FURNITURE DESIGN TOOLKIT

Key resources for your design process

FIRA

Furniture Industry Research Association

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Thanks are also extended to all other organisations and individuals who contributed to the Toolkit.

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Foreword

Outstanding, durable furniture, be it for the domestic or contract market, requires innovation, design, ergonomics and engineering in equal measure in order that furniture can be both safe and aesthetically pleasing, as well as fit for purpose and sustainable.

Therefore furniture designers need to have knowledge and skills not only in design, but also in how to apply ergonomic principles and product Standards to their situation, in particular for the commercial market.

This need has fuelled the way for the Furniture Design Toolkit, which aims to provide designers with quick, usable advice about key ergonomic areas, and information about the relevant Standards for products aimed at the UK market.

The Furniture Industry Research Association is pleased to present this interactive PDF, which will be updated with new information as appropriate, and provides the information to:

- Produce furniture designs that are fit for purpose with regards to users' needs and environments
- Ensure the safety and performance of the designs in terms of regulations and relevant Standards
- Ensure that the products are comfortable and easy to use
- Promote the well-being of users
- Improve the efficiency, productivity and effectiveness of the way the products are used in a wide range of environments through their design

These design guidelines help designers to concentrate on what they are good at, designing visually attractive and desirable products.

Michael Powell,
Furniture Industry Research Association Chairman,
September 2013

Contents

The toolbox

Please note that this is not a guide that needs to read from cover to cover, the sections can be used when necessary.

Below are links to the key areas:

Image courtesy of Orangebox

1.

Introduction

1.1. Introducing the Furniture Design Toolkit

Furniture design needs to be good, as it involves products that come into direct contact with people. However, it can be the case that a furniture design is aesthetically excellent but is not comfortable or easy to use. Without the right information at hand, it is easy to overlook an important issue, resulting in the design process taking longer and costing more than expected. This is why FIRA has created the Furniture Design Toolkit, which does not dictate how to design, but aims to help advise design choices and improve efficiency in the development process.

During the project's development phase, FIRA experts asked designers what they thought the main issues were as they designed their furniture and three main areas came up repeatedly:

- General questions over ergonomic principles
- Uncertainty over how to conduct user trials for development
- Confusion over understanding Standards

The Toolkit has been developed with these areas in mind:

General ergonomics/design

There are several general sections to help with areas like anthropometrics, task analysis and Standards. Specific suggestions are included in the sections for each furniture type. There are also links to other resources not contained within this Toolkit.

User trials

A beautiful product is of no value unless people can use it. Great aesthetics and ease of use equate to great design. The best way to assess ease of use is through user trials. Within the Toolkit there is an introduction to user trials and how to conduct them to help get the best results. In addition, a sample questionnaire has been provided for use or modification as necessary.

Standards

For each market sector there is an introduction to the basic legislation and Standards that are important to consider. This includes explaining which Standards the products need to comply with, and sometimes which clauses within a Standard are important to focus on.

1.1.1. Scope

This Toolkit is designed to be used by furniture designers producing products for:

- Offices
- Educational institutions
- Contract and hospitality use such as hotels, care homes, transport termini and public spaces

The Toolkit itself should help to design:

- Seating
- Work surfaces, including tables and desks, and working at sitting and standing heights
- Storage items

The information provided within this Toolkit may be used for other applications, however for specific requirements, please contact FIRA

Image courtesy of Interstuhl

2.

Key Tools

2.1. Ergonomics

Ergonomics is the study of the fit between people, the things they do, the objects they use and the environments they live in (whether it be work, rest travel or play). Ergonomics deals with the interaction of technological and work situations with the human being and for this reason, is often called ‘Human Factors’.

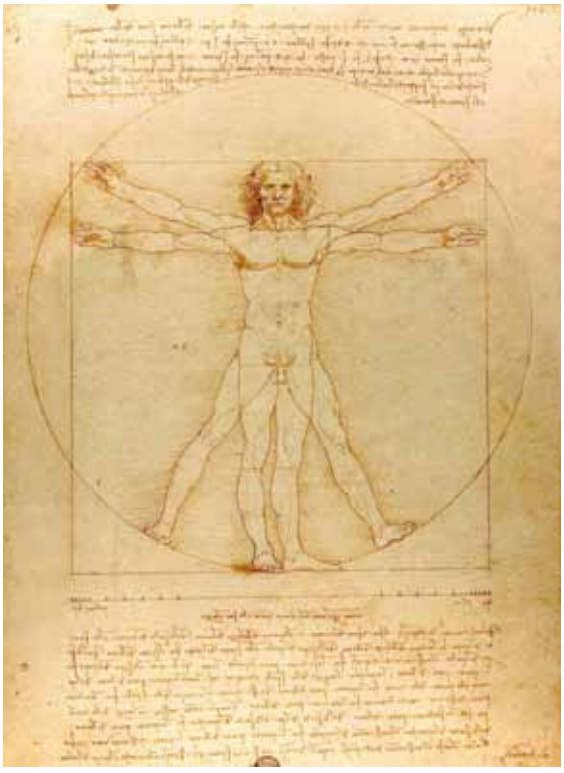
The aim of ergonomics is to ensure that humans and technology work in complete harmony. As such equipment and tasks should be aligned to human characteristics to reduce the stresses on humans. In many cases, humans can adapt to unsuitable conditions, but such adaptation often leads to inefficiency, errors or physical and mental cost. Designing equipment and work arrangements to improve working posture and ease the load on the body can reduce instances of injury such as repetitive strain injury and work related upper limb disorder, which, if unchecked can, in extreme cases, result in musculoskeletal disorders and costly litigation.

The application of ergonomics in the design of furniture products is important. Good ergonomics is an important factor in the overall health, safety and well-being of individuals. For example, the benefits of an ergonomically designed workplace may include increased productivity, increased morale of staff and reduced absenteeism. Good, ergonomically designed furniture occurs when it has been designed with both the intended user(s) and the intended use in mind.

2.1.1. Important factors

The ergonomic design of furniture has to take into account of the following factors:

- The size of furniture matching the size of intended user populations
- Well-being, safety and comfort of users
- Productivity and efficiency of users in carrying out their tasks
- Furniture meeting the needs of the intended users
- Furniture meeting the needs of the task and the job users are carrying out
- Ensuring unimpeded interaction between the user and the equipment (including furniture)
- Time spent working at the workplace (e.g. time spent sitting, standing)
- Matching the forces required to operate any equipment (including furniture) and the capabilities of the intended user population
- Safety of the furniture which should not be the source of risk of injury during intended use
- Inadvertent operation of any of the controls and their consequences
- Acceptable misuse of furniture and their consequences
- Ensuring furniture can accommodate intended IT devices (screens, CPUs, monitor arms) in a safe manner
- The ability of users being able to move freely at their workstation and ability to adopt a range of comfortable, dynamic postures without being restricted by the furniture
- The latest scientific findings



Da Vinci: the original human factors engineer!
Image courtesy of Luc Viatour / www.Lucnix.be

2.2. Anthropometrics and dimensional fit of furniture to people

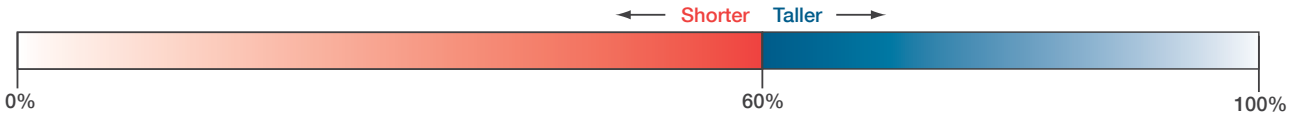
At the core of any real life product should be its function. For furniture, this involves how well it fits the user. While there may be dimensional Standards for a particular product, it is important to understand why these dimensions have been chosen and for this it is necessary to understand anthropometrics.

This section of the Toolkit introduces the basic concepts of anthropometrics and guides the reader towards the best available anthropometric data sources.

2.2.1. The point of percentiles

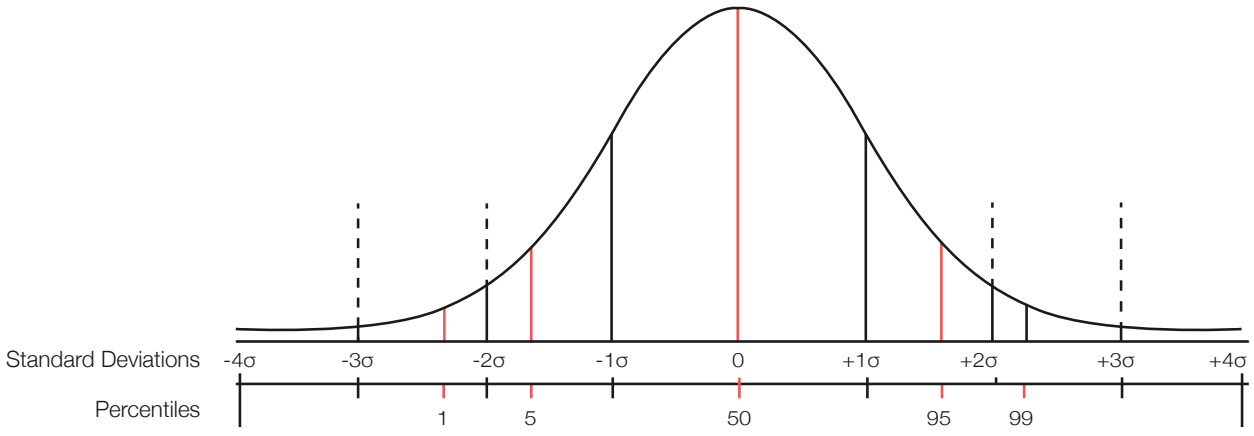
Percentiles are frequently mentioned in anthropometric data, but what does the term actually mean? Simply put, it is the percentage of a population that is less or more than a particular anthropometric dimension. The easiest way to explain is with an example:

If data told us that the 60th percentile stature of UK males was 1777mm, it would mean that 60% of the population were shorter than this, and 40% were taller than this.



Or if data said that the reach of a 5th percentile female was 623mm, it would mean that 5% of the population had a shorter reach than this, and 95% had a longer reach.

The distribution of percentiles is not even. On a graph, a distribution would look something like this:



Notice that the scale of percentiles is not linear; there are more people closer to the 50th Percentile.

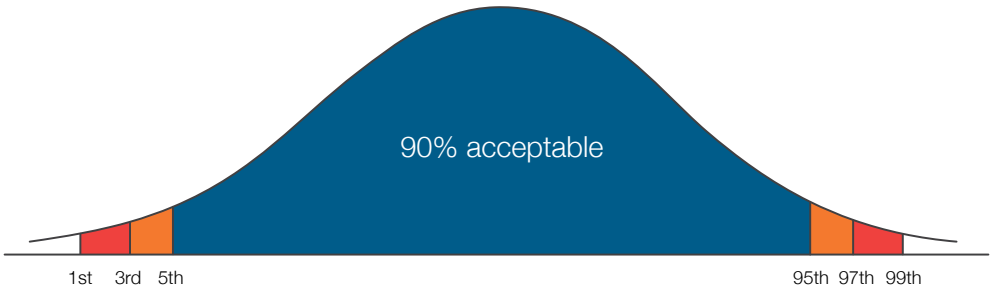
2.2.2. Why no one is average…

One thing you should never hear a designer saying is 'let's just design it to the average person.' The reality is that there is no real average person. If a person is the 50th percentile in terms of stature, it is unlikely that they are also the 50th percentile in weight or in arm length etc. This is true for any percentile. The human body varies greatly in body proportions, so a person average in every measurement would be very rare indeed!

2.2.3. Best practice for design

In an ideal world, it would be possible to design for the entire population from the 0th percentile to the 100th so that the entirety of a population could use the product without a problem. It is important to aim to design for all, but in reality the cost of fitting the broad range between the extreme dimensions is not practical.

In most situations, it is common practice and perfectly acceptable to design for the 5th to the 95th percentiles of a population, as shown here:



This means that the majority (90%) of the population would be able to use the dimension/product without issue. It is also possible that some of the 5% at either end of the scale can use the product without too much difficulty (shown in the example above as amber).

It is important to specify the population carefully. Population in this context doesn't automatically mean the whole of the country. Designing for the elderly or for a specific subset of the population (e.g. pregnant women) requires different data as the location of the percentiles shifts based on the attributes of the people. This doesn't just apply to body dimensions, but also the capabilities of the users. For example, an elderly woman may have less physical strength than a younger counterpart. This may affect the design of items such as levers and controls.

Be careful not to make the mistake of designing for the wrong population. The data used is essential for the success of the product. As an extreme example, you cannot use data for the Chinese population and expect it to work for the UK!

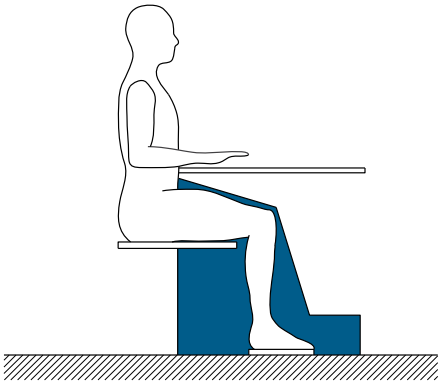
2.2.4. What percentile should you be designing for?

Because the human race varies greatly in body dimensions and capabilities, it is important to consider the correct application of anthropometric data. For example, if a door height was designed for the average person, then 50% of the population would struggle to get through without banging their heads or stooping! By using the 95th percentile male requirement, then the rest of the population, who are shorter, will fit through without a problem.

Pheasant[1] discusses some of the common application areas that may need to be considered:

2.2.4.1. Clearance

For a dimension involving clearance, a larger percentile should be used.
E.g. When designing a desk, it is important to ensure that there is enough space under the desk to accommodate a tall man. By designing the clearance under a desk to the 95th percentile male, then the rest of the population, who have shorter legs, will have plenty of space under the desk.



Legroom clearance under a desk

2.2.4.2. Reach

For a dimension involving reach, a smaller percentile should be used.
E.g. If a lever is designed for the 'average' person, then 50% of the population would struggle to reach it! By using the 5th percentile female requirement, then the rest of the population, who have longer reach, can operate the lever without difficulty.

Image courtesy of Boss Design

Image courtesy of Orangebox

2.2.4.3. Posture

This refers to the relationship between the dimensions of the workstation and the user, and how this may affect the user's posture for better or worse. There is likely to be an impact if extreme dimensions are used (for example 95th or 5th percentile values). It is important to consider both the larger and smaller users. For example, if a seat uses a depth from a 50th percentile male, then some shorter users may slouch or slide forwards in order to have their feet on the floor.

