

ERGONOMICS FOR THE FEET

DESIGN IN THE COMFORT – DESIGN OUT THE DANGER



“designing footwear for a particular application and for the users’ comfort is of utmost importance”

Welcome to the world of Product, Process and Equipment Design and the need for Applied

Ergonomics - especially in footwear design. One of the first things that you need to consider while you are working on the first iteration of product, equipment or process design is the integration of ergonomics and safety.

Whether you are developing a new product, process or piece of equipment, the users’ interface with the new design must be considered. Designing footwear for a particular application and for the users’ comfort is of utmost importance.

Standing is a natural human posture and by itself poses no particular health hazard. Working in a standing position on a regular basis, however, can cause

ailments from sore feet to stiffness in the neck and shoulders, and other health problems. These are common complaints that employees who are working as machine/equipment operators, assembly-line workers and others whose jobs require prolonged standing.

These conditions commonly occur where the job is designed without considering the characteristics of the human body. When job design ignores the basic needs of the human body (and individual workers), work can cause discomfort in the short term and can eventually lead to severe and chronic health problems such as rheumatism and arthritis.

Too much walking over hard or uneven surfaces is also a problem for leg and foot discomfort that might lead to an injury. The design of footwear that is

specific to a job design considering the safety aspects and comfort can mitigate the injury potential.

There is an old saying that goes, “When your feet hurt, you hurt all over.”

There are two major categories of work-related foot injuries. The first category includes foot injuries from punctures, crushing, sprains, and lacerations. They account for 10 % of all reported disabling injuries. The second group of injuries includes those resulting from slips, trips and falls. They account for 15 % of all reported disabling injuries. Slips and falls do not always result in a foot injury, but lack of attention to foot safety plays an important role in their occurrence.

Surveys suggest that two out of every three workers suffer from some form of a foot problem. ▶

The type of flooring used in the workplace can also contribute to foot problems and has an important influence on comfort, especially on tender feet. Hard, unyielding floors like concrete are the least comfortable surfaces to work on, while slippery floors are hazardous for slips and falls that can result in sprained ankles or broken foot bones.

Prevention of foot injuries

There is not a workplace where an employee is not exposed to foot injury potential. From hospitals to oil rigs the hazards differ according to the workplace and the types of tasks the employee performs. The first step in developing a strategy to reduce foot problems is to identify the relevant hazards at the workplace. Such hazards should be assessed in each workplace, no matter how safe or how dangerous it may seem.

Actively tackling hazards

The most important goal of job design is to avoid fixed positions, especially fixed standing positions. Good job design includes varied tasks requiring changes in body position and using different muscles. Job rotation, job enlargement and teamwork are all ways to make work easier on the feet.

- *Job rotation moves workers from one job to another. It distributes standing among a group of workers and shortens the time each individual spends standing. It must, however, be a rotation where the worker does something completely different such as walking around or sitting at the next job*
- *Job enlargement includes more and different tasks in a worker's duties. If it increases the variety of body positions and motions, the worker has less chance of developing foot problems*
- *Teamwork gives the whole team more control and autonomy in planning and allocation of the work. Each team member carries a set of various operations to complete the whole product. Teamwork allows*

workers to alternate between tasks which, in turn, reduces the risk of overloading the feet

- *Rest breaks help to alleviate foot problems where redesigning jobs is impractical. Frequent short breaks are preferable to fewer long breaks*

How can the workplace design improve foot safety?

Redesigning the job alone will not effectively reduce foot problems if it is not combined with the proper design of the workplace.

