



**ELTEN**

WHITEPAPER

# **PROTECT THE HEALTH OF YOUR EMPLOYEES AND YOUR WALLET WITH PROPERLY FITTING SAFETY FOOTWEAR**

**HEALTHY FEET, HEALTHY EMPLOYEES, HEALTHY WALLET**

# LIST OF CONTENTS

|  |           |
|--|-----------|
| <b>1. WHAT THIS WHITEPAPER IS ABOUT</b> .....                  | <b>02</b> |
| <b>2. THE CONSEQUENCES OF THE WRONG FIT</b> .....              | <b>03</b> |
| <b>3. PROTECT FEET AND SAVE CASH!</b> .....                    | <b>04</b> |
| <b>4. HOW PERFECTLY FITTING SAFETY FOOTWEAR CAN HELP</b> ..... | <b>06</b> |
| <b>5. SUMMARY</b> .....  | <b>10</b> |

**ELTEN** GmbH  
Ostwall 7 – 13 | D – 47589 Uedem  
PHONE +49 (0) 2825 8068 | E-MAIL [service@elten.com](mailto:service@elten.com)  
Author: Sabrina Sigmund | [sigmund@elten.com](mailto:sigmund@elten.com)  
**[WWW.ELTEN.COM/EN](http://WWW.ELTEN.COM/EN)**

## 1. WHAT THIS WHITEPAPER IS ABOUT

No footwear is worn so long and frequently as safety shoes. In industry, trade or on the building site, safety footwear is worn for several hours every day, but what is the point if they are uncomfortable and fit badly? The main thing for safety footwear that is used for several hours every day is a proper fit! If they are too loose or too tight, they just become an additional burden for the wearer. If blisters, inflammations or chronic pressure points develop they have an effect on well-being. Ill-fitting footwear often leads to incorrect posture that can in turn cause permanent complaints such as knee problems or backache. The consequences: The performance and concentration of the shoe wearer decrease – while the risk of accidents increases.

The comfort of safety footwear for the wear thus has a direct influence on occupational safety within a company.

This whitepaper aims to examine the importance of properly fitting safety footwear in the workplace. We will examine the potential risks and dangers associated with ill-fitting safety footwear. Based on several studies we will make it clear how important it is for workers to have properly fitting footwear at work, and the personal and financial consequences if this is not the case. The wrong footwear can lead to severe consequences in the long run – for workers and employers alike.

## 2. THE CONSEQUENCES OF THE WRONG FIT

Some studies conducted in the past show that it is often difficult to find shoes that fit perfectly. In a study conducted by the Clinic and Polyclinic for Orthopaedics at the University of Bonn in cooperation with Tecmath AG in Kaiserslautern, 46 women's feet were examined to demonstrate that there is no proportionality between forefoot width and foot length. In conclusion, the study showed that there is relatively high variance in feet of the same length, width and circumference. Accordingly, providing shoes made with standard lasts cannot be considered sufficient.<sup>1</sup>

Another study with 20 test persons, whose feet were measured with a 2D scanner on the one hand and who were asked to evaluate the fit of four different shoe models on the other hand, showed that there are already significant differences of one shoe size in the forefoot and hindfoot area. The respective shoe lasts were measured and compared with the measurement results of the feet of the test persons. This led to the conclusion that especially in the forefoot area, in all models tested the shoes were narrow compared to the feet measured.<sup>2</sup>

In order to characterise certain foot types and thus to ultimately improve the accuracy of fit of safety shoes, Christian Hofgärtner dedicated his doctoral thesis at the Medical University Clinic and Polyclinic in Tübingen to evaluating the foot measurements of industrial workers.<sup>3</sup> The questions he raised were: Is it possible to characterise certain foot types, which would enable the footwear industry to improve fit? Are industrial jobs associated with abnormal foot positions or foot complaints that are connected with the type of foot protection they wear? A total of 517 male industrial workers took part in his study.