In some cases the only clear option is adjustability. For example, a fixed height armrest will never be able to be set at an optimal height for the majority of the population, whereas an adjustable armrest can be set to the user's preference.

These criteria are often harder to define than clearance or reach dimensions, but some basic guidelines are given below[1]:

- Encourage frequent changes in posture
- Avoid forward inclination of the head and trunk
- Avoid causing the upper limbs to be held in a raised position
- Avoid twisted and asymmetrical positions
- Avoid postures which require a joint to be used for long periods at the limit of its range of motion
- Provide adequate back support in all seats, or provide a viable alternative to a backrest
- Where muscular force must be exerted the limbs should be in a position of greatest strength
- When the weight of the body must be supported, avoid the build-up of pressure on sensitive areas of tissue

2.2.4.4. Strength

It is important to consider all users in their physical abilities regarding force. For control operation, it is often acceptable to design for the weakest person (5th percentile strength data) in order that everyone else can operate it without issue. If the intention is to prevent children from operating such equipment it is better to use strength data for the 99th percentile child to ensure that children cannot operate the control inadvertently.

Lifting ability is another area requiring consideration. For the height of a shelf, it is important to consider the weight being lifted. Heavier objects should be placed on lower shelves. The abilities of the user should be considered to ensure that everyone can lift safely. No object should go beyond the lower percentile abilities of the target population.

The Department for Business Innovation and Skills (formally the Department for Trade and Industry, or DTI) produced several resources containing strength data, which can be accessed online.

For flat packs, it is important to provide strategically placed handholds in larger packages in order to allow people to lift as safely as possible automatically. For especially large objects, it may be necessary to label the box as requiring two people to lift.

Image courtesy of Flickr, Daniel Julie (dany13), 2010

Strength varies from individual to individual. Size does not necessarily mean strength!

2.2.5. Anthropometric data

The relevant dimensions for a design project can be found from anthropometric data sources. The requirements found in Standards usually have their foundation in anthropometric data and is usually referenced. It is essential, however, that the correct data is selected.

2.2.5.1. Decide on the user group

Be careful to identify the correct target user population. What age range? What sex? Which country? etc. The more specific, the better. Some populations may have a 50/50 split of men and women, but others may differ.

Male	Children	Elderly	Africa
Female	Adults	UK	China

Different sizes and abilities

Choosing the best and most relevant data is vital to a suitable design solution.

2.2.6. Static and dynamic data

Anthropometric data comes in two main varieties and the choice depends on the values that need to be identified. Some sources of anthropometric data contain both varieties of information.

2.2.6.1. Static anthropometric data

Static anthropometric data covers the fixed structural dimensions of the body, generally measured in a range of standard positions. For example, stature, length of limbs, breadth of shoulders, weight etc.

2.2.6.2. Dynamic anthropometric data

Dynamic anthropometric data covers areas such as reach or clearance. The measurements are taken under a functional condition. For example, 'reach to fingertip', or 'reach to grip around a handle' etc. Read the description of the data carefully to find out how the measurement was taken and whether it applies to the design situation at hand.

Other dynamic dimensions can include: strength, joint movement ranges, etc.

2.2.6.3. Clothing allowances

It is common for the anthropometric measurements to be carried out on nude or near nude subjects. This gives accurate body measurements, but it means that clothing is not taken into consideration. Below are some recommendations for adding clothing allowances[1]:

Heavy outdoor wear

- +10mm for sitting eye height
- +35mm for thigh thickness
- +20mm for buttock to knee length
- +40mm for shoulder breadth
- +50mm for hip breadth
- ≤40mm for chest/bust depth
- ≤40mm for abdominal depth

Indoor clothing

- +10mm for shoulder breadth
- +25mm for hip breadth

Shoe sole height

- +25mm for general use/male users
- +45mm for females (where high heels are likely)

Hats

- +25mm for general headwear
- +35 for hard hats
- +35mm for clearance across ears
- +90mm for protective helmets

Gloves

- ≤25mm for hand breadth

2.2.6.4. Example of application

An early tank design was careful to design the entrance hole to be large enough for any user by using data available at the time. The size of the hole needed to be as small as possible to avoid a strategic weak point.

The issue came when soldiers in full uniform attempted to enter the tank: they couldn't fit through the hole when dressed and equipped! This shows the importance of considering the practical use of a product carefully.

2.2.7. Linking anthropometric data to design

Anthropometric data is only useful if the correct data is successfully applied to the design problem. The diagrams below represent some basic anthropometric measurements and table 2.2.7 gives examples of how these measurements can be used.

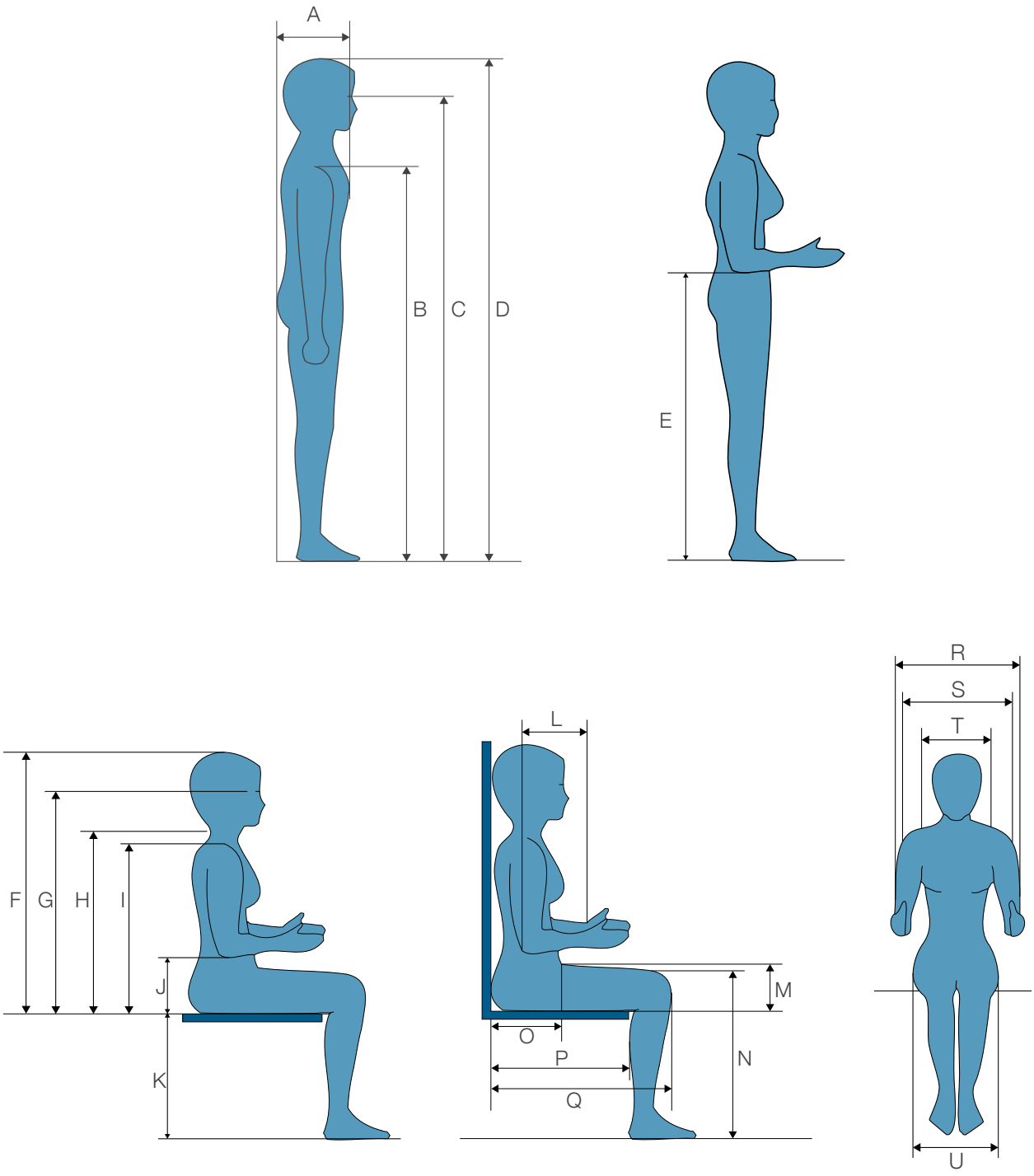


Table 2.2.7

Key	Measurement	Uses
A	Body depth (standing)	Clearance between objects
B	Shoulder height	Coat hooks Max height for lifting onto a shelf
C	Eye height	Standing desk monitor height Signage Line of sight for high shelving Mirrors
D	Stature	Door heights Clearance
E	Elbow height	Standing work surface height Height of counters General work surfaces
F	Sitting height (erect)	Headrest height
G	Eye height (sitting)	Monitor height
H	Cervicale height (sitting)	Backrest height
I	Shoulder height (sitting)	Backrest height
J	Elbow height (sitting)	Desk surface height Armrest heights
K	Lower leg length (popliteal height)	Seat height
L	Elbow-wrist length	Armrest length
M	Thigh clearance	Height/thickness of work surface
N	Knee height	Legroom desk clearance
O	Buttock-abdomen depth sitting	Armrest protrusion
P	Popliteal length	Seat depth
Q	Buttock to knee length sitting	Minimum clearance between seats in auditoriums, arenas, transport etc. Under work surface legroom depth
R	Elbow to elbow width	Armrest width
S	Shoulder (bideltoid) breadth	Backrest width
T	Shoulder (biacromial) breadth	Backrest width
U	Hip breadth (sitting)	Minimum seat width

2.2.8. Sources of anthropometric data

There are a number of sources of anthropometric data. As with any product, the quality and usefulness of the data is reflected in its cost. Below are examples of the type of data available:

2.2.8.1. Comprehensive data for dedicated research

CAESAR (Civilian American and European Surface Anthropometry Resource Project)
Date: 1998 to 2000
Cost: $3,500 to $10,000
Description: "…designed to provide you with the most current measurements for today's body…The project collected and organized data on 2,400 U.S. & Canadian and 2,000 European civilians and a database was developed… This database is the first to include 3-D model scans in addition to traditional 1-D measurements."
Link: http://store.sae.org/caesar/

WEAR (World Engineering Anthropometry Resource)
Date: Dates vary depending on database being used
Cost: £Varies.
Description: "Online access to over 145 databases including in excess of 12 million individual datum; incorporating CAESAR data base, with all the 3D body scans, used by NATO, CEN, ISO and ASTM."
Link: http://wear.io.tudelft.nl/

SizeUK
Date: 2004
Cost: Not stated
Description: "The UK has recently completed its National Sizing Survey (SizeUK) of 11,000 subjects using 3D whole body scanners to automatically extract 130 body measurements from each subject. This highly accurate size and shape data, together with each subject's 3D point cloud, is held securely in a UK anthropometrics web-database, available for online data mining." SizeUSA also available.
Link: http://www.size.org/

Image courtesy of Interstuhl

2.2.8.2. Data designed for frequent use

PeopleSize 2008

Date: 2005-2006
Cost: 2008 Easy: £149+VAT, 2008 Professional: £395+VAT
Description: Interactive software covering multiple populations (American, Australian, Belgian, British, Chinese, French, German, Japanese, Swedish). Easy to find the relevant dimension and specify to advanced percentiles.
Link: http://www.openerg.com/psz/index.html

Childata, Adultdata, Older Adultdata

Date: 1985, 1998, 2000 respectively
Cost: Out of print, but copies available through main web book suppliers (cost varies)
Description: These three resource books provide data on many anthropometric dimensions and other information about the target group. They are starting to date, with the first being published in 1985, but are useful cost effective resources. Also accessible through the British Library.

PD CEN ISO/TR 7250-2:2011 'Basic human body measurements for technological design. Statistical summaries of body measurements from national populations'

Date: Varies on table of data from 1990 – 2007
Cost: £196.00 for non BSI Members
Description: Basic human body measurements for technological design. Statistical summaries of body measurements from individual ISO populations (Currently Germany, Italy, Japan, Kenya, Korea, Netherlands, Thailand, U.S., but more data is to be added as it becomes available)
Link: Available through the BSI shop

BS EN 547-3:1996+A1:2008 'Safety of machinery. Human body measurements. Anthropometric data'

Date: Not dated other than Standard publication date
Cost: £82.00 for non BSI Members
Description: This gives anthropometric data for human body measurements for the calculation of access opening dimensions as applied to machinery. "The data are based on information from anthropometric surveys representative of population groups within Europe comprising at least three million people. Both men and women are taken into account. Measurements are given, as required by BS EN 547-1 and BS EN 547-2, for the 5th, 95th and 99th percentiles of the relevant population group within Europe."
Link: Available through the BSI shop

BS 4467:1991 'Guide to dimensions in designing for elderly people'

Date: Various sources from 1974 - 1983
Cost: £100.00 for non BSI Members
Description: "Provides guidance in terms of anthropometric dimensions on the design of equipment and buildings for elderly people."
Link: Available through the BSI shop

2.2.8.3. Data for infrequent use

Bodyspace: Anthropometry, Ergonomics and the Design of Work, Third Edition, Stephen Pheasant

Date: Dated 2005, data itself likely to be older
Cost: R.R.P. £50
Description: "In the 20 years since the publication of the first edition of Bodyspace the knowledge base upon which ergonomics rests has increased significantly. The need for an authoritative, contemporary and, above all, usable reference is therefore great. This third edition maintains the same content and structure as previous editions, but updates the material and references to reflect recent developments in the field. The book has been substantially revised to include new research and anthropometric surveys, the latest techniques, and changes in legislation that have taken place in recent years."
ISBN: 978-0415285209

The Measure of Man and Woman: Human Factors in Design, Dreyfuss

Date: Dated 2002, data itself likely to be older
Cost: R.R.P. £50
Description: "Human factors research impacts everything from the height of kitchen counters to the placement of automobile pedals to a book's font size. And in this updated and expanded version of the original landmark work, you'll find the research information necessary to create designs that better accommodate human need. Featuring more than 200 anthropometric drawings, this handbook is filled with all of the essential measurements of the human body and its relationship to the designed environment. You'll also discover guidelines for designing for children and the elderly, for the digital workplace, and for ADA compliance. Measurements are in both English and metric units."
ISBN: 978-0471099550

2.2.8.4. Free sources

Remember to be careful if the data uses combined male/female results.

