

A collage of thermal images showing various views of human feet and legs. The images are arranged in a grid-like fashion, with some showing the soles of feet, others showing the sides or tops of feet, and some showing legs. The color palette is dominated by reds, oranges, and yellows, indicating heat. The background is dark, making the warmer colors of the feet stand out.

STANDING SMART

Increasing the comfort of standing workers

By Professor Redha Taiar
Biometrics Engineer at University of Reims, France
www.redha-taiar.com



Table of Contents

- 1. Purpose of the Research**
- 2. Research Methodology**
- 3. How We Stand: Pressure on the Foot**
- 4. Testing**
- 5. Results**
- 6. Testimonies & Conclusions**
- 7. Advice to Workers**
- 8. About the Author: Professor Redha Taiar**



STANDING SMART

Increasing the comfort of standing workers

By Professor Redha Taiar

Biometrics Engineer at University of Reims, France

Purpose of the research

1

The ambition of the research work that we are conducting is aimed at increasing the comfort of users at work by studying the gestural ergonomics and by minimizing the constraints on an articular level in real experimental situations.

Studying the upright position of the human body, the stability of the body and its ergonomics on the job, the adjusting of its segments to maintain its balance and diminishing muscular problems are the main

elements to highlight in order to improve the everyday (working) life of users.

The difficulties accentuated by the users represent major stakes for companies that want to achieve high productivity.

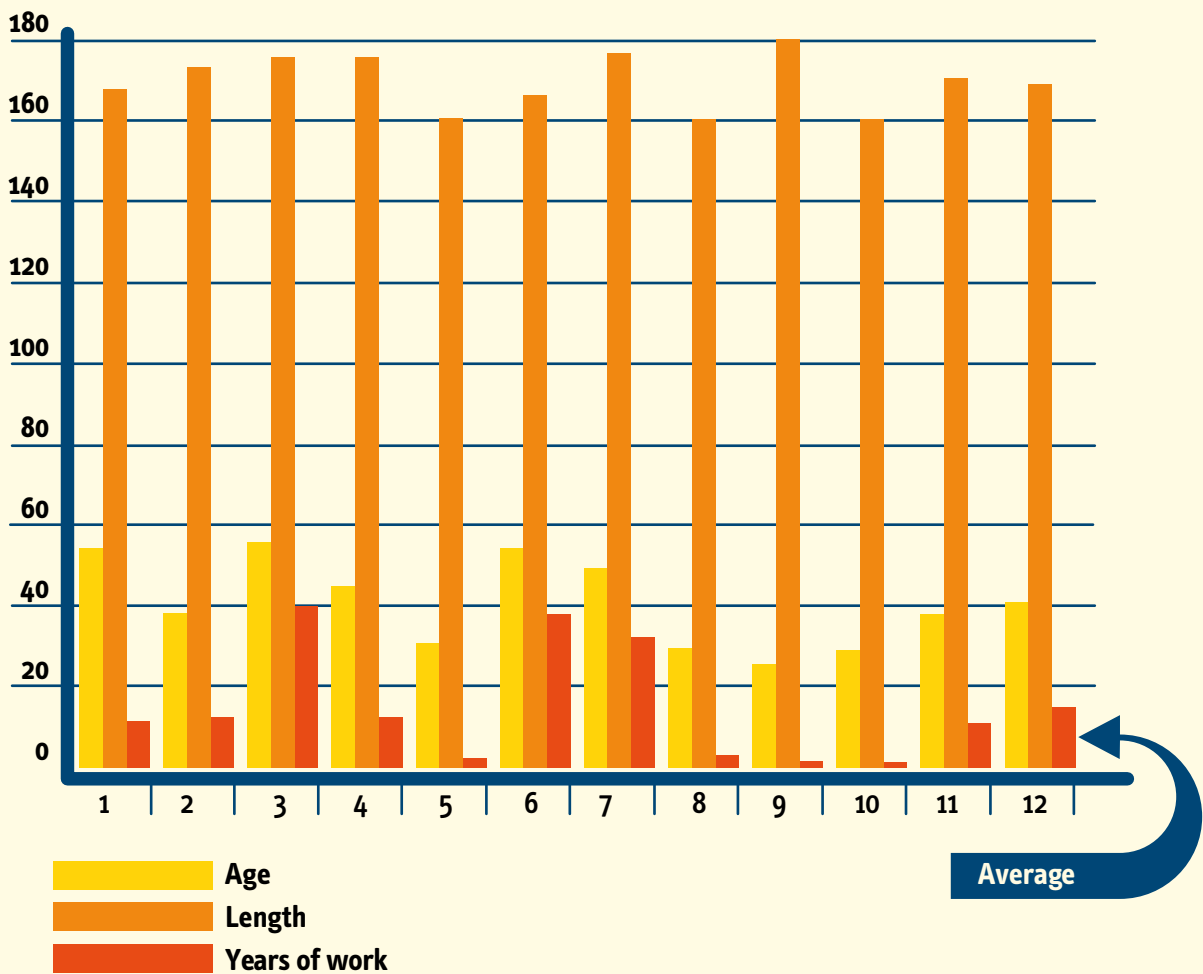
Based on the optimization of new materials, the project consists in validating prototypes destined to improve ergonomics at work and to optimize the comfort of users (new anti-fatigue mats).