The evaluation of the foot measurements of the industrial workers in this study showed that it is not possible to meet the requirement of being able to offer perfectly fitting safety shoes with only one model per foot width and shoe size. With a large number of foot measurements of one shoe size, the measurements varied, in some cases considerably. Foot typing proved the need to distinguish between three types with different ball widths, ball or toe lengths, ball angles and heel widths.

### THREE FOOT TYPES

A cluster analysis resulted in the following three foot types:

- **FOOT TYPE 1:** Short toes, Wide ball and heel area, Steep ball angle
- **FOOT TYPE 2:** Long toes, Medium-wide ball and heel area, Flat ball angle
- **FOOT TYPE 3:** Medium-sized toes, Narrow ball and heel area, Medium ball angle

<sup>1</sup> Schmitz A., Gäbel H., Schmitt O.: Variability in foot shape and shoe fitting-a 3D study. *Othopaedic Practice*, 2001. Pages 609-612.

<sup>2</sup> Cf. Witana C.P., Feng J., Goonetilleke R.S.: Dimensional differences for evaluating the quality of footwear fit. *Ergonomics*, 2004. Pages 1301-1317.

<sup>3</sup> Hofgärtner, C.: Evaluation of the foot measurements of industrial workers by means of 3D scanning with special consideration of foot malpositions. Doctoral thesis at the University Hospital and Polyclinic Tübingen, 2007.

The three foot types were then compared with some lasts used in safety footwear construction. The comparison showed clear deficits in the fit. An excessively long ball length, an excessively flat ball angle and an excessively narrow ball width narrowed the feet of the test subjects in the forefoot area and impeded the natural rolling behaviour of the feet. A clinical examination of the feet made it possible to

confirm the effects of ill-fitting footwear. The formation of calluses on the big toe in almost 50% and on the little toe in almost 30% of all those examined, as well as a percentage of hallux valgus in over 26%, make a correlation with too tight shoes very probable. Frequently, other foot deformities such as splayfeet, flat feet and hollow feet were also detected.

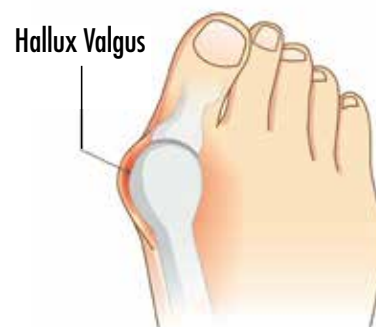
### 3. PROTECT FEET AND SAVE CASH!

As the studies presented here illustrate, poor positioning of the foot in the shoe and shoes that are too tight are the main triggers of multiple complaints. A poor fit often results in foot deformities or other foot diseases. Shoes that are too short in length and too tight, especially in the forefoot area, are often the cause of hallux valgus (= crooked toe). The more pointed the shoe in the toe area, the more the toes are squeezed together. Furthermore, the feet slide forward step by step in the footbed, which often provides no support, leading to a

compression of the toes, which in the long run promotes the development of hallux valgus.<sup>4</sup> Apart from obesity and ligament weakness, inappropriate footwear and standing for long periods without moving the feet play a major role in the development of splayed, flat and hollow feet. In view of the prolonged and monotonous movement sequences of employees in industry and trade, an optimal fit is particularly important in this respect.

#### HALLUX VALGUS

Hallux valgus – also referred to as a bunion – is a common deformity of the big toe (hallux). It often occurs on both feet at the same time. This causes the big toe to bend beyond its normal position at the base joint towards the outside of the foot, while the tip of the big toe points inwards and displaces or overlaps the second toe (valgus position).