DINED Database

Date: Latest 2004
Description: This database has a wealth of Dutch anthropometric data with some international results too. Good graphical interface.
Link: http://dined.io.tudelft.nl//ergonomics/

DINBelg 2005

Date: 2005
Description: Up to date anthropometric data of the population of Belgium.
Link: http://www.dinbelg.be/anthropometry.htm

NASA

Date: 2000
Description: Current update of their Anthropometric measurements, completed with American and Japanese men and women.
Link: http://msis.jsc.nasa.gov/sections/section03.htm

Humanics

Description: Collection of resources and data sets, including strength data.
Link: http://www.humanics-es.com/recc-ergonomics.htm#anthropometrics

Image courtesy of Orangebox

2.3 Task analysis

2.3.1. What is task analysis?

Task analysis is a systematic breakdown of job elements to identify the operational sequence of the work and the way in which the worker uses the information and equipment provided.

Looking at office furniture, both BS EN ISO 9241-5 (Ergonomic requirements for office work with visual display terminals) and BS 3044 (Ergonomics principles in the design and selection of office furniture) discuss task analysis as a useful design tool. Neither Standard, however, actually explains how it is completed in any great detail.

Task analysis is usually completed on a system rather than a product, but many of the tools can also be applied to design projects and furniture. This section of the Toolkit gives an introduction to task analysis and how to use it to help improve development processes.

Task analysis is an initial step to complete before beginning the design process. It helps to identify how the furniture needs to perform to aid the user and function well. The importance of a detailed task analysis varies with the complexity of the job, the variety of tasks and the range of equipment and materials needed.

Image courtesy of Interstuhl

2.3.2. What are the aims and benefits of task analysis for designers?

By applying task analysis during the design process, it ensures that a product is easy to use and meets the user's needs. Even if two or more people at an organisation are completing the same job, the way in which they complete it may be very different. Task analysis can help to ensure that each person is taken into account.

The benefit of task analysis is that by considering what equipment people use, what environment they work within, and the frequency of tasks they complete, it can reveal a better picture of what the product needs to do.

An excellent example of the integration of task analysis into design is the Newton Chair, designed by Orangebox. During research, the designers worked out that school children were spending time leaning forward over their desk to get closer to their work as well as sitting back listening to the teacher. This is why the chair rocks forwards, allowing the user to keep their back straighter when leaning over.

Image courtesy of Orangebox

Consider how fast technology is advancing and how this is impacting on work and educational environments. It is clearly key to examine how people are working now. For example, tasks and equipment are changing and older solutions are not compatible. One important area is how to help people to achieve better postures when using portable devices such as smart phones and tablet computers. It is possible to use task analysis to improve the quality of product design in an ever changing world.

2.3.3 Considerations

Such a task analysis should include the consideration of [2–4]

The major tasks to be carried out

- E.g. office: job description, associated equipment, frequency/duration of use?
- E.g. education: learning styles, associated equipment, frequency/duration of use?

The inter-relationship between tasks

- E.g. office: need to use screen and telephone simultaneously?
- E.g. education: individual work, group work, work with teacher?

Visual attention areas

- E.g. office: screens, tablets, paper, desk space?
- E.g. education: paper, laptops, tablets, whiteboard, teacher etc.?

Support equipment

- E.g. office: location, frequency, enough space for busy periods?
- E.g. education: learning aids, storage of furniture when not in use?

Storage of documents at or near workstations

- E.g. office: filing, printing?
- E.g. education: storage for teachers, trays for students?

The position and use of hands in the tasks to be carried out

- E.g. office: typing, writing, reaching?
- E.g. education: typing, writing, reaching?

Image courtesy of Haworth, www.haworth-europe.com

2.3.4. Identifying the target users

In order to ensure that there is adequate consideration of the variation in the size of the people, it is necessary first to know the general nature of the population involved, e.g. is it predominantly male or female or is a mixture of both sexes involved? Additionally, are there significant numbers of people with individual needs using the furniture (i.e. the elderly, children, large users etc.).

It is sometimes important to determine the work systems the organisation is going to employ. For instance, shift work, hot-desking, working individually in offices, open plan offices, or team work, will have significantly different task requirements. The amount of time individuals spend at their place of work is another important factor to consider.

2.3.5. Techniques

There are many task analysis techniques that have been developed over the years. For brevity and simplicity, this document only covers some of the most common tools and how to complete a task analysis.

2.3.5.1. Identifying the tasks

There are several common ways in which the tasks that the users complete can be identified:

Observation

This relates to direct observation of the job or behaviour under study. The benefit of this is the ability to see how long the users take to complete a task, or whether there are any steps that they may not mention in person. There is an inevitable feeling of being watched by the observer, so better results come from when the user is more relaxed in their environment. Once they have forgotten that they are being observed, they demonstrate exactly how they would complete a task.

Observation can be carried out in person, or by using cameras to record over time. This helps to give a complete picture of the tasks that are carried out at a workstation, even if they are not specifically work related. E.g. eating lunch at a desk.

Interviews

Speaking directly with the user to find out what tasks they complete and how they are completed. An interview usually has a structure of questions in order to ensure that information received is comparable between users so that a picture can be built up of the likely tasks. As well as the structure, the interviewer has the opportunity to ask additional questions that may arise during the discussion. This helps to identify areas that the user themselves may have missed.

Surveys

Surveys may be carried out remotely over the internet, the main benefit being a broader range of results from users. They are less flexible than other formats because there can be no prompting the user for more information.

2.3.6. Task analysis process

For the sake of this document, the process has been simplified into achievable steps. *Kirwan and Ainsworth*[5] describe many different methods and is a good reference guide for more extensive task analysis.

See chart on following page for an example of task analysis.

2.3.6.1. Process

1. Identify the tasks

First find out what main tasks are likely to be completed using the product. Use **Observation, Interviews, Surveys** etc. It is best to identify the tasks with more than one user to ensure that the entire population is considered.

2. Task representation

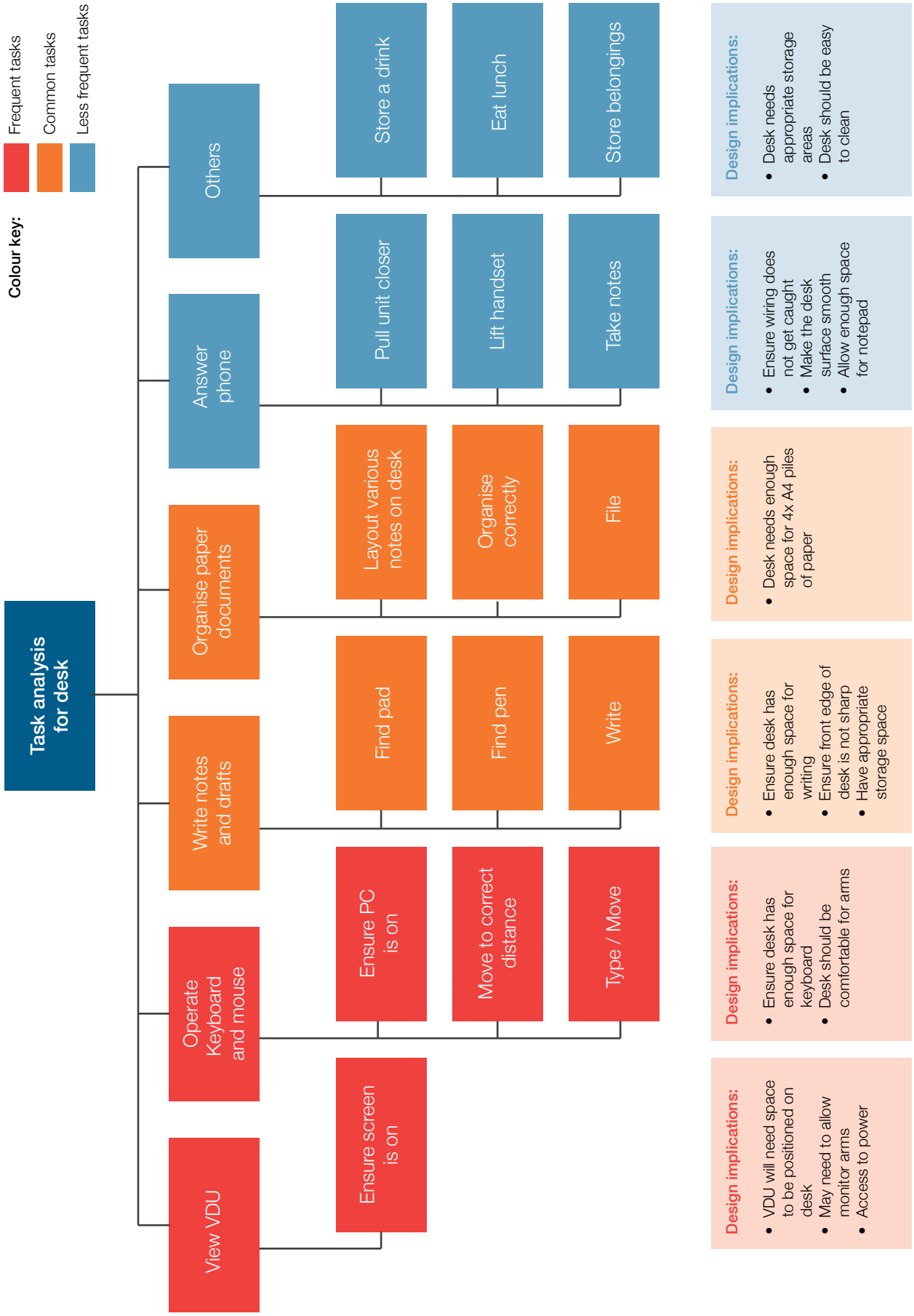
Using the data collected, create a list of the overall tasks that are frequently completed using the product. Some tasks may have more than one sub-task. These tasks should then be made into a diagram or table to show the flow.

3. Feedback to users

Discuss the results with the users to ensure that nothing has been missed. Step 2 can then be completed again to amend anything necessary.

4. Apply to design process

With this analysis completed, use it in the design process to improve a product and ensure that it caters for the tasks at hand.


Colour key:
Frequent tasks
Common tasks
Less frequent tasks
Task analysis for desk
View VDU
Operate Keyboard and mouse
Write notes and drafts
Organise paper documents
Answer phone
Others
Ensure screen is on
Ensure PC is on
Find pad
Find pen
Write
Layout various notes on desk
Organise correctly
File
Pull unit closer
Lift handset
Take notes
Store a drink
Eat lunch
Store belongings
Design implications:
• VDU will need space to be positioned on desk
• May need to allow monitor arms
• Access to power
Design implications:
• Ensure desk has enough space for keyboard
• Desk should be comfortable for arms
Design implications:
• Ensure desk has enough space for writing
• Ensure front edge of desk is not sharp
• Have appropriate storage space
Design implications:
• Desk needs enough space for 4x A4 piles of paper
Design implications:
• Ensure wiring does not get caught
• Make the desk surface smooth
• Allow enough space for notepad
Design implications:
• Desk needs appropriate storage areas
• Desk should be easy to clean

2.4. User trials

2.4.1. Introduction

User trials are essential to most design processes. This is using subjects from the target user population to test and use the product (or a prototype/ mock-up) to ensure that it is fit for purpose, comfortable and easy to use.

It is important that the trials are completed properly, or there is no benefit in the data. During research, several designers talked about how they had seen design decisions made by an individual using the product. If he/ she didn't like or fit the product, then it needed to be changed. This is a very flawed way of looking at things because it is incredibly subjective and dependent on the size and physical characteristics of one person.

This section of the Toolkit introduces the area of user trials and provides a basic questionnaire to help in the development of products.

Image courtesy of Orangebox

2.4.2. User trial process

The majority of user trials require the following[4]:

Users
Members from the target population.

A product
Prototype or mock-up to test with. Needs to be accurate enough for the purpose, nothing more.

A set of tasks
What the user will complete during the trial.

User performance criteria
How to judge the product's effectiveness.

Measurement techniques
How to measure the effectiveness.

Location for trial
Preferably somewhere neutral.

Investigator
Person carrying out the trial.

This looks a lot more complicated than it actually is. The depth and complexity of the trial depends on what needs to be answered in regard to the product.

2.4.3. Selecting users

The sample of users needs to reflect the target population as a whole. *Wilson and Corlett*[4] state that this includes consideration of characteristics such as:

General characteristics
- Age
- Gender
- Target demographic

Basic physical characteristics
- Senses
- Body dimensions
- Physical capabilities

Cognitive characteristics
- Problem solving
- Decision making

Attitudinal characteristics
- Personality
- Motivation
- Initiative

Specific skills
- Level of education/qualification
- Specific experience regarding product

General experience with type of product
- Used before
- Expectations

This is obviously a fairly extensive list; it is unlikely to have to consider all of these areas.

2.4.3.1. Sample size

Depending on the time available, select a reasonable number of users. As a guideline, a sample of 10-50 users is recommended. As with all data, the accuracy of the results can increase with the amount of users involved.

If possible, use outside users (people not directly involved with the design of the product) who will not have any bias. When time and cost dictate otherwise, use people readily available, but stress that they should evaluate the product as honestly as possible.

Even at a basic level, use as wide a range of users as possible:

- Male and female
- Tall and short
- Large and small
- Young and old

Always ensure that they are considered to be part of the target population.

It is always made more difficult if designing for other countries or users, but it is important to stick to the target users as best as possible. One reason why it is best to use people from the target country is to ensure that the cultural factors involved are understood. There may be areas that are perfectly acceptable to us that other cultures would not accept. This can lead to costly design changes.

Image courtesy of Flickr, ThisParticularGreg, 2006

2.4.4. Quality of prototypes

How good do the prototypes need to be?

This depends on the aim of the user trials. If a cardboard model will suffice, then do not spend extra time creating anything more complex. It may not be necessary to create a mock-up of the whole product depending on which aspects are being assessed.

For comfort trials, ensure that all the materials are as close to the final product as possible, or use the final product itself. If mainly testing the shape and usability of a product, then a more basic prototype can be used. It is important with any user trial to use similar and neutral colours to prevent user bias.

There is no hard and fast rule for this other than it only needs to be good as it needs to be!

The image shown is of a prototype chair created by Zoeftig as part of their development process. The chair was constructed with simple materials but matched the digital design of the seat perfectly, enabling the prototype to be used for user trials and for the shape to be developed for the best fit for the most people.

Image courtesy of Zoeftig

2.4.5. Running the trials

It's best to try and get each user to complete the same tasks in a similar manner. It is preferable not to explain to the user how the product works, as this is a good test of intuitiveness. This helps to ensure that the results that are collected are accurate.

It is also good practice to record each user's personal attributes for referral later (data like height, weight etc.). In order to comply with data protection legislation, it must be stressed that these records should be kept confidential and destroyed after an agreed period of time.