- *For standing jobs, an adjustable work surface is the best choice. If the work surface is not adjustable, two solutions include installing a platform to raise the shorter worker or a pedestal to raise the object for a taller worker*
- *Work station design should allow the worker room to change body position*
- *A foot-rail or footrest enables the worker to shift weight from one leg to the other. This ability reduces the stress on the lower legs and feet*
- *Where possible, a worker should be able to work sitting or standing at will. Even when work can only be done while standing, a seat should be provided for resting purposes*

Examples of workplace foot injuries

Injuries	Common causes
Crushed or broken feet, amputations of toes or feet	Feet trapped between objects or caught in a crack, falls of heavy objects, moving vehicles, conveyor belts
Punctures of the sole of the foot	Loose nails, sharp metal or glass objects
Cuts or severed feet or toes, lacerations	Chain saws, rotary mowers, unguarded machinery
Burns	Molten metal splashes, chemical splashes, contact with fire, flammable or explosive atmospheres
Electric shocks	Static electricity, contact with sources of electricity
Sprained or twisted ankles, fractured or broken bones because of slips, trips or falls	Slippery floors, littered walkways, incorrect footwear, poor lighting

Improving jobs and workplace designs also have the potential to increase foot safety in workplaces that are specifically hazardous. Here are some examples:

- *Separating mobile equipment from pedestrian traffic and installing safety mirrors and warning signs can decrease the number of accidents that might result in cut or crushed feet or toes*
- *Proper guarding of machines such as chain saws or rotary mowers can avoid cuts or severed feet or toes*
- *Effective housekeeping reduces the number of accidents at workplaces. For example, loose nails, other sharp objects, and littered walkways are hazards for foot injury*
- *Using colour contrast and angular lighting to improve depth vision in complicated areas such as stairs, ramps and passageways reduces the hazard of tripping and falling*

Other factors

Flooring can be a source of prevention as well. Standing or working on a hard, unyielding floor can cause a lot of discomfort. Wood, cork, carpeting, or rubber - anything that provides some flexibility - is gentler on workers' feet. Where resilient floors are not practical, footwear with thick, insulating soles and shock-absorbing insoles can alleviate discomfort. Anti-fatigue matting can also be useful wherever workers have to stand or walk. While this provides ►

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cushioning which reduces foot fatigue, use carefully as when installed improperly, it can lead to tripping and slipping accidents.

Special anti-slip flooring or matting can reduce slipping accidents. If installed properly, these mats are useful, but workers may find that their feet burn and feel sore. The non-slip properties of the flooring mat cause their shoes to grab suddenly on the flooring making their feet slide forward inside the shoes. Friction inside the shoes produces heat that creates soreness and, eventually, calluses. A non-slip resilient insole can reduce this discomfort.

Proper footwear is important, not only for foot comfort but also for one's general wellbeing. Improper footwear can cause or aggravate existing foot problems. Unfortunately, being fashionable sometimes takes precedence over choosing well-fitting, supportive safety footwear. Many safety footwear manufacturers, however, produce safety footwear that does look fashionable.

The best way to involve employees in programmes to protect their feet is to provide:

- *Training and information on the health hazards of wearing improper shoes*
- *The principles for selecting proper shoes*
- *The simple rules of general foot care*

How to purchase footwear for working purposes is extremely important. Good footwear should have the following qualities:

- *The inner side of the shoe must be straight from the heel to the end of the big toe*
- *The shoe must grip the heel firmly*
- *The forepart must allow freedom of movement for the toes*
- *The shoe must have a fastening across the instep to prevent the foot from slipping when walking*

- *The shoe must have a low, wide-based heel - flat shoes are recommended*

People buying footwear for work should embrace the following advice:

- *Do not expect that footwear which is too tight will stretch with wear*
- *Have both feet measured when buying shoes - they normally differ in size*
- *Buy shoes to fit the bigger foot*
- *Buy shoes late in the afternoon when feet are likely to be swollen to their maximum size*
- *Ask a doctor's advice if properly fitting shoes are not available*
- *Consider using shock-absorbing insoles where the job requires walking or standing on hard floors*

When selecting footwear, one should remember that tight socks or stockings can cramp the toes as much as poorly-fitted shoes. Wrinkled socks, or socks that are too large or too small, can cause blisters. White wool or cotton socks may be recommended since coloured socks may cause skin allergies in some people.

Employees need to understand the importance of footwear that is properly designed. When considering these strategies to protect foot injury, we have to remember the fundamental principle of occupational health and safety: that occupational hazards should be eliminated at the source.

