Summary of Outcome of foot measurements (Female Subjects)

4.6 Discussion

The summary of the outcome of the foot measurements for both genders based on their shoe size is presented in figure 4.4 below. The chart indicates that up to 34% of male subjects wear shoe size 42, making it the most popular size among the male subjects. This is followed by size 43 with 24% subjects. On the other hand, shoe size 38 is the most widely worn by the female subjects with up to 24% participants. This is closely followed by those wearing size 40 with a value of 20%. The mean age of all male subjects was found to be 37.0 and for female subjects, the mean age was 26.9.

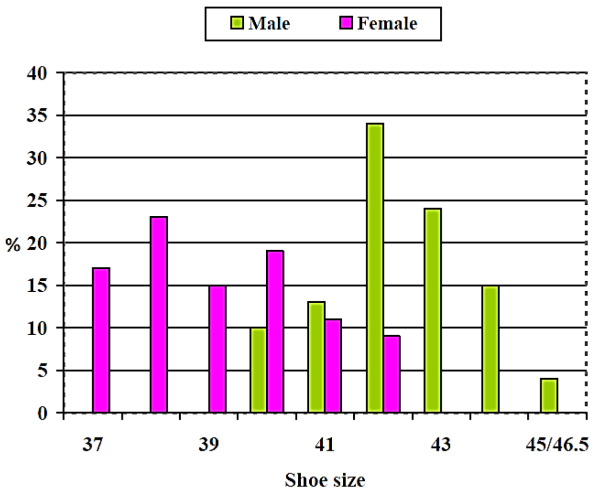


Figure 4.4 Participants' shoe size

The results of the foot measurements carried out are discussed under three sub-titles namely; length, joint girth or width and in-step. According to Tyrrell & Carter (2009), these are the first basic measures used by clinicians to determine the type of footwear needed to meet the patient's requirements. It is generally noted that the outcome of the right and left foot measurement of most individuals differ one from another. Similarly, the results of the foot dimensions of those wearing the same shoe size varies one from another. These findings are in complete agreement with the research outcome of Broussard (2002) that indicates that most people's feet are two different sizes.

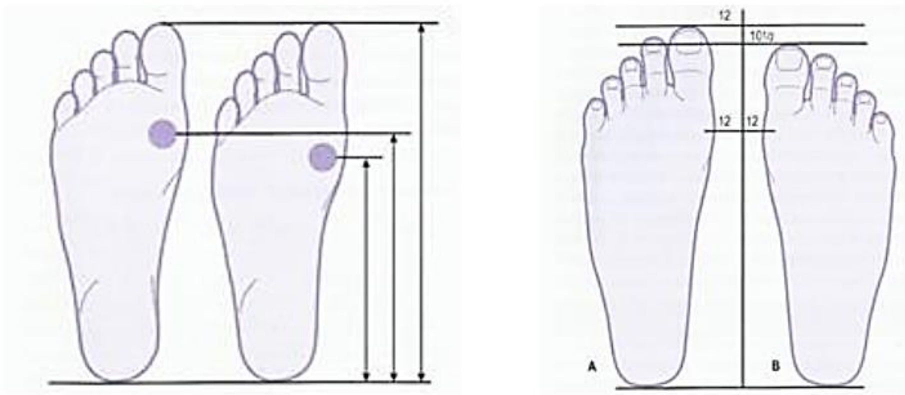
4.6.1 Foot Length

It is clear from the outcome of this survey that very few people have the same foot length for both the right and the left foot. The difference in some people's foot length can be negligible whereas the difference may be appreciable among others. Such differences can be clearly observed in table 4.5 and 4.7 where a difference of up to 14mm and 33mm was recorded against subjects ME27 and FA02 respectively. The differences in foot dimensions (length) recorded in this study for subjects wearing the same shoe size are up to 21mm (refer to subject MB19 and MB15, table 4.2). In like manner, up to 20mm difference in width exist between subjects MA06 and MA11. These differences can become a source of serious foot discomfort for the subjects when such differences were not taken into consideration. A study conducted by Pezza (2011) reported that it is rare to find a diabetic patient who is wearing the proper shoe size and width. He argues that there is a direct correlation between recurrent foot problems and improper footwear. The current findings are in complete agreement with this argument.

Tyrrell and Carter (2009) further point out unequivocally that all feet are different. They explained that even if the whole shoe length is correct, but the heel-to-ball length (see fig.4.5a) of the footwear does not correspond with the heel to MTP (metatarso-phalangeal) joint measurement of the foot, the foot flexion will not be able to meet the point the shoe is designed to flex.

Generally, comfortable footwear should be designed in such a way that it can accommodate the longest part of the foot. It should also be noted that the longest part of the foot differs one from another. Mostly, the hallux is longer than the other toes but in some patients, one or more of the other (lesser) toes may be longer than the hallux. It is generally advisable that patients wear footwear that are large enough to provide room for changes in dimension of the foot that may occur during walking or sitting for long periods of time. Although there is need for additional space in the footwear to allow for the elongation of the foot during the stance phase of the gait cycle, the amount of space may not be more than 1cm or 0.5 inch. However, there is no fixed rule for the amount of free or extra length required at the end of the toe box. But in general, research has shown that men tend to wear footwear that are too large and women the opposite (Pezza 2011).

It should be noted that individuals could have the same overall foot length but different heel-to-ball length and some could also have the same heel-to-ball length but different overall length (see fig. 4.5a & fig.4.5b). For the comfort of the wearer, it is important that footwear for the diabetic foot should be designed to flex at a specific angle across the 1st to 5th metatarsals joints. In other words, the flexion angle within the footwear should match the angle between the 1st and 5th metatarsal heads of the foot. It has been reported that two thirds (2/3) of diabetic patients wear poor fitting footwear, but that shoes designed for people suffering with diabetes could reduce re-ulceration rates by half (Leese 2009).



(a) (b)

Figure 4.5 (a) Feet with same overall length but different heel-to-ball measurement. (b) Feet with different overall length but same heel-to-ball measurement (Tyrrell & Carter 2009, p.66)

4.6.2 Foot Width

The length of the foot/ footwear as discussed above is only but one feature that should be critically considered; the other measurement that should be taken into account to provide footwear that fits well includes the width (particularly, the joint width; see fig. 4.6). Similar to foot length, it was discovered that there are variations between the width of an individual's feet as well as among people wearing the same shoe size. However, the differences in the foot width are not as wide-ranging as the differences recorded for foot length. This research shows that the difference in foot width could be up to 12mm as recorded in Table 4.6 (ME22). Measurement of this part of the foot is considered very important because the MTP (metatarsal phalangeal) joints are seen as the most complicated parts of the foot because their shape changes during walking and standing positions. In addition, it has been suggested that the width of the footwear should be adequate to accommodate orthotic in case a patient needed to wear them, and that proper fastening to hold the foot and to avoid rubbing should always be put in place (Chen 1992).

Research has shown that a normal foot will usually expand by about 5% over the course of a day. This equals to one shoe size in volume. But where there is circulatory problem (for instance, neuropathy), the foot could expand up to 10% during the day. This could cause considerable pressure and swelling inside the shoe which could lead to development of pressure lesions and injury (Tyrrell & Carter 2009). According to Tyrrell and Carter (2009), footwear width corresponds with length. However, patients with wide feet tend to choose footwear that is too long for them so as to obtain their required shoe width. This can cause negative effects on the foot because it means that the MTP joints will be positioned proximal to the footwear tread line and the footwear flexion will not correspond to foot flexion which could lead to creases on the vamp. To ensure that the foot and the footwear bend together, prescription footwear must be designed in such a way that the 1st metatarsal joint or ball joint fits to the widest part where the footwear flexes across the metatarsal heads from 1st to 5th.

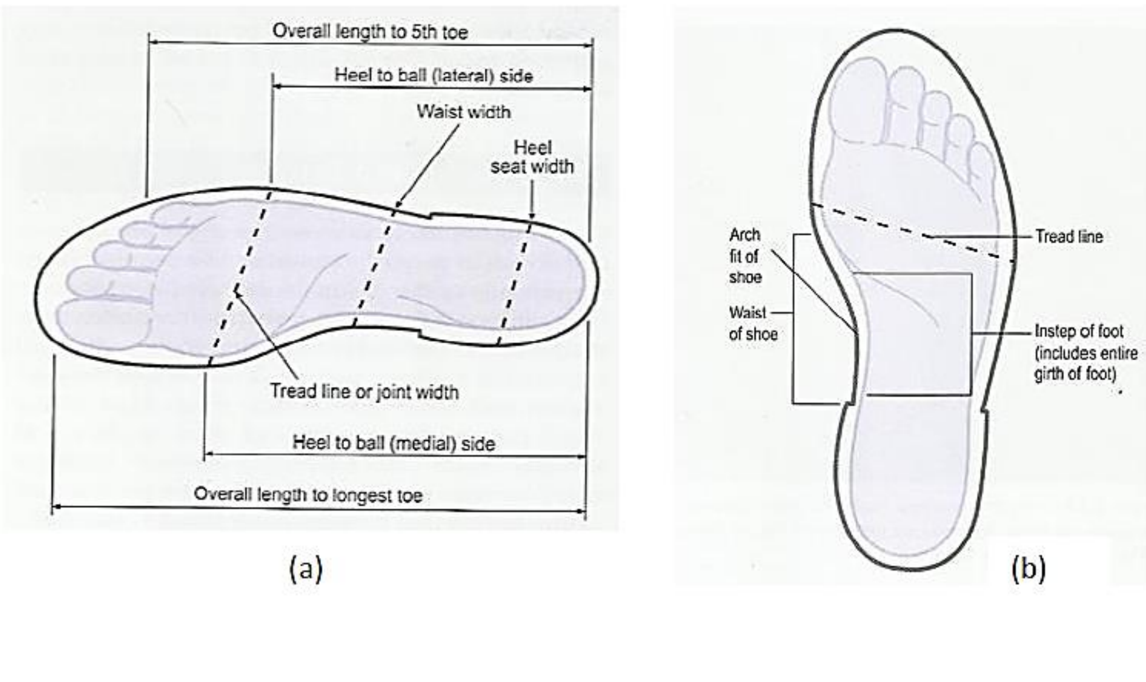


Figure 4.6 (a) Sketch of a foot showing joint width. (b) Sketch of a foot showing In-step of foot (Tyrrell & Carter, 2009. p.67/72).

4.6.3 In-step girth and tolerable allowance

As mentioned in sub-section 4.6.1, the in-step measurement is very important in determining suitable footwear for people at risk of developing foot heel pain. The in-step refers to the whole girth of the foot around the arch and onto the dorsum (see fig.4.6b). There could be significant differences of this part of the foot from one individual to another, even people wearing the same shoe size. A typical example can be seen in table 6.3 where we have a difference of up to 20mm between subjects MC02 and MC03 even though they wear the same shoe size.

This work revealed that some people have low instep which may cause considerable stress on the shoe arch fit. In such a case, it is advisable that the patient uses orthotic in order to improve shoe fit and function. It was also observed that some people's feet have a high instep. Similar to low in-step, footwear fit could be compromised. Therefore, the space may be insufficient to accommodate the foot and the facings will not be able to meet correctly across the fastening of the footwear which will be evident as the facings will be pulled too far apart.

In respect to the foot tolerable allowance, this study indicates that the average tolerable allowance for the male subjects fell between 2.9mm to 4.0mm (see table 4.13) and 3.2mm to 4.0mm values were recorded for the female participants (see table 4.14). The average tolerable allowance for both men and women subjects was found to be 3.45mm.

The analysed data for tolerable allowance of the subjects based on their shoe sized are provided as figure 4.7. The graph indicates that men wearing shoe size 43 gives an average value of 4mm tolerable allowance whereas those using shoe size 38 has the highest average value of 4.0mm. The implication of these values for shoe fitting is discussed in the next chapter.

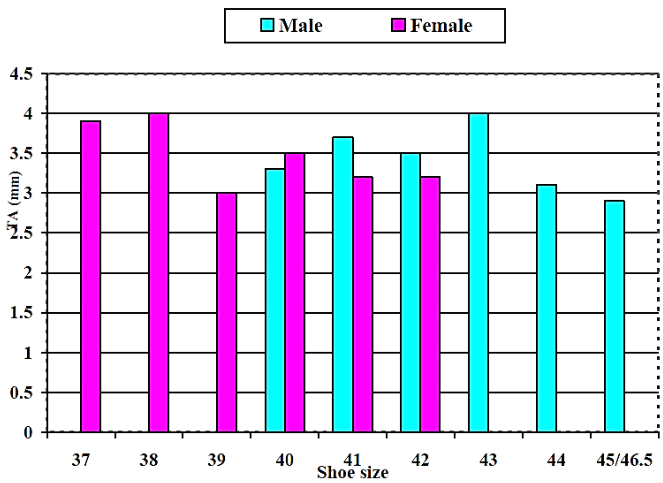


Figure 4.7 Tolerable allowance of subjects according to their shoe size

4.7 Chapter Summary

The work of this chapter demonstrates that accurate foot measurement is required to be able to make comfortable footwear for an individual (particularly foot patients). The data provided in this study clearly show that very few people have the same foot length and width for both right and left foot. The difference in some people's foot length can be negligible whereas some people's foot length and width could be appreciable. It was also discovered that whereas some people have low in-step which may cause a lot of stress on the shoe arch fit, some have high in-step which could also lead to a compromise in footwear fitting. A typical example can be seen in table 6.3 where we have a difference of up to 20mm between subjects MC02 and MC03 even though they wear the same shoe size.

In this study, simple but accurate tools and procedures were used to gather the data. The basic foot dimensions (that is length, joint girth or width and in-step) used by clinicians to determine the type of footwear needed to meet the patient's requirements were recorded and analysed. For future work, the author recommends the use of more advanced technological equipment like laser scanning devices that can record hundreds of measurements of specific important positions of the foot.

5 CHAPTER "Prototypes Development and Assessment"

5.1 Introduction

Research has shown that footwear plays an important role in the prevention and management of foot problems, but that poor fitting and non-compliance to recommended footwear among people suffering with heel pain is a cause for concern. It was also discovered that a major problem is the rejection of certain footwear due to cultural, cost and aesthetic reasons (Nather & Singh 2008). In view of this, the present work was undertaken to investigate acceptable footwear that could benefit people suffering with heel pain. Firstly, the aim and objectives of the study were formulated, secondly, Product Design Specification (PDS) was developed for the study and thirdly, sketches of footwear were made and presented to potential users to indicate their preferred style, and finally, three functional prototypes were produced based on the PDS and trial assessment carried out.

As clarified by Polydoras et al. (2011), a prototype is an artefact or model that enables designers to test various aspects of their ideas before committing themselves to the expense and risk of producing commercial quantities. The process of building or making this pre-production model to test various aspects of its design is considered as prototyping. A prototype can be used to discover issues about a product or project and to test various aspects of its design or prove a strategic approach (Udell 2013). The prototyping is meant to provide the designer with insight and information about different aspects of product technical attributes, grouped into three main areas; form, fit and function. Therefore, the prototypes were used to evaluate the aesthetics, fit, form, ergonomics, and performance of the product. The models or prototypes were also used to verify acceptability of the product from potential users.

Based on their ability to serve the discrete stages of the design process, prototypes are generally categorised into the following broad prototyping classes (Udell 2013; Eujin 2009 & Barge 2008)

- Design/ aesthetic prototypes, or design/ appearance models. These types of models are mostly concerned with the physical or the external outlook without taking into consideration any functional features.

- Geometrical prototypes. These have all or most of the exact form features and dimensions of the product.

- Functional prototypes. These are described as having similar or the exact material as the final product. They are used to investigate functional concepts of a product including yield and performance factors. For this study, functional products (open shoe) are used to show important functional parameters of the products.

- Technical/ technological prototype. This is usually produced with similar or the exact production method and prototype tooling, where the focus is on attributes of the tools during manufacturing of the product.

- Pre-production models. These are mainly used to fine-tune parameters of the production methods and processes. They are also seen as final design models used to check a product and it's finishing as a whole and to carry out production assessment in small batches.

But another categorisation of prototypes according to Eujin (2009) and Ullman (2003) are; visual prototypes such as sketches or drawings, screen-based prototypes, models that are physical representations of a product, and fully working or functional prototypes. Researchers (Ullman 2003; Frishberg 2006) point out that models are better suited during the early stages of development of a product for problem solving and idea generation, whereas prototypes are employed towards the later stages to confirm and assess the aesthetics, ergonomics and performance of the design.
In this study, ten different footwear design styles/ sketches were produced based on the results of the empirical study carried out in the previous chapters. The top 3 styles from the 10 design styles were developed into functional prototype that enabled me to test the various aspects of design concepts among heel pain patients. The prototyping and assessment of the products provided me with insight and information on different aspects of the preferred footwear styles, features and attributes from potential users of the products. The chapter ends with a brief discussion on the findings of the prototype trials and assessment.

5.2 Aim and Objectives of this chapter

5.2.1 Aim

The aim of this chapter is to develop appropriate heel pain relief by arch supported footwear design styles and prototypes based on empirical studies.

5.2.2 Objectives

The specific objectives of this study are:

- To identify the most preferred type of footwear design style for people suffering with plantar fascia or even minor heel pain.
- To study the preferred type of shoe upper materials for making required footwear.
- To study the type of footwear fastening most preferred by people suffering with foot problems.
- To make footwear prototypes based on the information gathered from research subjects.
- To evaluate the required footwear prototypes produced.
- To provide recommendations for acceptable types of footwear.
- To identify areas for further research.

5.3 Protocol for this study

Figure 5.1 provides a flow chart of the protocol used to carry out the work presented in this chapter.

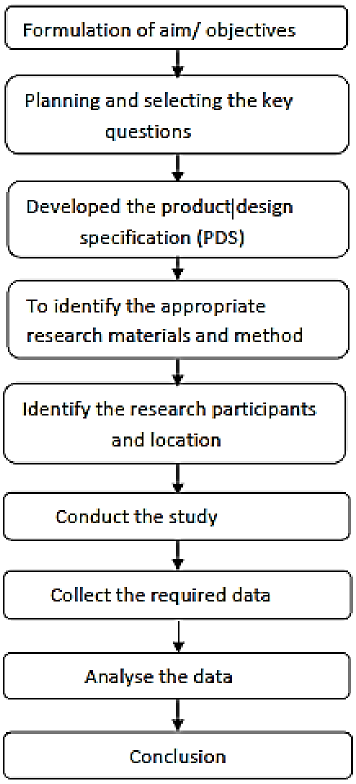


Figure 5.1 Protocol for testing of heel pain footwear prototype

5.4 Materials and methods

5.4.1 Materials

The shoe upper materials (leather and stretch material) used to make the prototypes were given to me free of charge for the purpose of this study. The contribution of those companies are hereby acknowledged and appreciated. Other simple materials and tools used to carry out this study include the following:

- Pencil
- Ruler
- Measuring tape
- White sheets of paper (A4)
- Velcro and Elastic
- Fibre board
- Gum
- Rings
- Leather, Stretch and Leather Lining Materials
- Micro cellular soling materials
- Shoe last development and outer sole and development materials.

In addition to the above mentioned materials and tools, a pair of last was used to make the trial prototypes. The appropriate last was selected from a pool of different lasts at the footwear department after consultations with the research supervisors and footwear designers/ technologists at Fagus, Zlin. Figures 5.2, 5.3, 5.4 and 5.5 give pictures of the different views of the lasts, and foot measurement from a heel pain patient and the last with lasted pullover respectively. While figure 5.5, 5.6 shows the bottom outline of the last, however, table 5.1 gives the dimensions and other features of the last development processes without arch support cut.

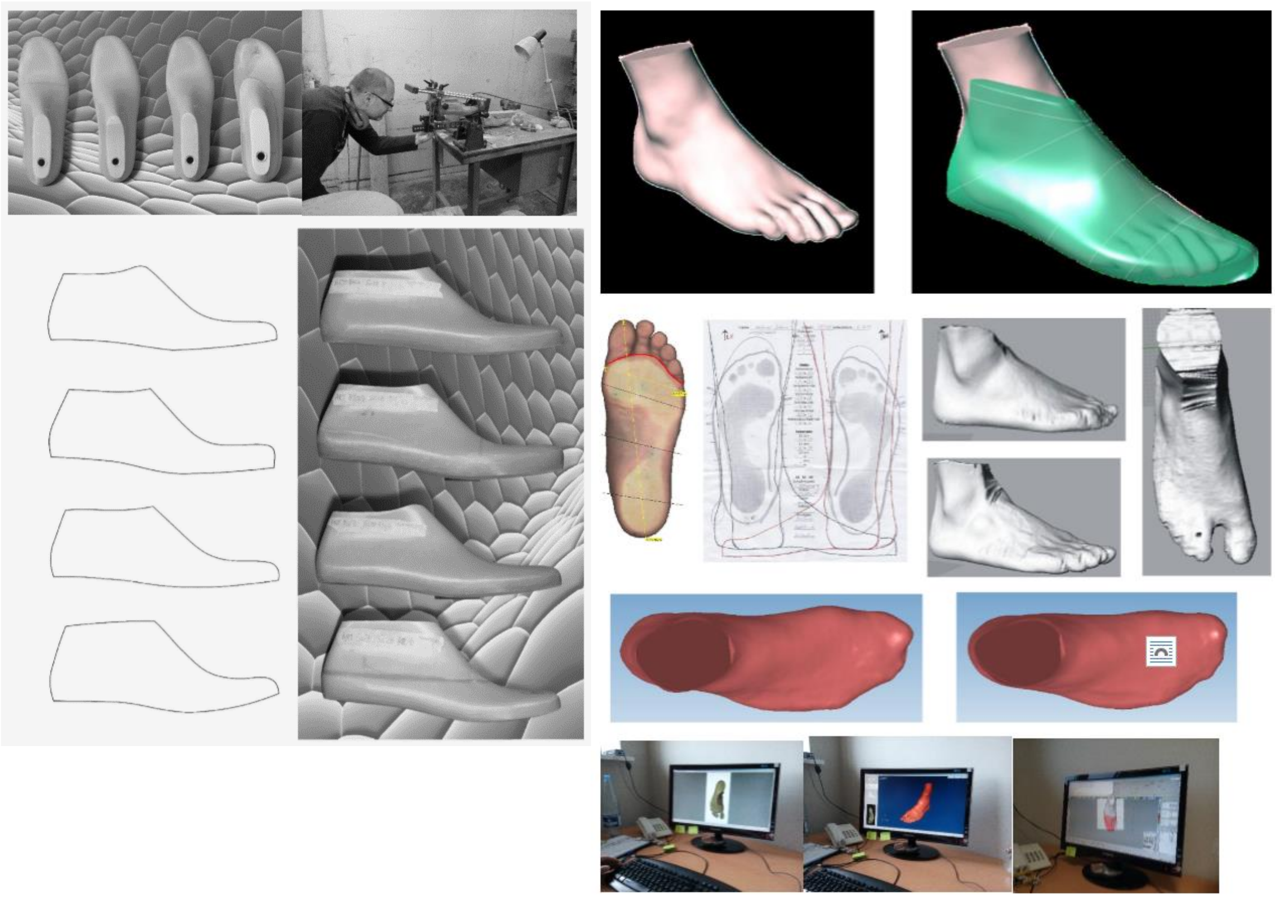


Figure 5.2 Volumes and Proportions of last development process without arch cut Volumes and Proportions of last development

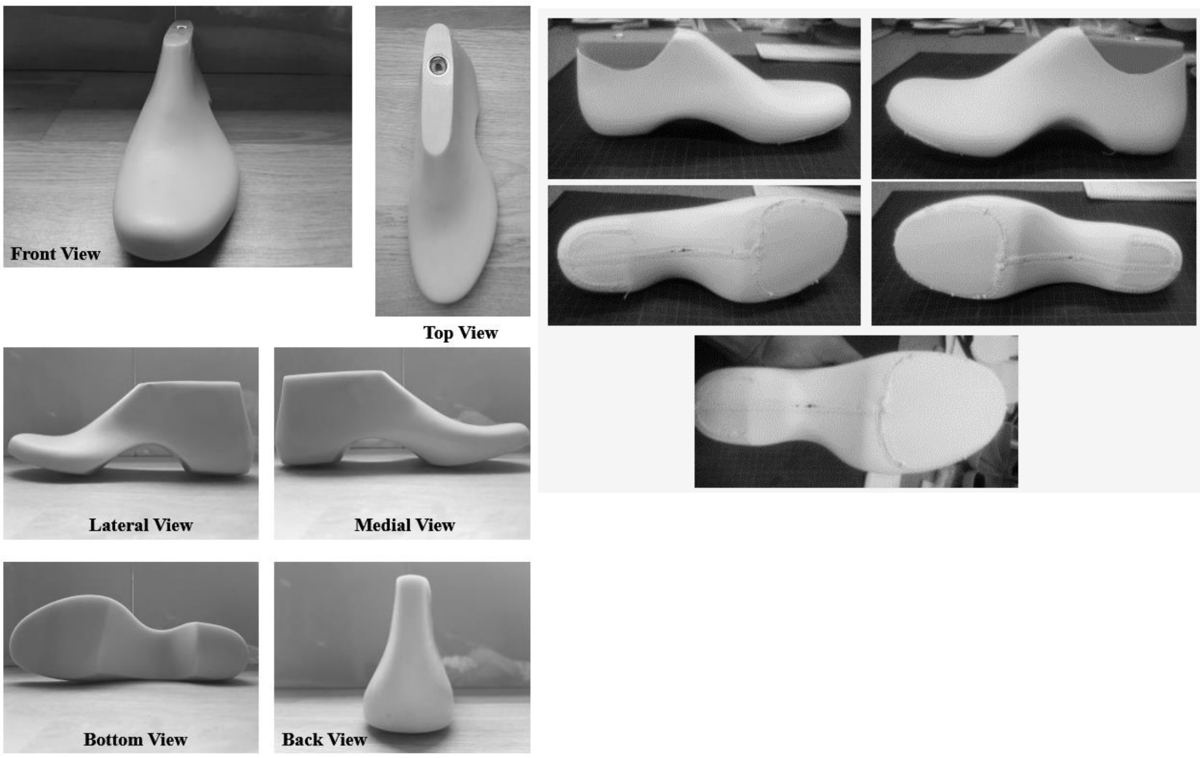


Figure 5.3 Different views of the last used for making of prototype and arch support. Development of last according to heel pain patient feet and arch measurements

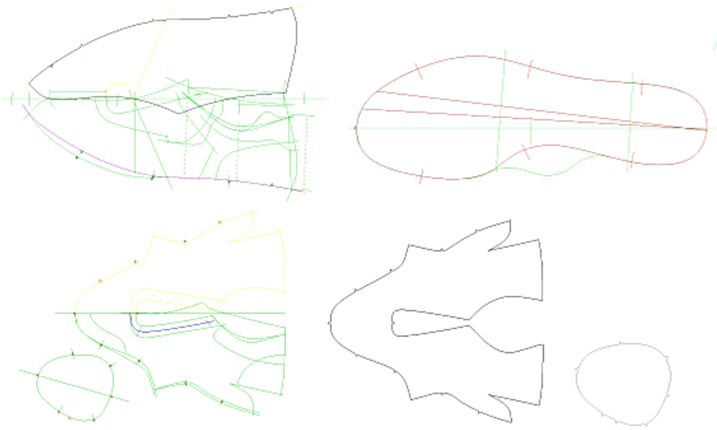
Figure 5.4 Pictures of last measurement for pullover and prototype

First and foremost, a standard operating procedure (refer to appendix) for sampling the opinion of the research subjects and testing of trial pullover was developed and used for the further study and development. Ten styles of footwear designs were initially developed based on certain features and information gathered from questionnaire and interview surveys among heel pain patients and medical doctors respectively (see chapter 3 & 4).
Recommendations given by previous research on required features for heel pain relief footwear were also taken into account during the design of the present designs. Figure 5.6 gives the different footwear design styles with arch support. The designs were presented to patients (n=43) to indicate their preferred footwear style using a questionnaire (the questionnaire is provided in this thesis in appendix details).