When the list of tasks and location for the trials is set, consider how to record the information that the user gives during the trial. Two common methods are explained below:

2.4.5.1. Questionnaires and interviews

These are useful for briefer trials where the aim is to understand the user's opinion. The trials should not be too long or complex but allow the user to quickly give feedback about the product. Sometimes it may be appropriate to use numerical (or Likert) scales to quickly gauge how somebody is feeling. A basic example is provided as part of this Toolkit to use for trials. See Appendix 7.2

2.4.5.2. Observation

This technique is used generally used for longer trials where the interest is in the user's subconscious/natural behaviour. Either observe directly taking notes, or use video cameras to remove the user's feelings of being watched; instead the aim is for the user to forget that the cameras are even there. This helps to spot how products can improve areas that the users are not consciously aware of.

2.4.6. Choosing and carrying out tasks

In order to get useful results, carefully select tasks that help to achieve the feedback desired:

- Ensure that all the attributes of the product that need testing are included
- Create tasks that simulate how the product will actually be used
- Create measurable tasks
- Carry out the tasks in a logical way relevant to how the user is expected to use the product
- Keep the tasks as consistent as possible for each user

Example tasks:

- 'Adjust the height of the chair to match your lower leg height'
- 'Adjust the tension of the chair until it is comfortable to recline'
- 'Type/write the following while sitting in the chair appropriately set up'

It may be advantageous for users to carry out their normal jobs while using the product being tested. That way it is certain that the tasks completed represent real life environments and work styles. For example, give the product to someone to use at their workstation for a number of days.

Image courtesy of Orangebox

2.4.7. Measurement criteria

It is very important to be able to collect measureable data to help the development process. There is no point in doing the trials if the results cannot be substantiated.

Some of the common measures include:

- Accuracy and errors in a given task
- Convenience and ease of use
- Comfort
- Satisfaction
- Physical health and safety
- Physical fit
- Physical effort and workload

It is often necessary to include both objective and subjective measures in a trial. For example, use objective measures like accuracy, physical fit and workload, then subjective measures for convenience, ease of use and comfort.

Examples for objective measures:

- 'Strength required to pull handle'
- 'Does seat height match lower leg height'

Examples for subjective measures:

- 'Rate out of 10 how comfortable you feel'
- 'Comment on how easy it is to adjust the seat depth'
- 'Ability to rotate a control knob (enough grip, correct size etc.)'

2.4.8. Using the results

Once the data has been collected and collated, it can be used to make important improvements to the prototype designs. This step varies greatly depending on the product and the way the trial was conducted. Below are a few ideas of common practice:

- Look for correlating problems that people have found or stated (or that was observed)
    - Attempt to resolve these problems for the best fit for the majority of the population; this involves ensuring that any fit/ reach/clearance criteria are met (see section)
- Identify areas that need to be changed and those for which the cost/benefit ratio is unrealistic
- Ensure that the potential changes do not jeopardise the products ability to pass any relevant Standards

Frequently the issues highlighted are specific to the product in question. There are often moments of realising 'I/we didn't think about that!' By completing user trials early, designs can be corrected with less hassle and cost.

Depending on the nature of the changes, it may be necessary to rerun the trials, even on a limited basis, to see if the updates have been successful and have not had adverse effects on other areas.

Image courtesy of Zoeftig

2.4.9. Sample evaluation form

To help encourage user trials, FIRA has supplied a sample chair evaluation form that can be used or modified for basic user trials involving comfort. Please see Appendix 7.2 for this form.

A more detailed chair assessment questionnaire for adjustable furniture would also need to include questions concerning reach to controls, ease of use and postural fit. If more in depth user trials are required, please get in touch with the FIRA Ergonomics Department who can tailor their services to many different requirements and projects. Their expertise can help to ensure that products are comfortable and safe.

2.5. Legislation and Standards

2.5.1. Introduction

When designing furniture it is important to ensure that the product is safe when it is in use and capable of fitting the intended population comfortably, while still being environmentally friendly and fit for purpose.

Standards are used to verify safety and dimensional fit of the furniture for fitness of purpose.

2.5.2. The difference between Standards and legislation

Legislation is law and must be complied with. Standards (unless cited in legislation) are voluntary, are developed under consensus and are an indication of best practice. In general they are not a legal requirement. However, in the event of a safety incident enforcement bodies would expect to see manufacturers/suppliers to have a 'due diligence' defence, which would normally reference Standards as a means of proving fitness for purpose.

There is a hierarchy of Standards that is normally followed as a due diligence defence:

- European Standards (BS EN) that are listed in the Official Journal of the European Community (OJEC). These are pan European Standards that exist in all member states, and are considered to meet the requirements of the General Product Safety Directive (GPSD)
- European Standards (BS EN). These are pan European Standards that exist in all member states
- National Standards (BS). These are Standards developed and published in the UK only
- International Standards (ISO). In the absence of European or National Standards, International Standards can be considered
- Industry Standards/best practice

In the office and contract environment, a useful resource is FIRA's Specifier Services guide. The website is intended for specifiers to create accurate tender requirements. It can be used to ensure that the correct Standards are referred to during the development process. It also allows a specifier to create a technical specification with the intended product requirements and it will provide an up to date list of the relevant Standards. This website can be used for free. More information can be found here: http://www.specifierservices.co.uk/

2.5.3. Reviewing Standards

Standards change - all European and British Standards must be reviewed after 5 years. If technology or the knowledge and understanding around the subject is significantly different, then the Standard is revised. It is likely that more research has been carried out since the Standard was last published, and so it is important to ensure that the Standard be updated with the latest experience factored in.

A European Standard can take three to four years to revise; but if need be, a British Standard can be revised in as little time as a year, after which time a new version of the Standard is published.

2.5.4. Finding out what the latest version is

The Furniture Design Toolkit should be updated regularly with the latest Standard publications. FIRA also has a database of Standards which is kept up to date. This can be used to check for updates to Standards: http://www.fira.co.uk/standards-plus.

Another place to check for the most up to date information is the BSI website. http://shop.bsigroup.com/ is a searchable site where it is possible to look up a Standard and find out what the latest version is. Standards can also be purchased for use.

It is also possible to purchase Standards through FIRA's parent company BM TRADA, via their website http://bookshop.bmtrada.com/.

It is important to ensure that the correct Standard is being used: sometimes the same Standard number can point to two different Standards, one British and one ISO (an International Standard that has been adopted by the UK). Be sure to check the title of the Standard to ensure that the correct one is in use.

2.5.5. Going beyond the Standard

The Standards are key to guiding the industry in the quality of their products. However, there is no guarantee that a product is actually comfortable or fit for purpose just because it passes the Standard. They are a good start but not an ultimate conclusion. This is why FIRA has an Ergonomics Excellence Award that confirms, following a detailed assessment by FIRA's Ergonomists, the products that claim to go above and beyond. Find out more about the Ergonomics Excellence Award.

Below are some key points in ensuring that products are ergonomically excellent.

- Furniture should fit the user, allow movement and encourage good posture
- Furniture should be adaptable (depending on the task and location of the furniture)
- Furniture should be durable and encourage feelings of ownership (good furniture indicates that the purchaser respects the users)
- It should be easy to access, identify and select fit for purpose furniture
- Furniture should be environmentally responsible
- Furniture should not cause distractions
- Furniture should make the user feel safe and secure
- Furniture should be straight forward and easy to operate

Levent Çaglar with the 2013 Ergonomics Excellence Award winners.

3.

Office Furniture Design

Image courtesy of Orangebox

3.1 Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for office environments.

One of the main challenges for today's office designer is designing cost effective chairs with good adjustable features, while still being comfortable and simple for people to use. A current trend is the use of automatic adjustable features, for example weight responsive seat tension that doesn't need adjusting manually. Use of these automatic adjustments wherever possible in a design can benefit the user, particularly if the chair is frequently used by different people (for example in a call centre).

Desk designers are faced with a similar issue. Standing at work has benefits to health and efficiency[6] but sit-stand desks tend to be very costly due to the mechanisms involved. It is a big challenge to develop the best ergonomic solutions in the current economic climate.

With so many hours of peoples' lives spent in the office, ergonomics and good design is essential for a comfortable and efficient workplace.

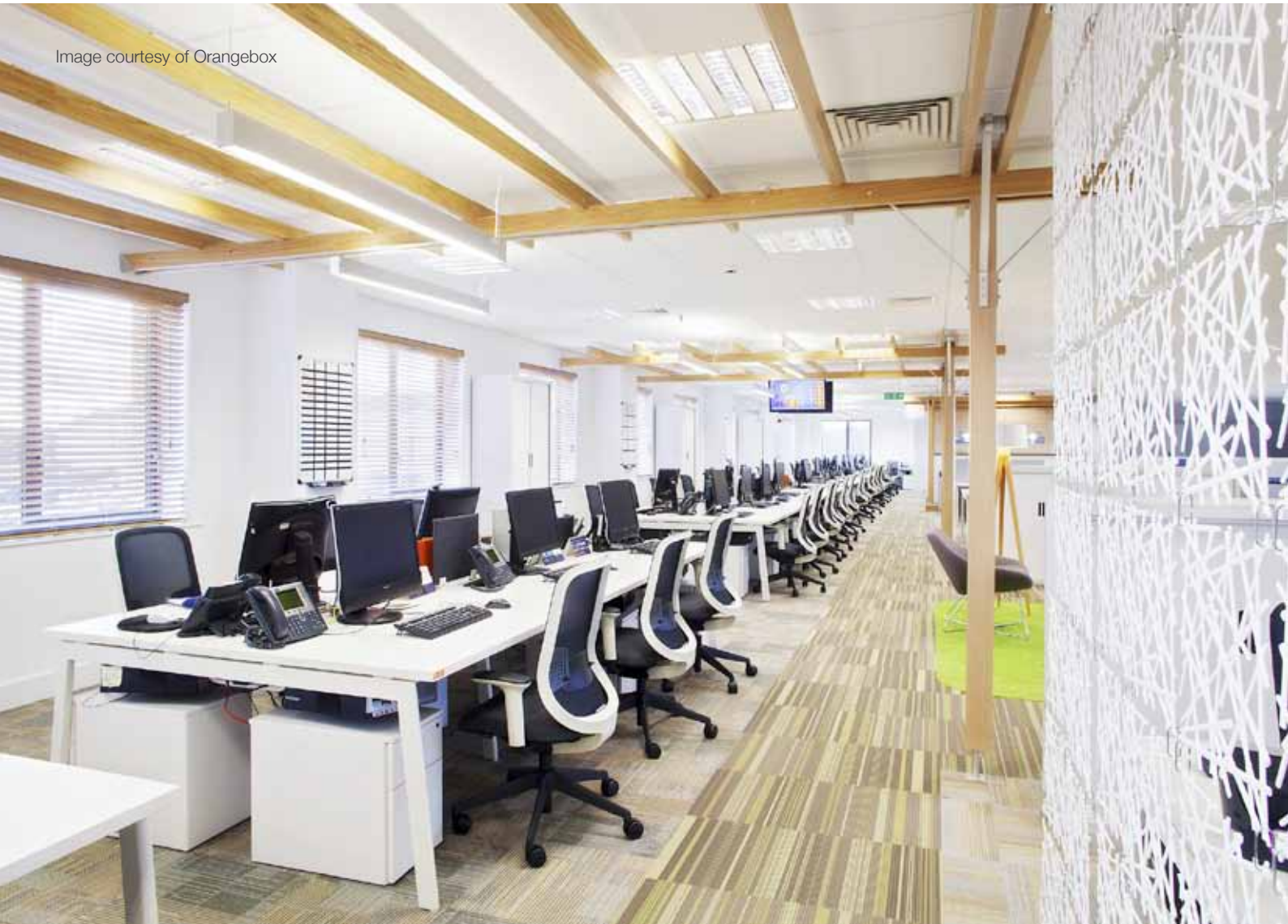


Image courtesy of Orangebox

3.2. Legislation and Standards

3.2.1. Legislation for office furniture

Legislation relating to the work place includes many regulations. While not exhaustive, the following have a direct impact on the design of furniture[7]:

- Health and Safety at Work etc. Act 1974
- Health and Safety (Display Screen Equipment) Regulations 1992
- Equality Act 2010 – replaces the DDA (Disability Discrimination Act), and can affect furniture (particularly work surface height)
- Machinery Directive 2006/42/EEC
- Regulatory Reform (Fire) (Safety) order 2005

The regulations mentioned above can be viewed free at www.legislation.gov.uk

More information can be found at the Health and Safety Executive (HSE) website, http://www.hse.gov.uk, including:

- Guide to seating at work: http://www.hse.gov.uk/pubns/books/hsg57.htm
- Guide to VDU work: http://www.hse.gov.uk/pubns/indg36.pdf

3.2.1.1. Health and Safety at Work etc. Act 1974 (HSWA)

This Act makes employers responsible for the health and safety of their employees as they carry out their work activities. This is relevant as it means that the seating or other furniture should not endanger the health and safety of people as they work.

The Act also makes manufacturers responsible in making sure that their furniture is safe, not proving a risk to health and safety. This responsibility includes providing instructions for use and for maintenance.

3.2.1.2. Health and Safety (Display Screen Equipment) Regulations 1992

The idea of these regulations is to reduce the health and safety risks from using Visual Display Units (VDUs) in a work environment. The regulations require employers to provide equipment which includes seating and desks in use at Display Screen Equipment (DSE) workstations to comply with the minimum requirements as set out in the Annex to the DSE Regulations include minimum requirements for workstations and seating. Health and Safety Executive (HSE) in their guidance document to the DSE regulations refer to European and International Standards as means of showing compliance with the minimum requirements in the DSE Regulations.

3.2.1.3. The Equality Act 2010

This replaced the previous Disability Discrimination Act and can affect the design of public place furniture which can also be used by the disabled. Furniture can include work surfaces, counters, storage and seating. There is a code of practice which has the relevant anthropometric data; it is the BS 8300: 2009: Design of buildings and their approaches to meet the needs of disabled people – Code of Practice.

3.2.1.4. Machinery Directive 2006/42/EEC

Under this directive all machinery (as defined by the directive) must be CE marked by means of risk assessment procedure. The Health and Safety Executive considers electrically adjustable desks to be a machine and therefore such desks need to be CE marked. The requirements will be contained within machinery standards such as BS EN 14378: 2002. Further information on the machinery directive and CE marking can be found at: http://ec.europa.eu/enterprise/sectors/mechanical/machinery/

3.2.1.5 Regulatory Reform (Fire) (Safety) order 2005

This Regulation can affect design as it has fire resistance requirement for upholstered materials. For further guidance refer to “Fire safety of furniture and furnishings in the contract and non-domestic sectors”. Available at: http://www.fira.co.uk/document/fira-contract-flammability-guide-october-2011pdf.pdf

3.2.2. Standards for office furniture

Although it is not a legal requirement for a product to pass a Standard (unless part of legislation, see section 2.5.2), it is common for tender documents to require that products comply with Standards to ensure that the products supplied meet the needs of their workforce.