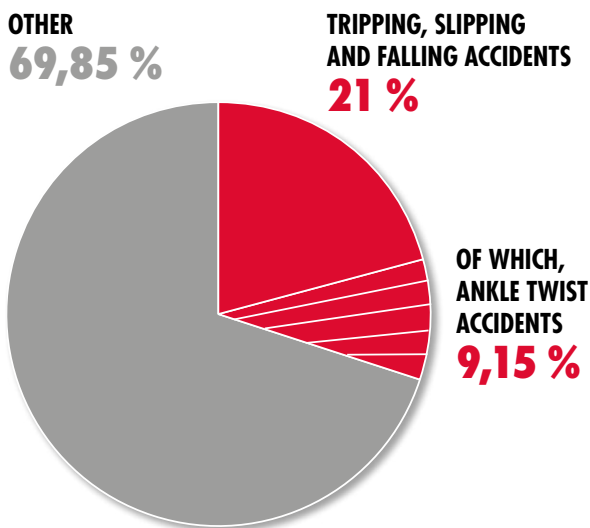


<sup>4</sup> Vgl. Mayo Clin Health Lett.: What is a hammer toe, and what causes it? Mayo Clin Lett, 2002.

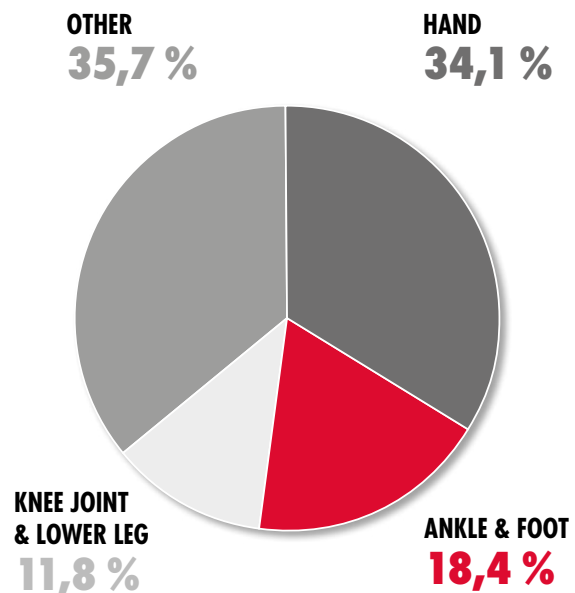
Pain in the musculoskeletal system can quickly lead to a lack of attention at the workplace. The painful foot distracts and blocks the timely and correct reaction to dangers. The employee gets tired more quickly, which reduces their ability to focus and they are no longer able to work to their full potential. In addition, medicines that are taken to prevent foot pain can reduce the ability to assess risks, which means that hazards are not recognised and avoided. The ability to react deteriorates, and tripping, a twisting of the ankle or a misstep is more likely to lead to an accident.

According to the DGUV publication ‚Arbeitsunfallgeschehen 2019‘ (Occupational Accidents 2019), the number of reportable occupational accidents due to slipping, tripping or falling (STF accidents) in 2019 came to a total of 169.538 cases. In the reporting year, there was a total of 780.581 reportable occupational accidents, with foot injuries accounting for 143,729 cases. A great number of injuries can be prevented by using the right safety footwear.

### TOTAL NUMBER OF REPORTABLE ACCIDENTS AT WORK



### DISTRIBUTION – OCCUPATIONAL INJURY PENSIONS



STF accidents and foot diseases are not only painful for the worker but also are costly for the company. The Federal Institute for Occupational Safety and Health has published a brochure on the economics of health and safety at work. Regarding the costs for each day of incapacity to work, it states: „On average, each day of incapacity to work in 2018 resulted in production loss costs of around 119 euros. In small and medium-sized enterprises, with a high level of staffing, especial-

ly in many small trade and service enterprises people are even more important – and also more expensive when they are absent from work. Depending on the type of trade and the size of the company, the Chambers of Skilled Crafts estimate the costs for a day of sick leave at around 200 to 400 euros. This is because, unlike in larger production companies, there are no staff buffers in these companies, the work is left undone or is done later, which has an impact on the annual

<sup>5</sup> Federal Institute for Occupational Safety and Health. With safety more profit - Economic efficiency of health and safety at work. BAuA, 2018.