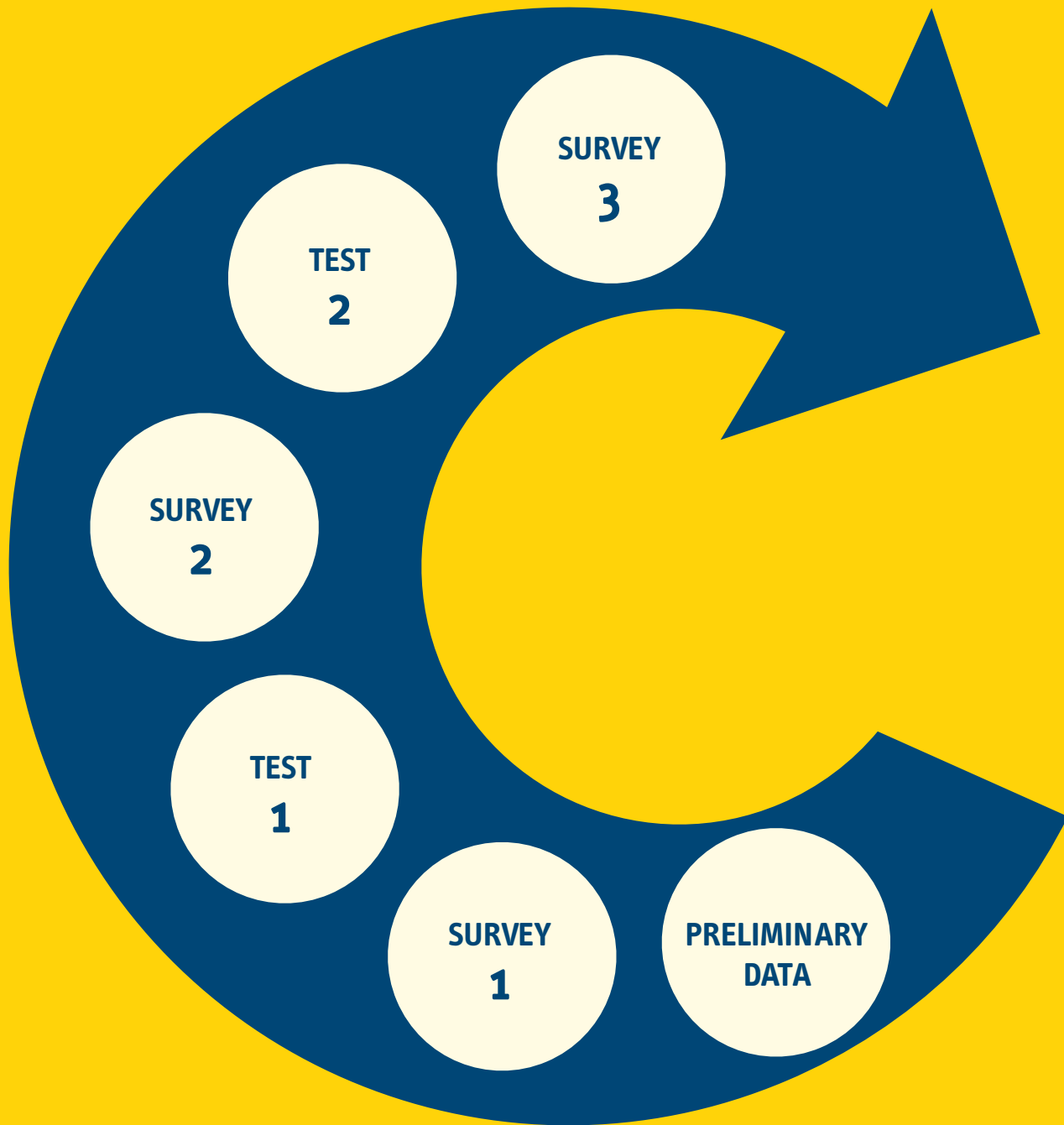
Research Methodology

1. Population
2. Testing Period
3. Testing Equipment
4. Testing Scale

Population

The population of the study counts 10 male and 10 female subjects.





Testing Period

SURVEYS

2010

week 42

Experience of the operators without anti-fatigue mats.

2011

week 2

Experience of the operators with anti-fatigue mats.

2011

week 6

Experience of the operators to determine preference for the type of anti-fatigue mat.

SHIFTS

The shifts involved in the study:

Morning: 8:00 am to 12:00 pm

Afternoon: 13:00 pm to 17:00 pm

Tested after 1, 2, 3, 4, 5, 6, hours of work and at the end of the shift.



Testing Equipment

2

The first measures are done with a pressure platform equipped with 1400 pressure sensors.

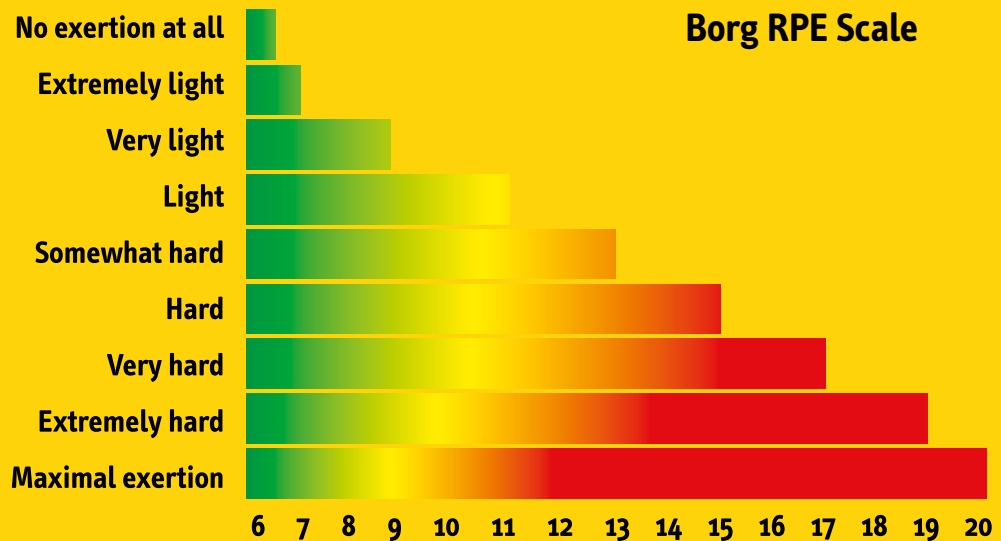
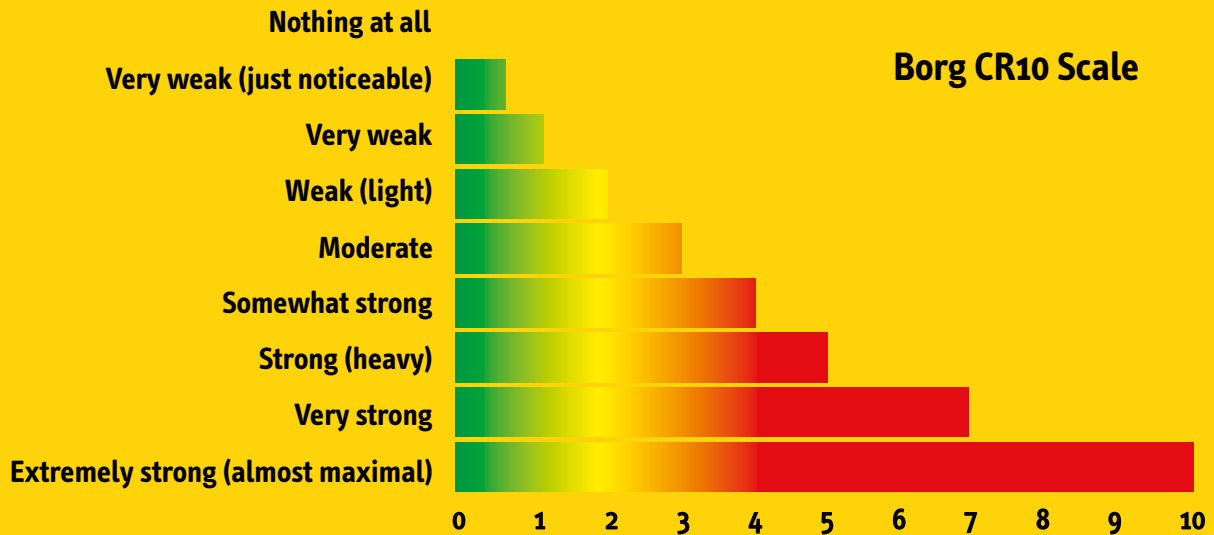
The platform is placed in front of the workstation.

For this test I used a 'Zebris' foot pressure platform.