The role of personal protective equipment is to minimise exposure to specific occupational hazards, not to eliminate them. Protective footwear does not guarantee total protection.

Broadly speaking

Providing adequate protective footwear is an effective protective strategy. By providing approved protective footwear

and requiring its use, the construction industry reduced the frequency of foot injuries by 60 % over the 15 years between 1968 and 1984.

All working footwear, for both men and women, whether it is safety wear or not, should provide comfort without compromising protective value. In addition, protective footwear should conform with all appropriate standards.

- *A steel toecap should cover the whole length of the toes from tips to beyond the natural bend of the foot. A soft pad covering the edge of the toecap increases comfort. If the toecap cuts into the foot, either the size or style of the footwear is incorrect*
- *Soles come in a variety of thicknesses and materials. They need to be chosen according to the hazards and type(s) of flooring in the workplace*
- *Uppers of protective footwear come in a variety of materials. Selection should take into account the hazards, and individual characteristics of the worker's foot*
- *A steel midsole which protects the foot against penetration by sharp objects should be flexible enough to allow the foot to bend*
- *No one type of non-slip footwear can prevent the wearer from slipping on every surface type*

Thermal environmental issues must also be considered. Selection should be made to suit the specific working condition. Working outdoors in cold weather poses a special requirement on selecting the proper footwear. 'Normal' protective footwear is not designed for cold weather. ►

“the role of PPE is to minimise exposure to specific occupational hazards, not to eliminate them”

“lack of attention to ergonomics may also lead to the injury and illness potential of the employee. There are stressors or ergonomics ‘risk factors’ associated with jobs”

‘Insulated’ footwear gives little temperature protection in the sole for it has no extra insulation there. Loss of heat through steel toecaps (commonly blamed for increased heat loss) is insignificant.

Foot protection against cold weather can be resolved by:

- *Insulating the legs by wearing warmers - ‘dancercise’ type*
- *Wearing insulating overshoes over work footwear*
- *Wearing insulating muffs around the ankles and over the top of the footwear*

Working in a hot environment such as those experienced by workers in the Middle East, foot care is especially important as severe problems can occur in these conditions.

Considering that the formation of blisters can be considerably reduced if the feet are kept as dry as possible, care should be provided to reduce the humidity close to the surface of the foot.

Even though a great diversity of so called ‘functional’ socks and ‘breathable’ shoes are available on the market today, there are still a lack of reliable and objective methods to simulate sweating inside the footwear at different levels of metabolic rate, and to measure the resultant temperatures and relative humidities. It is, therefore, difficult to judge or compare different footwear systems (consisting of shoes, socks and inlay soles) and their influence in a variety of climates.

Socks have a major influence on the climatic wearing comfort of footwear systems for extreme environments. Thicker socks will provide a drier foot climate without considerably raising the skin temperature.

It is as important to keep the feet dry and comfortable as it is to attend carefully to the design of footwear in the first place - an activity in which ergonomics play a vital part.

Ergonomics background - a definition

Ergonomics: n: sing or pl: an applied science concerned with the characteristics of people that need to be considered in designing and arranging things that they use in order that those things may be used most easily, effectively, and safely - called also human engineering, human factors engineering. A combination of two Greek words, ‘ergo’ means work, ‘nomos’ means law; the study of the human response to exposure in the work environment; the interaction between humans and the tools, equipment and work methods needed to complete a task; fitting the task to the employee.

The science of ergonomics

Ergonomics is a multidisciplinary science comprised of engineering, mathematics, anatomy, physiology, psychology, biomechanics and anthropometry.

Whatever you are designing, it must fit the person it is designed for. People come in all shapes and size, like or dislike colours, textures, forms and shapes. Consequently, when we design products, factors such as these should be kept in mind. But the most important factor is the fit, a function of anthropometry (the science of human body measurements). One size does not fit all!

If safety glasses slide down and don’t fit the visual field, many employees will not wear them. If hearing protection is uncomfortable, many employees will not wear it - and so on.

Ergonomics is mainly concerned with working out measurements, in order to improve the design of products.