Image courtesy of Interstuhl

3.2.2.1. Office swivel chairs

The following Standards are applicable for up to 8 hours use by people weighing up to 110kg:

BS EN 1335-1: 2000
Office furniture. Office work chair. Dimensions. Determination of dimensions.

BS EN 1335-2: 2009
Office furniture. Office work chair. Safety requirements.

BS EN 1335-3: 2009
Office furniture. Office work chair. Safety test methods.

The following Standards are applicable for up to 24 hours use by people weighing up to 150kg:

BS EN 1335-1: 2000
Office furniture. Office work chair. Dimensions. Determination of dimensions.

BS 5459-2: 2008
Specification for performance requirements and tests for office furniture. Office pedestal seating for use by persons weighing up to 150kg and for use up to 24 hours a day, including type-approval tests for individual components.

The following Standards are applicable for up to 24 hours use by people weighing up to 200kg.

FIRA FS 055: 2005
Specification for performance requirements and tests for office furniture. Office pedestal seating for use by persons weighing up to 200kg and for use up to 24 hours.

Image courtesy of Boss Design

3.2.2.2. Workstations and tables

The following requirements apply to the following product groups:

- Workstations
- Desks
- Side and printer tables
- Other ancillary office work surfaces

BS EN 527-1: 2011

Office furniture. Work tables and desks. Dimensions.

BS EN 527-2: 2002

Office furniture. Work tables and desks. Mechanical safety.

BS EN 527-3: 2003

Office furniture. Work tables and desks. Methods of test for the determination of the stability and the mechanical strength of the structure.

BS EN ISO 9241-5: 1999

Ergonomic requirements for office work with visual display terminals (VDTs). Workstation layout and postural requirements.

BS EN 13722: 2004

Furniture Assessment of the surface gloss. Measured using 60 degree geometry, (Requirement <40 gloss units. Source BS EN ISO 9241-5)

BS 6396:2008

Electrical systems in office furniture and educational furniture. Specification

Image courtesy of Haworth, www.haworth-europe.com

3.2.2.3. Storage furniture excluding filing cabinets

The following requirements apply to the following product groups:

- Mobile, fixed and desk attached pedestals
- Side filers
- Cupboards
- Door-fronted storage
- Tambour-fronted storage
- Wall-mounted cabinets
- Multi-drawer stationery cabinet

BS EN 14073-2: 2004

Office furniture. Storage furniture. Safety requirements.

BS EN 14073-3: 2004

Office furniture. Storage furniture. Test methods for the determination of stability and strength of the structure.

BS EN 14074: 2004

Office furniture. Tables and desks and storage furniture. Test methods for the determination of strength and durability of moving parts.

Image courtesy of Haworth, www.haworth-europe.com

3.2.2.4. Filing cabinets

BS 4438:1969
Specification for filing cabinets and suspended filing pockets.

BS EN 14073-2: 2004
Office furniture. Storage furniture. Safety requirements.

BS EN 14073-3: 2004
Office furniture. Storage furniture. Test methods for the determination of stability and strength of the structure.

BS EN 14074: 2004
Office furniture. Tables and desks and storage furniture. Test methods for the determination of strength and durability of moving parts.

Careful design of filing cabinets should allow the product to fulfil the following additional safety requirements:

- Filing cabinets must be fitted with an anti-tilt device to prevent more than one drawer being opened at the same time
- Holes on the sides and backs of the filing cabinets shall be provided in order to connect them to each other or to walls

Image courtesy of Haworth, www.haworth-europe.com

3.2.2.5. Screens

Movable or fixed office screens, including desk attached screens and free standing (floor standing) screens. This does not include screens that are permanently attached to the building structure.

The height of the screens depends on the amount of privacy needed. For teamwork, lower screens are used to allow eye contact. For more focused tasks, screens are higher than standing height to allow privacy and better concentration.

BS EN 1023-1: 1997
Office furniture. Screens. Dimensions.

BS EN 1023-2: 2000
Office furniture. Screens. Mechanical safety requirements.

BS EN 1023-3: 2000
Office furniture. Screens. Test methods.

Image courtesy of Orangebox

3.2.3. Fire safety requirements

FIRA has created guides to the regulations for both contract and domestic fire safety requirements. Download the guides from the website: http://www.fira.co.uk/publications/flammability-guides

3.3 Key considerations for meeting the requirements of Standards

Below are some of the often overlooked areas that can cause a product to not meet a Standard. Use the information during the development process to prevent expensive mistakes.

3.3.1. Finger traps

Finger traps can often occur when mechanical systems are being used. However, the requirements vary in their application and values from Standard to Standard. To be in compliance with current, and future, requirements, FIRA recommends having no shear or squeeze points around moving parts between >5mm and <25mm and no holes >5mm and <12mm.

3.3.2. Height of the armrests above a seat

It is important to ensure that the armrests of a chair can be lowered in order for smaller users to pull themselves closer to the desk. Often armrests bump or clash with the work surface and cannot be lowered any further. BS EN 1335-1 states that the armrests should be able to be lowered to 200mm above the seat surface.

Note: This is measured with a 64kg dummy on the seat pad.

Image courtesy of Interstuhl

3.4 Ergonomic design principles

MacLeod[8] gave some key concepts for ergonomics in the workplace. Below are some key design principles for furniture design adapted from this information:

3.4.1. Encourage neutral working positions

Image courtesy of Haworth, www.haworth-europe.com

Working in awkward, contorted postures can increase fatigue and physical stress on the body, as well as reducing strength and dexterity, which over time may make it more difficult to complete the task at hand.

A key factor is to prevent pelvic rotation that results in pressure on the spine (see appendix 7.1 for more information). The spine should be kept in its natural 's-shape' whether standing or sitting. This can be achieved in a number of ways such as a lumbar support, pelvic support or forward tilting chair. For more information, read Dauphin's Ergonomics Brochure, available on their website http://www.dauphin-group.com, which gives an excellent overview of the common musculoskeletal problems. Other considerations should be keeping the elbows and wrists in their neutral positions as much as possible.

3.4.2. Ensure everything is within easy reach

It is important to ensure that the size of the work surface is large enough to ensure that all the necessary equipment is in easy reach. Frequent stretching and reaching can cause issues over time that would be easily sorted by ensuring that commonly used objects are in easy reach. Consider the reach envelope – the semicircles made by arms stretched out.

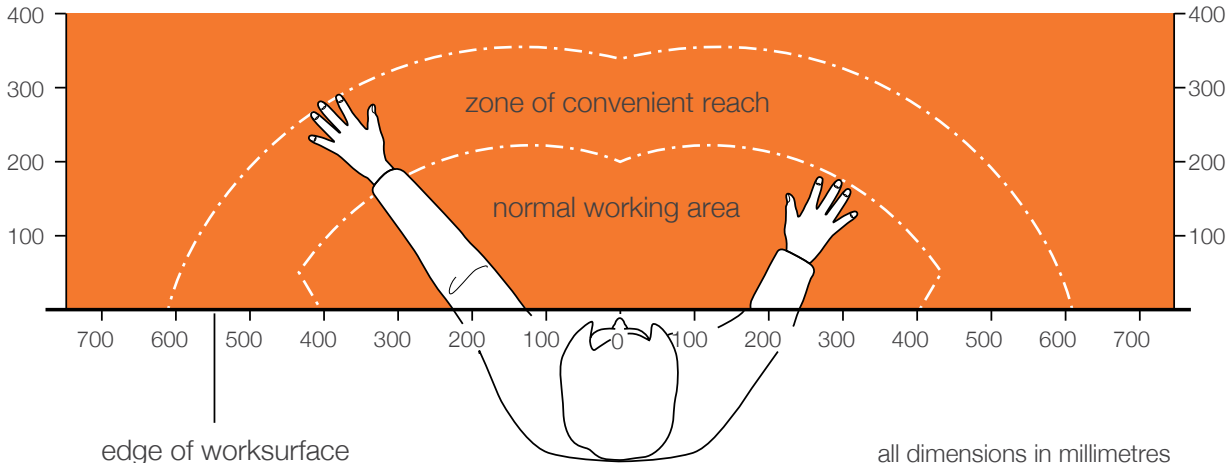


Image courtesy of HSE, Seating at work guide

3.4.3. Work at the correct height

A mismatch in heights between people and the furniture that they are using can lead to poor posture, fatigue and discomfort. In particular, the mismatch between sitting height and table height should be avoided at all costs. Work is often best completed at elbow height – to help keep the arms in a neutral position. Height adjustable surfaces are beneficial, but they are not always affordable or appropriate. Precision work is sometimes carried out higher in order to keep the work closer to the eyes. Heavier work requiring force exertion is usually carried out lower down to prevent strain.

Image courtesy of Haworth, www.haworth-europe.com

3.4.4. Minimise fatigue and static load

Holding the same position for a period of time, known as static load, can cause pain and fatigue. For example, when you hold a pen for too long your muscles tire and begin to hurt. Pain and discomfort from static load is noticeable in minutes. This is why it is important to encourage frequent movement and posture change.

It is good to change position and move. There is no 'correct' posture that is best for an entire work day so furniture that allows for the small unconscious movements that a person makes is ideal. The best posture is the next posture!

Image courtesy of Interstuhl

3.4.5. Minimise pressure points on soft tissue

Pressure points on soft tissue are felt quickly, causing fidgeting and discomfort, and often occur when the user is not seated on the chair as intended. For example, pressure on the thighs from the front edge of the seat if the feet are not touching the floor because the seat is too high. Points like this must be minimised as they can reduce blood flow and cause discomfort and fatigue. The main pressure from the body should be directed through the ischial tuberosities, which are designed to bear the weight.

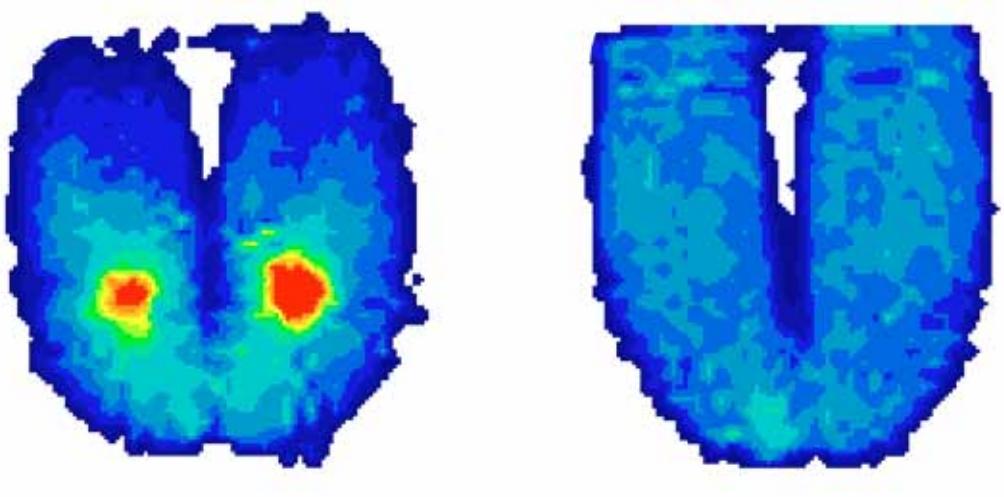


Image shows two examples of pressure mapping results on seated users, one showing high pressure points (left)

Image courtesy of Orangebox

3.5. Posture in the workplace and the challenge of the future

The traditional posture for the workplace has been explored and written about in great detail. For example see the picture of this reference posture below:

Image courtesy of HSE, Seating at work guide

This reference posture can give basic guidance as to how to set up a workstation, but it is not necessarily an optimal posture for a long length of time. The body should be encouraged to move and change postures frequently. Dynamic sitting should be encouraged with chairs that allow micro movements.

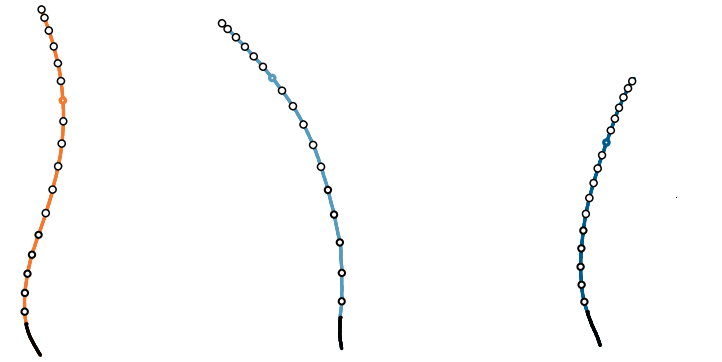
In today's workplace the multitude of digital devices like laptops, smartphones and tablets in use means that the classic work posture is no longer applicable. Research is underway into how to take these new devices into account in the office environment. For example, see Steelcase's recent study resulting in their new 'Gesture' chair.

Be sure to engage with research studies that look into how new devices may impact their users to future proof designs. Technology is a fast developing field and the impact of new equipment on postures is not yet fully understood. There is a big challenge for office furniture design to catch up with the fast pace of technology and to supply new furniture ideas that encourage the best possible posture for use with new technological devices. As an organisation, FIRA is keen to encourage this and to promote new ideas and concepts in working.

3.6 Spinal tracing and pressure mapping

3.6.1. Spinal tracing

Spinal tracing is a useful tool for furniture development. Using a spinal 'mouse', it is possible to trace the curve of the spine in various postures in order to compare on screen.

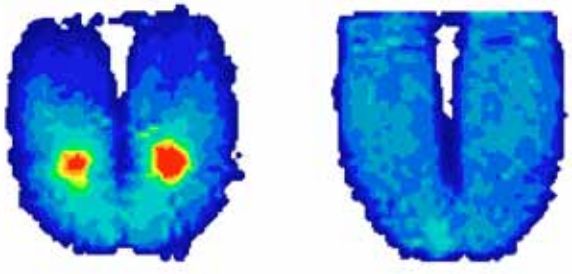


Standing Slouching Seated lumbar curve

The benefit of this tool is especially apparent when developing chairs with mesh backs. This tool can confirm whether the mesh is deforming correctly for back support. Good mesh should deform around the back of user to mimic the shape of the spine in standing posture. Correspondingly, bad mesh would mimic sitting in a slouched posture.