This platform which contains a large number of sensors will enable us to transcribe the dynamic and static pressure executed by the feet. This pad is equipped with 32 x 47 sensors totalling 1504. One sensor is 1 cm², has a precision of 0,5N/cm² and an acquisition frequency of 60Hz.

Testing Scale of Measurement

The Borg scale to quantify the intensity of the pains



Testing Method

Joint pains

Shoulders

Elbows

Wrists

Hands

Hips

Knees

Ankles

Feet

Rachis pains

Cervical

Back

Lumbar Vertebrae

Other Signs

Headaches

Eyes

Ears

Stomach

Legs

Stress

2

How We Stand: Pressure on the Foot

1. Anatomy of the Foot
2. Pressure While Walking
3. Pressure While Standing

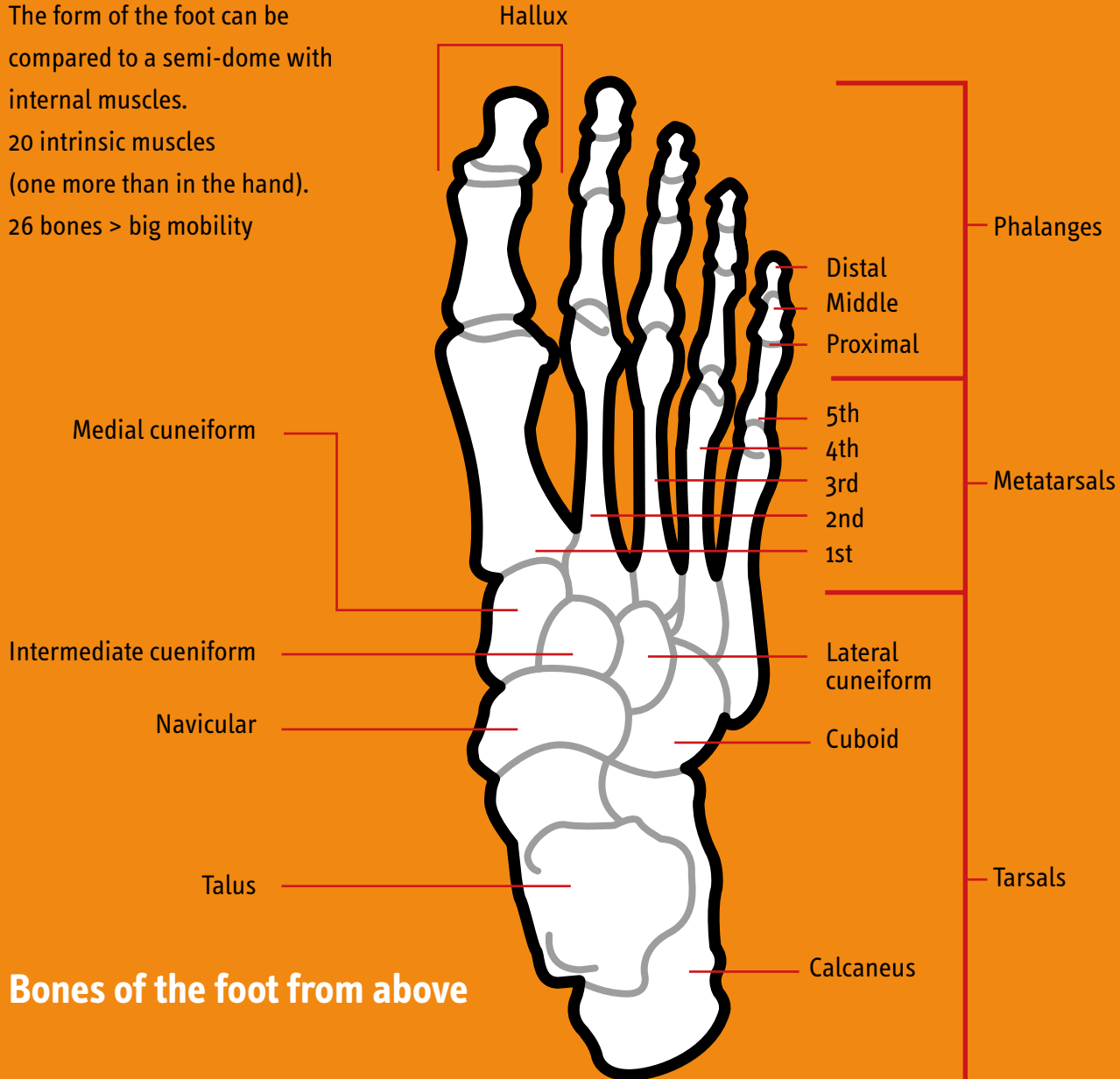
Anatomy of the foot

The form of the foot can be compared to a semi-dome with internal muscles.

20 intrinsic muscles

(one more than in the hand).