<sup>6</sup> Cf. Federal Institute for Occupational Safety and Health. With safety more profit - economic efficiency of health and safety at work. BAuA, 2005.

turnover or affects customer satisfaction.”<sup>5</sup> The incapacity of staff for work results in considerable production losses, as also illustrated by the chart on the following page. In 2018, illnesses of the musculoskeletal system led to a loss of production in Germany worth around 18.5 billion euros. Injuries, poisonings and other illnesses amounted to around 9 billion euros. Consequently, health and safety play an important role in securing the future of every company, as success is particularly dependent on the experience and qualifications of each individual employee. As a rule we can say that only healthy and satisfied employees are motivated, committed, capable and willing to perform. Health and safety pay off. As an example, a long-term study in the USA found that over a period of 50 years, the

turnover achieved by employee-oriented companies (so-called visionary companies) was over 15 times the market return.<sup>6</sup>

The actual economic damage from workplace injuries, however, is not just a loss of wages or time. The costs for ongoing medical treatment, lost production and increased workers’ compensation payments are among the most evident and measurable aspects. In addition to this, however, there are also hidden costs. While these are more difficult to measure, an increasing rate of work-related injuries can lead to higher levels of stress or tension among employees and potentially impair both their morale and productivity.

#### PRODUCTION DOWNTIME COSTS BY DIAGNOSIS GROUP 2018

| ICD 10               | DIAGNOSIS GROUP  | DAYS OF INCAPACITY FOR WORK |              | PRODUCTION DOWNTIME COSTS |                                 | LOSS OF GROSS VALUE ADDED |                                 |
|----------------------|--|-----------------------------|--------------|---------------------------|---------------------------------|---------------------------|---------------------------------|
|                      |  | Million <sup>1</sup> €      | %            | Billion €                 | FROM GROSS NATIONAL INCOME<br>% | Billion €                 | FROM GROSS NATIONAL INCOME<br>% |
|                      |  |                             |              |                           |                                 |                           |                                 |
| F00 – F99            | Psychological and behavioural disorders                      | 111,8                       | 15,8         | 13,3                      | 0,4                             | 22,8                      | 0,7                             |
| I00 – I99            | Diseases of the circulatory system                           | 35,1                        | 5,0          | 4,2                       | 0,1                             | 7,2                       | 0,2                             |
| J00 – J99            | Diseases of the respiratory system                           | 103,7                       | 14,6         | 12,4                      | 0,4                             | 21,2                      | 0,6                             |
| K00 – K93            | Diseases of the digestive system                             | 34,2                        | 4,8          | 4,1                       | 0,1                             | 7,0                       | 0,2                             |
| M00 – M99            | Diseases of the musculoskeletal system and connective tissue | 155,0                       | 21,9         | 18,5                      | 0,5                             | 31,7                      | 0,9                             |
| S00 – T98, V01 – X59 | Injuries, poisoning and accidents                            | 75,3                        | 10,6         | 9,0                       | 0,3                             | 15,4                      | 0,4                             |
| all others           | Remaining diseases   | 193,2                       | 27,3         | 23,1                      | 0,7                             | 39,5                      | 1,1                             |
| <b>I – XXI</b>       | <b>All diagnosis groups</b>                                  | <b>708,3</b>                | <b>100,0</b> | <b>84,5</b>               | <b>2,5</b>                      | <b>144,7</b>              | <b>4,2</b>                      |

Rounding errors

<sup>1</sup> The data presented here were corrected in September 2020.