S/No.	*Parameter*	*Dimensions/ Features*
1	Last number	210106
2	Size	8
3	Colour	Green
4	Overall length (mm)	288
5	Heel to ball Length (mm)	195
6	Width (mm)	105
7	Circumference at In-step (mm)	280

Table 5.1 Last dimensions and features

In addition, the views of the respondents about the 10 styles (see figure 5.6 & 5.7) were analysed and the top 3 most preferred footwear styles were developed into trial prototypes. Real prototypes which could be described as functional prototypes or high-fidelity prototypes was made for this study.



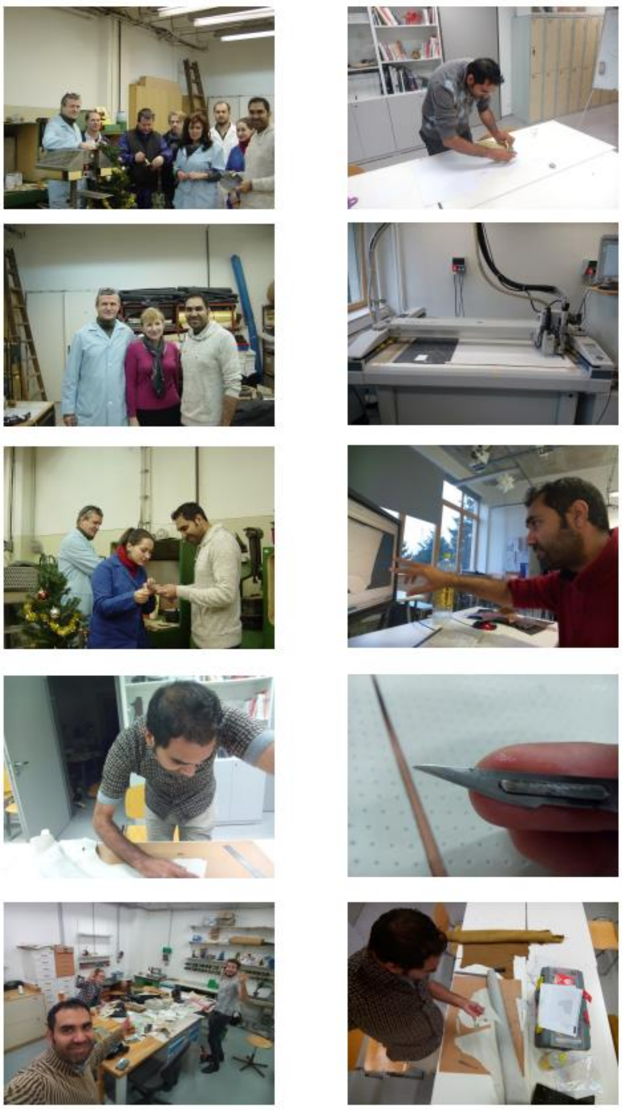


Figure 5.5 Different views of the process. Different views on CAD/CAM patterns used for pullover trail

The shoe upper materials were analysed (refer to chapter 5) to determine whether or not they met the minimum basic requirements in terms of physical properties for making heel pain relief footwear. Other materials (soling materials, lining, insole and other accessories) used for the construction or making of the prototypes was sourced from footwear materials shops in Zlin area.

Traditional methods of making footwear (open shoe) were used to make the prototypes as outlined in appendix details. Photos of the different stages during the construction of this prototypes are also provided in appendix details. A Photoshop, Crispin CAD/CAM software and manual way was used to draw design lines on the last after covering it with masking tape. As usual, the cover was separated from the last and was unfolded onto cardboard paper for making of the design patterns.

The patterns were used to cut the upper leather and the lining. The closing of the uppers was carried out with two different sewing machines (Post bed and flat bad sewing machines). The lasting of

the shoe was done using strobel construction on the same lasts used to design the prototypes by hand lasted. Strobel machine was used for strobel upper and bottom strobel board.
Other making processes like sole preparation and attachment were all carried out at Tomas Bata University, Shoe workshop at U16. See figure 5.6 for different views of the process.

To evaluate the prototypes, a questionnaire was designed (see appendix in details) and was used in conjunction with the prototypes to carry out the trial. The results of the evaluation of the prototypes are presented below (in sub-section 5.7).

5.5 Product Design Specification (PDS)

For clarity of the design and construction of the trial prototypes, a product design specification was developed as presented below (in table 5.2).

S/No.	Parameters	Specifications
1	Product	Arch Supported Footwear
2	Product user	The target users of the product are people living with heel pain and other foot pain problems like plantar fascia
3	Gender	Male and female
4	Age Group	Diabetic and heel pain patients of age group 26- 45 years
5	Materials selection or short listed materials	Upper Components: Good water permeability materials (mainly leather/ stretch synthetic for the upper and light leather or stretch fabric for the upper/lining). Insole: Multi-density Ethylene vinyl acetate (EVA) and, or Polyurethane (PU). Outsole: Ethylene vinyl acetate (EVA) and, or Polyurethane (PU) or TPU-R Thermoplastic polyurethanes rubber.
6	Construction	• Select an appropriate last, or make the required last (particularly if there is foot deformation) based on recorded measurements of the customer's feet. • Create the footwear style and the pattern pieces • Close the upper sections and bottom strobel • Strobel the insole component to the upper • Pull down the prepared upper onto the last • Skive excess leather, add bottom filler and attach sole unit

		• Remove last and carry out quality checks on the finished product.
7	Special features	• No or low heel height • Functional fastening to minimize compaction of fore foot • Flexible soling with adequate cushioning properties • Firm sole, but not rigid • Very soft, minimal or seam-free full leather linings • Firm upper material • Highly comfortable footwear with high level breathability or good ventilation, long lasting cushioning and light weight footwear.
8	Comfort and Ergonomics	• To make the footwear comfortable for the wearer and to prevent the heel pain footwear from sliding around on the feet, the upper should be designed in such a way that it can be easily adjusted to fit. • The product should be designed ergonomically taken into consideration the fact that some patients can have problem with their sight and a significant number of them might have neuropathy or numbness. Therefore, the design should be simple in order to make it very easy for the customers to use.
9	Environment	The prospective product users would be people living with heel pain or plantar fascia. The weather in Czech is generally cold year-round. It is cold and wet most part of the year in the North and in the South. The average temperatures are: 06-12 during the day and -4 to -10 during at winter night.

Table 5.2Product Design Specification (PDS)

5.6 Assessment and Results

5.6.1 Results of Initial survey on preferred footwear style.

The initial survey on preferred footwear style was carried out among heel pain patients (n=43). Figure 5.6 gives the different footwear styles presented to the research participants to indicate their preferred choice and the outcome of the survey is shown from figure 5.7 to figure 5.12.

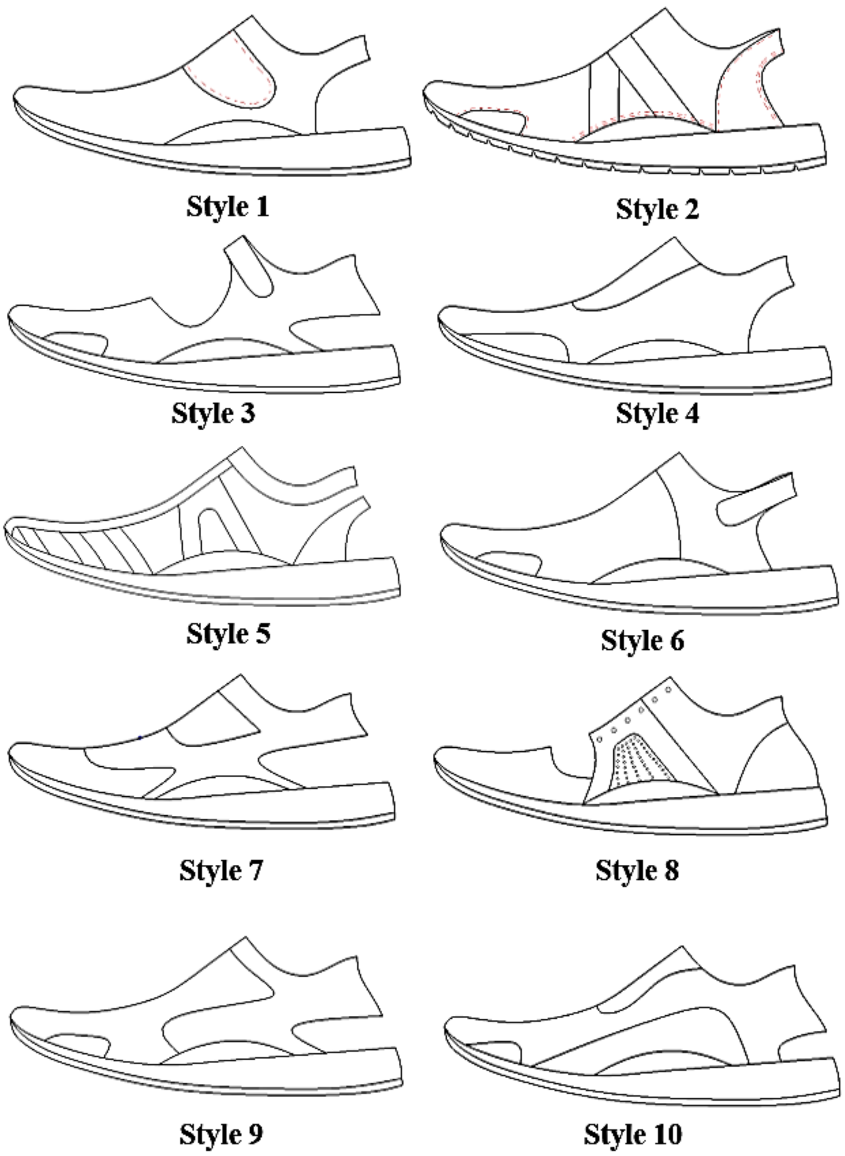


Figure 5.6 Different footwear styles presented to patients to indicate their preferred style

The above footwear sketches/ design styles (fig.5.6) were presented to potential users to select their most preferred style. Among the male participants, the outcome of the survey indicates that style number 3/1 and 2/7 have the highest percentages of 41.17, 23.53 and 11.76% respectively. But for the female participants, their views on the different styles show that style number 2 with a score of 29.41% is the most preferred (see fig. 5.7).

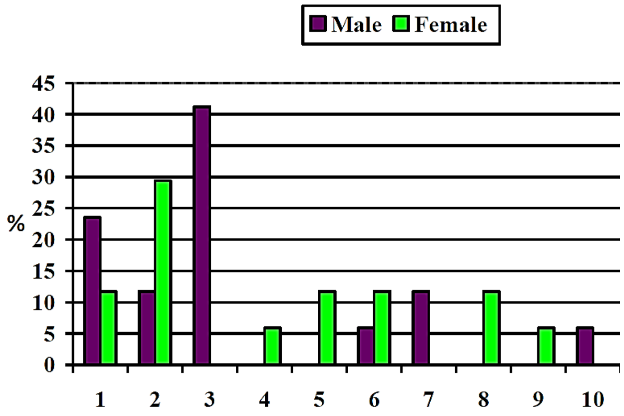


Figure 5.7 Preferred footwear

To understand the most popular shoe size, the participants were asked to indicate their shoe size during the survey. The findings presented in figure 5.8 clearly show that size 42 is the most popular (43%) men's shoe size. The result for the female indicates that up to 31% used size 40.

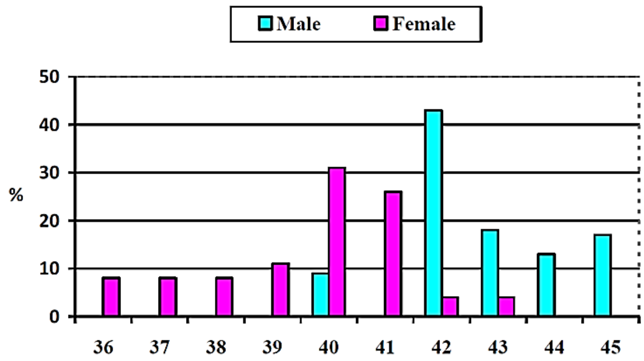
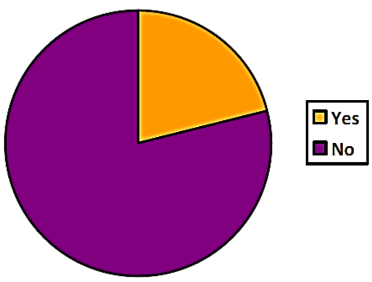


Figure 5.8 Subjects' Footwear sizes

Other foot problems were the important issue that was considered during the initial survey. The findings given in figure 5.9 provides that up to 21% of the participants were suffering with one form of foot problem or the other and 79% did not have any foot problem at the time of carrying out the study. In respect to preferred shoe upper materials, up to 82% participants preferred leather/ comfort materials. The preference for cheap



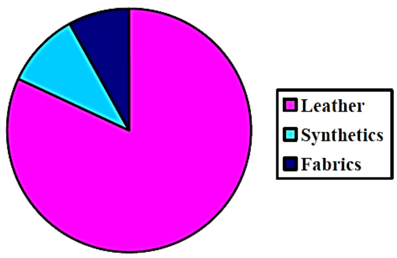
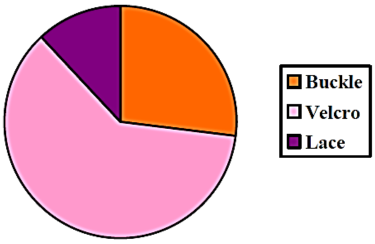


Figure 5.9 Preferred upper material (Prototype).

Figure 5.10 Participants with or without foot problem

synthetics and fabrics is very low; 10% and 8% respectively (see fig. 5.10).
Due to the importance of fastening system in the construction of heel pain relief footwear, the views of the subjects were sought about their preferred fastening system. This study clearly shows (fig. 5.11) that up to 61% would like to use footwear made with a Velcro/ elastic fastener. As seen in figure 5.12, it is obvious that the most popular colour is black. Nonetheless, an appreciable percentage (39%) of the subjects would prefer the colour of their footwear to be brown.



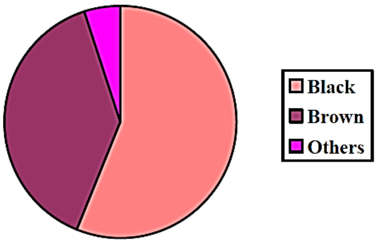


Figure 5.11 Preferred colour

Figure 5.12 Preferred footwear fastening system.

5.6.2 Result of Assessment of trial prototypes

The top 3 footwear styles presented in figure 5.13 were developed into functional prototypes. A questionnaire (see appendix in details) was also developed and a validation test was first and foremost carried out with a small

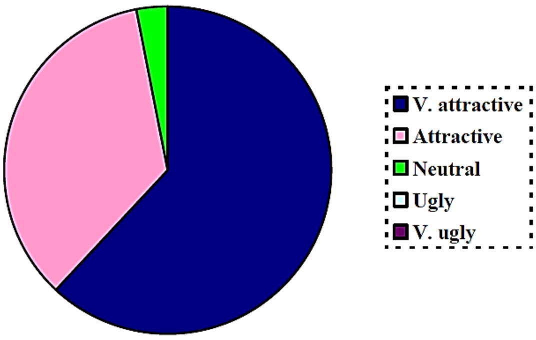


Figure 5.13 Outcome of visual assessment of the prototypes

sample size (n=10). The result of the pre-test is provided in this thesis as appendix. Following the selection, evaluation and validation of the prototypes, the actual assessment of the prototypes was carried out. The prototypes were presented to the potential users (n=37) to indicate the particular type they liked the most and to try it on their feet. The majority (46%) of the participants preferred style 1 (see fig.5.15). This is contrary to the outcome of the initial survey given in figure 5.7 do I have style 3 as the most popular choice with a

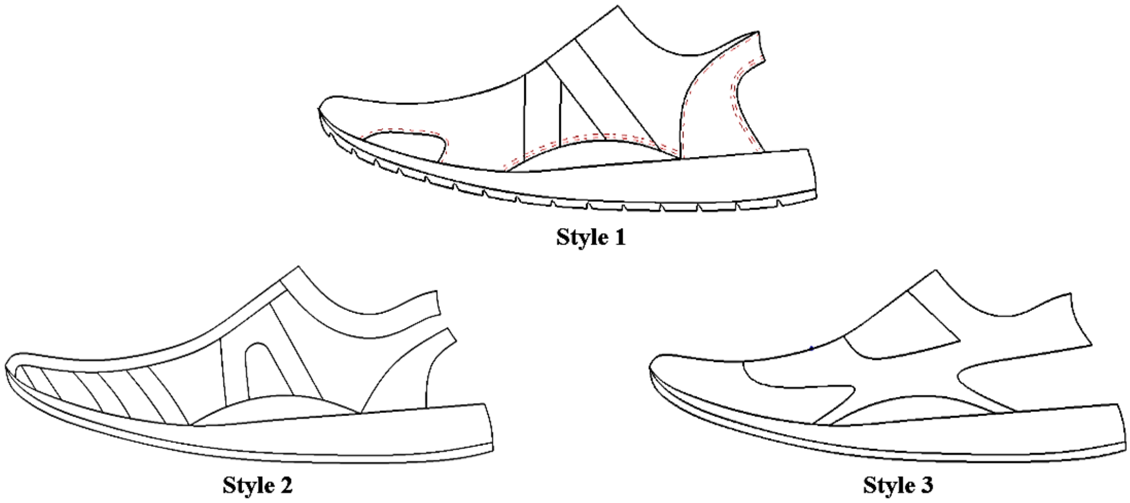


Figure 5.14 Top 3 footwear styles developed into trial prototypes

score of 41%. But the result of this final assessment is consistent with the outcome of the pre-test which also gives a very high score (50%) for style 1 (refer to appendix). Therefore, I would like to argue that using functional prototypes to assess a product from prospective users provides better and more reliable views about the product when compared with using sketches, print-out or other formats of prototypes representations.

However, materials and colour preference remain the same (refer to fig.5.10, 5.12 and 5.16). Other findings on the assessment of the prototypes are presented below.

A visual assessment of the prototypes demonstrates that the footwear styles were very appealing and attractive. Only 3% of those that participant in the survey indicated that the products were neither attractive nor ugly. Interestingly, none reported that the prototypes were ugly.

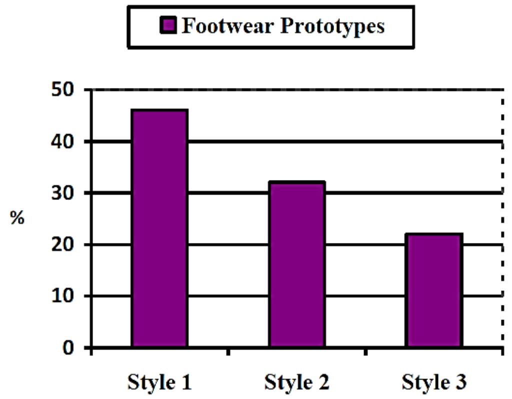


Figure 5.16 Preferred colour

Figure 5.15 Most preferred footwear style

Fit and comfort assessment of the prototypes presented in table 5.2 shows that up to 86% of those that participated in this research could wear the sandals/ open shoes easily. Over 80% reported that they were alright with the length and the width of the footwear and arch support in the bottom part is well made to support the provide planter fascia. Similar percentage of the subjects also indicated that they were comfortable with the top line at the in-step. But it should be noted that up to 19% show that they experience some degree of discomfort when wearing the sandals/ open shoe. These were mainly patients that had swollen feet or some form of other foot problems. Consequently, 24% reported that some form of adjustment to the footwear would be required in order to accommodate their feet well. Nonetheless, none of the patients observed or reported any new swollenness or blisters after the footwear was removed from the patients' feet. Similarly, I could not observe any colour change in any part of participants' feet after the footwear was removed.

* Refer to fig. 5.13. **Fitting Assessment was based on mainly: In-step fit, Length/ Width, whether shoe style go onto feet easily or not, and whether the fastening/ elastic strap aligned properly or not.

Key: DNM –Do not want to mention; AA- Acceptable but a little adjustment is requ Table 5.4 gives more detail information of the subjects that were involved

S/No.	*Enquiry*	*Yes (%)*	*No (%)*
1	Sandals go onto your feet easily.	86	14
2	The width of the footwear is alright.	84	16
3	The length is alright.	84	16
4	Comfortable with the top line.	86	14
5	The fastening aligned properly.	84	16
6	The depth of the Instep is alright.	92	08
7	No experience of new pain in any part of the feet.	95	05
8	The footwear is not too tight.	81	19
9	No experience of discomfort in any part of your feet.	81	19
10	Adjustment is not required in order to accommodate feet well.	76	24
11	No colour change was observed in any part of participants' feet after footwear was removed.	100	0
12	No swelling was observed in any part of patients' feet.	100	0
13	Blister was not observed in any part of the participants' feet after footwear was removed.	100	0

Table 5.3 Outcome of fit and comfort assessment of the trial prototypes

in the testing of the designed prototypes. The age, preferred style, foot length, width, In-step girth and remarks on fitting assessment of each participant are provided. Whereas 28 persons (that is 76%) reported that the shoe fit them well and were very much acceptable, 9 subjects (representing 24%) reported that the footwear were unacceptable in terms of fitting and that a little adjustment would be required to make the footwear comfortable for them. There was no single person that indicated that the footwear was unacceptable tried to accommodate feet well; OK- Fitting well; & UA- Unacceptable.

From this assessment I observed that those that reported that the footwear was tight or not fitting perfectly were patients that had swollen feet. In this case, participants P17 and P21 present a typical example were we have a difference of up to 30mm and 15mm between their right and left feet respectively.

Subjects	Age (yrs)	*Preferred Style	Foot Length Right (Left) (mm)	Foot Width Right (Left) (mm)	In-Step Girth Right (Left) (mm)	**Fitting Assessment		
						AA	OK	UA
P01	55	I	262 (262)	101 (102)	255 (246)		✓	
P02	63	I	265 (266)	108 (103)	261 (255)		✓	
P03	47	III	275 (270)	107 (107)	260 (266)		✓	
P04	47	III	290 (284)	104 (106)	265 (268)	✓	✓	
P05	70	I	286 (282)	117 (113)	275 (265)	✓		
P06	52	III	275 (271)	103 (108)	275 (248)		✓	
P07	58	I	286 (290)	112 (110)	282 (281)	✓		
P08	52	I	265 (268)	103 (98)	240 (240)		✓	
P09	75	II	264 (266)	89 (86)	230 (235)		✓	
P10	67	II	260 (257)	90 (92)	235 (229)		✓	
P11	30	III	274 (274)	83 (85)	230 (231)		✓	
P12	62	II	257 (256)	95 (96)	240 (235)		✓	
P13	76	III	257 (257)	91 (92)	236 (229)	✓		
P14	23	I	271 (270)	102 (108)	260 (253)		✓	
P15	23	II	257 (256)	93 (94)	241 (241)		✓	
P16	27	II	270 (267)	101 (95)	250 (254)		✓	
P17	DNM	III	265 (268)	92 (97)	260 (290)	✓		
P18	64	I	250 (246)	96 (96)	231 (225)		✓	
P19	80	I	265 (260)	107 (103)	262 (268)		✓	
P20	15	II	250 (248)	88 (84)	215 (220)		✓	
P21	48	II	265 (259)	101 (98)	270 (285)	✓		
P22	65	I	262 (260)	101 (10.1)	250 (260)		✓	
P23	DNM	II	255 (255)	96 (96)	235 (240)		✓	
P24	45	I	275 (280)	113 (106)	260 (265)		✓	
P25	54	I	264 (266)	106 (105)	260 (263)		✓	
P26	53	II	261 (267)	100 (100)	263 (260)		✓	
P27	53	III	271 (267)	100 (103)	286 (286)	✓		
P28	71	II	268 (269)	106 (107)	261 (260)		✓	
P29	45	I	271 (271)	107 (109)	285 (288)	✓		
P30	60	II	268 (264)	92 (93)	230 (230)		✓	
P31	75	I	260 (253)	104 (106)	258 (259)		✓	
P32	75	I	255 (255)	104 (100)	255 (2.0)		✓	
P33	50	III	260 (258)	96 (91)	245 (247)		✓	
P34	40	I	261 (265)	95 (97)	282 (283)	✓		
P35	45	I	255 (257)	95 (102)	245 (242)		✓	
P36	52	II	255 (248)	98 (96)	262 (260)		✓	
P37	40	I	258 (259)	85 (95)	258 (259)		✓	

Table 5.4 Result of foot measurement and fit/comfort assessment

The selection of the research participants at this stage of the work was biased in terms of gender and shoe size. It should be noted that only male patients and those who could comfortably wear normal size 42 (or 8) were involved in the testing of the prototypes. This is seen as a limitation of this research project. A further study that would involve both genders and broad shoe sizes is therefore strongly recommended.

Some of the remarks made by the subjects on the footwear fitting (whether it was very tight, or very loose or fit perfectly) and the dimensions of their foot measurements were compared with the tolerable allowance for men (determined in the previous chapter). The calculated average tolerable allowance for male subjects was found to be 3.5mm. Therefore, looking at the dimensions of participants P17 and P21, particularly their In-step girth which was found to be 290mm (left foot) and 285mm (left foot) respectively, it can be confidently said that the dimensions of their feet are above the tolerable allowance. Table 5.1 shows that the circumference of the last (used to make the prototypes) at the in-step is 280mm. So when this is compared with the dimensions of the in-step girth of the above mentioned participants, we would notice that their foot dimensions exceeded the tolerable allowance with up to 6.5mm and 1.5mm for participant P17 and P21 respectively. This has given a clear proof that patients' feet must be measured correctly if they are to obtain footwear that fits well and maintains healthy feet.

5.6.3 Expert Assessment

In addition to testing of the prototypes with patients, the footwear were presented to the foot care doctors (mainly orthopaedic doctors and members of Czech Podiatry Association) for criticism and expert feedback. The doctors/ foot experts gave convincing statements that the prototypes will meet the needs of their patients, particularly those at risk of developing heel pain and other foot problems. They also mentioned, however, that those with deformed feet or flat foot will require customised or bespoke footwear with these types of arch supported styles. One of the medical experts pointed out that "footwear designed for heel pain relief and arch support is a welcomed technology. It will help in preventing foot injuries related to diabetes". Overall, a very positive feedback was received from the foot care experts about this new style arch supported designs, styles and materials used for the construction of the footwear.

Furthermore, foot care technologists' and podiatrist' members at Czech Podiatry Association views about the designs and construction were sought. The footwear experts expressed optimism that the products would meet the required parameters in terms of technical, aesthetic, comfort and fitting specifications.

5.7 Design Framework

A framework was developed as shown in figure 5.17 as a representation of the output of the research findings. The framework shows three step-by-step procedures for provision of appropriate footwear to people suffering with heel pain. The first step involves identifying individuals with heel pain and categorising them into patients with foot problems or at high risk of developing foot problems/ plantar fascia. The second level of the framework deals with assessing the specific footwear needs of the patient, and selection of suitable footwear materials/ components to make the appropriate footwear is done at the third level.

Regarding the implementation of the design framework, wide spectrums of professionals are considered to be key stakeholders. Nevertheless, the main stakeholders at the first level include podiatrists and foot care specialist. These have the responsibility of identifying heel pain patients with an at risk foot or with foot problems like a plantar fascia.
Immediately someone with foot problems or at risk of developing foot problems is identified, it is recommended that other stakeholders, mainly orthopaedic doctors, orthotics, and biomechanics should be involved at the second level of the framework. These professionals are expected to identify the nature of the patient's foot problem and the most appropriate type of footwear that could be recommended for the patient.