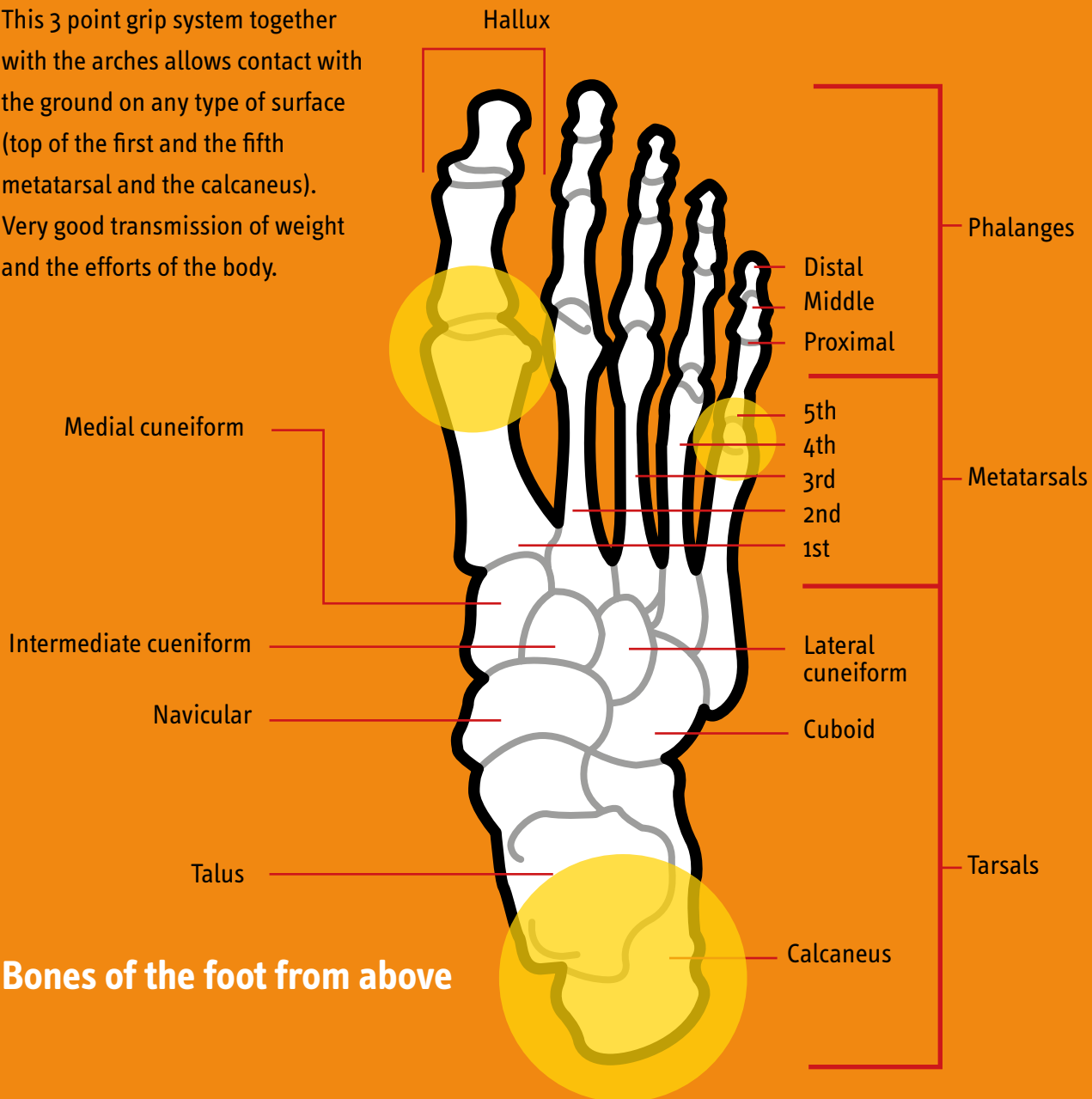
26 bones > big mobility



Bones of the foot from above

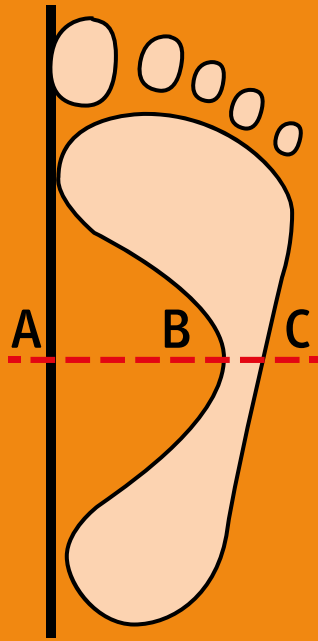
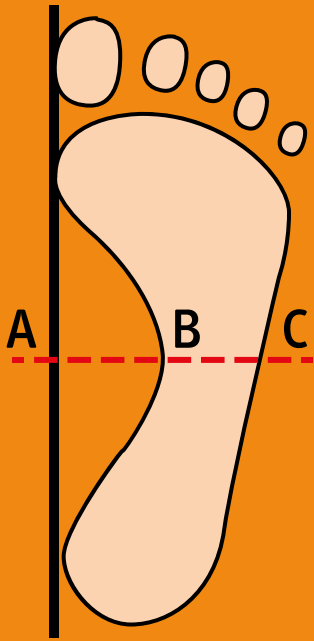
3 Ground contact points

This 3 point grip system together with the arches allows contact with the ground on any type of surface (top of the first and the fifth metatarsal and the calcaneus). Very good transmission of weight and the efforts of the body.

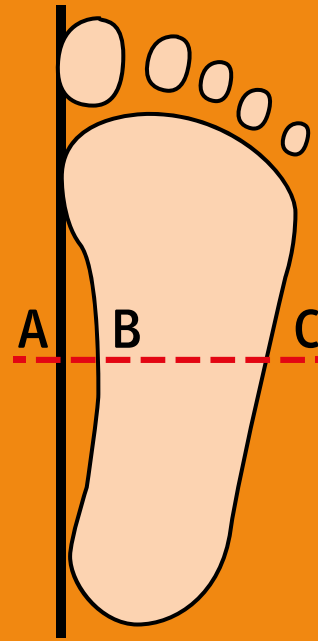


Bones of the foot from above

Shapes of the foot



$BC < 1 \text{ cm}$



$AB < 1 \text{ cm}$

1. Normal foot:

has no major biomechanical problems

2. Cavus foot:

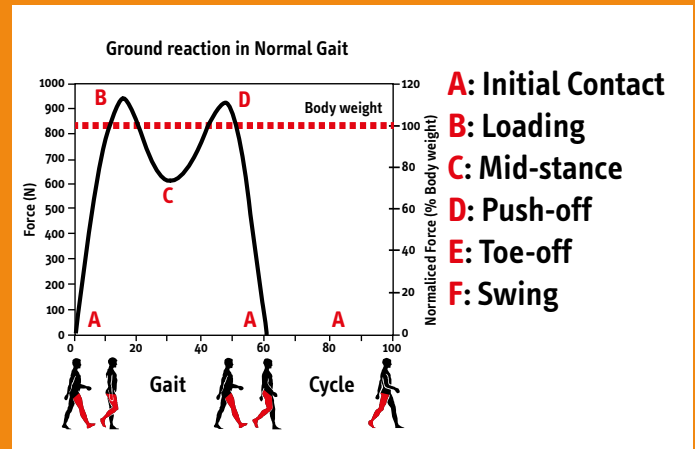
characterized by a very high arch

3. Flat foot (pes planus)

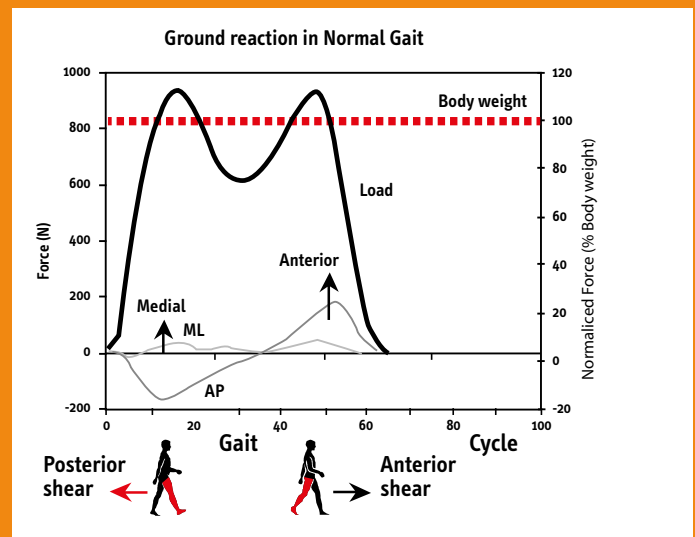
showing a collapsed arch.
In a static state, a deviation can be noticed which could be accentuated with the reproduction of the movement.