An example for the need of good anthropometrics is seen when feet are measured for footwear. Incorrectly measured feet can lead to the purchase

of footwear that is unsuitable in terms of its size and that can be comfortable and unhealthy to wear. The more data collected relating to feet size, the more shoe designers and manufacturers will be able to produce shoes that are comfortable and healthy for the purchaser.

Musculoskeletal stress and injury

Lack of attention to ergonomics may also lead to the injury and illness potential of the employee. There are stressors or ergonomics ‘risk factors’ associated with jobs. The risk factors for ergonomics are:

- *Awkward postures*
- *Repetitive motions*
- *Excessive forces*
- *Aging*
- *Environmental factors*
- *Contact stressors*
- *Genetics*

These risks when produced as one or combined, can produce cumulative trauma disorders (CTDs) also called musculoskeletal disorders (MSDs), overuse syndrome, repetitive strain injuries, repetitive motion injuries, all of which are subtle and costly injuries and illnesses that can occur over any body part and happen over time. They are described as:

- *Tendonitis - inflammation of a tendon*
- *Tenosynovitis - inflammation of the tendon sheath*
- *Back injuries and low back pain from the neck to the base of the spine sometimes including the legs*
- *Ganglionic cysts - a small cystic tumour containing fluid and connected with a joint membrane or tendon sheath*
- *Carpal Tunnel Syndrome - located in a passage between the wrist ▶*

and hand, it is a condition caused by compression of the median nerve in the carpal tunnel and characterised by weakness, pain and loss of sensation in the hand

- Vibration - hand/arm and whole body
- Contact or mechanical stress - kneeling or leaning against hard or sharp objects; improperly fitting tools

Administrative controls

Some of the considerations for the reduction of ergonomic risk factors offered to engineers are administrative controls. Some examples of the administrative controls are:

- Reducing the total number of repetitions per employee by decreasing production rates and limiting overtime work. This reduces quality problems as well
- Providing rest periods within the job design to allow body parts to rest and recover
- Increasing the number of employees assigned to a job especially during heavy lifting or carrying or in extremes of ambient temperatures
- Providing job enlargements (rotation) which provides a greater amount of jobs using a variety of muscle-tendon groups for the employees instead of using the same muscle groups over and over
- Increasing the number of employees assigned to a task to alleviate risk factors

- Establishing criteria for the maintenance of facilities, tools and equipment
- Ensuring there are no language barriers
- All signage is readily accessible to all employee heights and visual needs

In closing, design in ergonomics is important information not just for the engineers but for the purchasing agents of the company as well. Our most expensive asset is the employee and we need them to continue working safely and efficiently. Ergonomics knowledge is the best tool we can provide throughout a company and job. Tool and equipment designs are integrated throughout this knowledge base to achieve profits and reduced injury potentials. ■

Author

Cynthia Roth has been a professional in the ergonomics industry since 1987.

In 1993 she co-founded Ergonomic Technologies Corp, (ETC), where currently she is the Chairperson of the Board and Chief Executive Officer. She has lectured to the Fortune 500 Companies in the US and abroad and to many international companies. Ms Roth lectures on safety, ergonomics, product designs, future trends, motivating employees, and biomechanics to top engineering universities and colleges around the world.

Ms Roth was elected to the Board of the American Society of Safety Engineers Foundation (ASSEF), served as Vice Chair and Chair and currently

serves on the American Society of Safety Engineers (ASSE) Council on Professional Affairs. She has also been appointed as a permanent member of New York State's Commission on International Trade and has travelled to Brazil, Argentina and Chile on behalf of the State of New York. Ms Roth is a member of the NYC Advisory Board to the Mayor and has also served as a consultant to the Department of Labor, OSHA, Occupational Hazards and CTD News. She represents University of Pittsburgh, as a board member to Fiat Pax (using technology for world peace).

Ms Roth is a published author having written the chapter on Ergonomics for Maynard's Industrial Engineering Handbook, used by the majority of engineering students worldwide, and wrote the Handbook on Ergonomics for the National Safety Council.

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