For a very successful management of foot problems, it is advocated that a specialist in footwear materials, product developers, footwear designers and manufacturers should be given the opportunity to make their professional inputs at the 3rd level. To make the framework a complete cycle where there is a proper flow of information from one level to another, the product designed and made for the patient at the 3rd level should be sent to the specialists at the 1st level to check for proper fitting. If there is need for amendments, the professionals at the 2nd and 3rd levels should be involved accordingly.

Note that the PDS (refer to sub-section 5.5) is particularly linked to this design framework at the 3rd level. During the selection stage of footwear materials/ components, the product developer or manufacturer should refer to the PDS for the specific guidelines on appropriate footwear materials and ergonomic factors that must be taken into consideration during the design and manufacture of heel pain relief footwear

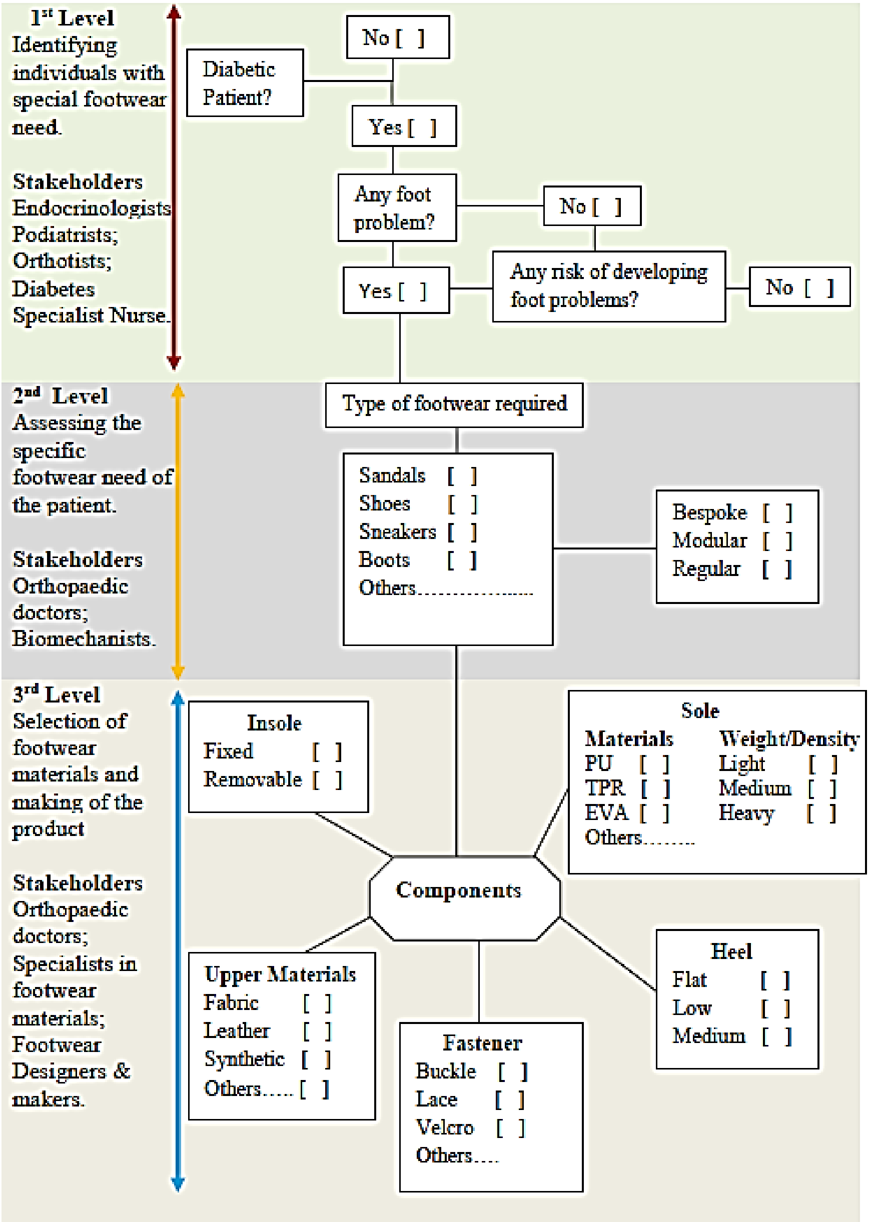


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Figure 5.17 Heel pain relief footwear design framework

As part of the strategy to solve the problems identified in this study, I have developed a design framework (see fig. 5.17) for making appropriate footwear for heel pain/ plantar fascia patients. The concept consists of identification of persons suffering with heel pain by clinicians and categorising them according to their foot care need; (a) patients with foot problems, (b) patients at high risk of developing foot problems like ulcers, and (c) patients at low risk of developing foot problems. After assessing the foot care need of the patients by clinicians, it is recommended that patients with foot problems and those at high risk of developing foot problems should be referred to a foot care team (comprising different professionals including foot care experts, designers, etc.) who will investigate further about the foot care needs of each patient and give recommendations about the specific type of footwear and footwear materials for each case. From the survey, certain patients may require more special shoe last to be constructed to make the shoes in order to accommodate their deformed feet or to off-load areas of high pressure. The largest population of the patients would require footwear to be made on selected last but constructed with appropriate materials that will provide adequate protection and comfort for the patient's feet.

5.8 Discussion

5.8.1 The last

The last is a complex structure made from several measurements that are statistically determined. It has been described as "a physical object whose shape is an abstraction of the human foot" (Kühnert et al. 2011 P. 31). It is not indistinguishable to the human foot in shape or proportions. It is seen as a compromise of the two (Tyrrell & Carter 2009). In comparison to the human foot, the last girth, size intervals and dimensions are regular whereas those of the feet are irregular. In terms of substance, the human foot is softer and flexible while the last is hard and firm. The last is seen as the main element in footwear making and it constitutes the base for the footwear lasting process (Davia et al 2013). Therefore, lasts are used for both design and production of footwear and their shapes vary between footwear companies and are confidential due to the fact that they characterize the shoemaker's knowledge about a good fit of the footwear. For custom made footwear, a last must be made which represents an appropriate shape for footwear for the individual patient's feet. It is obvious that the need to have an individual last made for people with foot problems is one of the reasons for high costs of making bespoke footwear. Sometimes it becomes necessary that a small portion of a standard last is modified to accommodate certain foot conditions. Such modification would result in cost effectiveness when compared with making an entire bespoke last.

In this study, a standard or normal last was used to make the arch support cut (refer to fig. 5.2 & table 5.1) to design and make the prototypes. The feedback provided by the patients after the testing for fitting and comfort factors point to the fact that some parts of the last would require amendments in order to accommodate some foot deformities. In some cases a bespoke last would definitely need to be made. However, previous research has shown that there is a great challenge in the customised footwear manufacturing process due to the fact that it is difficult to apply specific models in the industry.

5.8.2 Trial Prototypes

This research resulted in making functional prototypes that were used to test various usability aspects of the product with prospective users. Footwear making is not as straightforward as many would think. It is described as “the art of producing a three-dimensional, dynamic article from a two-dimensional material; and pattern making requires the conversion of the round curves of the last into the flat upper components and then back into the curved shape of the shoe” (Tyrrell and Carter 2009. p. 33). The processes involved in the making of the prototypes and photographs of different stages in the making process are provided as appendix.

This research has revealed that comfort footwear are well accepted among people suffering with heel pain in this part of the world. As can be observed from figure 5.6, sandals/ open shoes come in many different styles and designs. However, most sandals/ open shoes are basically the same. It has been shown that footwear style is not just a matter of design, but of foot comfort as well (Davia et al. 2013; Tyrrell & Carter 2009; Erasmus & Jorgensen 2008). For instance, some people cannot bear the feeling of a strap between their first and second toes. Still, some other individuals may have some type of foot deformity that would necessitate choosing one style of shoe over another.

Whereas a shoe will often put the foot under pressure by squeezing it, one of the advantages of wearing sandals/ open shoes is that they do not put the foot under pressure at all, and allow the foot to function normally (Erasmus & Jorgensen 2008; Nather et al. 2008). Therefore, sandals/ open shoes could be made not only to meet the aesthetic taste of the customer, but also to provide the desired foot comfort and to accommodate certain peculiarities or deformities in foot shape. As a matter of fact, sandals/ open shoes can easily be designed in such a manner that the possibilities of leather straps rubbing against tender spots or areas of high risk of developing ulcers are completely avoided.

The true aim of prototyping is not to show that the design is perfect or correct, but rather to reveal any feature that will affect quality, cost or consumer acceptance. Prototyping is also aimed at revealing mistakes, errors, and flaws prior to a release and mass production of a product. Therefore, prototyping is about revealing mistakes. According to Roosevelt (2010), “The only man who never makes mistake is the man who never does anything”.

In this study, it was noticed that real prototypes improved communication of the different features of the design compared with the printed version. For instance, the type of fastening/ elastic straps used in the design of the sandals/ open shoes are better appreciated with the actual prototypes when compared with the response received with the printed version. This could be the reason for the wide variations in the preference of different fastenings between the initial survey (printed version) and the actual prototypes. A similar view is expressed by Chua (2010) on his write-up about the principles and application of rapid prototyping.

Apart from considering ventilation in the design of these prototypes, convenience and ease of use were also seen as factors that give a very wide acceptance of this type of footwear among people suffering with heel pain.

Previous studies or researches have shown that the use of a prototype as a communication device has many advantages, most especially when communicating ideas to those who do not understand or appreciate prints or CAD. In this study, the prototypes were made with materials used in actual manufacturing of the product. This was done deliberately to aid potential users to understand every aspect of the product, to feel it and to try it.

This work has proved that there is urgent need for collaboration across a number of disciplines including designers, engineers, clinicians, biomechanics, footwear technologists, etc. to be fully involved to make footwear that could benefit a wide range of heel pain/ plantar fascia patients.

5.9 Chapter Summary

A brief description of the materials and methods used to make and test the prototypes was clearly given. A pair of last and various types of footwear materials were used to make the trial models and approved questionnaires were used to sample opinions on footwear designs and to assess the trial prototypes. Initially, 10 different footwear styles were designed and presented to potential users of the product and the top three selected were developed into functional prototypes.

Visual, fitting/ comfort assessment of the prototypes recorded high acceptability by the intended users of the product. In a similar way, feedback received from foot care doctors and footwear designers/ technologies was very positive. The podiatrist' belief was that the product would be beneficial to heel pain patients if the prototypes are fully developed, produced and made available to the prospective users. The information provided in this chapter demonstrates that development of appropriate footwear for people suffering with heel pain/ plantar fascia requires so many considerations including footwear style or design, fitting/ comfort factors, cultural and environmental issues. This study indicates that sandals/ open shoes are well accepted by potential users. The research showed that shoe size 42 or 8 is the most popular size for male subjects whereas size 40 is seen as the most widely used size among female subjects.

In summary, this research shows that people suffering with heel pain, especially those that are at risk for plantar fascia and who do not need custom shoes currently could benefit from this type (models) of footwear. The next chapter provides general discussions on the major outcome of the whole project.

6 CHAPTER "General Discussion"

6.1 Introduction

No doubt, heel pain is associated with foot problem. However, data on the scale and nature of foot problems associated with the disease in developing countries are very poor. In addition, the level of awareness by patients and health care providers about the role of footwear in the management and/ or maintenance of foot health is very low. Therefore this study investigated how properly arch support designed footwear could be used to better manage foot problems because footwear is seen as a health intervention tool (William 2008; & Katreddy et al 2010). It also examined footwear materials in respect to foot health, the dimensions of shoe last and dimensions of the foot. Lastly, prototypes were made and used to test usability of the product from prospective users.

The findings from this research are seen as very important because to the knowledge of the researcher, a study in this subject area has not been undertaken. Following is a discussion of the major outcome of this study. The significance and importance of the project are also outlined in this chapter.

6.2 Research Methodology and Data Analysis

1. Research Methodology

The choice of the type of research methodology adopted for this study was largely informed by the research aim/ objectives, the expected outcome and the time frame. It was discovered that the nature of the research demanded a methodological approach that embraces both qualitative and quantitative data collection. Crouch & Pearce (2012) strongly advocated for this type of research methodology for any study that needs to generate research findings that can be generalized across a large population and at the same time to understand in some depth the individual experiences of a small group of people.

The questionnaire survey (refer to chapter 3) used for collecting information from heel pain patients was chosen because it was anticipated that it would provide data from a sizeable number of patients that could be used for making inferences for the whole foot problems population. At the same time, I used a structured questionnaire to interview the foot doctors/ podiatrist bearing in mind that such an approach would provide him with the required information within the research time scheduled. A non-structural interview method that requires more time to gather information and analysed could not be used.

Nonetheless, open-ended types of questions were included in the structured interview questionnaire in order to allow the interviewees to describe or explain their experience of particular issues in more detail (see appendices in details). Also, to complement the findings gathered through the questionnaire and interview surveys, two additional studies (footwear design style analysis, shoe last and foot measurement) were designed. The footwear experimental analysis provided valuable information regarding the physical and mechanical properties of the shoe upper materials that could influence the comfort of footwear. The results of the foot measurement were very useful in determining footwear fitting features mainly during the assessment of the trial prototypes.

This mix-methods approach enabled the researcher to use some of the methods or aspects of the methods to identify the key issues whereas other aspects or methods provided detailed information on some of the issues raised. In addition, some of the methods complement the findings of other methods.

For effective data gathering and understanding of the researcher methods adopted, the researcher carried out a thorough literature review throughout the period of the study. The data gathered both from the primary and secondary research were used to develop PDS, design framework and functional prototypes. The prototypes were evaluated and the findings from all aspects of the study were discussed. Finally, the implications of the research work, conclusion and recommendations for further research were identified and outlined.

2. Data analysis

There are many approaches to analyse research data. Qualitative data concerns the interpretation of text. Quantitative research involves working with numbers and using statistical analysis.

Crouch & Pearce (2012) proposed that any researcher work which use questionnaires as a form of data collection may not need to go beyond the use of descriptive statistics and the exploration of the interrelationships between pairs of variables (using for example, cross tabulation). It would be adequate to say that so many responded (either the number or the proportion of the total) answered given questions in a certain way. Such an analysis makes wide use of proportions and percentages, and of the various measures of central tendency (averages) and dispersion (ranges). In order to ensure that the right approach to the analysis of the data collected in this study was employed, I first consulted professionals in statistical analysis at U13 Library, Zlin in UTB.

The analysis of the outcomes from interviews, questionnaire surveys and foot measurements was carried out systematically, first through thematic analysis,

followed by computing the data using Microsoft Word 2010 and Excel 2010 to represent the outcomes in the form of bar and pie charts and tables.
However, the results from the experimental analysis were done mainly by using formulae and representing the results in tabular forms.
The data from different methods used were analysed, re-arranged and represented to show low and high values. The represented values were observed for certain patterns so that comparative analysis could be done, for example type of footwear worn most often by male versus female.

6.3 Diabetes

The current global epidemic of diabetes (type 2 in particular) has led to an increase in both foot ulceration and amputations, which are regarded as significant health problems to populations worldwide. It has been established (Bakker 2011; White 2010) that people with diabetes experience foot ulcers, swollen feet and different types of foot deformations.
Mbanya et al (2006) argues that despite some local data, the burden of diabetes is difficult to estimate. Accordingly, the findings from this study (from diabetic patients' respondents) shows that at least 67% did not know the type of diabetes they were suffering with. Nonetheless, 28% reported that they were suffering with type 2 diabetes and only 5% indicated that they have type 1 diabetes. And from the viewpoint of the doctors/ podiatrist interviewed, up to 93% of their patients could be suffering with type 2 of the disease, whereas at least 7% might be suffering with type 1. The data from this project has therefore contributed to the information on diabetes.

6.4 Foot problems and footwear

Foot problems are seen as the major complication of diabetes (National Diabetes Fact Sheets 2011; Vernon 2007). The literature (Krentz & Bailey 2001; World Footwear 2008; Johnson & Rogers, 2011) points out that people suffering with diabetes could easily develop foot problems or heel pain because of how easily nerve damage can occur there without immediate detection. This usually leads to loss of blood flow, and subsequently numbness to the extremities. Consequently, infections may go entirely unnoticed until it spreads beyond repair. This condition can also have a significant effect on wound healing and management (White 2010). Therefore, it is advisable that people with heel pain should be more vigilant to prevent injuries that are more likely to damage their feet (Kennedy 2010; World Footwear 2006). Results on the nature and scale of foot problems and heel pain were presented in chapters 3 and 4. The results show that up to 40% of research respondents were suffering with foot problems.

A recent study (Stimpert, 2014) on customized footwear points out that people in the developed world with foot issues or health problems now have a wide array of options in customized footwear, more than ever before. Nonetheless, this study shows that such options have not be made available to people who need custom shoes.

It has been explained that footwear can have a negative or positive influence on the foot depending on whether the footwear is appropriate for the wearer or not (Vernon, 2007). Also, researchers (Munro & Steele 1998; Haspel 2007; Wright 2010; Jude 2011) continue to argue that foot complications could be prevented and/ or minimized with early diagnosis of diabetes, good patient education, effective treatment and the use of quality footwear to off-load areas of the feet which have ulcerated or potentially will ulcerate. Other authors (Przybylski 2010; Ulbrecht & Cavanagh 2010; Ivy et al. 2008; Boulton 2008; Knowles & Boulton 1996) point out that foot problems incur a substantial economic burden for society, patients and families globally. The work of Nathan and Singh (2008) on "Diabetic footwear: Current status and future directions" indicates that shoe-related injuries are the major cause of diabetic foot problems. However, they show that the prescription of diabetic footwear leads to a reduction in new foot ulceration and as a result, a reduction in lower extremity amputation rates. Similarly, information gathered from both diabetic patients and the doctors/ podiatrist in this study clearly indicates that inappropriate or ill-fitting footwear has a negative influence on the heel pain foot. While the research outcome of Ulbrecht & Cavanagh (2010) shows that up to 37% of patients wear ill-fitting shoes that result in foot ulcerations, even in the non-diabetic patients, 24% wear shoes in the wrong shoe size. This present work provides data that point out that urgent intervention is required to stop or at least reduce the rate of foot complications as a result of wearing inappropriate footwear.

The findings from the questionnaire survey (refer to chapter 3) give evidence that the majority of heel pain patients lack knowledge about foot care and use 'bad' footwear that could contribute to the most devastating, preventable foot complications. I argue that poor knowledge of foot complications and lack of knowledge on how to manage the disease are among the major reasons for the high percentage of heel pain patients experiencing foot complications in this part of the world. Contrarily, there are well-established research teams in Europe and America that conduct studies on foot problems, its complications, and how to solve such problems. For instance, the European Union gives special attention to solving the problems of foot by sponsoring a research project (SSHOES Project) to design and develop new sustainable product concepts, such as footwear and insoles for diabetic feet (S-Shoes, 2012). It is therefore recommended that similar projects should be initiated in Asian countries.

In order to relate the doctors' views and the patients' experience on the most widely used footwear type, a comparison is made between the results obtained from the interview and the questionnaire surveys (see table 6.1). The views on the type of footwear most widely used by diabetic patients from the perspective of the doctors and the patients were found to be consistent all through. Looking at the table, both surveys show clearly that sandals or open shoes are the most popular type of footwear used by male patients, while slippers are seen as the most widely used footwear by the female patients. This further justifies the choice of sandals/ open shoes for making the trial prototypes. From the results of this research it can be concluded that the concept of utilizing footwear to protect the foot from injury, the factors that go into establishing patient's footwear needs and footwear modifications are seriously lacking among patients and health providers. It is believed that this project will go a long way in creating awareness about the many roles footwear can play in the management of foot problems.

	Gender	Shoes (%)	Half Shoes (%)	Sandals (%)	Boots (%)	Slippers (%)	Sneakers (%)	Custom Made (%)
Findings from the doctors	Male	15	17	35	05	26	01	01
	Female	11	18	25	00	45	00	01
Findings from the patients	Male	17	14	29	01	37	02	00
	Female	13	15	19	00	53	00	00

Table 6.1 Comparison of the outcome of the interview and questionnaire surveys in respect to type of footwear most often used by patients.

6.5 Product Design Specification (PDS) and Design Framework

In general terms, design is essentially a rational, logical, sequential process intended to solve problems (Novak-Marcincin 2012; Jimeno-Morenilla & Davia 2010 ;). The process of this work began with the identification and analysis of footwear needs and proceeded through a structured sequence in which relevant literature was researched and ideas explored and evaluated until a solution to the need was proposed. Specifically, this project investigates acceptable footwear that could benefit people suffering with heel pain. This was done by studying a range of factors that could determine the design and appropriateness of footwear for heel pain foot through the formulation of a Product Design Specification (PDS). The PDS was useful in the selection of materials and designs for the prototypes. The key elements that must be considered in the design and selection of materials for footwear include comfort and ergonomics, environment, etc. (see chapter 5, sub-section 5.5).

Based on this study, a close relationship between the PDS and the research framework, particularly at the third level (i.e. selection of footwear design styles and components), can be observed (see previous chapter, sub-section 5.8). The framework provides a concept which consists of identification of persons suffering with heel pain by clinicians, categorising them according to their foot care needs and recommendations about the specific type of footwear and footwear materials for each case. It is believed that clinicians and product developers can confidently use these tools to develop appropriate footwear or orthotics for individual patients. This is considered as a very important contribution of this project in the subject area.

This work further shows how it is difficult to give a generalized specification for heel pain foot as the shape of the feet may differ significantly one from another due to different foot problems some of them experience. However, a number of functional requirements or necessities affect the structure or type of footwear. These functional necessities add to the complication of the designer's task in designing the most appropriate footwear, and give the designer the necessary elements out of which he can produce the variety of his footwear styles and shapes. Therefore in an attempt to meet the design requirements of heel pain relief footwear, I discovered from the data obtained from both the primary and secondary research that functional requirements or need of the heel pain foot should come first, and then structure requirements, and finally requirements of aesthetic appearance (Covington 2009; Harvey 1992).

6.6 Last and Foot Dimensions

Different views of the last that was used to design and make the prototypes and its dimensions are given in this thesis as figure 5.2 and table 5.1 respectively. It has been pointed out that the last is the main element in footwear design and it constitutes the base for the footwear lasting process (Davia, et al 2013). In chapter 5, it was demonstrated that to make suitable footwear for heel pain feet, an appropriate last must be made which represents an appropriate shape for required footwear for the individual patient's feet and the height of arch.

In regards to the dimensions of the foot, it is generally noted that the outcome of the right and left foot measurement of most individuals differ one from another. Similarly, the results of the foot dimensions of those wearing the same shoe size varies one from another. These findings are in complete agreement with the research outcome of some studies (Pezza 2011 & Sandrey, et al. 1996) that note that it is rare to find a patient who is wearing the proper shoe size. Similarly, this research shows that the differences in foot dimensions (length) for subjects wearing the same shoe size could be up to 21mm (refer to subject MB19 and MB15 in table 4.2). In like manner, a difference of at least 20mm in foot width was recorded between subjects MA06 and MA11. Appreciable differences could also exist at the in-step of individuals wearing the same shoe size. It is therefore argued that these differences could become a source of major discomfort for the subjects when wearing footwear when such differences were not taken into account. Generally, it is observed that the differences in some people's foot length, width and in-step can be negligible whereas some could have appreciable variations.

6.7 Trial prototypes: Why Sandals/open shoes?

The need to design appropriate footwear for heel pain patients' satisfaction has been noted in the introduction (sub-section 1.3). It was also pointed out that most of the studies on diabetic and orthopaedic footwear were mostly based on clinical need and perspective, without an in-depth understanding of patients' expectations and perceptions of footwear. The literature has shown that two thirds (2/3) of patients wear poor-fitting footwear, but that shoes designed for people suffering with heel pain could reduce re-ulceration rates by half (Leese 2009). For this research, trial prototypes were developed after a careful study of the problems from previous works, from the viewpoint of doctors/ podiatrists and from the perspectives of patients.

Tyrrell & Carter (2009); Nathan and Singh (2008) pointed out that shoes, sneakers and bespoke footwear are the recommended types of footwear for at risk foot. However, financial constraints or limited economic resources force most people suffering with heel pain to use cheap footwear regardless of whether they provide the desired protection and comfort to them or not. For many patients (see sub section 3.7.7), price rather than quality is the major concern when buying footwear. The majority of the population lives in poverty and faces economic challenges. In view of the above factors, sandals/ open shoes were considered as the most appropriate type of footwear to be developed as the prototypes. In addition, Open shoes became the best choice on the basis that they are popular and that a well-designed, constructed with appropriate materials would provide the desired protection and comfort to the wearer which is affordable. This is because the cost of making a pair of sandal usually is not as high as shoes or sneakers. Another good point for choosing this type of footwear is due to the fact that they could provide enough room to comfortably fit swollen feet. Also, the rate of feet perspiration in this part of the world could be very high (refer to table 5.2) and the use of sandals/ open shoes are considered very appropriate as they provide good ventilation.

Clearly, there was a mismatch between the types of footwear desired (leather shoes) and the type of footwear that are available and affordable. Different kinds of slippers are the most prevalent types of footwear used among the patients. These are cheap and widely available in the local markets. Although they are accessible, they are considered as inappropriate for the patients because they do not provide good protection and due to the fact that low-quality materials are used to make them, and they may be uncomfortable.

Therefore, after a careful survey on the most preferred and appropriate footwear for the patients, three basic types of footwear (sandals/ open shoes) were produced and used to assess the acceptability of the products from prospective users. The idea behind the three designs (see fig.5.13) was to provide footwear that would give good instep support to the foot as well as support to the foot arch whereby preventing the foot from sliding forward to exert pressure on the metatarsal head of the foot. Other features critically considered in the design of the prototypes were comfort, ventilation and lightness of the footwear. This is in line with the general guidelines for provision of healthy footwear for heel pain foot.

The outcome of the assessment of the prototypes presented in chapter 5 clearly shows that the products are well accepted by both patients and foot care doctors/ podiatrists. The products are therefore recommended for all heel pain patients that do not have a major foot deformity and for people who may find it very difficult to use lace or buckle shoes. They can equally be used by middle age and old people whose feet may or may not be at high-risk of developing foot problems.

6.8 Footwear materials and components

1. Upper materials

The upper part of the footwear (see fig.6.1) comprises of the counter (the part of the shoe extending around the heel), toe box (the part that covers the toe area), vamp (the part that covers the instep), and throat (the part at the bottom of the laces). Leather and stretch fabric materials is seen as the most used natural material for footwear upper because of its versatile properties of plasticity and elasticity and other ideal characteristics for footwear (Bata 3013; Tyrrell & Carter 2009). Leather is soft, it breathes, offers very good absorption ability and is able to adjust to an individual’s foot shape.

The result of the analysis of footwear materials presented in chapter 3 demonstrates that leather has good comfort and strength properties. For instance, the breathability of the samples determined using the water vapour permeability test indicates that diabetic footwear upper should be made with leather because it has properties of particular value in terms of foot health. It has excellent ability to allow air and water vapour to pass through the cross section of the upper. Other materials like coated fabrics and poromerics have excellent properties in respect to water repellence and resistance. However, they have low water vapour permeability property, hence poor breathability (Harvey 1992; June 2000).

It was learnt from the interview survey that the majority of podiatrists would prefer footwear made for their clients to be constructed with leather (refer to fig.4.11). Similarly, the patients are of the view that leather is the best material for shoe upper (see fig.3.14) Furthermore, the following are particularly noted in regards to the construction of the footwear upper after a review of the literature and the primary research: The upper should be designed with no interior or minimal seams (or covered seams) to prevent rubbing injuries; the seams can be used only where the shoe does not flex; the design should give room for easy adjustment to fit, to prevent the diabetic shoe from sliding around on the feet; appropriate fastener must be used for the upper.