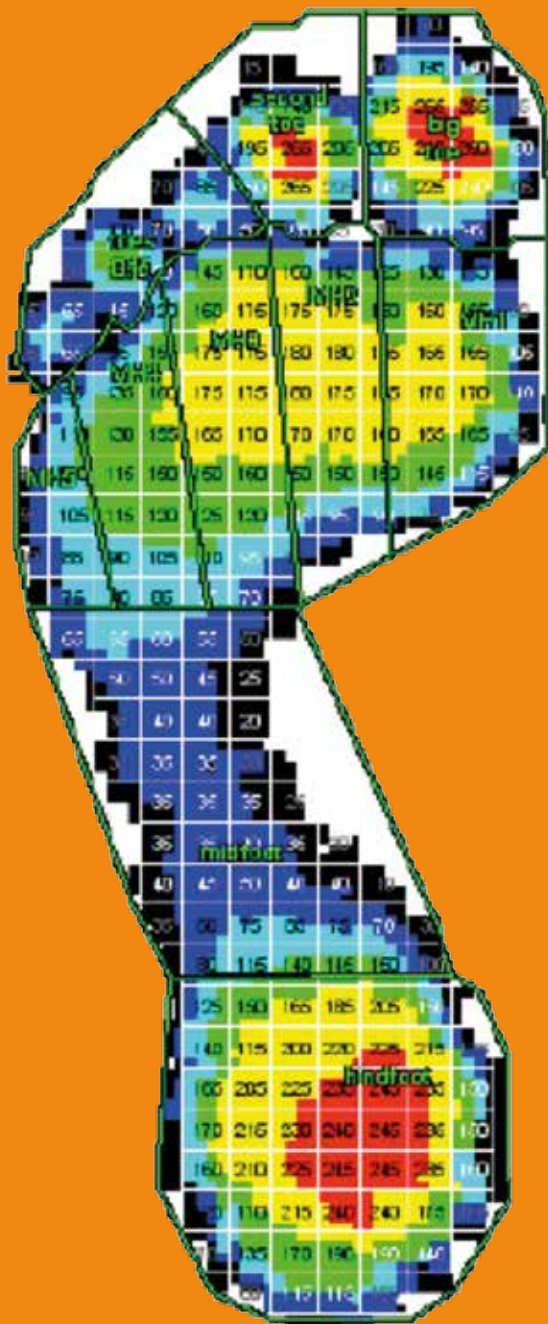


Vertical GRF: Normal Gait



For a person walking normally there are contact phases which are characterized by relatively short temporal phases. During work we tend to make small movements, which leads to increasing articular constraints as well as muscular-skeletal problems.





In Pen

300

230

150

100

80

30

10

Foot pressure depends on the contact zone of the foot with the ground.

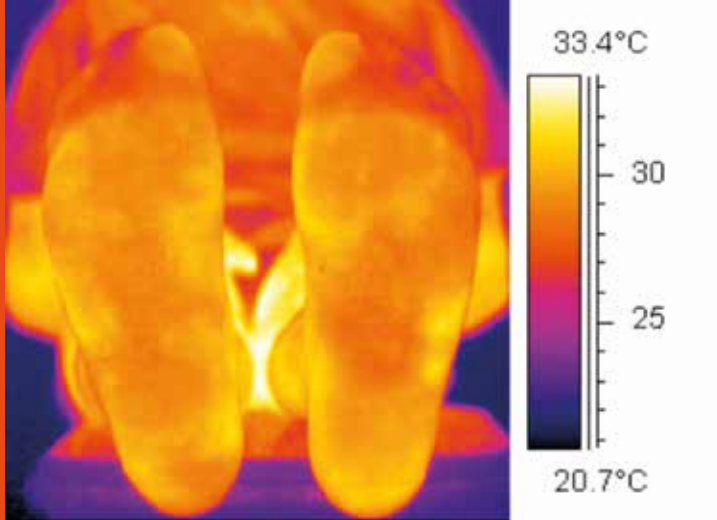
An important pressure will be predominant in the quality of the movement.

3

Testing

1. Measurements While Standing
2. Static Without Mat
3. Static With Mats
4. Dynamic With Mat

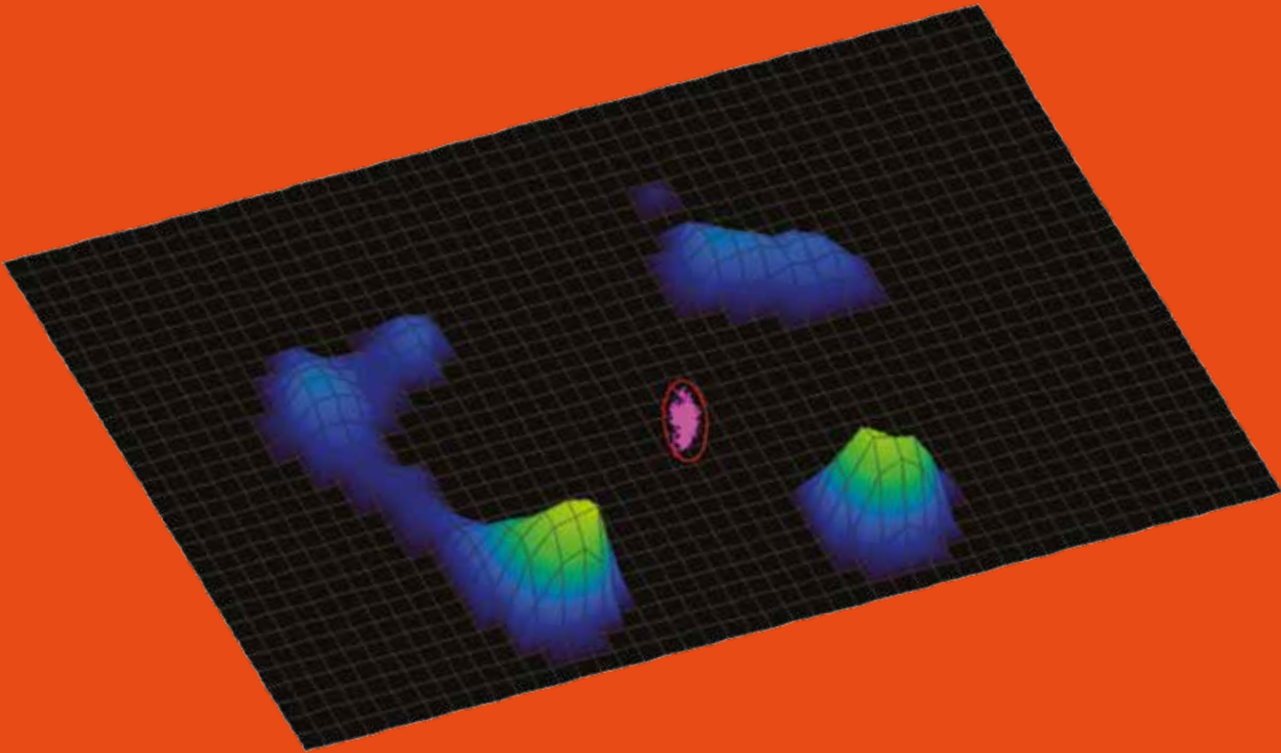
Testing



This experiment will allow us to observe the evolution of the foot pressure after a defined movement. The subject will keep an upright position on the 'Zebris' platform. We observe at the same time through a colour gradient the evolution of the different pressures made by the foot surface in contact with the machine (from blue to red, the pressure is growing). The results are obtained in a static position representing the keeping of an upright position and in a dynamic position characterized by the actual working situation in front of the production tool.