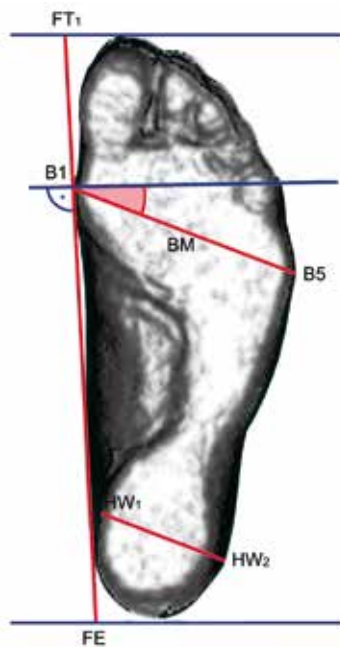
## 4. HOW PERFECTLY FITTING SAFETY FOOTWEAR CAN HELP

The safety footwear manufacturer ELTEN has recognised the importance of suitable footwear in relation to occupational safety and is working constantly towards improvements, for example in the area of fitting. Although other manufacturers also try to solve the width problem by adding or removing volume, they do not offer individual fit solutions.

To overcome the problem in the long term, manufacturers need to offer individual foot type solutions. In the search for the perfect fit, ELTEN has worked in cooperation with researchers at the University Hospital of Tübingen – under the direction of Prof. Dr. Stefan Grau and Dr. Bettina Barisch-Fritz – in the development of custom-fit safety footwear. In doing so, they have studied the anatomy of the foot and biomechanics

and taken the natural movements of the human gait into account in the development of the shoes. In an initial field study in 2005, the static foot data of 1,000 industrial workers were recorded. The measurement campaign revealed that the feet of adults differ not only in length and width, but also in toe length, heel width and the angular position of the ball of the foot. Based on the over 25,000 individual datasets collected in the study, the researchers developed three corresponding types of fit. The new lasts – three variants per size – take into account not only the length and width of the foot, but also the toe length, the heel width and the angular position of the foot. The result is the Ergo-Active safety footwear range with individual and significantly more comfortable fits.

### ERGO-ACTIVE



|                                   |             |
|-----------------------------------|-------------|
| FE - FT <sup>1</sup>              | Foot length |
| B <sup>1</sup> - FT <sup>1</sup>  | Toe length  |
| B <sup>1</sup>                    | Ball width  |
| BM                                | Ball angle  |
| HW <sup>1</sup> - HW <sup>2</sup> | Heel width  |
| HW - HW <sup>2</sup>              | Heel angle  |

#### TYPE 1



For strong feet  
Short toes  
Wide ball and heel area  
Steep ball angle

#### TYPE 2



For normal feet  
Long toes  
Medium-wide ball and heel area  
Flat ball angle

#### TYPE 3



For slim feet  
Medium-sized toes  
Narrow ball and heel area  
Medium ball angle



## THE ADVANTAGES OF ERGO-ACTIVE AT A GLANCE

### ERGO-ACTIVE ...

- ... is geared to the individual needs of the wearer.
- ... gives the foot support and guidance.
- ... improves personal wearing comfort.
- ... promotes foot health through an optimised fit.

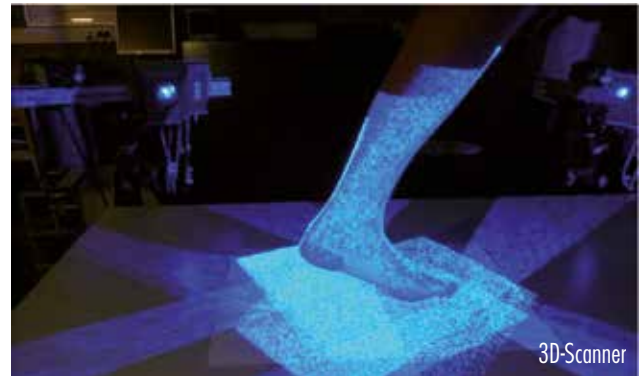
The researchers and product developers were not satisfied with the newly gained knowledge of the three different fits. They reached the conclusion that they could make safety footwear even more comfortable to wear if they analysed the feet in motion and then took the findings into account when designing the shoes. The central questions they pursued in a second biomechanical study were: How does the foot change shape in motion when walking, bending or kneeling? Does the shoe still offer enough space or is the foot cramped at crucial points?