Figure 6.1 Parts of a shoe. Available from:
http://gluxus.com/wpcontent/uploads/2013/07/parts-of-shoe.jpg

2. Insole

Even though the experimental analysis of the footwear materials mainly focused on shoe upper; the secondary research shows that arch supported bottom insoles provide the important interface between the foot and the shoe and, together with outsole modifications, offer the most direct approach to the reduction of potentially damaging tissue and stresses on the plantar part of the foot. And in respect to arch supported bottom insole shape functions in reducing local peak pressures, research has shown that contoured insoles are significantly better than flat insoles.

Research has shown that there are a great variety of insoles materials available for shoe designers to use, but for diabetic or heel pain relief footwear construction, multi-density EVA or PU are recommended (Tyrrell & Carter 2009). This is because they can easily be moulded and trimmed to the desired foot shape. Very soft PU or EVA materials are found to have good cushioning property; hence they are very suitable for making footwear for those suffering with diabetes and heel pain or people that need to offload high pressures from the metatarsal heads (MTHs) and other areas.

3. Sole and Heel

Again, the literature (Cavanagh & Ulbreacht 2008; Rahman 2003) clearly shows that the most common sole suitable for diabetic foot is the rigid rocker-bottom shoe or a variant thereof called a roller. The rocker has a break in the contour of the sole, whereas the roller has a smooth curve. The principle for designing the diabetes or heel pain relief out-soles is to allow the patient to walk with minimum motion of the joints of the foot. The following are the desired elements of out-sole and the arch supported bottom insole shape in regards to heel pain relief footwear.

- Firmed and resilient
- The top of the arch supported bottom insole shape should be soft, flexible and hard at the bottom
- Should be made with two components (dual density)
- To reduce pressure on the metatarsal head, medium to low arch supported bottom insole shape should be used.

In summary, to design or make good and acceptable footwear for people living with heel pain, the points given below must be critically considered:

- Foot or heel pain relief footwear should be seamless or have less seam at positions where the shoe does not flex.
- The shoe should be wide because some patients can have claw toes.
- The shoe upper should be deep and flexible enough to accommodate arch support bottom insole shape.
- The upper should be soft and breathable.
- Medium to low or flat heel should be used in the design and construction of heel pain relief footwear.
- Dual density sole should be used.
- The insole material must be soft, flexible and should have good pressure distribution properties.

- Proper fastening (using Velcro or Elastic) is very important for adjustments.
- The design should be fashionable, socially and culturally acceptable by the patients. Design that may imply or encourage stigmatization must be avoided.
- The shoes should be made with environmentally friendly materials.
- The design size should be available in different widths to allow for proper accommodation of wider feet.
- The appropriate materials, for example soft leather or stretch material for the upper should be used for making the shoes.

6.9 The need for a multidisciplinary approach

It was stated in chapter 1 that the management of foot complications needs a multidisciplinary approach because diabetic foot problems are multifaceted. The role played by such teams in regards to foot care have proven to decrease amputation rates among diabetics and increase their satisfaction with footwear. Therefore, practitioners treating people with diabetes advocate that each team member must understand the principles and practice of comprehensive foot care, including the prescription of appropriate footwear (Mclnnes 2011; Tyrrell & Carter 2009; Noble-Bell & Forbes 2008). In this study, podiatrists involved in the treatment of diabetic foot complications also expressed the need for active involvement of all professional members in the early stage of the treatment in order to improve results. A point to note on this issue is the unfortunate situation that the multidisciplinary approach to addressing diabetic foot problems is yet to be understood and practiced. To make the point clear, a comment made by an orthopaedic doctor during the interview survey is given thus:

Diabetic foot ulcers/ sepsis is the common cause of non-traumatic cause of amputation of human limbs worldwide and has a great burden of diabetic mellitus. There is paucity of multidisciplinary approach to diabetics with orthopaedics being the least consulted until very late in the management. Thus there is need for early referral to orthopaedics and the need for orthopaedic surgeon to rise to the challenge to prevent this depressive event and not just to amputate a limb.

In summary, the multidisciplinary foot care team is seen as the most effective way to provide patient education and to manage foot problems (Ellis, et al. 2010; Nather et al. 2010).

6.10 The need for education and awareness

With increased awareness of the role of footwear in the prevention and management of foot problems along with expertise in the design of appropriate footwear, it is believed that the high rate of amputation reported amongst patients would be drastically reduced.

Whereas probably the most important area to research in the developed world would be usability of diabetic footwear; in the developing world, the problem is first and foremost the matter of awareness and education about foot complications and the role of footwear in the management of foot problems or for the maintenance of good foot health.

Foot care doctors/ podiatrists that participated in this research pointed out that foot health practitioners involved in the treatment of patients would need further and continued education of the role footwear plays in the management of foot problems and/or prescription of diabetic or heel pain relief comfortable footwear. They further state that information and education on footwear should be introduced in health care centres.

6.11 Cost consideration

The study of chapter 3 suggests that the current situation in regards to provision of appropriate footwear for foot patients is not that the best shoemaker cannot provide a very good solution for individuals with foot problems; but it is difficult to make quality or standard footwear for the vast majority of patients at a realistic cost. Even though the majority of diabetic patients would be willing to use orthopaedic footwear, a greater percentage of them would not be able to afford prescriptive footwear that could cost double the amount they use to buy footwear (refer to sub-section 3.7.7). And based on the cost implications of the open shoes made for this project (turn to chapter 5), the approximate cost for producing the footwear is found to be around (€ 60-80). Considering the outcome of the survey in chapter 3 in respect to the amount the patients would be willing to spend on a pair of prescriptive footwear, the majority would not be able to afford the product even at that rate. The result of the study (see fig. 3.17) shows that only 9% and 3% of male and female subjects respectively would be willing to spend up to (€ 40-60) on a pair of diabetic footwear.

This is seen as a very challenging situation. Therefore for proper diabetic foot care in Czech, I advocates for involvement of government and non-governmental organizations in the provision of prescriptive footwear to people suffering with foot problems by supplying appropriate footwear free of charge or at a subsidised rate.

6.12 Significance and Implication of the Project

Through this study, current and relevant data on a wide range of issues regarding foot problems and footwear have been obtained and documented. The outcome of the research will be helpful to designers, manufacturers of prescriptive footwear, the academics, etc. to design appropriate footwear for foot care patients and to educate the patient's population on the role of footwear in the management of their foot problems.

The findings have shown that an appreciable percentage of people living with heel pain have other foot problems. The number of those suffering with foot problems in this part of the world is particularly high when compared with the result of similar surveys conducted in the UK. This can be linked to a low level of awareness of how to manage their foot problems using correct footwear in addition to the medical care. It was also discovered that many foot patients are wearing inappropriate footwear that could cause or complicate their foot problems, as it has been shown that ill-fitting footwear can actually cause foot problems (Cavanagh 2008; Vernon 2007 & Edmond & Foster 2005).

This implies that urgent action must be taken to improve the lives of those affected with foot problems by providing them with shoes that fit and support the feet because it has been pointed out in the literature review (Levin & O'Neal 2008; Bus 2008; Jeffcoate et al. 2008) that appropriate footwear improves the standard of living for diabetic foot patients.

Dimensions of the left and right feet of some individuals can slightly differ in length and width. In this study, it has been demonstrated (see sub-section 4.5) that the foot morphology can differ significantly from one individual to another. It is therefore concluded that proper foot pressure measurements and footwear fitting is required for effective treatment of heel pain problems.

In addition, treatment should focus on prevention as well as treatment with suitable materials including footwear styles that is culturally appropriate and adapted to populations with poor incomes since the majority of the population in every region is classed as low-income earners.

One important approach to achieve and, recommended that designers and manufacturers should understand individual personal foot characteristics when designing and making footwear for people with foot problems or at risk of developing foot problems.

Based on the Shoe and Allied Trade Research Association (SATRA) Standards for water vapour permeability and related tests, the shoe upper materials analysed have revealed that leather has good breathability properties required for diabetic footwear manufacture. This shows that leather allows water vapour (or perspiration from the foot) to pass through. This is very important in determining the comfort of a shoe and indicates that the materials that should be used to make diabetic or other heel pain relief footwear must be carefully selected.

Finally, the study provided areas for further studies which if properly investigated could provide better footwear styles and materials in design solutions and/ or options for people living with heel pain or other foot problems.

6.13 Chapter Summary

In this chapter, the author gives a general discussion on the main findings and an overview of the significance and implications of the research. The discussion points to the fact that footwear can play many roles including foot protection, comfort and improving foot health. To make appropriate footwear available to the foot patients, there is an urgent need for a joint effort by professional groups (e.g. health care providers, designers, industrialists, etc.), government, non-governmental organizations and an active participation of people suffering with diabetes or other foot problems.
The conclusion and recommendations for further studies of this study are stated in the next chapter.

7 CHAPTER "Conclusion and recommendations"

7.1 Introduction

This thesis is divided into seven major chapters. A summary of each chapter has been given but this last chapter summed up the entire work. Conclusions based on the research objectives are outlined followed by the shortcomings of the project. Other important issues pointed out in this chapter are; the contribution the work has made to knowledge, collaborations entered into during the course of the research, reflections from the research and recommendations for further studies.

7.2 Meeting the research objectives

1. To search and review the relevant literature regarding the subject area.

Following a review of the literature associated with this subject area, it was discovered that inappropriate footwear can cause or complicate foot problems, especially among heel pain patients. Interestingly, the literature also revealed that appropriate footwear plays an important role in the management of the pain foot (Ulbrecht & Cavanagh 2010; Mara 2011; Edmonds & Foster 2005). The review of the literature shows that there are quite a number of footwear styles that have been developed in developed societies that are aimed at meeting the specific needs of the diabetic foot. However, there is a persistent problem of patient dissatisfaction and low usage of diabetic footwear in developed societies (Williams & Meacher, 2001), and the need for a multidisciplinary approach to solving the problem has been identified.

Data obtained from previous research reveals a different problem of the issue in developing societies. It was discovered from the literature that information on foot problems, and the use of appropriate footwear is very poor (Tagang 2010; Mbanya 2006). Secondly, there is the problem of education or awareness of the role of footwear in the management of foot problems. Thirdly, the provision of required services (including a multidisciplinary approach to solving the problem) and the product are lacking (Abbas and Archibald 2007).
Consequently, this study has discovered major gaps in the literature in respect to data on diabetes and foot problems, appropriate designs for heel pain foot, and technical requirements for footwear materials and appropriate last for designing and making of footwear for heel pain patients. Thus in summary, the present

work was an attempt to provide data that would meet at least some aspects of the identified gaps in the literature.

2. To source for relevant information from foot patients using a questionnaire survey.

To achieve this very important objective, a questionnaire was designed for the study and a total of 156 questionnaires were correctly filled in by foot patients, returned and analysed. For the validation of the questionnaire, a pilot study was first and foremost carried out to obtain professional feedback about the initial version of the survey materials, to collect preliminary information from the proposed research participants, to identify ways to improve the survey items and to identify ways to administer the actual survey to participants effectively.

In this study, it was discovered that up to 67% of the participants did not know the type of foot problems they were suffering with and up to 40% of the patients were suffering with foot problems like pains, ulcers, blisters, wounds, etc. In addition, up to 75% of the diabetic subjects that participated in this study reported that they had not received information about the type of footwear they should wear most often. Therefore, this thesis has made very clear the need for health care providers to become very proactive in designing awareness programmes that could provide patients with information about diabetes and the different types of the disease.

Another important finding of this study is the nature or type of footwear worn by foot patients in this part of the world. Our data reveal a very poor choice of footwear by people suffering with foot problems. It was discovered that majority of the patients were wearing slippers most often. In regards to footwear fitting, the outcome of this study shows that at least 29% of the subjects found it very difficult to put on or take off shoes and 31% agreed that their footwear needed modification in order to accommodate their feet well. Also, a greater percentage of them do not have access to practitioners trained in fitting footwear for diabetic foot.

3. To source for information from health professionals on the important factors to be considered for designing heel pain relief footwear.

In this study, a structured interview questionnaire was used to collect information on the research areas from doctors/ podiatrists and foot specialist with varying years of experience. The mean years of experience of the respondents was found to be 10.2. The interview provided insight into medical opinions about the issues. Again, a pilot survey was carried out which provided valuable information that was used to plan and conduct the main survey successfully.

The findings from the doctors/ podiatrists and foot specialist revealed that at least 32% of foot patients could be suffering with foot problems in this part of the world. According to the respondents, the majority (82%) of foot problems could be related or linked to wearing ill-fitting or inappropriate footwear that contributes significantly to the susceptibility of the diabetic foot to injury and infection. The survey further revealed that a large proportion (68%) of the doctors/ podiatrists and foot specialist indicated that regular shoes are unable to accommodate the feet of their patients due to one type of foot problem or another. Even though custom-made footwear (e.g. orthopaedic shoes) are seen as an appropriate footwear that could be prescribed to a wide variety of patients to diminish or prevent foot problems (Netten et al. 2010), unfortunately, in this study it was discovered that custom-made footwear are not being prescribed to sufferers of diabetes in the country, even those with foot problems.

The overall score of knowledge of in this part of the world on foot care and provision of special footwear like orthopaedic/ diabetic footwear was found to be very low. The doctors/ podiatrists and foot specialist experts also pointed out that many clinicians have overlooked the importance of footwear in the management of foot problems and they believe that this work will create more awareness among health care providers and patients on the subject matter. These findings did not differ significantly in comparison with previous studies (Frykberg 2006; Abbas & Archibald 2007) that revealed lack of knowledge of foot care among patients and health care providers and other less developed countries, leading to further foot complications.

In addition, it was discovered that the majority (up to 66%) of the patients may be wearing footwear that do not have any form of fastening. That is, most of them are using slip-on or slippers (with no fastening mechanism) most often. It is really regrettable to observe that footwear with important fastening features like lace, buckle, elastic or velcro are the type of footwear least-used by foot patients in the country. Therefore, it is argued that footwear available in the markets is not meeting foot health requirements of foot patients.

It is concluded that to change the dreadful situation of diabetic foot complications, identification of a foot problem by clinicians must be followed by appropriate treatments including prescription of appropriate footwear. Also, to help patients make informed choices of self-care, particularly in relation to footwear, health care providers should always give foot patients relevant information and assistance on how to recognize footwear broadly suitable to the maintenance or improvement of foot health and the type of footwear that should be avoided as being potentially detrimental. It is also very important that healthcare professionals support and stimulate research in establishing heel pain relief footwear programmes.

4. To study appropriate footwear materials for making heel pain relief footwear.

The experimental analysis of footwear materials gives a glimpse into the physical properties of the material widely used for footwear manufacture. Tests were undertaken on key parameters like water vapour permeability/absorption and water absorption, tensile strength, apparent density etc., to determine and assess comfort and strength properties of shoe upper leather samples. These tests have been shown as the most frequently used experiments to measure the comfort and strength properties of shoe upper leathers (Covington 2009; Wilson 2000; Bata 2013).
This study demonstrates that a careful selection of materials based on their comfort and performance properties have far-reaching benefits in terms of foot health. It has been stressed that leather is the most used natural material for footwear manufacture because it presents ideal characteristics for footwear (Bata 2013). This study has further proven that leather has properties of particular value in respect to foot health. Generally, the results obtained were found to be similar to the outcomes of previous studies and in conformity to set standards. In summary, the experiments indicate that a thorough knowledge of the physical properties of footwear materials would lead to identification of suitable materials that could improve foot comfort and safety to the wearer.

5. To develop appropriate footwear design(s) solutions for people living with heel pain.
To meet this objective, a number of studies were carried out including determination of last and foot dimensions, development of product design specification, making and assessment of trial prototypes and development of a research framework. 280 normal adult volunteers were involved in the study of foot dimensions. Of this number, 186 (66%) were male and 94 (34%) female. The basic foot dimensions (that is length, joint girth or width and in-step) used by clinicians to determine the type of footwear needed to meet the patient's requirements were measured, recorded and analysed.
In order to understand if the prototypes would fit the user well or not, the measured values were compared with the last dimension and the tolerable allowance (which was found to be 3.4mm and 3.5mm for male and female subjects respectively). The outcome indicates that no individual's feet are exactly the same, even as people wearing the same shoe size might not have the same foot dimensions (refer to chapter 4, sub-section 4.6). This is in agreement with what is obtained in the literature (Olivato, et al. 2007; Hawes, 1994; Goonetilleke 2003; Broussard 2002) which shows that most people's feet are two different sizes. These findings further concretised the argument of Pezza (2011) that it is rare to find a foot patient who is wearing the proper shoe size and width.

Therefore, the data presented in this thesis bring out the need for extra emphasis on accurate measurement of the foot in order to make shoes to an individual's correct shoe size and to eliminate guess work. These findings are found to be very significant as the relation between foot shape and shoe shape is seen as a cause of discomfort, foot problems, or even injury due to the fact that an individual's shoe size and foot size can differ appreciably. It was concluded that to provide the best fit of footwear for the foot problem population, correct measurement of their feet should be carried out before they buy shoes or footwear is made for them.
At this point in the work, a normal last was used to make trial prototypes. Note that a clear description of the materials and methods used to make and assess the prototypes were outlined in sub-sections 5.4.1 & 5.4.2. The dimensions of the last were critically looked into and the outcome of the trial prototypes for fitting and comfort factors point to the fact that some parts of the last would require amendments in order to properly accommodate minor foot deformities.

However, the majority of patients can use footwear made from the normal last. It was also discovered from the study that sandals/ open shoes are well accepted by potential users, especially in the Northern Region. In regards to shoe size, the survey showed that shoe size 42 or 8 is the most popular size for male subjects whereas size 40 is seen as the most widely used size among female subjects.
A visual and fitting or comfort assessment of the prototypes showed high acceptability by the intended users of the product. Similarly, feedback received from podiatrist and footwear designers/ technicians was very positive. The foot care specialists believe that the product would be beneficial to the foot patients if the prototypes are fully developed, produced and made available to patients.

Consequently, a research framework was developed (see fig. 5.17) as a representation of the output of the research findings. The framework gives three step-by-step procedures for provision of appropriate footwear to people suffering with heel pain. In conclusion, this study demonstrates that diabetic patients who are at risk of developing foot ulcers or wounds and who do not require custom shoes may benefit from this type of footwear.

6. To identify areas for further research.

This study has led to the discovery of many areas that would require further investigations as outlined in sub-section 7. 7.

7.3 Limitations of the research

Even though it could be argued that this research was carried out at different clinics, foot care workshops, foot care centres, foot car hospitals in Czech and around the Prague that admit patients from different regions of the country and employ the services of professionals trained at universities across the country and from overseas, still, generalizations of the findings of this study should be made with caution. In addition, even though all the respondents and interviewees were foot patients and qualified foot practitioners (foot doctors/ podiatrists) respectively (see sub-sections 3.4.1 & 3.6); there is a lack of perspective of other health professionals like orthotics, podiatrist, nurses etc. For a complete view of the role of diabetic footwear in the prevention of diabetic foot complications, their opinions should be included. Additionally, prospective studies that could evaluate the impact of footwear practices on outcomes such as foot ulcers and amputations would further help to determine the potential for interventions to improve practice and reduce complications.

Another weakness of this study is the sample size for both the interview and questionnaire surveys. To improve the reliability of the results, involvement of more subjects is recommended. Additionally, measurement of feet was done using simple but accurate tools and procedures. The use of more advanced technological devices and equipment may improve the reliability of foot pressure and foot measurement.

The experimental analysis of shoe upper materials was carried out only on the most widely-used material for the construction of footwear. Analysis of different materials use for shoe upper would give a clearer picture of their unique properties.

7.4 Contributions to knowledge

This research provides the latest insights on different areas related to foot problems, foot complications, foot care materials and design, diabetic footwear, etc. The key original contributions from this research are outlined thus:

1. The research investigated the scale or nature of foot problems experienced by people suffering with the condition from a developing country. Researchers (Tagang 2010; Abbas & Archibald 2007; Mbanya 2006;) have shown that data on diabetic foot problems from developing countries, are very poor. The outcomes of this project provide information not only on arch support protection but also on the nature of other foot problems.

2. The popularity of using slippers and other types of inappropriate footwear by diabetic patients in this part of the world was established through interview, questionnaire and market surveys. This research revealed that financial constraints among other factors are the main barriers to use of appropriate footwear in the region. Many use cheap footwear regardless whether they provide the required protection and comfort to their feet or not.

3. Product Design Specification (PDS) was developed and used to make the research trial prototypes. The specification has brought out a range of very important elements that could guide manufacturers, researchers and product developers/designers on key design factors.

4. A research framework (see fig.5.17) was developed that would help to identify foot patients with special needs of footwear and to provide them with suitable products. It was designed to be used along with the PDS mentioned above to give clear guidance on appropriate design features or elements for foot care to footwear manufacture. The materials selection component of the framework in particularly is considered a key element of the original contribution of this work that could be of great benefit to researchers, industrialists, etc. both in the developed and underdeveloped countries. It would provide manufacturers with a better understanding of suitable comfortable footwear materials selection and would also be useful for their costing and supply chain. The framework would also help potential users to anticipate the nature and features of the end product to be supplied to them.

5. Last but not least, this research has provides areas for further study. It is believed that additional information of this research findings will serve as a catalyst for further research in the subject area.

7.5 Collaboration

During the course of this project, some health providers showed interest for collaboration on how the proposed design framework could be implemented for the benefit of heel pain and diabetic foot patients in the country.
Whereas Czech Podiatry Association, Ceska podologicka spolecnost, z.s Praha, ING Corporation, Frydek-Mistek and Czech Footwear and Leather Association, Zlin is a higher institutions with a mandate of trainings, seminars and workshops on foot care, footwear, leather and leather products (as foot care being a key department in the associations)
While Czech Podiatry Association and Ceska podologicka spolecnost would provide the medical and non-medical expertise, Czech Footwear and Leather Association and ING Corporation, Frydek-Mistek would meet all the footwear design and technical requirements of the projects. It is believed that through this collaborations, a fully functioning multidisciplinary team (with a wide range of expertise) could have dramatic impact on the foot-care and well-being of foot patients in Czech.

7.6 Reflections from the research

The figure below (fig. 7.1) gives a activity representation of the PhD journey. The major activities carried out each year (from 2013 to 2016) in the course of the project are pointed out. The Gantt chart (refer to appendix) developed at the beginning of the study was a very useful tool that helped me to manage the project and stay on schedule. It should be made clear that training courses (managing research and references, planning and managing research, literature searching and reference management, writing skills, taking a critical approach to your research, publishing research findings, etc) attended by me at the Tomas Bata Univeristy in, Zlin provided me with the excellent knowledge of research methodology and related relevant tools for carrying out effective research. Consequently, I presented research findings to professional meetings in Czech and Germany. Furthermore the doctorate degree experience afforded me the opportunity to develop a strong intellectual grasp of writing research proposals, formulation of standard operating procedures for interviewing professionals and conducting questionnaire surveys.
Other key activities undertaken in the course of the research included visiting clinics/ hospitals, companies, laboratories for materials analysis, etc. Also, the recent training program at adidas group on Creating and Managing Large Projects, Effective Presentation Using Power Point, Managing Data with Excel etc., have further equipped me on handling large projects and analysing data.

List of workshops, Seminars attended and Conferences visits

2016 Securing Information and Protecting Privacy at adidas Group Germany
2015 Code of Conduct, Best Practices at adidas Group Germany
2015 Study abroad program by University of Tomas Bata, Zlin at adidas group headquarter, Germany
2015 Go-Tec Foot care workshop by ING Corporation at High-Tech Centrum, Frydek-Mistek Czech Republic
2015 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic
2015 11th Annual Dokbat Seminar at University of Tomas Bata, Zlin, Czech Republic
2014 Footwear Health Tech & Future Footwear Materials Conference, Eindhoven, The Netherlands
2014 Czech Podiatry Association congress 2 Days, Léčebné lázně Bohdaneč, Masarykovo CZ
2014 Superfeet Insloe Workshop for Footcare Patients, Zlin CZ with Ing. Milan Borsky.
2014 Orthopedic Foot Care experience Workshop- Plzen, CZ with Milan Sagl (Jednatel)
2014 Tekscan Workshop-Pressure Mapping for Patient Care, Zlin CZ with Ing. Milan Borsky.
2014 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic.
2013 Examination of feet in pedicure experience-Ostrava, CZ with (MUDr.Marie Součková)

Exhibition & Fairs Visited

2014 Footwear Exhibition" STYLE KABO Trade shoe fair Brno CZE
2014 International Expo Riva Schuh fair for footwear sector Riva del Garda, Italy.
2014 International trade fair AUTOMATICA Munich, Germany
2014 Budapest International Leather and Shoe Fair, Hungary
2013"Bata Shoe Museum, Zlin CZE"

Figure 7.1 Activity during research

7.7 Recommendations for future work

This study has identified certain areas that would require further investigation. The key aspects identified are outlined below.

1. It was pointed out in the introduction (sub-section 1.5) that a comprehensive technical understanding of comfort footwear materials is still lacking. In this study an analysis of footwear materials was carried out as an attempt to investigate physical properties of shoe upper leathers/ stretch materials for their suitability for comfort footwear or otherwise. However, I suggests that further investigations on different upper materials and composite specimens of both upper and lining should be conducted. Furthermore, it is strongly recommended that further tests should be done on soling materials and adjustable height arch supported insole to establish the best material combination options that would improve foot health.

2. I recommend that a study on how foot patients would be effectively educated about the role of footwear in the management of foot problems should focus more on prevention. However, emphasis should also be made on how footwear could be used as an effective treatment strategy by using styles and materials that are culturally/ environmentally acceptable and appropriate footwear designs.

3. A research on how clinicians would be able to work closely with footwear manufacturers/ retailers to develop a guideline for buying good footwear to assist consumers in selection of healthy footwear.

4. I discovered a professional gap in persons qualified to provide correct footwear fitting. Therefore with the opinion that we should study ways that government and non-governmental organizations could encourage persons with interest and required basic knowledge to be trained effectively to meet this important need.

5. More research on how to make footwear more comfortable, functional and yet aesthetic for customers with health challenges in their feet should be carried out urgently.

6. The sample size for some aspects of this study was found to be small. It is therefore recommended that a similar study with a larger sample size should be carried out. In particular, further data should be gathered through interview surveys involving major health professionals involved in the management of diabetes and heel pain foot.

7. A study on how to encourage a multidisciplinary approach to addressing foot problems is advocated.

8. For future work, I recommend the use of more advanced technological equipment like laser scanning devices that can records hundreds of measurements of specific important positions of the foot.
These areas identified for further studies are considered very important as the findings of the study itself. It is therefore strongly suggested that these aspects should be explored in order to improve the experiences of foot patients in regards to footwear.