During this experiment the platform was positioned on each anti-fatigue mat. The test was to stand upright for 3 minutes. We record the evolution of foot pressure in function of the appearance of fatigue and we quantify the impact of 7 working hours on the mechanical behaviour of the user. To increase reliability of the results, multiple tests were done. The same experimental procedure was used for the dynamic analysis.



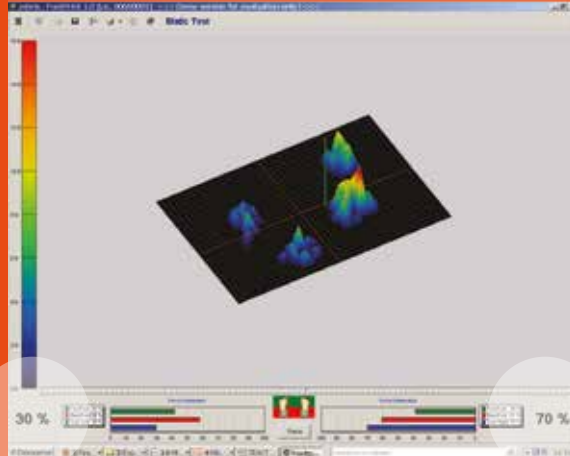
The figure shows the distribution of pressure underneath the foot in an upright position. I have made a recording of one minute to determine the evolution of the pressure centre.

The red circle shows how the latter has evolved. We notice that the pink coloured points are distributed in the interior of this circle. This means that the body has moved to maintain its balance. The smaller the circle the lesser the body moves to maintain its balance.

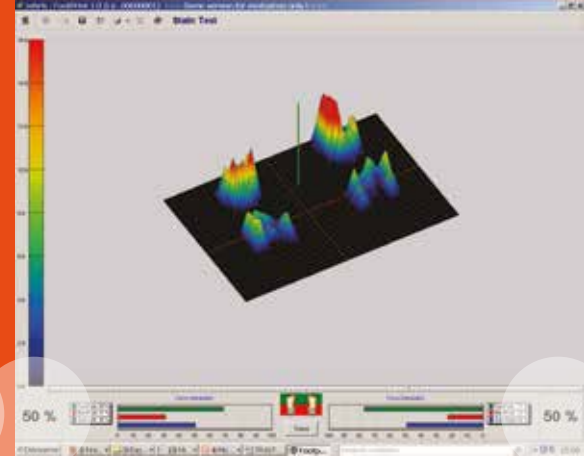
Testing

I have taken in this case several images to illustrate the difference in posture stability with and without the use of mats.