In a doctoral these at the University of Tübingen (explained at the beginning of the whitepaper), the possibilities of a dynamic 3D scanner newly developed by the Chemnitz company Vialux had already been

On behalf of ELTEN, in 2017, Grau and Barisch-Fritz and their team used this technology to measure over 1,000 feet of people working in automobile production and industrial workplaces. For this purpose, employees of the sports medicine department in Tübingen set up the dynamic foot scanner at selected locations. The scanner was used to create a 3D image series of the feet in motion.

The evaluation of the results showed that the foot lengths and certain widths of all test persons increased during movement. Other measurements, such as the size of the back of the foot, however, became smaller. In addition, large individual differences were found, with average differences of up to 30%. The evaluation

examined. This makes it possible to measure the foot three-dimensionally in dynamics, and in turn makes it possible to record precisely the classical measurements on the foot as well as changes in volume in the step.



also took into account various factors that influence the dynamic shape of the foot, such as age, gender and weight. For practical purposes, this is additional information that is incorporated into shoe, last and insole construction and was implemented for the first time in the Ergo-Active foot protection concept.

ELTEN has responded to the detailed and extensive measurements. The existing Ergo-Active multi-wear concept has been further developed and expanded. Starting points for this were, for example, the addition or removal of volume at the ball point and a change in the ball angle. The result is Ergo-Active 2.0 – with three optimal fits, including during movement.



**ERGO-ACTIVE 2.0****TYPE 1****Motion optimized fit**

For strong feet  
Short toes  
Wide ball and heel area  
Steep ball angle

**TYPE 2****Motion optimized fit**

For normal feet  
Long toes  
Medium-wide ball and heel area  
Flat ball angle

**TYPE 3****Motion optimized fit**

For slim feet  
Medium-sized toes  
Narrow ball and heel area  
Medium ball angle

**A LOOK INTO THE FUTURE**

ELTEN will continue to use the detailed measurements from scientific studies for the development of safety footwear models in order to further improve the fit in the long term – for example by incorporating flexible upper materials into its models. A flexible material optimally compensates for any imbalances during movement, for example in the arch of the foot. The safety shoe can thus widen to a defined extent at the appropriate point, while providing more support at other points. In simpler terms: the safety shoe adapts to a greater extent to the natural movement and expansion of the foot. Different cap widths, different types of outsoles as well as models that are specially adapted to the anatomy of women's feet also contribute to increasing the range of options for wearers now and in the future.

## 5. SUMMARY

In most industrial and trade enterprises, the wearing of special safety footwear is mandatory. As they are by far the most frequently worn shoes by workers, it is especially important for these shoes to ensure a perfect fit. Due to the demands placed on them, they are of great importance in injury prevention and play their part in occupational safety within a company. On the one hand, precisely fitting shoes are important to minimise the risk of accidents caused by aching feet. On the other hand, properly fitting foot protection can alleviate foot complaints, prevent foot diseases and deformities and relieve the strain on the intervertebral discs and back in the long term. This is ideal for long periods of standing or walking, as is often the case in the majority of workplaces in industry, trade and construction. In view of the interaction between the musculoskeletal

system of the shoe wearer and his/her working environment, ergonomic footwear design is important because it aims to minimise risk factors of disease or injury. Other goals are to increase efficiency and comfort. Safety footwear manufacturer ELTEN became familiar with ergonomic design principles from an early stage and worked with scientists and product developers to develop the Ergo-Active and Ergo-Active 2.0 shoe ranges. This led to the development of a new generation of individual high-tech safety footwear that meet today's growing ergonomic requirements and offer wearers an additional plus in safety and comfort. Let us conclude with Prof. Dr. Stefan Grau's words: „Improving safety footwear fit will support workers' health in general, as well as support safety prevention at the workplace“.<sup>7</sup>

### HOW TO RECOGNISE THE RIGHT FIT:



<sup>7</sup> Barisch-Fritz, B., Grau, S.: Improvement of safety shoe fit - evaluation of dynamic foot structure. Footwear Science, 2018. Pages 1 – 9.