8 Bibliography

- *3D Foot Scan to Custom Shoe Last. IJCCT, Special Issue of. Hong Kong, China: International Conference, [ACCTA-2010], 3-5, August, 2010. Vol.1 Issue 2, 3, 4.*

- *Abbott, John., 1964. "Footwear Evidence", Charles C. Thomas Publishing Company, (Springfield), pp. 19-23*

- *Abboud, R.J.,Copyright., 2002. "Current Orthopaedics", Elsevier Science Ltd.,Vol. 16, pp. 165-179, available online at http://www.idealibrary.com*

- *Adrian, K.C., 1991. "American Last Making: Procedures, scale comparisons, sizing and grading information, basic shell layout, bottom equipment standards", (Arlington, MA: Shoe Trades Publishing)*

- *ANSVASTM F539.78., 1986. Standard for fitting athletic footwear, 229.235.*

- *A Fit Metric for Footwear Customization. Ameersing Luximon, Ravindra S. Goonetilleke and Kwok-L Tsui. China: Research Grants Council of the Hong Kong Special Administrative Region, Vol. Project No. HKUST 6074/99E.*

- *Adams, G. R. and SCHVANEVELDT, J. D., 1985. Understanding Research Methods. New York. Longman. p. 50.*

- *Ahonen, J. P. T., 2008. Biomechanics of the foot in dance: A literature review. Journal of Dance Medicine & Science, 12 (3) pp.99-107.*

- *Adidas Group., 2009. Sustainability Review. [WWW] Available from: http://ser2009.adidas-group.com/environment. (Accessed February, 2014).*

- *Ariavie, G. SADJERE, E. EFOSA, O, 2012. Rapid Prototyping: Implication for Developing Economies. International Journal of Academic Research, 4 (2), pp. 186-189.*

- *Australasian Podiatry Council Conference., 2011. Melbourne, Australia : BioMed Central Ltd (Journal of Foot and Ankle Research), 20 May., 2011. Vols. 26-29.*

- *Bata, 2013. We Shoe the World. [WWW] Available from: http://www.bata.com/world-of-shoes/. (Accessed on 9/12/2013).*

- *Barry, T.Bates, 1999. "A Human Performance Model", B.S.E., Ph.D., FACFE, Proceedings of the 64th Convention of the Oregon State Bar*

- *Bergin, S. M. et al, 2013. Australian Diabetes Foot Network: Practical guideline on the provision of footwear for people with diabetes. Journal of foot and ankle research, 6 (6).*

- *Bernabeu, J. A. et al, 2013. CAD Tools for Designing Shoe Lasts for People with Diabetes. Computer-Aided Design, 45 (6), pp. 977-990.*

- *Boer, H. and Seydel, E. R, 1998. Medical Opinions, Beliefs and Prescription of Orthopaedic Footwear: a Survey of Dutch Orthopaedists and Rehabilitation Practitioners. Clinical Rehabilitation. Issue 12, pp. 245-253.*
- *Bonnie, Y. S. T, et al., 2004. Effectiveness of insoles on plantar pressure redistribution. Journal of Rehabilitation Research & Development, 41 (6A), pp. 767-774.*
- *Bodziak, William J., 1990."Footwear Impression Evidence", edited by Elsevier Series, (New York), pp. 4-5.*
- *Bojsen-Moeller., 1978. "F. Biomechanic"s Vl-A, Baltimore, IL: 261-266,*
- *Brace. I, 2008. Questionnaire Design: How to Plan , Structure, and Write Survey Material for Effective Market research. 2nd Edition. London & Philadelphia. Replika Press Pvt Ltd.*
- *Byrne, M., Curran, M.J., 1998. "The development and use of a footwear assessment score in comparing the fit of children's shoes", The Foot, Vol. 8, pp. 215-218.*
- *Casellia, M. A., 2011. Prescription shoes for the foot pathology: using footwear properly adds to your treatment armamentarium. Podiatry management. PP. 165-174. [WWW] Available from: www.podiatrym.com (Accessed January, 2014).*
- *Cassidy, Michael J., 1980. "Footwear Identification", edited by Canadian Government Printing Centre (Canada) , pp. 109-122.*
- *Cavanagh, P.R., 1980. "The Running Shoe Book", edited by Emmaus: Rodale Press, (Anderson World, CA: Mountain View)*
- *Chang, C. and LUH, D., 2012. User as Designers: A design model of user creativity platforms. Journal of Integrated Design and Process Science, 16 (4), pp. 19-30. [WWW] Available from: http://www.sdpsnet.org. (Accessed on 4/11/2013).*
- *Chang, W. and Seireg, A., 1997. "Frictional Properties of the Skin and Blister Formation", Third Symposium on Footwear Biomechanics, Tokyo, Japan*
- *Chen, R. C. C., 1993. An investigation into shoe last design in relation to foot measurement and shoe fitting for orthopaedic footwear. A thesis submitted for the degree of Doctor of Philosophy in the Department of Medical Engineering and Physics, King's College, School of medicine and dentistry, University of London.*
- *Chen, H.; Nigg, B.M.; Koning, J.D.E., 1994. "Clin. Biomec.., 9,6. 335-341.*
- *Clarks, 1976. "Manual of Shoemaking", edited by Clarks Training Department (UK) (Ceeny E The form of the foot in relation to footwear The Chiropodist 304-311*
- *Choi, B.K. 1991. "Surface Modeling for CAD/CAM: Advances in Industrial Engineering", edited by Elsevier (Amsterdam)*
- *Cheskin, M.P., 1987. "The Complete Handbook of Athletic Footwear", (New York: Fairchild Publications)*

- *Corlett, E.N., 1989. "Ergonomics", Applied Ergonomics, Vol. 32, No: 3, pp.257-269*

- *Colin, Mc Dowell,Preface by Monolo Blahnik., 1998. Shoes Fashion And Fantasy, Lacing for just pp 72,73 Country Dances pp 156,157*

- *Choosing shoes: a preliminary study into the challenges facing clinicians in assessing footwear for rheumatoid arthritis patients. Renee N Silvester, Anita E Williams, Nicola Dalbeth & Keith Rome.*

- *CUSTOMIZED FOOTWEAR INSERTS FOR HIGH ARCHED FOOT-ONE CASE STUDY. Aura Mihai, Marta Catalina Harnagea and Mariana Pastina. Iasi, Romania : XIIth International zmir Textile and Apparel Symposium, Oct 28 – 30., 2010. Vol. XIIth. 490-493*

- *Davia, M. JIMENO-MORENILLA, A. & SALAS, F., 2013. Footwear Bio-Modelling: An industry Approach. Computer Aided Design, Vol. 45. pp. 1575-1590.*

- *Denvir, C., 1979. "The sports shoe" in Baynes K & Baynes K (eds) The shoe show: British shoes since 1790 Crafts Council*

- *DE CASTRO, A. P. REBELATTO, J. R. and RABIATTI, T., 2010. The relationship between wearing incorrectly size shoes and foot dimensions, foot pain, and diabetes. Journal of Sport Rehabilitation, 19 (2). pp. 214-225.*

- *Dimaggio, John Dr., 1994. "The Foot and Shoe: an Important but Overlooked Identification Combination, International Association for Identification Annual Conference, Phoenix,*

- *Downey, C.A., 1989. "Observational Gait Analysis Handbook", edited by Professional Staff Association of Rancho Los Amigos Medical Center, pp. 252-256*

- *Designing footwear: back to basics in an effort to design for people. GOONETILLEKE, Ravindra S. Human Performance Laboratory, Clear Water Bay, Hong Kong : SEAMEC, 2003, Vols. Department of Industrial Engineering and Engineering Management, University of Science and Technology. 25-30.*

- *Editorial (SPECIAL ISSUE) Unstable shoes. Nigg, Peter Federolf & Benno. Footwear Science, Oslo, Norway: Taylor & Francis., 17 May June 2012. Footwear Science, Vols. Vol. 4, No. 2,, pp. 71–72.*

- *Edward, J.C. D and DAVIS, J., 2011. Anatomy and biomechanics of the foot and ankle. Mini Symposium: Foot and ankle-Elsevier. Orthopaedic and Trauma, 25 (4). pp. 279-286.*

- *Franke, E. H., 1951. "Mechanical impedance of the surface of the human body", Journal of Applied Physiology, vol. 3, pp.582-590.*

- *Fredrick, E.C., "The Running Shoe: Dilemmas and Dichotomies in design", edited by Human Kinetics Publishers Inc. (Champaign)*

- *Fredrick, E.C., 1984. "Sport Shoes and Playing Surfaces", edited by Human Kinetics Publishers Inc, (Champaign)*

- *Frey C., Thompson F., Smith J., Sanders M., Horstman H., 1993, "American orthopedic foot and ankle society women's shoe survey." Foot & Ankle; vol.14, pp.78-81.*

- *Frey C., 2000, "Foot health and shoewear for women." Clin Orthop; vol. 372, pp.32-44. Freychat P. and Bouche N. 1999, "Dynamic Arch Deformation and its Consequence on Shoe Design", Footwear Symposium, Canmore / Canada, (August 5-7, 1999), Advanced Research Department, Decathlon Production, France, Vol. 25, p.650*

- *Forner, A. García, A.C. Alcántara, E. Ramiro, J. Hoyos, J.V. Vera, P., 1995. "Foot Ankle Int.", Vol.16, No:12, pp:778-786*

- *Forlee, M., 2010. What is the diabetic foot? CME 28 (4), pp. 152-156*

- *Foto, J. G., 2008. Compact and Portable Digitally Controlled Device for Testing Footwear Materials: Technical Note. Journal of Rehabilitation Research & Development, 45 (6), pp. 893-900.*

- *Footwear Science (Ecological gait dynamics: stability, variability and optimal design). C.J. Palmer, R.E.A. Van Emmerik & J. Hamill. No. 2, Department of Kinesiology, University of Massachusetts, Amherst, MA, USA : Taylor & Francis, June 2012, Vol. Vol. 4. 167–182.*

- *Foot pain: common, of consequence, and consulted about. Roddy, Edward. Australasian Podiatry Council Conference 2011, Melbourne, Australia : BioMed Central Ltd (Journal of Foot and Ankle Research)., 20 May, 2011. Vols. 26-29*

- *Gage, J.R., 1990. "An overview of normal walking". Instructional Course Lectures, vol. 39, pp. 291-303.*

- *Gardener, R., 1856. "The illustrated handbook of the foot", London*

- *Goonetilleke, R. S., 2003. Designing footwear: back to the basics in an effort to design for the people. In: Khalid, H. M, Lim, T. Y, and Lee, N. K (Editors), Proceedings of SEAMEC., 2003. Kuching. pp. 25-31.*

- *Goonetilleke, R.S., 2003. Ergonomics, vol.46, p.364*

- *Goonetilleke, R.S., 1998. "Designing to Minimize Discomfort. Ergonomics in Design", vol.6, No.3, pp.12-19*

- *Goonetilleke, R.S. and Luximon, A., 1999. "Foot are and foot axis", Human Factors, Vol. 41, pp.596-607.*

- *Goonetilleke, R.S. and Eng, T. J., 1994. "Contact area effects on discomfort", In Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting Santa Monica, CA: Human Factors Society, pp. 688-690*

- *Goonetilleke, R.S., 1999. "Footwear Cushioning: Relating Objective and Subjective Measurements", Human Factors, vol. 41, no.2, pp.241-256*

- *Goonetilleke, R.S. et. al., 2004. "Dimensional differences for evaluating the quality of footwear fit", Ergonomics, vol.47, no.12, pp.1301-1317*

- *Goonetilleke, R.S., Kwok L.T., Luximon A., 2003. "Foot landmarking for footwear customization", Ergonomics, vol.46, no.4, pp.364-383*

- *Goonetilleke, R. S., Luximon, A., and Tsui, K.-L., 2000. "The Quality of Footwear Fit: What we know, don't know and should know", Proceedings of the Human Factors and Ergonomics Society Conference, 2000, San Diego, (July 29- August 4, 2000). Volume 2, pp. 515-518.*

- *Greg T. Graglia., 2001. "Shoegear: The right shoe for the right activity", DPM, Madison VA Hospital, (Madison, Wisconsin), vol. 1, no.5*

- *Harvard Health Letter., 2011. Feet and Falling: Taking care of your feet could improve your chances of staying on them, 37 (1).*

- *Hamm, Ernest D., 1995. "Characteristics in Footwear Examinations", European Meeting for Shoeprint and Tool Mark Examiners, (Vantaa, Finland)*

- *Hanna A., 1985. "Design in strode: Explorations in shoe design Industrial Design", Jan/Feb pp.40-45.*

- *Herva, M. ALVAREZ, A. and ROCA, E., 2011. Sustainable and Safe Design of Footwear Integrating Ecological Footprint and Risk Criteria. Journal of Hazardous Materials. Vol. 192, pp. 1876-1881.*

- *Hennig, A. Stacoff E., 2001. "Comparision of Foot-orthosis dimensions with an anthropometrical database of Children Healthy feet", Proc. of the 5th Symp. on Footwear Biomechanics, (Zuerich / Switzerland), vol.38*

- *Hennig E.M., 2002. "The human foot during locomotion - Applied research for footwear", Wei Lun Public Lecture (10 October), Hong Kong: The Chinese University of Hong Kong;. pp.350-357*

- *Henning, E. & Milani, T.L., 1995. "In-shoe Pressure Distribution for Running in Various Types of Footwear", Journal of Applied Biomechanics, Vol. 11, p. 299-310.*

- *Hilderbrand, Dwane., 1999. "Footwear-The Missed Evidence", Staggs Publishing, Temecula, CA., pp. 7-8*

- *Hilderbrand, Dwane., 2002. Four Basic Components of a Footwear Examination, The Magnolia Print*

- *Ho, C.F., 1998. "3-Dimensional foot digitization", Unpublished master's thesis, Hong Kong University of Science and Technology.*

- *Holscher E.C. and Hu K.K., 1976. Detrimental Results with the common Inflared Shoe. Oithonedic Clinics of North America, vol.7, pp.1011-1018.*

- *Horovitz, Z., 1991. "Sole construction for footwear", Andover MA, Composites, USA, (12 September 1989-2 March 1991), Volume 22, Issue, p.165*

- *Hughes J.R., 1995. "Footwear assessment", Merrimen LM, & Tollafield, (Ediburgh:Churchill Livingstone), pp.227-247*

- *Huard, R. (n. d) Footwear Fundamentals: Understanding the Basics Leads to Safety and Comfort. Cicle 240. p. 59.*

- *Janisse, D. J., 1992. The art and science of fitting shoes. Journal of Foot and Ankle, 13 (5), pp. 257-262.*

- *Janisse, D. J., 1995. Prescription Insoles and Footwear. Clinics in podiatric Medicine,12 (1), pp.41-61*

- *Janisse DJ., 1992. "The art and science of fitting shoes." Foot & Ankle; vol.13, pp.257-262.*

- *Johansson, L., Kjellberg, A., Kilbom, A., and Hagg, G. A., 1999, Perception of Surface Pressure applied to the hand. Ergonomics, vol.42, no.10, pp.1274-1282.*

- *John, Peacock., 2000. Men's Footwear 1900-1913, Fashion Accessories 20th century sourcebook, pp 8, 102, 173, 174*

- *John, Peacock., 2000. Women's Footwear 1900-1906, Fashion Accessories 20th century sourcebook, pp 29*

- *Kanagy, J. R., 1977. Physical and performance properties of leather. In: O'Flaherty, F; Roddy W. T. & Lollar, R. M. The Chemistry and Technology of Leather, Vol. IV. Florida. Krieger Publishing Company Malabar.*

- *Karwowski, W., 2000. "The science of an artifact-human compatibility", Theoretical Issues in Ergonomics Science, vol.1, no.1, pp. 76-91.*

- *Karwowski, P. Mondelo and M. Mattila All rights reserved., 2001. "Designing for Comfort: A Footwear Application", Computer-Aided Ergonomics and Safety Conference '200, Edited by B. Das, W.*

- *Kennedy, S., 2010. Choosing the right shoe. In motion Journal, 20 (2).*

- *Kevin, Weaks., 2011. May, 19-25 Labor Tribune/ Your Health pp8*

- *Kimura, M. MOCHIMARU, M. KENADE, T., 2009. 3D Measurement of Feature Cross-Sections of Foot while Walking. Machine Vision and Applications, 22, pp. 377-388.*

- *Kolarik, W. J., 1995. Creating Quality. New York: McGraw-Hill.*

- *Kroemer, H., and Elbert, K., 1994. Ergonomics. How to design for ease and efficiency. New York: Prentice Hall.*

- *Levin, M. E. and O'NEAL L. W., 2008. Foreward. In: Bowker, J. H. & Pfeifer, M. A. (2008) Levin and O'Neal's, The diabetic foot. 7th Ed. China. Mosby Elsevier.*

- *Lemmon, D. et al., 1997. "The effect of insoles in therapeutic footwear – A finite element approach", Journal of Biomechanics, Vol. 30, No.6, pp. 615-620.*

- *Ling, M. Z. et al., 2008. Anatomy of the foot. In: Aziz Nather. Diabetic foot problems. Singapore. World Scientific Co. Pte. Ltd.*

- *Liu, W., Miller, J., Stefanyshyn, D. and Nigg, B.M., 1999, "Accuracy and reliability of a technique for quantifying foot shape, dimensions and structural characteristics", Ergonomics, vol.42, pp.346- 358.*

- *Luximon A., Goonetilleke R.S., K.L., 2003. "Foot landmarking for footwear customization", Ergonomics, 2003, Vol. 46, No. 4, pp.364-383*

- *Lucy, Pratt Linda Woolley., 1999. Victoria and Albert Museum & Fashion Accessories, pp 12,63,73, 83, 86, 102, 103*

- *Mara, T., 2011. Nurse Practitioners and Diabetic Shoes-"Beauracracy at work" WNA STAT Bulletin, March 2011.*

- *Manning J.R., 1966. "Size standardization", Europoint The Chiropodist, vol. 21, no.6, pp.187-200.*

- *Manning J.R., 1976. "Mondopoint: A metric system of shoe sizing and marking", Australian Podiatrist, pp.102-103.*

- *Martin D.R., 1997. "Athletic Shoes: Finding a Good Match", The Physician and Sports Medicine, vol.12, no. 9,*

- *McKenzie J., 1997. "The best in sportswear design", (London:BT Batsford), pp20-23. Naganoa A,*

- *Modgil, V, SHARMA, S, and SINGH, J., 2012. 'Performance modeling and availability analysis of sole lasting unit in shoe making industry', Nature & Science, 10 (2), pp. 45-49.*

- *Mundermann, A., 2004. Long-term effects of footwear on gait may be most critical. In: AGM, A and August S., 2004. Feet First. Australian Medical Grade Footwear Association Inc. 2 (2), pp.1-8.*

- *Komurac T., 2003. "Longer moment arm results in smaller joint moment development, power and work outputs in fast motions", Journal of Biomechanics, vol.36, pp.1675–1681*

- *National Diabetes Education Programme., 2000. Feet Can Last a Life Time. A health care provider's Guide to preventing diabetes foot problems. p. 14.*

- *Netten, J. J. V. et al., 2010. Patients' expectations and actual use of custom-made orthopaedic shoes. Journal of Clinical Rehabilitation. Vol. 24. pp. 919-927.*

- *Nigg, Benno M., 1986. "Biomechanics of Running Shoes", edited by Human Kinetics Publishers, (Champaign)*

- *Nigg BM, Bahlsen HA., 1988. "Influence of heel flare and midsole construction on pronation, supination and impact forces in heel-toe running", Int J Sports Biomechanics, vol.4, pp.205-219*

- *Nigg BM, Cole GK, Nachbauer W. Effects of arch height of the foot on angular motion of the lower extremities in running. J Biomech., 1999. 26: 909-916*

- *Nelson, Douglas. If The Shoe Fits, Think Twice. S.l. : Precision Neuromuscular Therapy Seminars., 2003.*

- *Ogrin, R., 2007. Review of podiatry relevant aspects of peripheral arterial disease in people with diabetes: part two- management. Australasian Journal of Podiatric Medicine, 41 (1), pp. 7 - 12.*

- *Olivato, P. et al., 2007. Foot Digitalization for Last Design and Individual Awareness of Personal Foot Charateristics. Department of Psychology, University of Turin, Italy. LNCS 4561, pp. 949-958.*

- *Owings. T. M. et al., 2009. Complications of plantar pressures in diabetic patients with foot ulcers which have remained healed. Journal compilation © 2009 Diabetes UK Diabetic Medicine, Vol. 26. pp. 1141-1146.*

- *Parham KR, CC Gordon & CF Bensel., 1987. "Gender and race differences in foot dimension", American Journal of Physical Anthropology, vol.72, p.240*

- *Parker, K., 1996. "Settling Footwear Complaints", SATRA Technology Centre (Northants)*

- *Pezza, C., 2011. The diabetic foot: The importance of footwear in your practice. Podiatry Management. [WWW] Available from: www.podiatrym.com.*

- *Paola, Buratto Caovilla., 1998. Shoes Object of Art and Seduction, pp 12,15*

- *Praet, S. F. E. LOUWERENS, J.W. K., 2003. The Influence of Shoe Design on Plantar Pressures in Neuropathic Feet. Diabetes Care, Vol.26, No. 2. pp. 441-445.*

- *Prevalence and correlates of foot pain in a population-based study: the North West Adelaide health study. Catherine L Hill, Tiffany K Gill, Hylton B Menz and Anne W Taylor. doi:10.1186, Adelaide, South Australia : BioMed Central Ltd (Journal of Foot and Ankle Research), 28 July., 2008. Vol. 1:2. 1757-1146-1-2.*

- *Rawling, J.S. et al., 1981. "A manual of orthopedic shoe technology", Precision Printing Co.*

- *Rodrigues, N. L., 1997. Correlation between the use of Leather Footwear Soles and Human Health. World Leather, August. pp. 39-41.*

- *Roebuck, J.A., 1993. “Anthropometric methods: designing to fit the human body”, Human Factors and Ergonomics Society, pp. 62-79*

- *Rossi, W.A. and Tennant, R., 2000. “Professional Shoe Fitting”, Pedorthic Footwear, (New York), pp.103-118*

- *Rossi W.A., 2000. “The complete footwear dictionary” edited by Kreiger Publishing Co., (Malabar)*

- *Rossi W.A., 2002. “Children’s Footwear: Launching Site for Adult Foot Ills”, edited by Kreiger Publishing Co., Podiatry Management, (Malabar), pp.83-100*

- *Rossi, William A, 1999. “Why Shoes Make “Normal” Gait Impossible ”, edited by Kreiger Publishing Co., Podiatry Management, pp. 50-61*

- *Rossi W.A., 2001. “Footwear: The Primary Cause of Foot Disorders” edited by Kreiger Publishing Co., (Malabar), pp.129-138*

- *Rossi W.A., 2001. “Fashion and Foot Deformation”, edited by Kreiger Publishing Co., Podiatry Management, (Malabar)*

- *Rossi, W. A., 1988. “The futile search for the perfect shoe fit”, Journal of Testing and Evaluation, X, pp.393-403.*

- *Sarnow, M. R. et al., 1994. In-Shoe Foot Pressure Measurements in Diabetic Patients with At-Risk Feet and in Healthy Subjects. Diabetes Care, 17 (9), pp.1002-1006.*
-
- *Sanders, M.S. and McCormick, E.J., 1987. “Human Factors in Engineering Design”, New York: McGraw Hill.*

- *Segresser, B., 2001. “Injuries and Sport Shoe Design: Wish and Reality”, Footwear Symposium, Zurich, Switzerland, (5-7 July 2001)*

- *Shuping, X. et al., 2010. 'A computer-aided design system for foot-feature-based shoe last customization', International Journal Of Advanced Manufacturing Technology, 46, pp. 11-19,*

- *Shackel, B.; Chidsey, K.D., Shipley, P., 1969. “Ergonomics”, vol.12, no.2, pp.269-306.. Stephen R. Lord, 1999, “Heel-Collar Height and Footwear and Postural Stability in Older People”, HYLTON B. MENZ, BPod (Hons), Volume 89 • Number :7 (July), pp.346-357*

- *The foot-health of people with diabetes in a regional Australian population: a prospective clinical audit. Byron M Perrin, Marcus J Gardner and Susan R Kennett. 1757-1146, Australia : BioMed Central Ltd (Journal of Foot and Ankle Research)., 2012. Vol.10.1186. 5-6.*

- *Times, New York. Health Guide. The New York Times. [Online] A.D.A.M., Inc., 10 January., 2014. http://health.nytimes.com/health/guides/symptoms/foot-pain/background.html.*

- *The foot-health of people with diabetes in a regional Australian population: a prospective clinical audit. Byron M Perrin, Marcus J Gardner and Susan R Kennett. 5:6, Bendigo 3552, Australia : JOURNAL OF FOOT AND ANKLE RESEARCH., 2012. Vols. 10.1186/1757-1146-5-6.*

- *The influence of two unstable shoe modifications on lower extremity kinetics during walking and postural balance in elderly men. Ann-Kathrin Hömme, Ewald M. Hennig , Christoph Müller & Christian Ninck. No. 2, Biomechanics Laboratory, University of Duisburg-Essen, Essen, Germany: Taylor & Francis (Footwear Science)., June 2012. Vol. Vol. 4. 83–91.*

- *Ulbrecht, J. S. and CAVANAGH, P., 2008. What the practicing clinician should know about foot biomechanics. In: BOULTON, A. J. M. CAVANAGH, P.R. AND RAYMAN, G. The foot and diabetes. 4th ed. Great Britain. John Wiley and Sons Ltd.*

- *Urbancic- Rovan, V. et al., 2010. Shoes from serial production in different width sizes- An urgent need or caprice? Conference paper presented at the 13th Malvern Diabetic Foot Conference. 12-14 May.*

- *Vass, L. and MOLNAR, M., 2006. Handmade Shoes for men. Printed in China. ISBN-10:3-8331-2240-4*

- *Vernon, W. et al., 2007. Expert Group Criteria for the recognition of healthy footwear. British Journal of Podiatry, 10 (4), pp. 127-133.*

- *Volken, M., 2013. Primary Patterns. World Footwear, March-April. pp. 22-24.*

- *Yavatkar, A. S., 1993. "Computer aided system approach to determine the shoe-last size and shape based on statistical approximated model of a human foot", Unpublished master's thesis, Tufts University, Medford, MA. 2-515*

- *Waaijman, R. et al., 2013. Adherence to Wearing Prescription Custom-Made Footwear in Patients with Diabetes at High Risk for Plantar Foot Ulceration. Diabetes Care Journals, 36, pp. 1613-1618.*

- *Waaijman, R., 2012. Pressure-Reduction and Preservation in Custom-made Footwear of Patients with Diabetes and a History of Plantar Ulceration. Journal of Diabetic Medicine, 29, pp. 1542-1549.*

- *Woodson, W.E., 1954. "Human engineering guide for equipment designers", University of California Press, (Berkeley)*

- *Williams, A., 2008. An Interpretive Phenomenological Study of User Experiences of Therapeutic Footwear. A PhD Thesis submitted to Salford University.*

- *Williams, A. E and NESTER, C. J., 2006. Patient perceptions of stock footwear design features. Prosthetics and Orthotics International, 30 (1). pp. 61-71*

- *World Footwear., 2013. What's New in Soling. World Footwear, January/ February. pp. 22-23.*

- *World Footwear., 2003. Diabetic Footwear has become a growth market. November/ December, pp. 29-30.*

- *Whittle, Michael. W., 1999. "Generation and attenuation of transient impulsive forces beneath the foot", a review Gait and Posture, vol.10, pp. 264–275*

- *WHITE, J., 2010 The Medicare Therapeutic Shoe Programme: New Challenges, New Opportunities. Podiatry Management. Available at: www.podiatrym.com . (Accessed on 5/3/2014)*

- *Wikler, DSC Simon J. Take Off Your Shoes and Walk. Take Off Your Shoes and Walk: Steps to Better Foot Health. United States: Devin-Adair., 1961. pp. 1-29.*

- *Why Shoes Make "Normal" Gait Impossible. William A. Rossi, D.P.M. MARCH., 1999. PODIATRY MANAGEMENT, pp. 50-61.*

- *Wikler, DSC Simon J. Take Off Your Shoes and Walk. Take Off Your Shoes and Walk: Steps to Better Foot Health. United States : Devin-Adair., 1961. pp. 1-29*

- *Why Shoes Make "Normal" Gait Impossible. William, A. Rossi, D.P.M. MARCH., 1999. Podiatry Management, pp. 50-61.*

- *Xiaosheng, D. et al., 2012. Preparation and application of denatured starches. Society of Leather Technologists and Chemists Journal. Vol. 96. pp. 189-194.*

- *Xia, B. and Robinson, J., 1997. "3D Kinematic Evaluation of Footwear Stability In Lateral Movements", Third Symposium on Footwear Biomechanics, Tokyo, Japan, Vass L. & Molnar M., 1999, "Handmade shoes for men" Cologne: Konemann. Voloshin, A.; Loy, D.J., 1994. "Gait and Posture", Vol.2, pp. 117-122.*

- *YI, C. et al., 2010. Oxygen plasma treated polyurethane leather coating with enhance water vapour permeability. Society of Leather Technologists and Chemists Journal. Vol. 94, pp. 205-211.*

8.1 Web Source

WEB_1, 1999, "Anatomy of a Running Shoe", Emmaus: Rodale Press, Runner's World Online: http://www.runnersworld.com/shoes/anatomy.html.