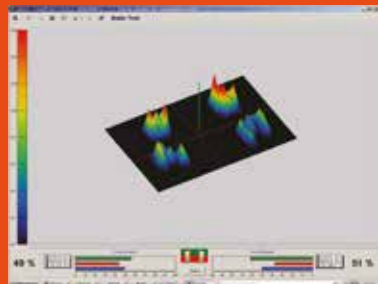
Static without mat



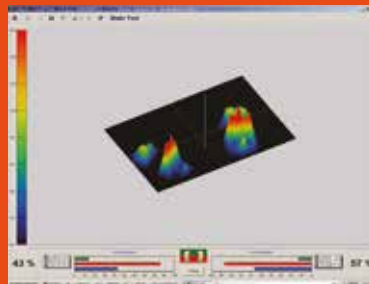
Static with mat



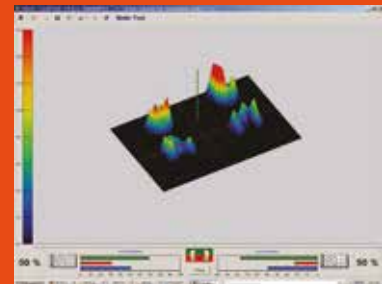
Test with Preference for Type of Mat



Static ERI C
479 Cushion Trax®

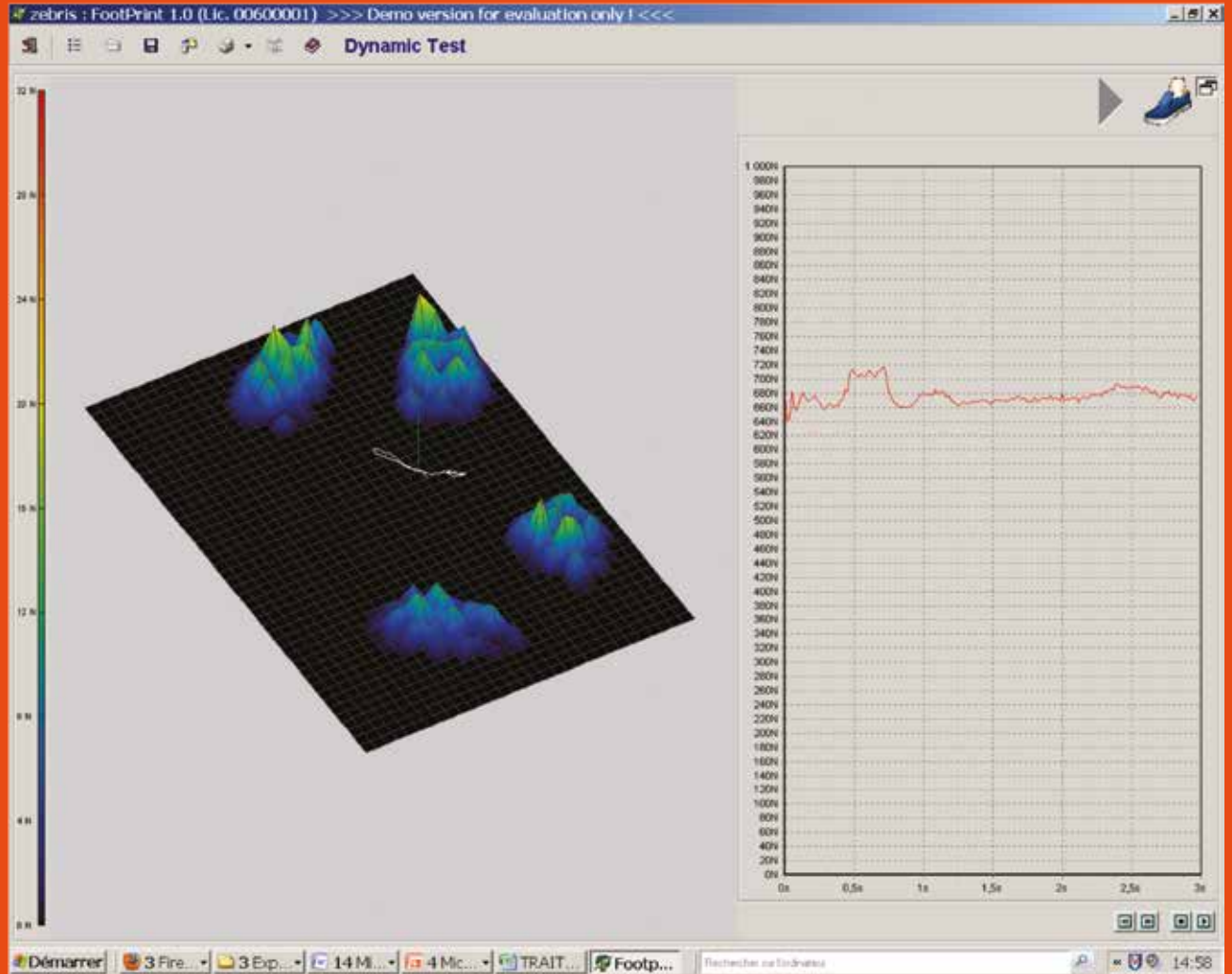


Static ATIA A
450 Skywalker™ II PUR

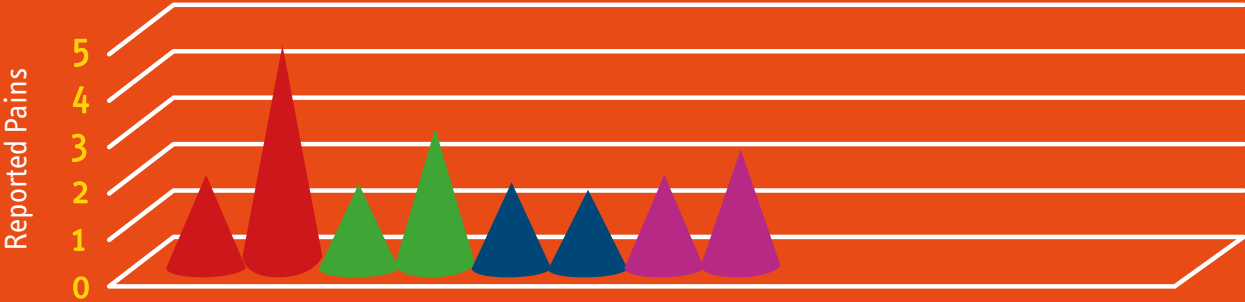


Static ERI B
556 Cushion Ease Solid™

Dynamic with Mat



Qualitative Data Analysis



Matting number

- Number of joints pain reported at the start without matting
- Reported pains at the end without matting
- Number of joints pain reported at the start with ATIA A
- Reported pains at the end with ATIA A
- Number of joint pains reported at the start with ERI B
- Pains reported at the end with ERI B
- Number of Joints pain reported at the start with ERI C
- Pains reported at the end with ERI C

Result

**“Without a mat
there is a dysfunction
in the balance of the person”**

Result

The obtained results show that in any test duration the feet and therefore also the body moves to keep its balance necessary to maintain upright position.

Without a Mat

We remark that without a mat there is a dysfunction in the balance of the person which can cause pathologies or repetitiveness and other work constraining factors which can accelerate the process. We observe here that with a distribution of foot pressure (30% and 70%) the weight of the body is mainly on the right side. This imbalance is very harmful for the human body.



With a Mat

We observe that in working situations where people make small movements constantly, the anti-fatigue mats that we tested show properties that give a muscular-skeletal comfort in upright working positions.

This can be verified by the constancy of the force evolution curve during the movement.





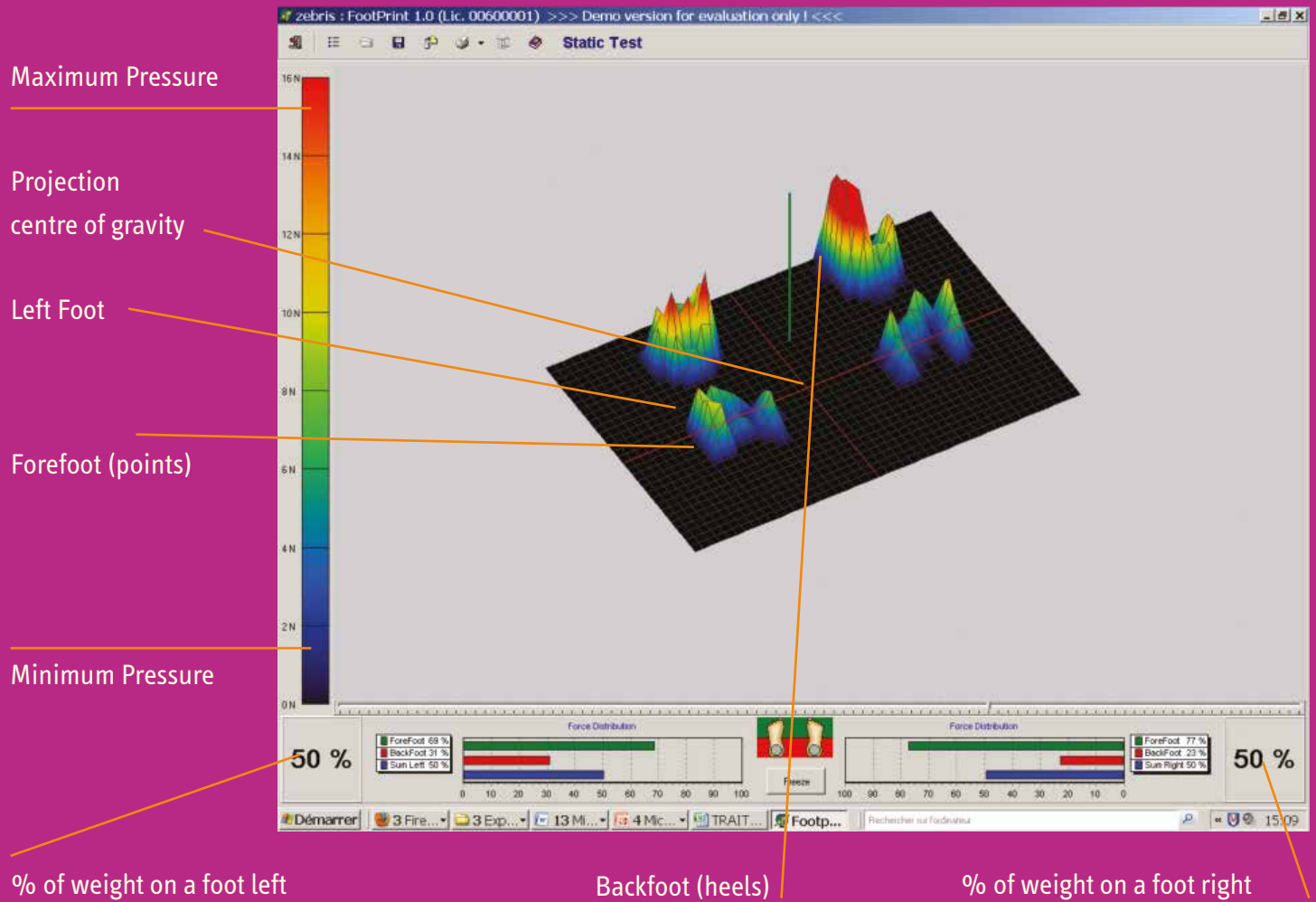
Actually to maintain an upright position it is necessary to have a well-adapted postural balance to decrease pathologies and their consequences in the everyday work of the users.