3.6.2. Pressure mapping

Pressure mapping is a tool using special pressure sensitive surfaces to objectively examine the pressure points that occur as someone uses an item of furniture. The information can be used to identify potential elements of the furniture that could cause it to be uncomfortable or not to fit correctly.



3.6.3. FIRA expertise

These tools require expert interpretation in order to get meaningful results. The FIRA Ergonomics Department can assist with any project requiring these tools and tailor the service to the product or issue at hand. Please contact FIRA for further information.

4.

Image courtesy of Perch/Hans Thyge & Co./Labofa

Educational Furniture Design

4.1 Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for educational environments. In 2008, FIRA published a document called 'Safe Seats of Learning – How good school furniture can make a difference' (available at: http://www.fira.co.uk/document/safe-seats-of-learning.pdf). It was written to raise awareness of the issues surrounding school furniture and ergonomics in schools. Below are a few quotes from the document[9]:

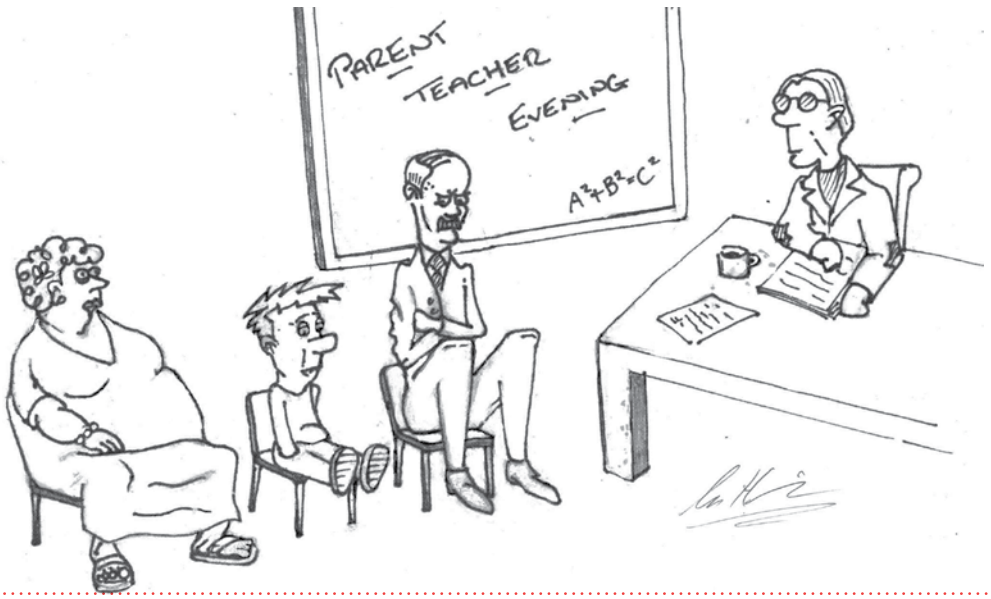
'We as a nation are embarking upon a major investment in our schools and teaching methods – but our school furniture design has changed little from the post-war era. It's not just about aesthetics – good furniture has a positive effect on both children's health and their classroom development.'

'With the exception of the introduction of polypropylene chairs in the 1970s, there has been no significant innovation in educational furniture in the last fifty years.'

'Much of furniture currently used in schools, if used in the workplace, would be deemed illegal under existing health and safety legislation'

Since this document was published, FIRA has worked with many designers who have created significantly improved furniture for educational environments. They have faced many difficulties but are passionate about seeing better furniture in schools.

A key issue is the fact that children grow continuously, not at a constant speed but in growth spurts. This means that a single size of furniture simply cannot accommodate all children, especially in secondary schools. A study found that less than 20% of the 11-13 year age range could find a suitable chair/desk combination[10]. There is no easy answer to this problem, so furniture should be carefully considered to give the best support to the most children.



"One size fits all?"
Lee Haines, FIRA
Testing Dept.

4.2 Legislation and Standards

4.2.1 Legislation for school environments

Existing Health and Safety Regulations apply to employees only and as the children are not employees, they are not covered by this legislation. However, teachers and anyone else working in the school premises are covered by a duty of care to provide safe furniture that is fit for purpose, of the correct size and safe for use. Such groups could use the British Standard for school furniture to specify furniture. By doing this they show they have discharged their duty correctly.

4.2.2. Standards for school environments

There is a European Standard for school furniture: **BS EN 1729 Furniture — Chairs and tables for educational institutions,** which has two parts:

- BS EN 1729-1:2006 provides dimensions for 7 sizes of tables and chairs for all ages of school children, along with recommendations for standing tables and adjustable furniture
- BS EN 1729-2:2012 provides requirements for safety, stability and durability of school furniture

The Standard covers fixed height and adjustable furniture for use with children, as well as work surfaces for standing work. This includes furniture for use with laptops and portables, and seats with double seat slopes.

As with many Standards, the dimensional Standard (BS EN 1729-1) is currently in revision. Please be aware that the new version is also likely to cover:

- Stools
- Tall chairs and tables
- Upholstered and swivel chairs

This section provides a guide to the key points in the Standard. Please contact FIRA Ergonomics Department for more detailed information and advice.

4.2.2.1. Educational Storage

prEN 16121
Non-domestic storage furniture. Requirements for safety, strength, durability and stability

BS EN 16122:2012
Domestic and non-domestic storage furniture. Test methods for the determination of strength, durability and stability

4.2.3. Size marks

Size marks are definitions used in the Standard to guide the size of furniture dependant on a child's age. The size marks have both a number and a colour assigned. The diagram below explains which size mark to use according to age group:

Image courtesy of Aalborg DK

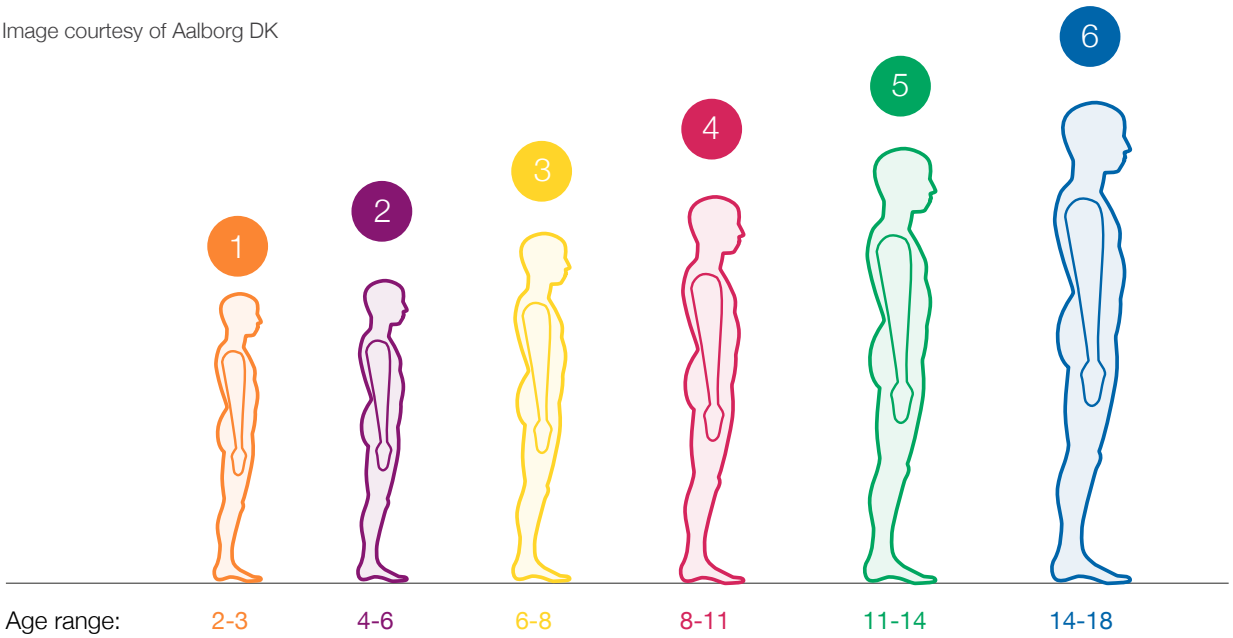
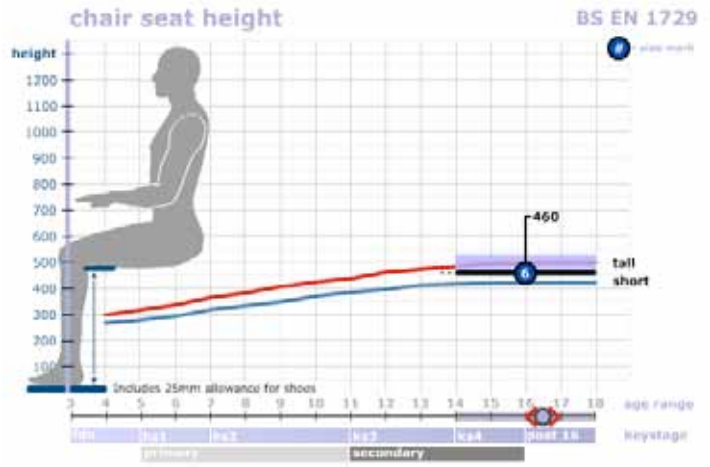


Image courtesy of Aalborg DK

4.2.3.1. Choosing the right sizes

There is an excellent web resource that can help to identify the correct sizes for the furniture being designed: http://www.schoolfurniture.uk.com

The website was created by FIRA, in conjunction with Counties Furniture Group and the Department of Education. The site contains information based on findings of FIRA's survey of school children in 2001. This data includes various standing and sitting dimensions and some of the basic size requirements found in the Standard. It also provides information on the selection of size marks. For example, for key stages, school types, and the pros and cons of the number of size marks selected to cover a range of children (e.g. all the children in secondary schools).



Screenshot of recommended chair seat height from the website

4.2.4. What a chair/table needs to do to comply with the Standard:

- Meet the relevant dimensional requirements in 1729-1
- Meet the additional requirements listed in Annex A.1 in 1729-1
- Have the correct markings (labels) and instructions provided in 1729-1
- Meet the requirements listed in Clause 4: Safety Requirements in 1729-2
- Pass any of the applicable tests in Clause 5: Testing of chairs, or Clause 6: Testing of tables in 1729-2

Image courtesy of Perch/Hans Thyge & Co./Labofa

4.2.5. Key dimensional requirements of BS EN 1729-1:2006

When the necessary size mark(s) has been identified, use the relevant dimensional requirements. Depending on the type of furniture, there are different sections within the Standard:

- Annex A: Standard chairs and tables – p9
- Annex B: High chairs with double-slope seats and associated tables – p17
- Annex C: Standing height tables – p23

Nb. Page numbers refer to BS EN 1729-1:2006

Each Annex includes diagrams and tables of dimensions, sorted by size mark.

Note that anything listed as a minimum dimension is an absolute minimum and so should be exceeded in order to comfortably pass the Standard. For other dimensions, pay close attention to the tolerances available.

4.2.5.1. Key dimensions for chairs

h_8	Height of seat	This is key because it helps ensure that the user is approximately the right height for the relevant table. It also ensures that the user can comfortably reach the floor with their legs.
t_4	Depth of seat	This ensures that the user's legs are well supported, while not causing discomfort by not allowing a user to reach the backrest correctly. i.e. to prevent slouching.
h_6	Height of point S	Height of point S refers to the most forward point of the backrest and is commonly known as the lumbar point. It is important to support the lower back at the lumbar region. This can be achieved by a lumbar device or a pelvic support which can prevent the backwards rotation of the pelvis.
ß	Backrest inclination	It is important that the chair is not too upright, or too reclined. This gives the user a good working posture.

4.2.5.2. Key dimensions for tables

H_1	Height of top	This ensures that the user can work at a comfortable height relevant to the floor and the chair.
T1	Depth of top	This ensures that the user has enough area to work.
-	Legroom	Legroom depth and width allows enough clear space for each user. See Table A.3 in the Standard.

Note: Although these key dimensions are highlighted, all the dimensional requirements in the Standard must be met in order to pass the Standard.

4.2.6. Key structural requirements of BS EN 1729-2:2012

FIRA has highlighted information about some of the elements of the structural Standard that products can struggle to meet. This is provided in order to allow informed design decisions. In most cases it is much easier to modify a design at the early stages but almost impossible to rectify without great expense later into a project.

4.2.6.1. General clause 4: safety requirements

It is possible to miss this page in the Standard, as it is separate from the actual test methods, but it is still very important to ensure that a product meets all of these safety requirements. Pay attention to the finger trap requirements (>8mm, <25mm) during the design process. In order to future proof designs, FIRA would recommend that there should be no gaps >5mm and <25mm around moving parts.

4.2.6.2. Chair tests

Clause 5.2 Stability

Chairs are tested for stability in each direction. Depending on the type of chair being designed, it may be more susceptible to tipping over in a certain direction. Use these requirements as a guide while designing to ensure that stability is correctly considered.

Clause 5.3.2 Seat and back static load

Chairs are tested with weights being loaded onto the seat and backrest. Particular care should be taken if designing a cantilever chair, as these have been known to be susceptible to failure in the past.

Clause 5.3.3 Seat and back durability

Chairs are tested with forces being applied to the seat and backrest up to 100,000 times.

4.2.6.3. Table tests

Clause 6.1 Stability

In a similar way to chairs, the tables should be stable enough to not tip over during normal use. The test puts force in the centre of the table near to the front edge as a worst case scenario.

Clause 6.2.3 Horizontal durability

This test puts strain on the table by applying horizontal forces onto the edges of the desktop. The desk needs to withstand the strain and not twist or buckle.

Clause 6.2.4 Vertical static load

This test puts load on the table by adding weights on the front edge. Care needs to be taken especially for longer double tables that need to be tested for the equivalent of two adults sitting on it.

Note: Although these key requirements are explained, all the structural requirements in the Standard must be met in order to pass the Standard.

4.2.7. Other Standards for educational environments

BS 5873-4: 1998

Educational furniture. Specification for strength and stability of storage furniture for educational institutions

Nb. This Standard is current, but will shortly be replaced by a European standard: BS EN 16121 (Requirements) and BS EN 16122 (Test methods)

BS EN 14434:2010

Writing boards for educational institutions. Ergonomic, technical and safety requirements and their test methods

4.3. Ergonomic design principles

MacLeod[8] gave some key concepts for ergonomics in the workplace, which are transferable to educational environments. Below are some key design principles for furniture design adapted from this information.

4.3.1. Encourage neutral working positions

Working in awkward, contorted postures can increase fatigue and physical stress on the body, as well as reducing strength and dexterity, which over time may make it more difficult to complete the task at hand.