WEB_2, Carrozza, Paul, 1999, "A question of durability", Emmaus: Rodale Press, Runner's World Online: http://www.runnersworld.com/shoes/buzz1019.html.

WEB_3, 2004, Technical Group on Footwear Biomechanics: http://www.teleport.com/~biomech/sneakers.html

WEB_4, 2002, The Engineering Behind Shoe Design, issue:iii Volume:5, "Anatomy of a Running Shoe." Runner's World Online:, Illumin. All Rights Reserved. Disclaimer http://www.runnersworld.com/shoes/anatomy.html,

WEB_5, Shorten, Martyn R. (Webmaster). "Technical Group on Footwear Biomechanics." International Society of Biomechanics. http://www.teleport.com/~biomech/sneakers.html

WEB_6, N.J.Mills, C. Fitzgerald, A. Gilchrist, R. Verdejo, 2003, Polymer foams for personal protection: cushion, shoes and helmets, Composites Science and Technology, 63, www.elsevier.com/locate/compscitech

WEB_7, The Medicare Therapeutic Shoe Programme: New Challenges, New Opportunities. Podiatry Management. www.podiatrym.com.

WEB_8, Cooke, A and Dixon, 2001-2002, S., Sports Science and Engineering in Education: Sport Shoe Design, http://www.cookassociates.com,

WEB_9, Larsen, J., 1995-2002, Slam Dunk Science, A Sport Research Lab In the Classroom, http://www.scire.com/sds/sdsmenu.html,

WEB_10, Emmaus: Rodale Press, 1999. Carrozza, Paul. "A question of durability." Runner's World Online: http://www.runnersworld.com/shoes/buzz1019.html.

WEB_11, FERNAND, 2002, TraceFeet. 21 June, http://www.fernandfootwear.com/html

WEB_12, 2002, Publishedby Elsevier Science Ltd. doi:10.1006/cuor.2002.0268, available online at, http://www.idealibrary.com

WEB_13, 2002, NIKE, (21 June 2002), http://nikeid.nike.com

WEB_14, 2000, Radovic PA: Feetfixer.com, http://www.nh.ultranet.com/~dd1822a/facts.html

WEB_15, 2004, Department of Podiatry, 13/10/2003, http://podiatry.curtin.edu.au/shoo.html#advice

WEB_16, http://www.nismat.org/ptcor/orthotics/

9 Vocabulary

Arch Height: Medial arch height of the insole.

Bespoke: Footwear made to measure to the highest specifications. In most cases a last is made especially to fit the wearer's foot, and stored by the bespoke maker. Arch - part of plantar that does not touch the ground.

Arch Support: Area of insole built up and strengthened to support metatarsal arch, or similar support which can be inserted in the shoe separately.

Ball: The swelling at the inner side of the foot where the big toe joins the head of the first metatarsal bone. The main line of flexing of the foot, and hence of the shoe occurs across this point, which is therefore important in shoe fitting. This part of the foot is sometimes referred to as the joint.

Bones of foot: It is interesting though not essential for the shoe fitter to study the anatomy of the foot in detail. It is more instructive for him (or her) to understand how the bones move in relation to each other and the differing degrees of restricted movement between them. In a men's shoe with rather high cut quarters it is sometimes possible for the top line to press painfully on the outer ankle bones when the leg i.e. angled outwardly sideways with respect to the foot.

Brannock Device: A foot-measuring device having a slide piece adjustable to show the length of the foot and another slide piece which can be moved to show the distance of the ball of the foot from the heel. This measurement is used in conjunction with the foot length measurement to give the shoe size required. The device also indicates appropriate widths. The Brannock system is widely used in America, where it originated.

Bunion: An inflammation of the tissues over a joint, caused by pressure and/or friction. It most commonly develops over the protuberant metatarso-phalangeal joint of the big toe in cases of hallux valgus.

CAD - Computer Aided Design: A shoe design is prepared on the screen of a computer it is then put into the computer memory. It can then be modified and sectional patterns produced and all grading completed. Patterns can then be cut by laser water jet or mechanical cutter on instructions from the computer. Some systems can show 3D pictures of the designs.

Chiropody: Remedial care of the foot, especially dealing with corns, toe nail disorders and toe displacements (pronounce ky-rop-ody). Construction - the basic method of making the shoe. In most cases this applies to the way the sole is attached to the upper.

Elasticity: the property of a body or material by which it stretches or undergoes other deformation under stress and resumes its original form when the stress is removed. If the stress continues beyond the limit of the material the material does not fully recover the original form. Elasticity is measured by the elastic modulus which is the ratio of stress to deformation.

Distribution of Measurements: Any distribution (set of measurements) can be represented by three statistics: mean (the average); median (midpoint at which 50% >, 50 %< than that point); and the mode (most frequently occurring number).

Footwear Forefoot Width: Width of the footwear in the forefoot region. Footwear Heel Width: Width of the footwear in the heel region. Footwear

Length: Length of the footwear. (Mündermann, 2001, pp:40) Forefoot Cushioning: Softness/hardness of the insole in the forefoot region.

Girth: The measurement round the wide part of the foot, namely the ball or joint. Used in several shoe fitting systems instead of simply the width. It is superior to the width system because it is possible for two people with the same foot width to have different joint girth measurements. The width system takes no account of the 'depth', that is the thickness of the foot the forepart. The fitter takes account of it when he sees the customer's foot and suggests an appropriate width fitting.

Grain: The pattern of pores and other surface peculiarities, characteristic of the animal concerned, visible on the outer surface of a hide or skin after the hair or wool has been removed.

Heel Cup Fit: Fit of the insole in the heel region, i.e. whether the insole is loose or tight.

Heel Cushioning: Softness/hardness of the insole in the heel region. Media-lateral Control: Position of the foot controlled by the footwear. Out flare: This describes the last is the opposite with the swing lying to the

Lateral side of the forepart. Straights last describe neither inflate nor out flare preference. The long axis of the last when drawn through the bisection of the heel curve describes two equal longitudinal halves.

Overall comfort: Overall impression of the footwear.

Permeability: The ability of a material to transmit water or water vapour through its thickness. The comfort of a leather shoe is due in part to this property of leather.

Plantar: - the lower surface of the foot. Sometimes used to describe the insole.

Plantar flex: Foot movement. To flex the foot downward so that the forefoot moves further away from the leg.

Platform: An extra component inserted between the insole and the outsole to add height to the wearer, or to give a chunky look to shoe design. The heel height has to be increased to accommodate the extra height. Platforms are made of various plastics, cork grain or even wood. In some cases they are moulded in one piece with outsole and heel.

SATRA: Shoe and Allied Trades Research Association, now known as the Satra Technology Centre. It is an international centre of shoe research, with headquarters and laboratories at Kettering.

Sizes: It should be remembered that there are two different size measurements. (1) Foot length and (2) last or internal shoe length. The differences between lasts are quite large and it is best to rely on the skill of a qualified shoe fitter rather than to rely totally on the information from a size-stick or measuring device. These should be considered as a useful first indication. See also Paris points and Mondo point. Further complication arises when shoes made on European lasts are imported into the UK. English sizes stamped on the shoes can never be accurate because English size interval of one third of an inch is different from the Paris Point increment of 0.66 cm; thus sizes get out of step.

Straight axis: The normal foot has a straight axes and lasted shoes can be worn on either foot.

Tread: This describes the width across the sole under the ball of the last and it should correspond to the dimension of the feet. The tread point on the last represents the bottom forepart just behind the ball and in contact with the base plane.

9.1 Used Short Acronyms and Abbreviations

CAD Computer Aided (or Assisted) Design

CAM Computer Aided Manufacture

UTB University of Tomas Bata

TBU Tomas Bata University

DNM Do Not Want to Mention

IULTCS International Union of Leather Technologists and Chemists

PDS Product Design Specification

SATRA Shoe and Allied Trade Research Association

SOP Standard Operating Procedure

TA Tolerable Allowance

WVA Water Vapour Absorption

WVP Water Vapour Permeability

2D Two Dimensional

3D Three Dimensional

9.1.1 Table of Figures

9.2 Appendix Time Management Plan

Task	Earliest Start	Length *Weeks*	Type of task X *Sequential* Y *Parallel*	Dependent No:
To plan for information search	Nov 2013	1	x	Research topic
Collect books & articles	Nov 2013	12	x	1.1
review and analyse relevant literature	Dec 2013	130	y	1.2
Plan for questionnaire & interview surveys	Jan 2014	8	x	1.3
To Prepare questionnaires	Feb 2014	8	x	1.3
Prepare structured interview questions	Mar 2014	8	x	1.3
To carry out initial investigations (questionnaire & interview surveys)	May 2014	16	x	2.2 and 2.3
To analyse results of the initial investigation	Sept 2014	4	x	3.1
Plan for questionnaire survey	Oct 2014	6	x	1.3 and 3.2
To conduct questionnaire survey	Nov 2014	16	x	3.1
To collect back filled questionnaires.	Nov 2014	16	x	3.2
Analyse outcome of the questionnaire survey.	Mar 2015	4	x	3.3
To plan for interview survey (make appointment with interviewees)	Oct 2015	6	y	1.3 and 3.2
Plan for experimental analysis (collect footwear materials)	May 2015	4	x	1.3, 3.1, 3.3, 3.4
Conduct footwear materials analysis	May 2015	8	x	4.1
Analyse results	July 2015	4	x	4.2
To develop footwear design models	Aug 2015	4	x	1.3, 3.1, 3.3,3.4
To sample patients' opinion on desired design models	Sept. 2015	2	x	5.1
To make trial prototype of the product	Sept. 2015	4	x	4.3 and 5.2
Evaluate product prototype	Oct 2015	24	x	5.3
To write thesis	Apr 2016	26	x	All the above activities
Print, bind and submit thesis	Oct 2016	2	x	6.1
Resubmit thesis	Apr 2017	24		All the above activities

Check points: Enrollment-31st Oct. 2013; Submission of Int PhD Study Protocol Document- Dec. 2013; Submission of Registration Form-March, 2014; 1st Submission of Thesis- Oct. 2016. 2nd Resubmission of Thesis- April. 2017

9.3 Appendix Gantt chart

Year	Task	10	11	12	01	02	03	04	05	06	07	08	09
2013/2014	Researcher Training	C1											
	Plan for Lit. Review			C2									
	Collect Materials						C3						
	Review relevant lit.												
	Plan for quest. survey												
	Prepare questions						C4						
	Conduct survey												
	Collect & anal. data												
	Plan for interview survey												
	Make Appointment. with Interviewees												
2014/2015	Prep.questions & SOP												
	Conduct interview & record information	C5											
	Analyse data												
	Plan for Experiment												
	Collect materials												
	Carry out experiment												
	Record & analyse results												
	Develop prototypes												
	Design prototypes												
	Collect materials												
2015/2016	Make prototypes												
	Assess prototypes	C6											
	Re-design prototypes												
	Re-make prototypes												
	Re-assess prototypes												
	Develop conclusion												
	Write Thesis												C7

Key: 01= Jan.; 02= Feb.; 03= Mar; 04= April; 05= May; 06= Jun; 07= Jul; 08= Aug.; 09= Sept.; 10= Oct.; 11= Nov.; 12= Dec. Check Points: C1 – Enrolment. C2 -Submission of Int PhD Study Protocol Document. C3 -Submission of Registration Form. C4 -Submission of Form. C5 – Visits. Review C6 – Prototypes Review. C7 - Submission of Thesis.

9.4 Appendix Questionnaire Survey

This questionnaire is designed to carry out a survey on the role of footwear in the management of foot problems. The researcher, MgA. Ing Naveed Anwar is a PhD student at University Tomas Bata, Zlin, Czech Republic. The information given will be handled/ treated confidentially and for academic purposes only. You are free to discontinue your participation in this survey at any point without given a reason. Thank you.

Please tick or mark [with X] the appropriate option.

Part I. Personal Information

1. Gender
a. Male □ b. Female □ c. Do not want to mention □

2. Age
a. ≤ 20yrs□ b. 21-35yrs □ c. 36- 50yrs □d. 51-65yrs□e. ≥ 66yrs □

3. Occupation
a. Employed □ b. Own Business □ c. Unemployed □ d. Retired □ e. Student □ f. Farmer □
g. Housewife □ h. Others……………………………………………

4. Where do you live?
a. Rural area □ b. Urban □ c. Do not want to mention □

5. Are you suffering with diabetes?
Yes □ No □

6. How long have you being living with foot problems?
a. ≤ 5yrs □ b. 6-10yrs □ c. 11-15yrs □ d. 16-20yrs □ e. ≥ 21yrs □

Part II. Information on Diabetes Foot Care and Foot Problems

7. Have you had your feet checked by a doctor or a health professional?
Yes □ No □

8. Have you ever reported or complained of any numbness or pain in your feet to your doctor or other health care professional?
Yes □ No □

9. Do you have foot problems (e.g., heel pain, plantar fascia, pain in front fore part, etc.)?
Yes □ No □

If yes, indicate on the pictorial grids with (X) on any of the diagrams given below (fig.1)

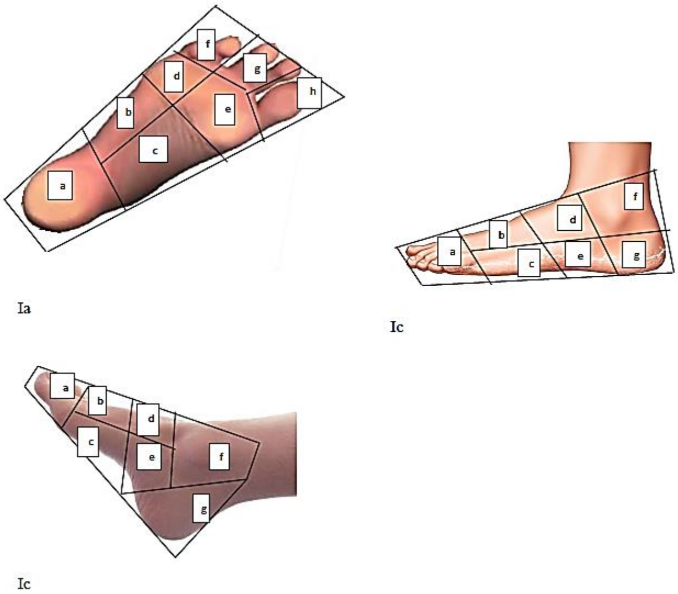


Fig.1 Different views of the Human foot-I

Part III. Foot problems developed as a result of using inappropriate footwear

10. Do your shoes give you discomfort (e.g. cause you pain or injury)?
Yes □ No □

11. Do you experience blisters or redness on your feet from wearing your shoes?
Yes □ No □

12. If your shoes cause you pain/ Injury, what are the reasons?

a. Shoes are too tight □

b. Shoes are rubbing my feet □

c. Shoes are pinching my feet □

d. Other reasons (please write)………………………………………………

13. From the diagrams below (fig. 2), please indicate area(s) of particular sensitivity or pains (if any) caused by your footwear (with 1 being very painful and 5 being not very painful)

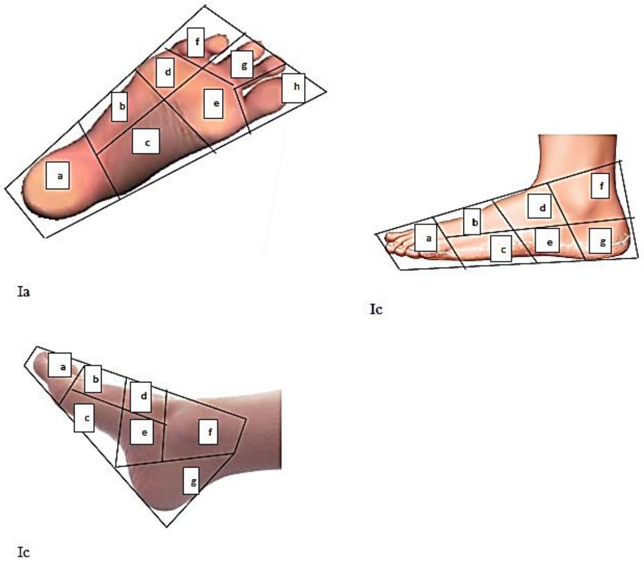


Fig.2 Different views of the Human foot-II

Part IV. Footwear Fitting/ Features

14. Do you have foot problems that make it difficult for regular shoes to accommodate your feet?
Yes □ No □.

If yes describe (e.g. heel pain, plantar fascia, pain in front fore part etc.)
………………………………………………………………………………………

15. Do you think your shoes need modification in order to accommodate your feet well?
Yes □ No □

16. Do you think ‘good’ footwear or arch supported shoe can improve your foot condition and allow you to walk better?
a. Yes □ b. No □ c. Do not know □

17. Are there times you walk without shoes or bare foot?
Yes □ No □

18. Do you have difficulties in putting shoes on or taking off your shoes?
Yes □ No □

19. Do you wear shoes without socks?
Yes □ No □

20. What type of footwear do you use often?

a. Shoes □
b. Half-shoes □
c. Sandals □
d. Boots □
e. Slippers □
f. Custom-moulded □
g. Sport shoes or Sneakers □

21. Are you comfortable with your shoes?
Yes □ No □

22. Do you receive information about the type of footwear you should wear?
Yes □ No □

If yes, write the source……………………………………………………………

23. What is your view on the soles of your shoes?

a. The soles of my shoes are too flexible □

b. The soles of my shoes are too rigid □

c. The soles of my shoes are neither too flexible non too rigid □
d. Do not know □

24. Do you know your correct shoe size?
Yes □ No □

25. Do your shoes fit well?
Yes □ No □

26. Do you think you need different sizes of shoes for your feet (left and right)?
Yes □ No □

27. If your doctor prescribes specially designed footwear with extra insert materials as insoles would you be happy to wear them?
a.Yes □ b. No □ c. Not sure □

28. What type of heel construction do you choose for your shoes? You can tick more than one option.
a. High heel □ b. Medium Heel □ c. Low heel □ d. Flat heel □

29. What type of shoe do you wear most often? You can tick more than one option.
a. Lace fastening shoe □ b. Buckle fastening shoe □ c. Velcro fastening shoe □ d. Un- fasten/ Slip-on shoe.

30. What type of upper materials do you choose for your shoes? You can tick more than one option. a. Leather □ b. Synthetic □ c. Fabric □ d. Others (please write) …………………………………………………………………………………….

31. How often do you buy shoes?
a. Quarterly □
b. Twice a year □
c. Once a year □
d. Less often than once a year □

32. How much are you always willing to spend on a pair of shoes? ………………

33. If your doctor recommends footwear that will cost you double the amount you usually spend on shoes, would you be willing to buy them?
Yes □ No □

34. When purchasing or selecting footwear, what are your most preferred elements?
Rank the following (with 1 for the most preferred and 13 for the least preferred).

a. Style/ Fashion □

b. Weight □

c. Sole □

d. Heel □

e. Comfort □

f. Brand □

g. Colour □

h. Quality □

i. Protection □

j. Adjustability □

k. Durability □

l. Breathability □

35. Do you have any comments about diabetes and footwear?
……… ……………

Thank you for your participation in this survey

9.5 Appendix Structure Interview questionnaire

Q1: How important do you think foot care is important in your shoe designs?

Q2: What kinds of foot protection do you like to use and important?

Q3: What kind of shoe materials do you think is good for supporting feet?

Q4: What is your opinion on the different kinds of shoe fastenings?

Laces? Zips? Elastics? Buckles? Velcro? Slip ons?

Q5: Which shoe colour do you like?

Q6: What sort of problems shoe have you encountered or are current experiencing?

Q7: Do you think that there are any new trends in foot care?

Q8: If you think that there are trends in foot care are these age-related?

Q9: Are you developing or thinking about developing any new kinds of foot care products?

Q10: Do you think that developing new foot care products can have design problems, and what might these be?

Q11: Are there any costing problems when developing and manufacture foot care product or shoes?

Q12: Have you ever experienced functional problems with fastenings, for examples durability?

Q13: What kind of material do you think is good for fastenings, Laces, Buckles, Zips, Elastics, Velcro, Slip Ons?

Q14: Which fastenings do you think are better for?

Sports Shoes, Special Occasion, Formal shoes, Casual Shoes, Everyday use.

9.6 Appendix Shoe sizing system

Shoe sizing systems vary across the world. Conversion charts for the various international sizing conventions are listed below:

Adult Shoe Sizes

International System		Sizes															
Europe		35	35½	36	37	37½	38	38½	39	40	41	42	43	44	45	46½	48½
Mexico							4.5	5	5.5	6	6.5	7	7.5	9	10	11	12.5
Japan	Mens	21.5	22	22.5	23	23.5	24	24.5	25	25.5	26	26.5	27.5	28.5	29.5	30.5	31.5
	Womens	21	21.5	22	22.5	23	23.5	24	24.5	25	25.5	26	27	28	29	30	31
U.K.	Mens	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	10	11	12	13½
	Womens	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	9½	10½	11½	13
Australia	Mens	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	10	11	12	13½
	Womens	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	10½	11½	12½	14
U.S. & Canada	Mens	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	10½	11½	12½	14
	Womens	5	5½	6	6½	7	7½	8	8½	9	9½	10	10.5	12	13	14	15.5
Russia & Ukraine	Womens	33½	34		35		36		37		38		39				
Korea (mm.)		228	231	235	238	241	245	248	251	254	257	260	267	273	279	286	292
Inches		9	91/8	9¼	93/8	9½	95/8	9¾	97/8	10	101/8	10¼	10½	10¾	11	11¼	11½
Centimeters		22.8	23.1	23.5	23.8	24.1	24.5	24.8	25.1	25.4	25.7	26	26.7	27.3	27.9	28.6	29.2
Mondopoint		228	231	235	238	241	245	248	251	254	257	260	267	273	279	286	292

Girl Shoe Sizes

Europe	26	26.5	27	27.5	28	28.5	29	30	30.5	31	31.5	32.2	33	33.5	34	35
Japan	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22
U.K.	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	1	1.5	2	2.5
U.S. & Canada	9.5	10	10.5	11	11.5	12	12.5	13	13.5	1	1.5	2	2.5	3	3.5	4

Boy Shoe Sizes

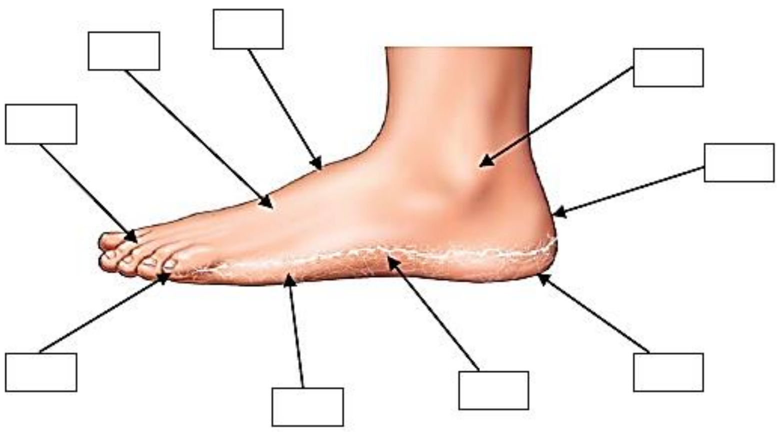
Europe	29	29.7	30.5	31	31.5	33	33.5	34	34.7	35	35.5	36	37	37.5
Japan	16.5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22	22.5	23
U.K.	11	11.5	12	12.5	13	13.5	1	1.5	2	2.5	3	3.5	4	4.5
U.S. & Canada	11.5	12	12.5	13	13.5	1	1.5	2	2.5	3	3.5	4	4.5	5

Shoe Sizing: Shoe Guide Org. (2006). Available at: http://www.shoeguide.org/Shoe_Sizing (Accessed on 01/12/2013). Shoe size is a numerical scale for the size of a shoe, which aids people in selecting an appropriate shoe size.

9.7 Appendix Standard Operating Procedure for Questionnaires Survey

Procedure	Enquiry	Response
At the Foot Clinic general reception	- Hello, I am a research student from UTB, Zlin, CZ - Where is the Foot care clinic located? - Thank you.	
At the reception of the foot care clinic	- Hello, I am a research student from UTB, Zlin, CZ - Where is the office of the consultant In-charge of the foot care clinic located? - Thank you.	
At the office of the consultant In-charge of the Foot care clinic	- Hello, I am a research student from UTB, Zlin, CZ. I have been given ethical approval by your foot care management to conduct questionnaires and Interview surveys (among foot patients and podiatrist) in your clinic. - Will you give me permission to conduct the survey in your clinic? - Will you allow me to carry out the survey for a period of 6-8weeks? -Which day do you attend to your patients in the clinic? -Thank you.	Yes No
Distribution of questionnaires to foot patients	- Hello, I am a research student from UTB, Zlin, CZ. I am carrying out a survey on 'footwear material choices and design for people suffering with foot problems or heel pain'. - Please, can you spare five minutes to fill my research questionnaire? - Thank you.	Yes No

9.8 Appendix One view of the human foot Image



The human foot

9.9 Appendix Photos with foot Drs, podiatrist, foot experts and patients at a different clinics

Photos of patients at a Foot care clinic showing the types of footwear they wear often. The photographs show that majority of people suffering with foot problems and heel pain, particularly in Zlin and Ostrava Region at Sanatoria Klimkovice wear slippers or slip-on footwear most times.

9.10 Appendix Visual Observation "Bata Shoe Museum, Zlin CZE"

Introduction

The visual observation of the shoe museum in Zlin was to research the efficiency of comfort across a range of footwear from historical designs.

Also to find out special shoes and boots with comfort for example, skiing and yachting in order to ascertain their appropriacy to comfort shoe design.

Findings:

1. The shoes in the museum were traditional old style from 1900 to 1980, which helped me to find out what types of fastening had been used in history and how the styles were designed.
2. I was interested in one of the boot, which had got very strong comfort style and fastening image, so I thought that I should try to design my ideas as same.
3. I found some sport shoes, which had very strong comfort images (see photographs).

Conclusion

The visual observation I undertook left me with a number of impressions about the kind of comfort materials and styles. I would like to use in my design. Initially, I felt that leather provided a strong image, however, this was not followed through as responses to any questionnaire and interviews with designers and manufactures revealed that leather were not a popular form of comfort. Given this, I reviewed the photographs I took on my observation and considered that, historically, laces were prevalent.