We have shown in this study that in a static position the body of the subject moves in order to maintain its balance.

This first handling 'variations in foot pressure' has made it possible to highlight the body's movements in a static position.

Result

Standing on an anti-fatigue mat



Testimonies

Cushion Trax®



André: Very good but I think it is a too soft, I have the impression to fall asleep on it, but on I feel no fatigue on this mat.

Dolorès: I like it, because it relaxing for the feet and I felt the fatigue much later than usual, when I leave work I no longer have pain in my legs.

Adeline: Is comfortable and well adapted: I feel less fatigue in my legs at the end of the day.

Estelle: The softest one, but the diamond plate top surface is cumbersome for the support of the foot.

Ghislaine: **The best.**

Testimonies

Skywalker™ II PUR

André: Too hard. I still have pain on the soles of my feet.

Dolorès:

Adeline: This one is the worst. It's not adapted at all. I still have the same intensity of pain in my legs as before.

Estelle: 2nd place. It absorbs less, more pain in the calves and thighs.

Ghislaine: Less comfortable: feels harder in the foot support .



Testimonies

Cushion Ease™

André: Perfect, this is the best, I have hardly any pains.

Dolorès: I also like this mat, the warming up of the soles of my feet and the pains in my legs are much later than before.

Adeline: It's the best: without any doubt this is because of the thickness of the mat, I feel better; I have less pain in my legs .

Estelle: Is the best: it seems quite hard in the beginning, but this disappears later. There are no irregularities, less fatigue in the legs at the end of the day and less muscular and articular troubles, better absorption of weight.

Ghislaine: The worst mat: impression that the support is more on the right side, I am not balanced, lower back pain and pain in the legs.



Conclusions

1. Explanations Bio Mechanics
2. An Automatic System
3. Changing the Automatic Functioning

Conclusions



Some explanations biomechanics And an upright posture

The muscles keep the segments of our skeleton vertical and constantly correct the balance of the whole.

The two feet are the starting point of the balance.

The pressure zones of the sole of the foot on the ground translate the different strategies we all use to stay upright: more pressure on the rear part or on the front part of the foot; more on the right foot or more on the left foot.

Conclusions

An automatic system

This posture state (upright) is encoded in our neuromuscular program, and each time we use the same muscles to do the work, without being conscience about this. This 'automated' muscular functioning is recorded in the brain and will be systematically applied in every situation (even outside the working environment). The muscular fibres involved in this programming are also called « Cinderella fibres », because even if they are tired they do their job . . . that's the start of muscular-skeletal troubles (pain, contractures, tendinitis ...).



Foot pressure on the floor can give indications on the functioning of the muscular chains used. We can observe that our footprints are marked by higher or lower pressure levels (either our support is more in the back (the heels) or on the front (the points of the feet); or on the outside, the inside, left or right).

It is possible to change this automated functioning . . .



by retaking control of the muscle commands in the brain. The learning of a new gestural or postural model requires special attention and concentration during several weeks. The old model will then be replaced by the new one and will also function in an unconscious and automatic way.

Every gestural or postural system is controlled by the brain; this allows a compromise between quick execution and saving energy. When the system is out of balance, the quick reaction speed is maintained at the cost of energy spending (fatigue). In a nutshell, to regain balance 'quick reaction /energy saving/ effectiveness', it is necessary to become aware of the different foot pressures on the ground and the most proper muscle action (from feet to head). This can be done easily by changing the foot pressure on the floor : by forcing oneself from time to time to move the pressure to the front of the foot or towards the back of the feet; or from the inside to the outside of the foot or more to the right and after that more to the left.

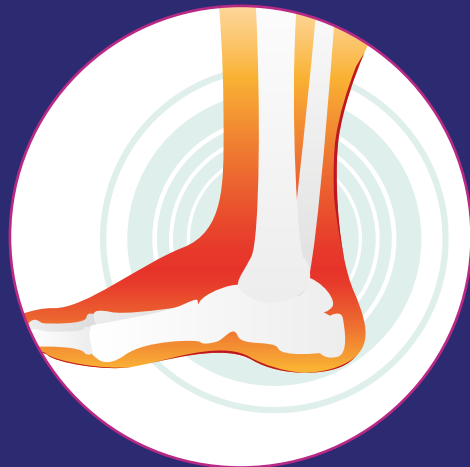
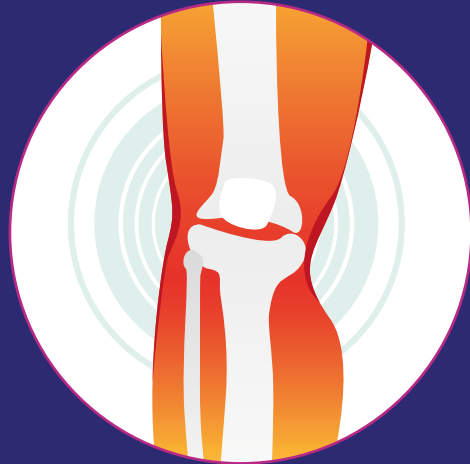
Advice to Workers

1. Vary Foot Pressure
2. Use Anti-Fatigue Mats

Advice to Workers

Proposition of a method to rebalance the muscular functioning.

The explanation of the biomechanics and the visualisation of the foot pressure on the floor will allow proposing and justifying the usefulness to change foot pressure in an upright position. It is recommended to change regularly (during a period of 1 month) the pressure point inside the shoe.



Advice to Workers

Vary Foot Pressure

The variation in pressure is the first stage in improving the upright standing position, initiated by the person itself:

- Push forward (bend the toes slightly by scratching the sole of the shoe)
- Push backwards on the heels (slightly lift the points of the feet by touching the shoe with the toe nails)
- Push on the outside border of the foot
- Push to the inside border of the foot
- Push more to the left
- Push more to the right

Use Anti-fatigue Mats

The second stage of improvement will be the floor, by using anti fatigue mats made from the latest technological materials.

The use of anti-fatigue mats enables correct balancing and a uniform distribution between the right and the left leg.

This observation can be made on all the mats. It should be noted that this balance will improve depending on the adaptation of the mat used.

Recommendations have been made to every user to benefit from the best results of this experiment. The use of anti-fatigue mats has helped to highlight the benefits of new materials on the optimisation of human mechanics.

About the Author



Prof. Redha Taiar

Email: redha.taiar@univ-reims.fr

Tel: +33 067 794 4628

Fax: +33 032 691 3806

www.redha-taiar.com



Prof. Dr. Redha Taiar is an expert in biomechanical, human locomotion, kinematic and kinetic analysis and biomedical technologies at the University of Reims in France.

For more details about his work:

www.redha-taiar.com.





MATS FOR PROFESSIONAL USE

www.notrax.eu