A key factor is to prevent pelvic rotation that results in pressure on the spine (see appendix 7.1 for more information). The spine should be kept in its natural 's-shape' whether standing or sitting. This can be achieved in a number of ways such as a lumbar support, pelvic support or forward tilting chair. For more information, read Aalborg's Ergonomics Brochure, available on their website http://www.aalborgdk.com, which gives an excellent overview of the common musculoskeletal problems. Other considerations should be keeping the elbows and wrists in their neutral positions as much as possible.

Image courtesy of Perch/
Hans Thyge & Co./Labofa

4.3.2. Ensure everything is within easy reach

Making sure that the table size is suited for the age group is important so that all of their school equipment remains in easy reach. Frequent stretching and reaching can cause issues over time that would be easily sorted by ensuring that commonly used objects are in easy reach. Consider the reach envelope – the semicircles made by arms stretched out.

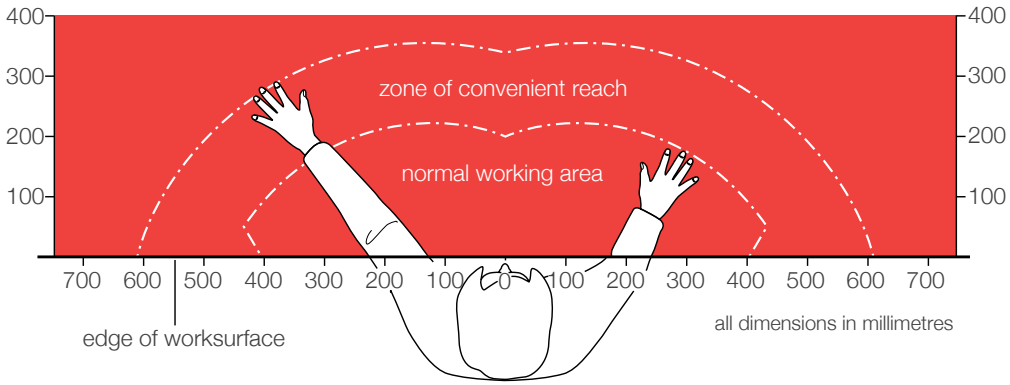


Image courtesy of HSE, Seating at work guide

4.3.3. Work at the correct height

A mismatch in heights between children and the furniture that they are using can lead to poor posture, fatigue and discomfort. In particular, the mismatch between sitting height and table height should be avoided at all costs. Work is often best completed at elbow height – to help keep the arms in a neutral position. Height adjustable surfaces are beneficial, but they are not always affordable or appropriate. Precision work is sometimes carried out higher in order to keep the work closer to the eyes. Heavier work requiring force exertion is usually carried out lower down to prevent strain.

Image courtesy of Community Playthings

4.3.4. Minimise fatigue and static load

Holding the same position for a period of time, known as static load, can cause pain and fatigue. For example, when you hold onto a pencil for too long your muscles tire and begin to hurt. Pain and discomfort from static load is noticeable in minutes. This is why it is important to encourage frequent movement and posture change. The challenge for educational designers is how to encourage this while keeping teachers who want their class still, quiet and happy!

It is good to change position and move. There is no 'correct' posture that is best for an entire school day, so furniture that allows for the small unconscious movements that a child makes is ideal. For example, the chair shown is the Newton Chair designed by Orangebox. This chair encourages movement by being able to rock. The best posture is the next posture!

Image courtesy of Orangebox

4.3.5. Minimise pressure points

Pressure points on soft tissue are felt quickly, causing fidgeting and discomfort, and often occur when the child is not seated on the chair as intended. For example, pressure on the thighs from the front edge of the seat if the feet are not touching the floor because the seat is too high. Points like this must be minimised as they can reduce blood flow and cause discomfort and fatigue. The main pressure from the body should be directed through the ischial tuberosities, which are designed to bear the weight.

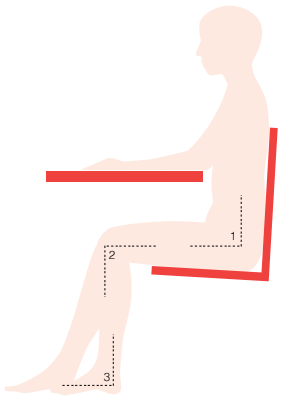
FIRA offers help with pressure mapping. Please see section 3.6.2.

4.4 Problems with typical postures of school children

A good posture is important for a human being because the spine is the main support for the body. It is particularly important in children as their bones are still developing.

Backcare[11] found several 'typical' postures of school children, discussed below. This information is provided so that designs can be adapted to counter the negative elements and encourage the positive elements.

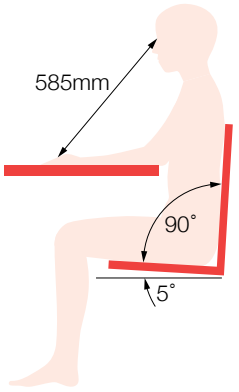
4.4.1. Three right angles



Children are often encouraged to sit as upright as they can, in the 'three right angles' approach. Children are made to sit with their thighs at ~90° to the spine, with their knees bent to keep the lower leg straight and keeping feet flat on the floor bent at ~90° at the ankle.

Positives: Reasonable for short periods of listening.
Negatives: Not sustainable for long periods of time.

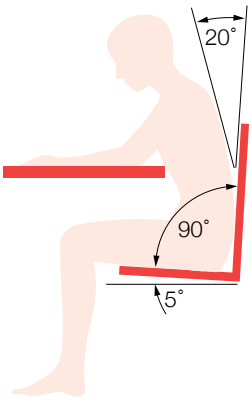
4.4.2. Upright position



Work begins from an upright position (three right angles), but the student's eyes are a long way from any work. This position loads the hip joints and the lumbar region in extreme positions. It's not a natural or a comfortable way to sit for any length of time.

Negatives: Neck strain, reading distance is too far from work to eyes, especially for younger children.

4.4.3. Working position

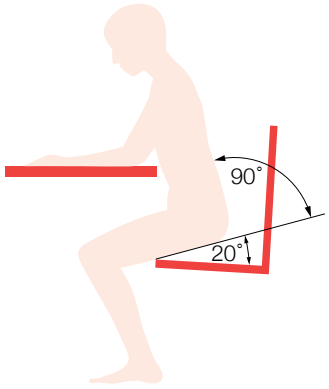


As soon as the student needs to read or write they adopt this position. Bending occurs in the lumbar region in order to bring the eyes closer to the page. Muscles, joints and ligaments are overstretched and the back begins to round (spinal kyphosis).

Positives: Eyes are closer to work for reading.
Negatives: Pressure on spine, angle between thighs and body is less than 90° (impacts oxygen and blood getting to brain).

4.4.4. Front of seat

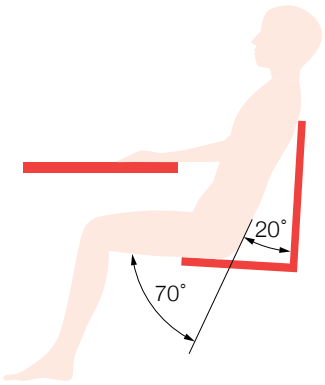
To avoid slouching, the student may shuffle forwards to the front of their seat. In doing so the front edge of the seat cuts into the thigh muscle and restricts the flow of blood to the legs. After a while soreness of the back and numb legs appear.
Positives: Eyes are closer to work and back is kept straighter, opens body up with a better angle between thighs and the back.
Negatives: If the body is not supported correctly, it can be uncomfortable.



Images courtesy of Aalborg DK

4.4.5. Resting position

For classroom activities that require low concentration levels such as watching a film, the posterior slides forwards on the seat. The effect is to reduce the bend in the hips from 90° to 70° and get the hip joints into a resting angle of 45°.
Positives: Reasonable for relaxing and listening for short periods.
Negatives: Backrest is too vertical, slouching posture, top of backrest can dig into shoulders.



By understanding these postures and applying the design principles in 4, it is possible to design furniture that really improves the children's posture and increase their well-being and comfort. This helps to increase their levels of attention, concentration and improve their behaviour, all of which cannot but help to improve their academic improvement.

4.4.6. Sloped seats and tilting tables

One thing to consider is using tilting table tops and high sloped seats to maintain the posture of the back while sitting and working. By raising the height and angle of the work surface, it becomes easier for the user to read without arching forwards over the desk. The high chair with forward slope encourages a natural posture in the back by preventing pelvic rotation.

More details about these ideas can be read in 'Good Posture Guide', created by Aalborg, which can be read on their website: http://www.aalborgdk.com

The example shown is of the RAY Chair, designed by Perch and Hans Thyge & Co, for Labofa. The designers used extensive research and user trials to develop the shape, and combined with aesthetic flare to create an attractive, modern seat that uses these ideas.

Image courtesy of Perch/Hans Thyge & Co./Labofa

Image courtesy of Perch/Hans Thyge & Co./Labofa

5.

Contract Furniture Design

5.1. Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for contract/non-domestic environments.

Contract furniture can be defined as tables and chairs (and other furniture) in non-task orientated areas for collaborative work, networking, meetings, breakout areas as well as furniture for visitors. Contract furniture also includes furniture in other non-domestic areas such as waiting rooms, hotels, restaurants, libraries and cafés.

Contract office furniture has seen a boost in recent years with tables and chairs for quick meetings and breakout areas becoming commonplace. Coffee shops and other social areas are also increasingly being used for longer hours as people work away from their desk using laptops and tablets. With the profile of contract furniture growing, it is important to take the design of such furniture seriously, especially as people are spending more time in these areas.

Image courtesy of Flickr, Hotel Concorde Berlin, 2010

5.2. Legislation and Standards

5.2.1. Legislation

Please see section 3.2.1 for information about workplace legislation.

5.2.2. Standards

Although it is not a legal requirement for a product to pass a Standard (unless part of legislation, see section 2.5.2), it is common for tender documents to require that products comply with Standards to ensure that the products supplied meet the needs of their workforce.

Currently there are no dimensional Standards or requirements for contract furniture. Please see section 5.4 for a set of recommended dimensions.

5.2.2.1. Contract tables

The following requirements apply to the following product groups:

- Meeting tables including those with folding legs and tilting tops
- Reception area tables including coffee tables
- Restaurant dining tables

BS EN 15372:2008

Furniture. Strength, durability and safety. Requirements for non-domestic tables. Test level 2

Image courtesy of Interstuhl

5.2.2.2. Non-task seating within office/reception/hotel/restaurant/library areas

BS EN 16139:2013
Furniture – Strength, durability and safety – Requirements for non-domestic seating

As can be seen in the table below, there are two test levels depending on the type of use. These are outlined in Annex B of BS EN 16139:2013[12]:

Level	Type of Use	Range of application
L1	General use	Areas in which seating is usually intended for mixed use (short-time and for a period of several hours, light to heavy load).
L2	Extreme use	Areas in which seating is occasionally or repeatedly subject to extremely high loads due to their specific types of use or due to improper use. Examples of end-use: night-clubs, police stations, transport terminals, sport changing rooms, prisons, barracks (non-controlled areas).

In addition, for linked seating the following Standard shall be used to assess the links:

BS EN 14703:2007
Links for non-domestic seating linked together in a row. Strength requirements and test methods.

Image courtesy of Haworth, www.haworth-europe.com

Waiting room, auditorium and beam seating permanently fixed to the floor shall be tested to the following Standard, test level 2 for conference areas and test level 3 public areas.

BS EN 12727: 2000
Furniture. Ranked seating. Test methods and requirements for strength and durability. Test level 4.

Wall mounted flip-up chairs are also covered by BS EN 12727: 2000.


Image courtesy of Johannes Jansson/norden.org

5.2.2.3. Contract Storage

prEN 16121
Non-domestic storage furniture. Requirements for safety, strength, durability and stability

BS EN 16122:2012
Domestic and non-domestic storage furniture. Test methods for the determination of strength, durability and stability

5.2.2.4. Steel clothing lockers including cube lockers for clothing

BS4680:1996
Specification for Clothes Lockers.


Image courtesy of Flickr, Hans Splinterhans (hans s), 2007

5.2.3. Key considerations for meeting the requirements of Standards

Below are some of the often overlooked areas that can cause a product to not meet a Standard. Use the information during the development process to prevent expensive mistakes.

5.2.3.1. Finger traps

Finger traps can often occur when mechanical systems are being used. However, the requirements vary in their application and values from Standard to Standard. To be in compliance with current and future requirements FIRA recommends having no shear or squeeze points around moving parts between >5mm and <25mm and no holes >5mm and <12mm.

5.2.3.2. Cantilever chairs

The seat and back loading tests for contract chairs are severe. Cantilever chairs should be carefully designed to ensure that the framework can withstand these forces, as it is common for them to fail by buckling backwards.

Image courtesy of Orangebox

5.3. Ergonomic design principles

5.3.1. Design principles for contract office areas

Section 3.4 contains several design principles that are also applicable in non-task focussed areas of the office environment.

5.3.2. General principles for other furniture areas

It is difficult to provide detailed principles when the furniture in question may be used for many different purposes. Below is a list of some more general principles that can be applied to any contract furniture situation[1]:

- Encourage frequent changes in posture
- Avoid forward inclination of the head and trunk
- Avoid causing the upper limbs to be held in a raised position
- Avoid twisted and asymmetrical positions
- Avoid postures which require a joint to be used for long periods at the limit of its range of motion
- Provide adequate back support in all seats, or provide a viable alternative to a backrest
- Where muscular force must be exerted the limbs should be in a position of greatest strength
- When the weight of the body must be supported, avoid the build-up of pressure on sensitive areas of tissue

5.4. Dimensional Recommendations

5.4.1. Recommended seat dimensions[13,14]

	Dimensions	Details	Typical applications (mm)	Soft seating applications (mm)
A	Seat height (at front) [i]	Fixed height	460 ± 10	400-470
		Adjustable	420 - 510	
B	Seat depth	Fixed depth	380-470 (450 preferred)	450-500 ii
		Adjustable	380-430	
C	Gap between armrests	Individual seat	460-510 (510 preferred)	
D	Minimum seat width per person	Individual seat	400	500
		For multi seating, sofas, benches etc.	500-600 (600 preferred)	500-600 (600 preferred)
E	Lower back support height [iii iv v]		200-250	
F	Armrest height	Fixed height	250 ± 10	200-250
		Adjustable	200-300	

Notes

[i] Seat height for upholstered seating should be measured when the seat is loaded with a 64kg dummy as in: *BS EN 1335-1:2000 Office furniture. Office work chair. Dimensions. Determination of dimensions* or *ISO/TR 24496:2012 Office furniture -- Office work chairs -- Methods for the determination of dimensions.*

[ii] 500mm seat depth would be too long for short females who may need scatter cushions in order to use the backrest.