9.11 Appendix List of workshops, seminars, conferences and study abroad program attended during research study

- 2015 Study abroad program by Tomas Bata University in, Zlin at adidas group headquarter, Germany
- 2015 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic
- 2014 Footwear Health Tech & Future Footwear Materials Conference, Eindhoven, The Netherlands

- 2014 Czech Podiatry Association congress 2 Days, Léčebné lázně Bohdaneč, Masarykovo CZ
- 2014 Superfeet Insloe Workshop for Footcare Patients, Zlin CZ with Ing. Milan Borsky
- 2014 Orthopedic Foot Care experience Workshop- Plzen, CZ with Milan Sagl (Jednatel)
- 2014 Tekscan Workshop-Pressure Mapping for Patient Care, Zlin CZ with Ing. Milan Borsky
- 2014 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic.
- 2013 Examination of feet in pedicure experience-Ostrava, CZ with (MUDr.Marie Součková)


Česká podiatrická společnost o.s.
uděluje
v rámci vzdělávání v podiatrii
CERTIFIKÁT
o získání odbornosti
VYŠETŘENÍ NOHOU V PEDIKÉRSKÉ PRAXI
6. prosince 2013 - Ostrava
Naveed Anwar
Náplň kurzu:
anatomie, deformity nohou, metody vyšetřování, měření, historie a současnost od plantoskopu po 3D scan, stélky, obuv, zásady správného obouvání, korekce deformit, nové typy ortéz, rady pro klienty, praktické ukázky a nácvik dovedností.
Počet bodů v systému vzdělávání ČPS: 6
MUDr. Marie Součková
prezidentka ČPS
ČPS – U Vršovického nádraží 14, 101 00 Praha 10


Česká podiatrická společnost o.s.
uděluje
v rámci vzdělávání v podiatrii
CERTIFIKÁT
za účast na školení dne 21.2.2014
Vyšetření nohou v pedikérské praxi – část 2.
Naveed Anwar
Náplň kurzu:
patologie nohy od narození po dospělý věk, zásady měření nohy pro zhotovení obuvi, druhy obuvi, obuvnické řemeslo, biomechanika nohy s využitím ke stavbě obuvi, stélek, zásady správného obouvání dětí, dětské nohy potřebují zvláštní péči, prevence, praktické ukázky a nácvik dovedností.
Počet bodů v rámci vzdělávání 7
MUDr. Marie Součková
prezidentka ČPS
ČPS – U Vršovického nádraží 14, 101 00 Praha 10

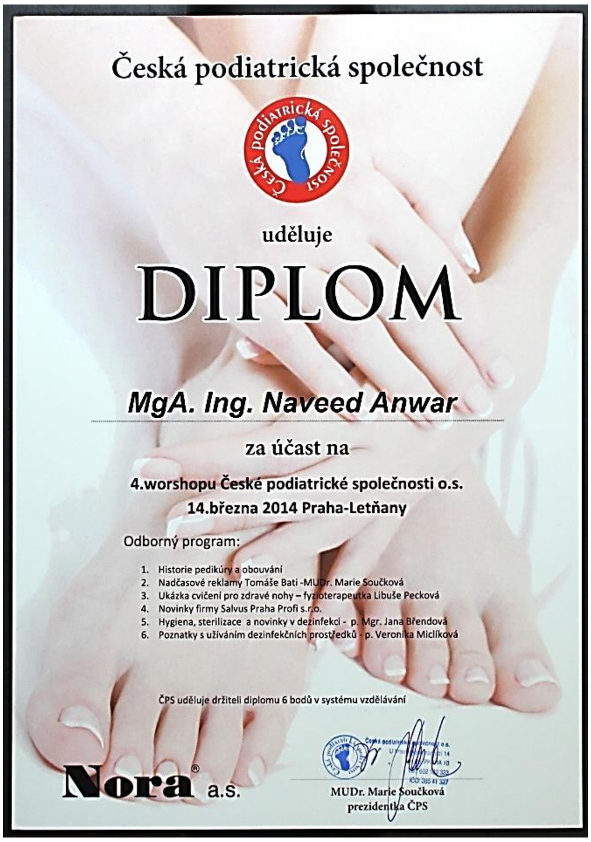
Examination of feet in pedicure experience - Ostrava

Examination feet in pedicure experience, plantogram, plantoskop, metric measurement, 3D scan, correction of deformities, news in the manufacture of individual devices, napkins, proper footwear, and other valuable advice to clients Profi- pedicure, Špálova 2, Ostrava.

The course : anatomy , foot deformities , methods of investigation , measurement, history and present of the plantoskopu D3D scan , insoles, making plantogram , the plantoskopu examination , examination of the strain gauge plate , footwear, principles of proper footwear , correction defomit , new types of orthoses , advice for clients, practical exercises for clients, practical demonstrations and training skills .

Examination of feet in pedicure Practice 2 - Plzen Principles of proper footwear not only children, health bespoke shoes, introduction to kalceotiky, demonstrations, skills training, advice into practice Plzeň, Cukrovarská 18 – orthopedic company.

The course : Pathology legs from birth to adult age, the principles for measuring feet for shoe making , types of footwear , shoe shop , biomechanics of the feet using to build a shoe insoles, evaluation plantogram Principles of good children footwear , children's feet need special care , prevention, practical demonstrations and skills training.



World of Beauty & Spa Spring 2014 traditional fair cosmetics, hairdressing, healthy lifestyle, wellness and spa for the members REALITY Prague 9 - Letňany, Fair and footcare workshop.

13th Congress of the Czech Podiatric Society , to be held on 29 March 2014 at 3.28 - Bohdaneč spas , Masaryk nám.6 , Bohdaneč
The program will be further refined, possible inputs, principal and general partner or sponsor, or even less
Professional program. Parts of the congress will be the presentation of companies on the stands.

Odborná konference

Multidisciplinární přístup v péči o nohy diabetiků

POTVRZENÍ O ÚČASTI

Jméno: NAVEED ANWAR

Datum narození: 29. 7. 1974

Účast: pasivní účast ☒ aktivní účast autor ☐ aktivní účast spoluautor ☐

Místo konání: Sanatoria Klimkovice
Termín: 17. - 18. leden 2014

Česká asociace sester vydala souhlasné stanovisko pod číslem ČAS/ KK/2715/2013, přiděleno 8 kreditů za 8 hodin vzdělávání. Podle vyhlášky MZČR č. 4/2010 Sb., kterou se mění vyhláška 423/2004 Sb., kterou se stanoví kreditní systém pro vydání osvědčení k výkonu zdravotnického povolání bez přímého vedení nebo odborného dohledu zdravotnických pracovníků, ve znění vyhlášky č. 321/2008 Sb.

Akce obdržela souhlasné stanovisko profesní organizace fyzioterapeutů České republiky UNIFY dle zákona 96/2004 Sb. a vyhlášky č. 4/2010 Sb. Číslo rozhodnutí 6567 přiděleno 8 kreditů za 8 hodin vzdělávání.

Česká podologická společnost udělila 8 kreditů za 8 hodin vzdělávání dle systému celoživotního vzdělávání v podologii, dle interních pravidel společnosti.

Garant: MUDr. Miroslav Koliba

www.diabetologieostrava.cz

V Klimkovicích 18. ledna 2014

Conference Klimkovice multidisciplinary approach to diabetic foot care 17 to 18 January 2014 Sanatorium Klimkovice - a rich program including a stay at a spa. Speakers from all related disciplines.

The conference will be devoted to the care of the legs of a patient with diabetes. The issue is now particularly timely in the sharp increase patient’s diabetes, which number has doubled since 1993. Cooperation diabetologists, rehabilitation physician’s solutions, orthopaedist, prosthetics, dermatologist surgeon and professional chiropodist -supervisor, allowed us to prepare for you a unique conference that will offer of specialists submitted comprehensible form with to extend compl Erasing í . The conference held in two days with cultural opportunities, use of spa treatments and accommodation. Program Friday,

ODBORNÁ KONFERENCE

Multidisciplinární přístup v péči o nohy diabetiků

POTVRZENÍ O ÚČASTI

Jméno a přímení: MgA. Ing. NAVEED ANWAR — Datum narození:

Účast: ☒ pasivní účast ☐ aktivní účast autor ☐ aktivní účast spoluautor

Místo konání: Sanatoria Klimkovice — Datum konference: 16. - 17. leden 2015

Česká asociace sester vydala souhlasné stanovisko pod číslem ČAS/ KK/2304/2014, přiděleno 8 kreditů za 8 hodin vzdělávání. Podle vyhlášky MZČR č. 4/2010 Sb., kterou se mění vyhláška 423/2004 Sb., kterou se stanoví kreditní systém pro vydání osvědčení k výkonu zdravotnického povolání bez přímého vedení nebo odborného dohledu zdravotnických pracovníků, ve znění vyhlášky č. 321/2008 Sb.

Akce obdržela souhlasné stanovisko profesní organizace fyzioterapeutů České republiky UNIFY dle zákona 96/2004 Sb. a vyhlášky č. 4/2010 Sb. Číslo rozhodnutí 7144 přiděleno 8 kreditů za 8 hodin vzdělávání.

Česká podiatrická společnost udělila 12 bodů za 8 hodin vzdělávání dle systému celoživotního vzdělávání ČPS, dle interních pravidel společnosti.

Organizátor akce: MUDr. Miroslav Koliba
V Klimkovicích 17. ledna 2014

Diagnosis & Analysis Plantar Fascia Tekscan 2014, certificates obtained

Certificate of Diagnosis & Analysis of Plantar Fascia by Tekscan, USA

- Plantar data analysis
- Diagnosis of static and dynamic foot defects by foot mapping pressure
- Operation of the device and operating Footcare Presto-Scan Module

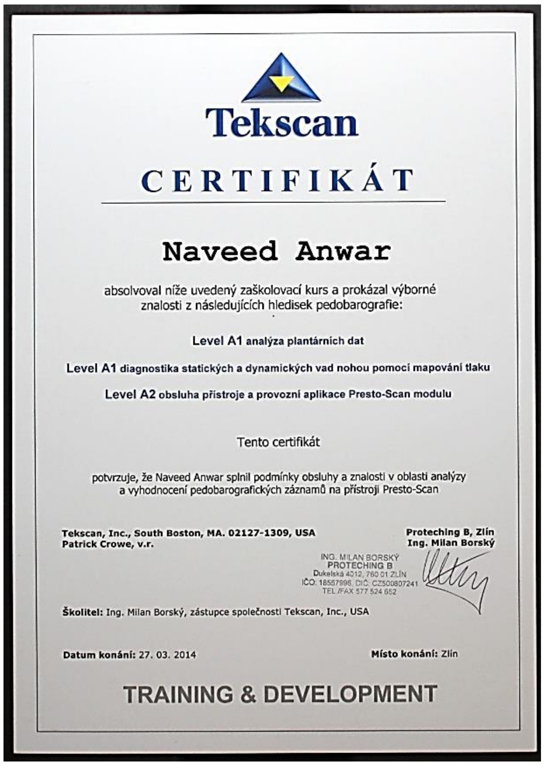
27-03-2014 Ing. Milan Borsky (Proteching B) Zlin, Czech Republic

Foot Biomechanics of the "Superfeet Insole" 2014, obtained

Certificate in Foot Biomechanics (Training & Development of Superfeet, USA)

- Biomechanics of the feet and lower limbs
- Diagnosis of static and dynamic foot defects (Orthopedic Footcare)
- Application of orthopedic insoles "Superfeet"
- Equipment installation orthopedic insoles "Superfeet" for shoes

27-03-2014 Ing. Milan Borsky (Proteching B) Zlin, Czech Republic



Potvrzení o účasti na vzdělávací akci

VÝROBNÍ TECHNOLOGIE FIRMY GO-TEC

JMÉNO A PŘÍJMENÍ:	MgA. Ing. Naveed ANWAR
NAROZEN(A):	29. 7. 1974
TERMÍN:	2. 7. 2015
ROZSAH:	7,5 hodiny
ŠKOLITEL:	Jens Majewski, ředitel firmy GO-TEC, Německo Henning Schnitter, specialista firmy GO-TEC, Německo
MÍSTO:	High-Tech Centrum, Dr. Jánského 3238, Frýdek-Místek

Uvedená akce obdržela podle zákona č. 96/2004 Sb. a vyhlášky č. 423/2004 Sb. MZČR a vyhl. č. 4/2010 Sb. souhlasné stanovisko organizace ISPO ČR pod registračním číslem 76 a je ohodnocena 4 kredity.

Jens Majewski
GO-TEC, Německo

Henning Schnitter
GO-TEC, Německo

Ve Frýdku-Místku, dne 2. 7. 2015

ING corporation, spol. s r.o.
Dr. Jánského 3238
738 01 Frýdek-Místek
Česká republika
Tel.: +420 558 663 215
www.ingcorporation.cz

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CERTIFIKÁT
za aktivní účast na konferenci

NAVEED ANWAR

ČLÁNEK
The impact of market orientation on performance of theatres

24. dubna 2015
Ve Zlíně

prof. Dr. Ing. Drahomíra Pavelková

organizátor:
Univerzita Tomáše Bati ve Zlíně
Fakulta managementu a ekonomiky

partneři:
Continental
The Future in Motion
greiner packaging

9.12 Appendix Internship and Study abroad program

Study abroad program at Adidas group 2015/2016, Germany was a great option for me to complete my idea to real. Development process for my PhD. Practical work at Company was so professional and amazing.

Certificate
OF ACHIEVEMENT

Naveed Anwar

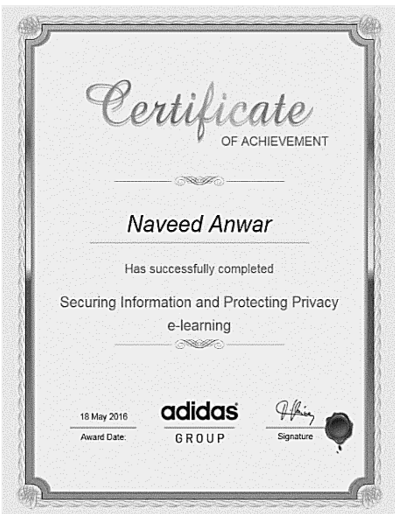
Has successfully completed

Code of Conduct: Best Practices

November 30, 2015
Award Date

adidas
GROUP

Signature



Certificate
OF ACHIEVEMENT

Naveed Anwar

Has successfully completed

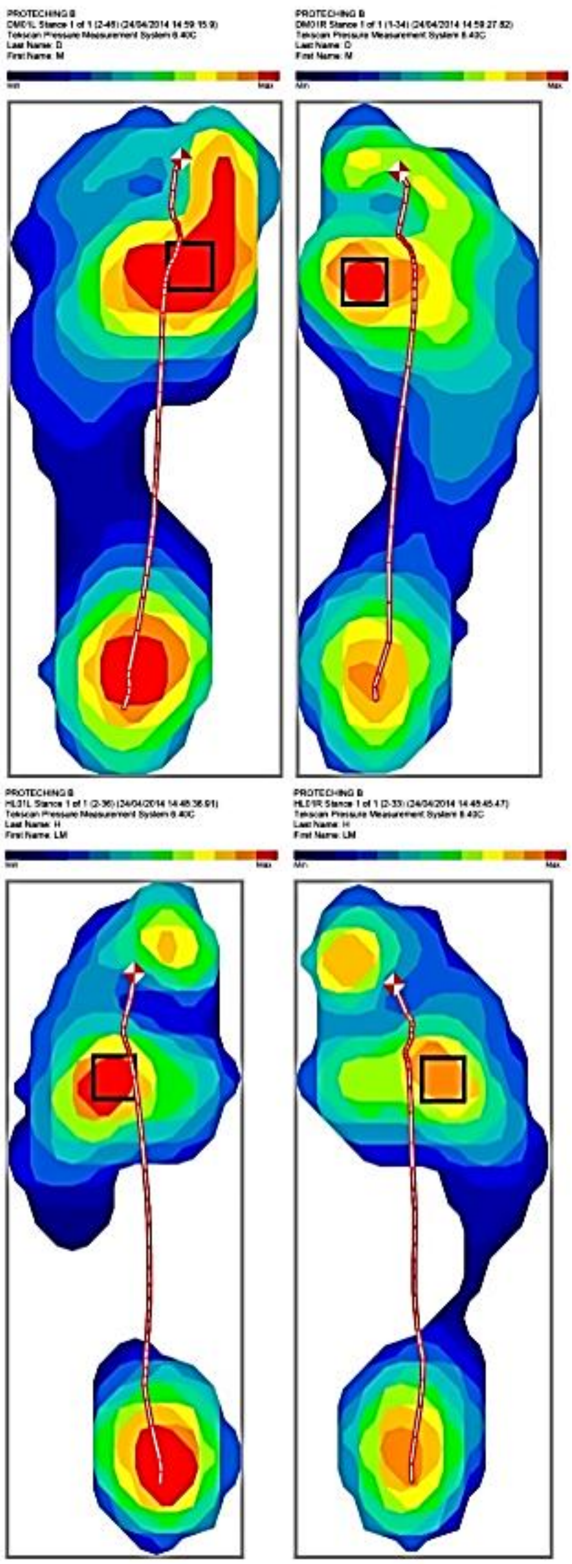
Securing Information and Protecting Privacy
e-learning

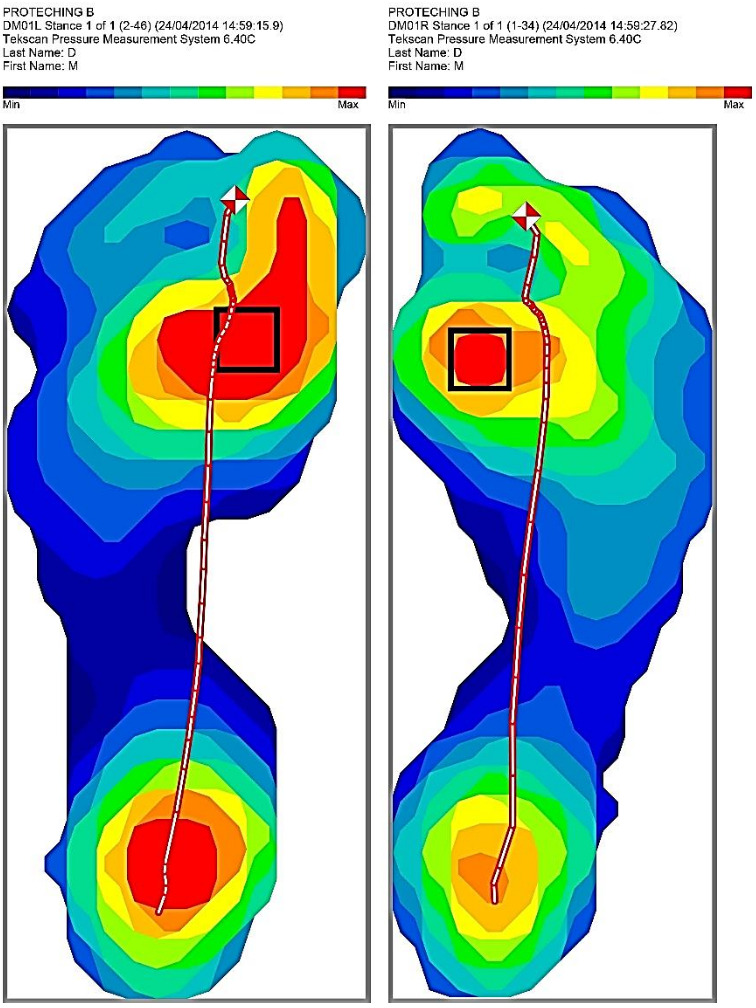
18 May 2016
Award Date:

adidas
GROUP

Signature

9.13 Appendix Foot scan images for analysis data from patient foot pressure

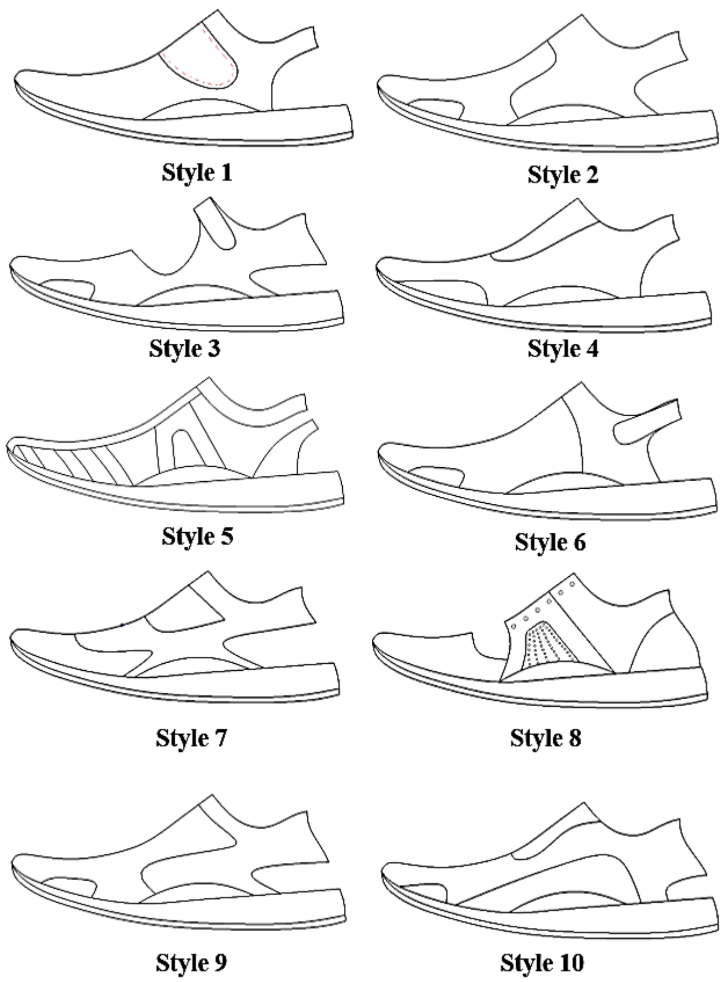



PROTECHING B
DM01L Stance 1 of 1 (2-46) (24/04/2014 14:59:15.9)
Tekscan Pressure Measurement System 6.40C
Last Name: D
First Name: M
Min
Max
PROTECHING B
DM01R Stance 1 of 1 (1-34) (24/04/2014 14:59:27.82)
Tekscan Pressure Measurement System 6.40C
Last Name: D
First Name: M
Min
Max

9.14 Appendix Questionnaire for sampling opinions of heel pain patients on their preferred footwear style.

As part of my PhD studies at Tomas Bata University in, Zlin; I required to undertake a research study titled: ***An Investigation into Shoe for Prevention of Heel Pain*** and at this stage of my study, I am intending to make a trial prototypes of heel pain patients.

Therefore, you are requested to rank the following footwear arch support styles (with 1 for the most preferred and 12 for the least preferred).



Options

- Light weight Microcellular polyurethane (PU), or Medium weight microcellular rubber
- **Fastener**: Touch fastener. *Velcro or Elastic*
- **Upper:** Full grain leather and some part mix with stretch material
- **Insole:** Fixed but fixable Insole for arch support.
- Rubber (TPR) sole, or; *polyvinylchloride (PVC) sole.

Please tick or mark [with X] the appropriate option.

1. Gender

a. Male [ ] b. Female [ ] c. Do not want to mention [ ]

2. Are you suffering with heel pain?

Yes [ ] No [ ]

3. What is your correct shoe size? (Please write)………………………………

4. Do you have foot problems that make it difficult for regular shoes to accommodate your feet?

Yes [ ] No [ ] **If yes,** please describe (e.g. ulcer, gangre, wound, etc.) ……………………………………………………

5. What type of footwear fastening do you prefer?

(a) Elastic [ ] (b) Touch fastening (Velcro) [ ] (c) Lace [ ] (d) others (please write)……………………………………………………..…

6. When purchasing or selecting footwear, what is your most preferred colour?

(a) Black [ ] (b) Brown [ ] (c) others (please write)………………..

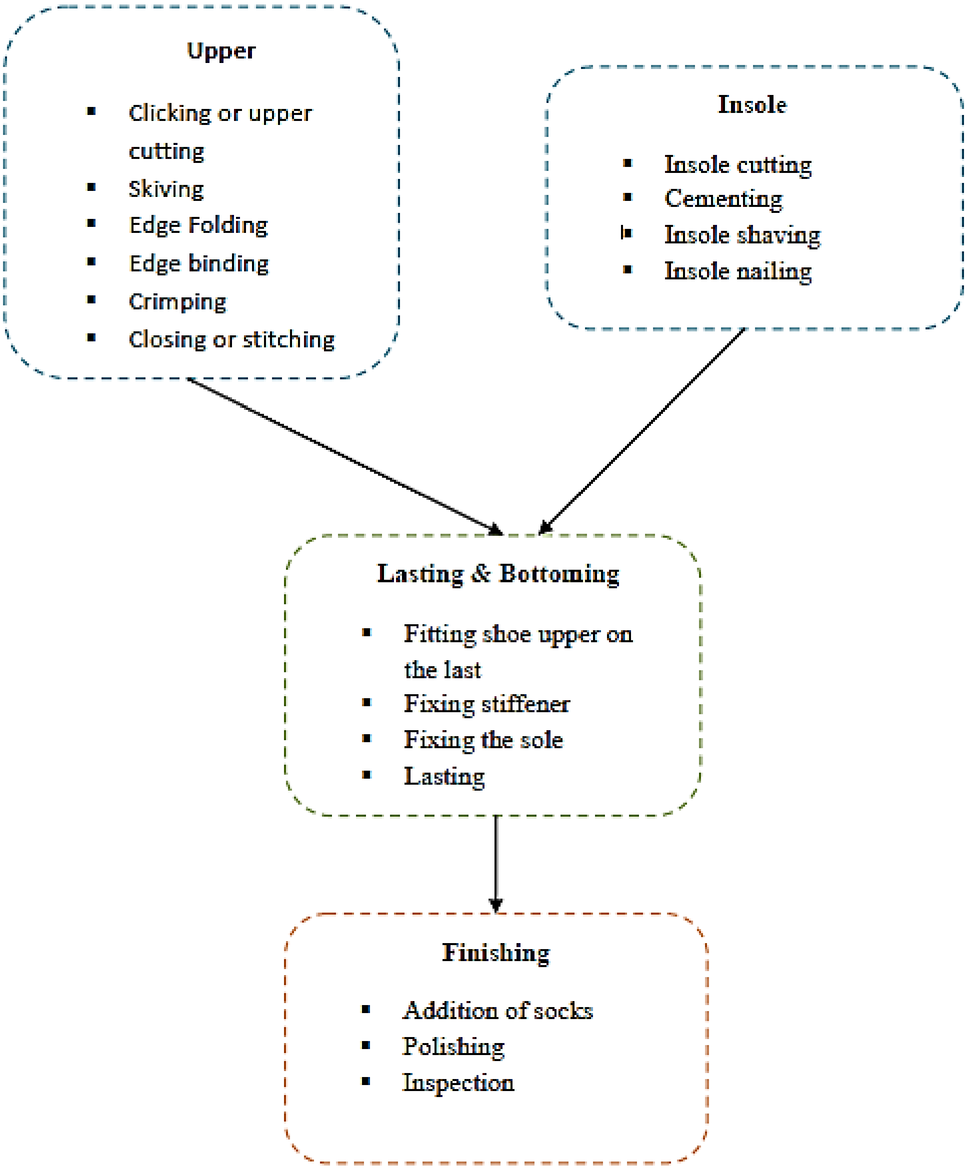
7. What type of upper materials do you choose for your shoes? You can tick more than one option.

a. Leather [ ] b. Synthetic [ ] c. Fabric [ ] d. Others (please write)

8. Please use the space provided below to describe or sketch your preferred footwear design/ style if you do not like any of the designs presented above.

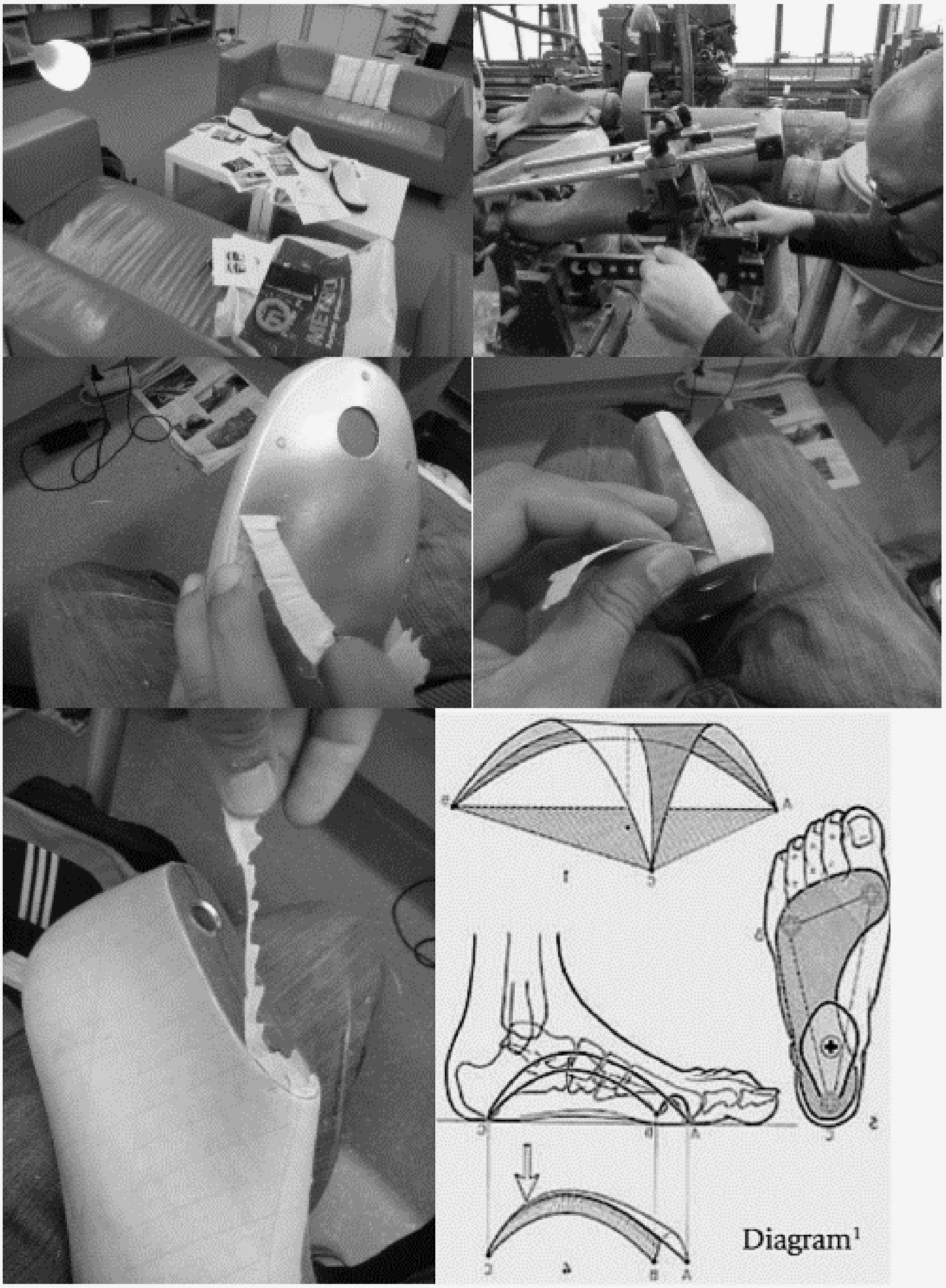
Thank you for your participation in this survey.

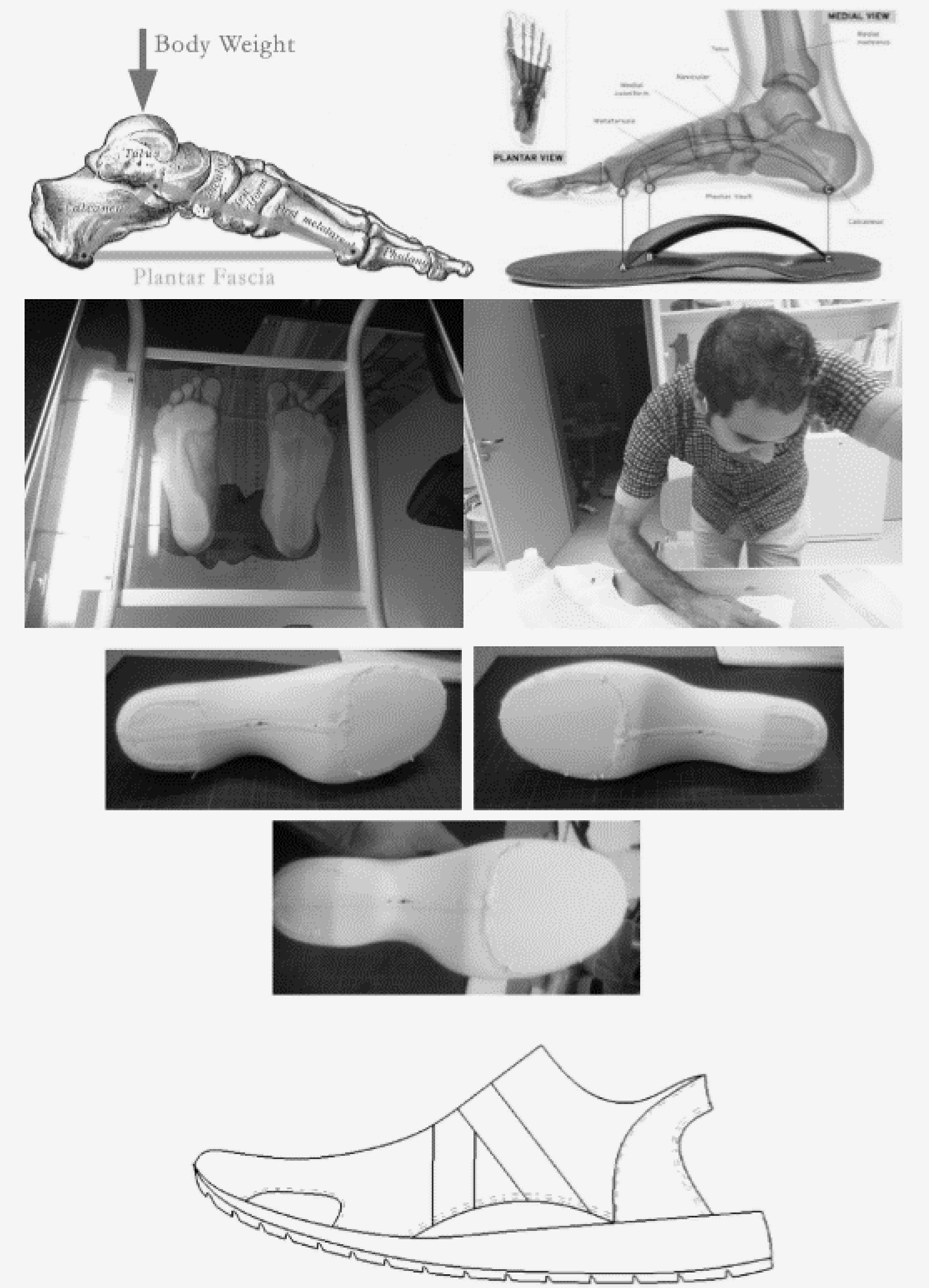
9.15 Appendix Major Stages/ flow chart of footwear making



9.16 Appendix Photos of some stages during making of the trial

Prototype

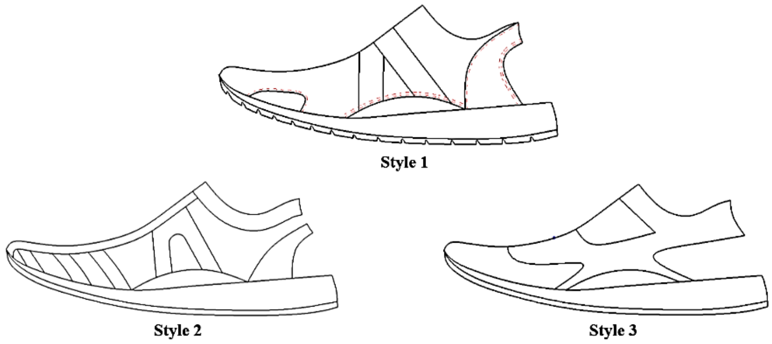




Style 1

9.17 Appendix Questionnaire for testing of trial prototypes

Part I. Visual and cosmetics assessment



1. **Do you like the styles of this footwear with arch support?**
   Yes [ ] No [ ]

If no, please write or describe your preferred style……………………………………

2. Which one is your most preferred style?

(a) Style I **[**] (b) Style II **[**] (c) Style III **[**]

3. Do you like the color?
Yes [ ] No [ ]

If no, please write your preferred colour………………………………………………..

4. Do you like the materials used for the construction of this footwear?
Yes [ ] No [ ]

If no, what type of materials would you prefer?

5. By your assessment, is this footwear?
(a) Very attractive [ ]
(b) attractive [ ]
(c) Neutral [ ]
(d) ugly [ ]
(e) very ugly [ ]

Part II. Fit and Comfort Assessment

	Yes	No
6. Do the sandals go into your feet easily?	[ ]	[ ]
7. Is the width of the footwear alright?	[ ]	[ ]
8. Is the length alright?	[ ]	[ ]
9. Are you comfortable with the top line?	[ ]	[ ]
10. Do the fastening aligned properly?	[ ]	[ ]
11. Is the depth of the Instep alright?	[ ]	[ ]
12. Are you experiencing new pain in any apart of your feet?	[ ]	[ ]
13. Do you think the footwear is too tight?	[ ]	[ ]
14. Are you experiencing discomfort in any part of your feet?	[ ]	[ ]
15. Do you think this footwear should be adjusted in order to accommodate your feet well?	[ ]	[ ]

Part III. Assessment after footwear is removed from participants' feet.

	Yes	No
16. Can you observe any colour change in any part of your feet?	[ ]	[ ]
17. Any swelling in any part of your feet?	[ ]	[ ]
18. Any blisters in any part of your feet?	[ ]	[ ]

19. From your experience, this footwear:

(a) Will improve walking [ ]

(b) Is same as own footwear [ ]

(c) Will not improve walking [ ]

21. How much will you be willing to buy this footwear?

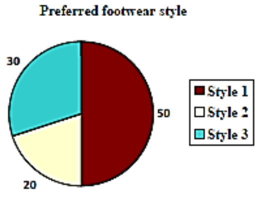
(a) €40-60 [ ]   (d) €70-80 [ ]

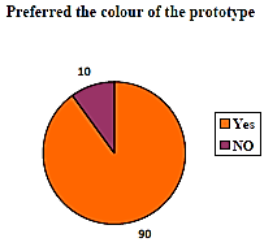
(b) €90-100 [ ]   (e) €120 [ ]

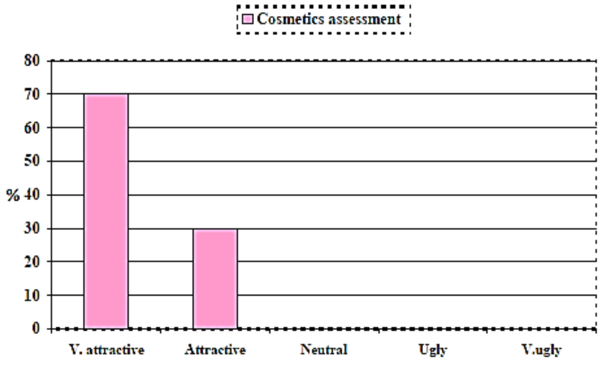
(c) €140 [ ]   (f) €150 & above [ ]

9.18 Appendix Outcome of prototypes pre – assessment

Part I. Visual and cosmetics assessment (n=10)



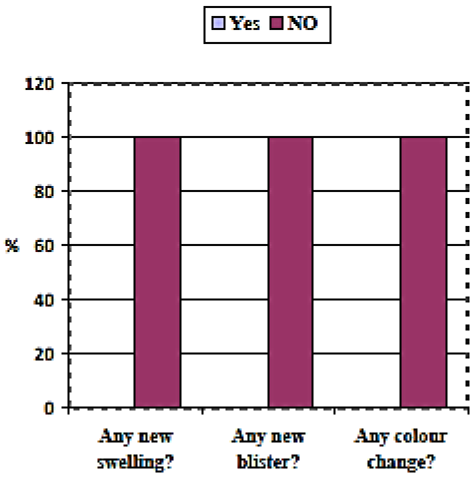


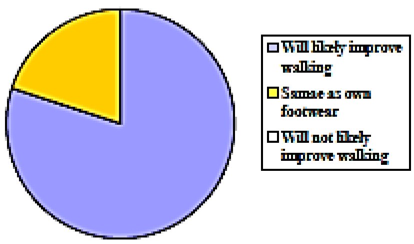


Part II. Fit and Comfort Assessment (n=10)

	Enquiry	Yes (%)	No (%)
a	Sandals go into the feet easily	90	10
b	Alright with the length of the footwear	90	10
c	Alright with the width of the footwear	90	10
d	Comfortable with the top line	100	0
e	Fastening aligned proprely	90	10
f	Alright with the depth of the Instep	90	10
g	Experience new pains	10	90
h	The footwear is too tight	10	90
i	Experience discomfort	10	90
j	Footwear need to be amended to accommodate feet well	10	90

Part III. Assessment after footwear was removed from the participants' feet. (n=10)





Walking capability

9.19 Appendix Publication during Research

Title: Deadly Shoe Horns: Save the Shoe Counter by Hurting the Foot Counter

Manuscript

Click here to download Manuscript Shoe Horn.docx

Click here to view linked References

Naveed Anwar

Title: Deadly Shoe Horns: Save the Shoe Counter by Hurting the Foot Counter

Introduction

The argument of our conceptual paper is that the use of shoehorns is very injurious for those who have recovered from calcaneus fracture; either patient is given surgical or nonsurgical treatments. The research literature abounds with the pleasing characteristics of shoehorns but it has never been questioned whether such types of apparatus are suitable for those who have recovered from serious calcaneus fractures

A live experience of a heel bone (calcaneus) fracture came to our knowledge. A man having a long-time healed up calcaneus fracture went to purchase a shoe. He selected a shoe and asked for a trial walk. By gently placing the shoe horn at his heel bone (calcaneus), the salesman helped him with stepping his foot smoothly inside the shoe. The struggles for inserting the heel bone into the shoe with the shoehorn caused severe pain in the customer's foot. In medical examination of the foot it was found that the use of shoehorn caused a new dislocation of the healed calcaneus fracture. Thus by employing inductive approach we assume that the use of shoehorns for those who have suffered from calcaneus injuries should be considered with great deliberation. The design and material of shoehorns should be re-evaluated. The designers should know not only the mechanism of foot-shoe insertion but they should also have good knowledge of the foot anatomy and especially fractures. Therefore, there is a need of improvement in shoehorn design and its usage.

In the known history of mankind, the shoe horns first originated in the 15th century. They were usually manufactured from the horns of the animals and later till now from a variety of materials. Nowadays, for example wood, plastic and metals are used for shoehorn manufacturing. A shoehorn is an apparatus that helps in inserting the foot smoothly into a shoe. It provides support to the heel bone in slipping inside the shoe without damaging the back counter and stiffener of the shoe. The shoes are handled carefully by the sales staff at shops. Sales staff offer a trial walk to their customers. For a smooth insertion of the foot, they mostly use shoehorns. On the other hand, most of the people, irrespective of their origin, have their own shoehorns at home as well. They feel at ease when putting on their shoes and boots with the help of shoehorns. A number of patents for shoehorns are available on the internet.

The fractures of calcaneus usually occur in industrial environments (R Sanders, 2000). It is the most frequently fractured tarsal bone in the human body. The other major causes of fracture might be a motor crash, imbalance landing from fall or a terrible incident. Whatever the causes and chances of this heel bone (calcaneus) fracture are, it takes three to five years for a complete recovery (Aaron, A. D, 1990). The symptoms of calcaneus fracture are pain, inability to put pressure on foot, swelling and heel bone deformity. The orthopaedic surgeons confirm the type and nature of fractures through X- rays and computed tomography (CT) scans of the foot. The surgical and nonsurgical treatments are recommended after a thorough examination of the injury. The orthopaedic doctors usually recommend nonsurgical treatments for non-displaced calcaneus bone (R Sanders, 1990). The fractures of calcaneus affect the biomechanics of the whole body.

R Sanders - The Journal of Bone & Joint Surgery, 2000, Current Concepts Review-Displaced Intra-Articular Fractures of the Calcaneus

9.20 Appendix Curriculum Vitae

MgA. Ing. Naveed Anwar

PERSONAL INFORMATION

Permanent Address: House No:3 Block G/2 M.A Johar Town, Lahore Pakistan

Current Address: Hall nam. T.G. Masaryka 3050, 760 01, Zlin Czech Republic

Pakistan: +92 3009423260 | **Czech Republic:** +420 778825629

Personal: naveed.utb@gmail.com

Skype: naveed297

Sex Male | Date of birth 29th July 1974 | Nationality: Islamic Republic of Pakistan

Occupation: Technical FW Designer / Researcher & Teaching in Higher Education

Accomplishments

- Twelve years of research and development experience in the area of safety or non-safety footwear and study abroad at Adidas group, headquarter Germany.
- Eight years of educational experience in the field of technical footwear design development & technology.
- Member of the Czech podiatry association “foot care”.
- Appointed assistant professor & head of department at University of fashion and design.
- Researched, developed, and delivered on time 4 years footwear design & leather accessories curriculum.
- Experienced as a product developer, creative designer & chief buyer at bata international.
- Appointed as a designer / pattern engineer at dubarry of Ireland.
- I have covered and study of primary grounding ESD standard EN 61340-4-3:2002, EN ISO 17249 and fighter standard: EN 15090:2012 EN ISO 20345:2011 to 20347:2012 and EN ISO 13287:2012.

Professional Experience

PhD. Scientific Researcher - Tomas Bata University, Zlin CzechRepublic. ▪ Oct, 2013 – 2017

- Researching on safety & non safety footwear design innovation in the environmental health care

Pedorthist/ Footwear Specialist –My Foot care Ltd, ▪ Nov, 2010 – October, 2013

- Acquisition of footwear modification and rectification of anthropometric data.
- Casting and measuring for custom made safety footwear and custom made orthotics.
- Material selection and fabrication.
- Fitting and adjusting orthoses.
- Fitting and modifying standard and orthopedic safety footwear.
- Accommodating/ incorporating complementary assistive devices.
- Fabrication of Pedorthic devices.
- Device structural evaluation.
- Foot Biomechanics.

Assistant Professor/Head of Department - University of Fashion Design, ▪ Nov, 09 – 13

- Developed, researched, and delivered on time 4 years footwear design & leather accessories curriculum.
- Make an active contribution to the Institute's strategic development. I have played a full part in institutional activities. Represented and promoted the interests of the Institute. Under the direction of the Vice-Chancellor to lead and manage the department so that it makes a significant contribution to the operation and strategic development of the faculty and institute, and to contribute to the management and direction of the faculty by working in partnership with other senior staff and external companies.
- Undertake specific cross faculty roles such as being an associate dean where appropriate. To represent the department at meetings and other committees, working parties and groups of the University as required. Lecturer of the subject called drafting.
- Taught manual footwear pattern engineering and on the CAD / CAM 2d & 3d Software system.

Product Developer as Creative Designer/ Chief Buyer/ Brand Manager - Bata International, ▪ June, 2006 – December, 2010

- I have technical and practical experience, knowledge of technical development of uppers engineering for safety and non-safety shoes. Design of a high quality and efficient production process for uppers with suppliers. Setting up of an effective process and quality control of uppers with suppliers. Follow-up and introduction of technical and design proposals for improvement of upper materials and construction.
- I have experience in supervision of test production of uppers during the development process. Ensuring the proper and timely testing of material and construction.
- I have cooperated with the Bata marketing department and other departments in many projects. Worked in Bata as Brand Manager with a full command of brand management knowledge. I have experience in developing brand strategy and statistics systems. Strategic consulting, including business plan & sales strategy development. Advising new businesses on formation of corporations and business structures, drafting privacy policies and structuring commercial transactions. Planning and Implementation of Promotional campaigns. Nurturing brand with different promotions and advertisements in all seasons and occasions.
- Planning on buying OTB, SKU, PD1, PD2 Doc etc. Strategic yearly plan for sales of the brand.
- Planning for advertisements and promotional campaign. School shoes, seasonal launching planning. In season and off season sales plan and inventory planning.
- Forecasting of in season and off season sales. Planning of seasons, promotion strategies, etc.
- Moreover, to that I have worked for Bata International as creative designer and used ShoeMaster CAD/CAM which was linked with the Bata Indonesia.

  - Designer/Product Developer – Midas Footwear Ltd UK, ▪ October, 2003 – December, 2004
    Designed and developed S/s & A/w shoe range collection.
    Outsource, manufactured and materials from Asian countries such as China/ India/ Bangladesh.

  - Technical Designer/ Pattern Engineer – Dubarry of Ireland, ▪ June 2001 – October 2002
    Design and developed shoe range for sub-brands.
    Designed country boots, sailing boots, deck shoes, aqua sport, casuals, comfort, and formal styles.
    Pattern-grading on CAD/CAM, helped develop lasts and soles calculations of area consummation, coordinate activities design department and member of the management team.

  - Designer/Pattern maker – Footlib Limited, June ▪ 1994 – June 1995
    Copied and approved samples from customers abroad, developed pattern/grade sizes and technical development till production and manufacturing.

- ➢ Training Designer/ Pattern Cutter – Firhaj Ltd (Hush puppies manufactures), June ▪ 1993 – 1994. Copied and approved samples from customers abroad, developed pattern/grade sizes and technical development till production and manufacturing.

Programming and Software Skills

Footwear 2d/3d Cad/Cam Distributor – USM International Ltd, Leicester UK & Crispin systems Ltd (Delcam) Birmingham, UK, ▪ January, 2005 – June, 2006

- Expert in ShoeMaster 2D & 3D footwear design Cad/Cam software from Torielli Italy.
- Expert in Crispin Dynamic, UK (Del Cam) 2D & 3D Cad/Cam Footwear Design Software.
- Expert in USM United Shoe Machinery UK, Ltd 2D & 3D Cad/Cam Software for Footwear Designer
- I'm Computer literate with experience in graphic design software as Coral Draw, Tex Design, Adobe Photoshop, Premiere, Director, Flash, Professional Dexis Image Modeller, and Magix Video & Music Maker and Rhinoceros 3D, Design CAD/CAM Software.

Education

- 1992-1993: S.D.M footwear designing & modeling, diploma obtained- Pakistan
- 1995-1997: B.TEC H.N.D product design “footwear” higher national diploma obtained- UK
- 1997-1998: H.A.D footwear design cad/cam higher advanced, diploma obtained- UK
- 1998-2000: B.A Bachelor of arts hon’s footwear design technology, degree obtained- UK
- 2000-2001: M.A Master of arts in design & manufacture “footwear” degree obtained- UK
- 2014-2014: Footcare Czech Podiatric Society, diploma obtained- 2013- CZE
- 2014-2014: Congress Diabetic & Orthopedic foot, diploma obtained- 2014- CZE
- 2013-2016: PhD. Scientific research “safety footwear design innovation”, pending- 2013-2016- CZE

Certificates

- GCSE school (Matic) in science 1990, obtained- Pakistan
- E.L English language 1991, obtained- Pakistan
- L.C.C Pre intermediate English course- London 1998, obtained- UK
- Product design & drawing technique- London 1998, obtained- UK
- Business & retail merchandising- London 1998 obtained- UK
- Master business administration (Marketing) - London 1998, obtained- UK
- Bata WMS brand & merchandising management 2007, obtained- India
- Examination of the feet “podiatry”-1 2013, obtained- Czech Republic
- Professional conference, diabetic feet 2014, obtained- Czech Republic
- Examination of the feet “podiatry”-2 2014, obtained- Czech Republic
- Foot biomechanics of the “Superfeet insole” USA 2014, obtained- Czech Republic
- Diagnosis & analysis plantar fascia Tekscan USA 2014, obtained- Czech Republic

Awards Received

While studying in the United Kingdom, I received the first prize in the Footwear Millennium Design Competition held at De Montfort University, Leicester United Kingdom. I was also selected for the New Designer Exhibition in London, United Kingdom.

Conferences & Workshops Attended

2015 Study abroad program by Tomas Bata University in, Zlin at adidas group headquarter, Germany
2015 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic
2014 Footwear Health Tech & Future Footwear Materials Conference, Eindhoven, The Netherlands
2014 Czech Podiatry Association congress 2 Days, Léčebné lázně Bohdaneč, Masarykovo CZ
2014 Superfeet Insloe Workshop for Footcare Patients, Zlin CZ with Ing. Milan Borsky
2014 Orthopedic Foot Care experience Workshop- Plzen, CZ with Milan Sagl (Jednatel)
2014 Tekscan Workshop-Pressure Mapping for Patient Care, Zlin CZ with Ing. Milan Borsky
2014 Diabetic Foot Care Conference 2 Days, Sanatoria Klimkovice Czech Republic.
2013 Examination of feet in pedicure experience-Ostrava, CZ with (MUDr.Marie Součková)
2011 Footwear & Accessories 2 Week Workshop in Modapelle Academy Milan, Italy
2011 Teaching Training Program 3 months' workshop with German consultant Mr. Lenschow at Pifd
2010 Curriculum Development, 6 months' workshop with German consultant Mr. Lenschow
2009-2010 Design & Development 6 month's workshop with German consultant Mr. Lenschow at Pifd.
2009 Ladies Hand Bags 5 week workshop with German consultant Mrs. IIdiko Zrinyi
2008 Foot Reflexology 3 weeks' workshop Yiwu, China
2002 Orthopedics Foot Care 6 months' workshop, Ballinasloe Co. Roscommon, S.Ireland

Exhibition & Fair Visited

2014 International Expo Riva Schuh fair for footwear sector Riva del Garda, Italy.
2014 International trade fair AUTOMATICA Munich, Germany
2014 Budapest International Leather and Shoe Fair, Hungary
2011 Lineapelle Footwear & Accessories Fair Bologna, Italy
2010 Shanghai Expo, China
2008 Juft Pakistan Footwear Exhibition Lahore, Pakistan
2005 Fashion & Accessories Exhibition, Guangzhou, China
2004 Pakistan Expo, Karachi, Pakistan
2002 Footwear Fair, NEC Birmingham, United Kingdom
2001 Shoe Fair, GDS Dusseldorf, Germany
2000 Leather & Footwear Fair, GDS Dusseldorf, Germany

References

- Ing. Milan Borsky (Managing Director) Proteching B
  Trida T. Bati, Areal Svit, 44 Budova Zlin, Czech Republic
  Tel: +420577524138 e-mail: info@proteching.cz

- Doc. MgA. Petr Stanicky (Director) Tomas Bata University in, Zlin
  Institute of Spatial and Product Design, Faculty of Multimedia Communications
  T. Bati 4342, 760 01, Zlin Czech Republic
  Tel: +420576036411 e-mail: pstanicky@gmail.com

- Mohammad Qayyum (Managing Director) Bata Pakistan Ltd
  Bata Pakistan Ltd Batapur G.T Road, Lahore, Pakistan
  Tel: +92 111044055 Ext 113 e-mail: bata@bata.pk.com

- Dr. M. Luqman Masood (Director) Audit & Account Audit and Account Training Institute, Lahore, Pakistan Mobile: +923009427220 e-mail: luqman24@gmail.com

Naveed Anwar, MgA. Ing
(Member of Czech Podiatry Association)

Vliv konstrukčního a materiálového řešení obuvi, pro prevenci bolesti v oblasti paty

An Investigation into Shoe Style for Prevention of Heel Pain

Doctoral Thesis

Published by: Tomas Bata University in Zlín,
nám. T. G. Masaryka 5555, 760 01 Zlín.

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