[iii] Lower back support should be an area about 50mm in height, 200-250mm above the seat surface, and curved in the sagittal plane without too much obtrusion (<30mm).

[iv] Backrests can be concave in the transverse plane.

[v] For reclined postures (greater than about 20 degrees from the vertical) higher backrests and supports for necks & heads should be considered to avoid people sliding down the seat in order to support their upper backs or heads.

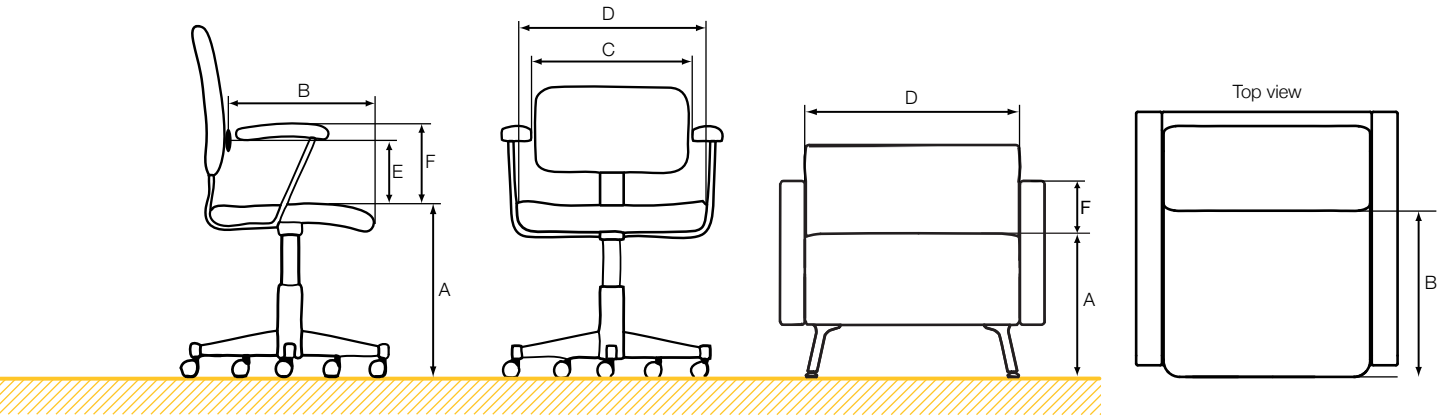


Image courtesy of Orangebox

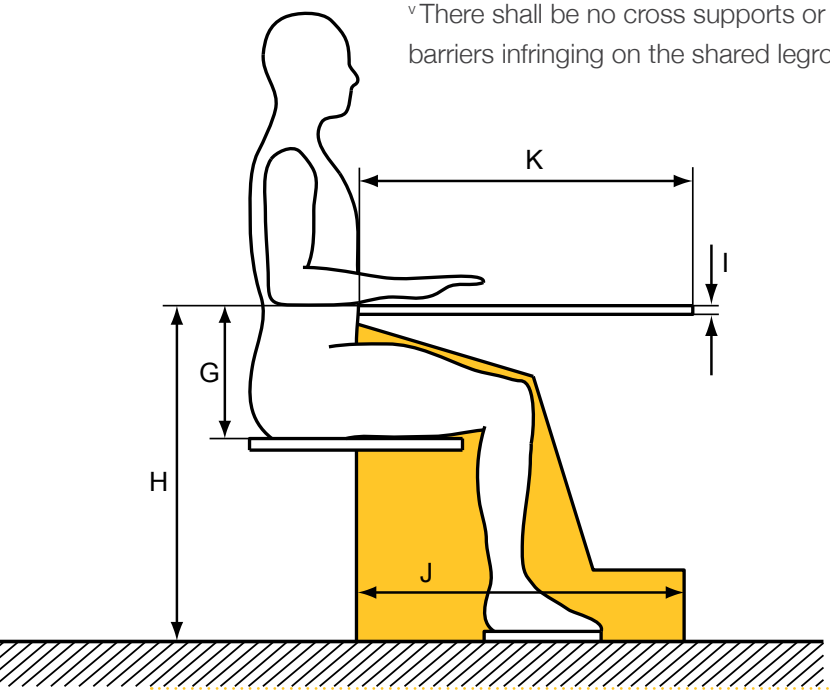
5.4.2. Recommended work surface dimensions

There is an important relationship between seat surfaces and work surfaces, which should not be ignored. This is a critical dimension to allow people to get their legs under a work surface comfortably. For contract applications this should be between 270 and 290mm (See dimension G).

	Dimensions	Details	Office applications (mm)	Dining applications (mm)	Dressing table (mm)
G	Distance between seat surface and work surface		270-290	270-290	270-290
H	Work surface height (fixed)	Sitting	740 ± 20	740 ± 20	740 ± 20
		Standing	1050 ± 50	1050 ± 50	
I	Work surface thickness (max)		70	100	100
J	Legroom depth	Individual	600-800	500 - 600	500 - 600
		Shared (face to face) [v]	900-1200	800-1200	
K	Surface depth	Individual	600-800	500 - 600	500 - 600
		Shared (face to face) [v]	900-1200	760 min (900 preferred)	

Notes

[v] There shall be no cross supports or other panels or barriers infringing on the shared legroom depth.



5.4.3. Recommended stool dimensions

Stools can be used for standing or other high surfaces. The gap between the top of stool seat and the top of work surface should be between 270 and 290mm (See dimension L). Any cross rails between the legs of the stool should be at a height (when measured from the top of stool seat to top of rail) corresponding to the recommended seat height (460±10mm) (See dimension M).

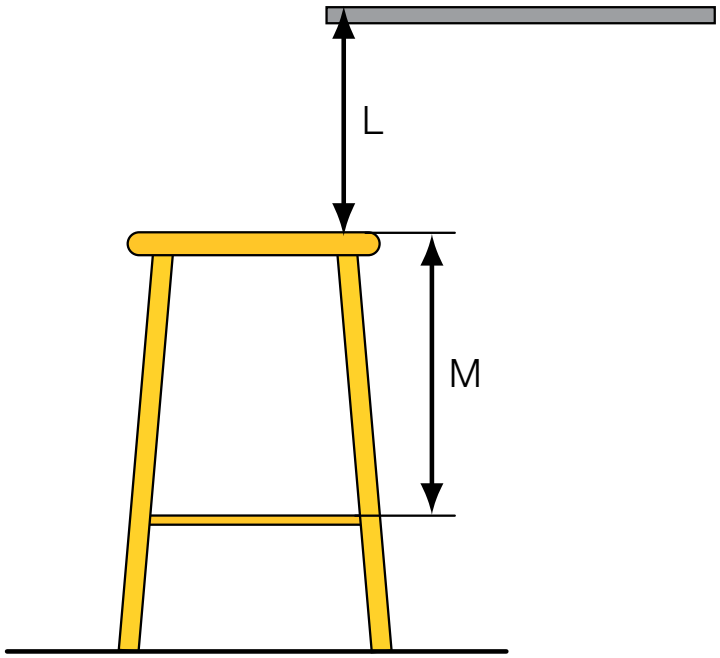


Image courtesy of Interstuhl

5.5. Posture

In today's society technology has developed to a level where information is always accessible, with a multitude of digital devices like laptops, smartphones and tablets in use in any location and posture. Research is underway into how to take these new devices into account in the office environment. For example, see Steelcase's recent study resulting in their new 'Gesture' Chair. However, research has not yet been extended to include general contract furniture situations.

In general, encourage movement wherever possible as static postures kept over time can cause discomfort and fatigue. Often people working in coffee shops will adopt a poor posture for several hours at a time as they can be hunched over a small table. With more people working in these environments, better suited furniture should be encouraged.

Be sure to engage with research studies that look into how new devices may impact their users to future proof designs. Technology is a fast-developing field and the impact of new equipment on postures is not yet fully understood. There is a big challenge for office furniture design to catch up with the fast pace of technology and to supply new furniture ideas that encourage the best possible posture for use with new technological devices. As an organisation, FIRA is keen to encourage this and to promote new ideas and concepts in working.

stock.xchng, Margarit Ralev, 2007

6.

Other resources

FIRA's expertise lies mainly in ergonomics and Standards. The main substance of the Toolkit reflects this, however there are many more areas of importance to a design process. This section provides pointers towards various resources that may help.

6.1 FIRA resources

6.1.1. General services

FIRA Ergonomics

Link: http://www.fira.co.uk/technical-services/ergonomics
Description: FIRA's ergonomists apply their knowledge of subjects such as engineering, anatomy, physiology, psychology and design to ensure that products and environments are comfortable, safe and efficient for people to use.

FIRA Testing

Link: http://www.fira.co.uk/testing-certification
Description: FIRA offers a unique facility covering many aspects of British, European and international test requirements for furniture, materials and components.

Furniture Industry Research Association Membership

Link: http://www.fira.co.uk/membership/
Description: FIRA offers a unique facility covering many aspects of British, European and international test requirements for furniture, materials and components.

6.1.2. Certification and award schemes

FIRA Gold Product Certification and FIRA Gold Installation Certification

Link: http://www.fira.co.uk/testing-certification/fira-gold-certification
Description: The FIRA Gold Certification scheme is a quality certification mark for a product or its installation within the furniture and kitchen industries and signifies that it has been assessed against specified performance levels through independent tests or evaluation.

Ergonomics Excellence Award

Link: http://www.fira.co.uk/technical-services/ergonomics/fira-ergonomics-excellence-award
Description: The Excellence Award recognises companies who design and manufacture ergonomically outstanding products, especially those that meet and generally exceed the requirements of British and European standards.

Innovation Award

Link: http://www.fira.co.uk/testing-certification/fira-awards-and-certification-schemes/innovation-award

Description: Recognising unique furniture products for their exceptional innovation, imagination and practicality.

6.1.3. Specific resources

FIRA's Specifier Services

Link: http://www.specifierservices.co.uk/

Description: FIRA Specifier Services offers a free, easy to use online portal that provides clear, concise and accurate information to support those specifying, developing or reviewing tenders for non-domestic and contract furniture.

Export Hub

Link: http://www.exportingfurniture.com/

Description: Exporting furniture creates new markets and new opportunities. Unfortunately, the process can be daunting, particularly for smaller organisations. The aim of this site is to guide furniture manufacturers along the export path and to signpost information sources that will assist the journey.

FISP: Furniture Industry Sustainability Programme

Link: http://www.fispfurniture.com/

Description: Launched in 2006 to support and improve the furniture industry's sustainability credentials, FISP has rapidly become established as the industry forum on all environmental and sustainable issues.

Fire safety requirements

Link: http://www.fira.co.uk/publications/flammability-guides

Description: FIRA has created guides to the regulations for both contract and domestic fire safety requirements.

Image courtesy of Interstuhl

6.2 Material selection

Material selection is a key part of any design process, ensuring that the materials used to construct the product are fit for purpose and aesthetically pleasing. If the wrong material is chosen, the characteristics of the product may be affected. For example, selecting a plastic that is too stiff and does not flex like the design intended. Below are links to useful resources.

6.2.1. Web/software

Matweb
Link: http://www.matweb.com/
Description: Data sheets for over 96,000 metals, plastics, ceramics, and composites.

CES Selector
Link: http://www.grantadesign.com/products/ces/
Description: CES Selector™ is a powerful PC software application that offers extensive materials property data, advanced graphical analysis, and specialist tools to support materials selection and substitution decisions.

Cambridge University Department of Engineering
Link: http://www-materials.eng.cam.ac.uk/mpsite/
Description: …a resource to aid good practice in the selection of materials for product design.

The Engineering Toolbox
Link: http://www.engineeringtoolbox.com/
Description: Resources, Tools and Basic Information for Engineering and Design of Technical Application.

6.2.2. Books

Handbook of Materials Selection, Myer Kutz
ISBN: 978-0471359241
Description: An innovative resource for materials properties, their evaluation, and industrial applications.

Books by Michael Ashby
ISBN: 978-0750655545
Description: Michael Ashby has written many books on this subject.

6.3 Manufacturing processes

New manufacturing processes are always being developed. Significant costs may be saved by selecting the correct process. Realistically, an understanding of this comes with experience, but below are some useful resources that provide an introduction to the subject.

6.3.1. Books

Manufacturing Processes for Design Professionals, Rob Thompson
ISBN: 978-0500513750
Description: The only encyclopaedic guide to manufacturing processes that explores established, new, emerging and innovative production techniques that have, or will have, an important impact on the design industry.

Making It: Manufacturing Techniques for Product Design, Chris Lefteri
ISBN: 978-1856697491
Description: Making It covers a broad range of almost 90 production methods. As well as describing each process, the text offers guidance on its pros and cons and on suitable production volumes, the costs involved, speed of production, relevant materials and typical applications.

Engineering Materials and Processes Desk Reference, Michael Ashby et al.
ISBN: 978-1856175869
Description: A one-stop Desk Reference, for engineers involved in the use of engineered materials across engineering and electronics; this is a book that will not gather dust on the shelf. It brings together the essential professional reference content from leading international contributors in the field. Material ranges from basic to advanced topics including materials and process selection; and explanations of properties of metals, ceramics, plastics and composites.

Image courtesy of Wikimedia, Mixabest, 2008

6.4 Environmental design

Designers have an important responsibility to be environmentally aware as they develop new products. The world is becoming increasingly aware of the Earth's limited resources and the speed that they are running out. Below are some links to the key resources around the topic. FIRA has already created some excellent resources within the 'Specifier Services' project, which is why the Toolkit has not tackled this in more detail.

One helpful list is provided in *BS 8887-1:2006, Design for manufacture, assembly, disassembly and end-of-life processing (MADE). General concepts, process and requirements.* It gives a list of advice on how to select and source sustainable materials[12]assembly, disassembly and end-of-life processing (MADE):

a. Use materials which are as ubiquitous and abundant as possible
b. Use materials and components which are as local in origin as possible
c. Use less dense (lighter) materials, unless density contributes to lower energy or materials requirements of the product in use which outweigh the additional energy and material embodied in the product. Construction products and products requiring toughness are good examples of where this might apply
d. Use materials with low embodied energy (that is, the energy used to extract, harvest or gather them from source, process and transport to the manufacturing facility)
e. Maximise the use of materials which can be extracted, harvested or gathered from source with zero or minimal collateral material not intended for the product
f. Use renewable materials
g. Where certification schemes exist covering environmental stewardship of natural resources, such as that of the Forestry Stewardship Council, use materials approved under an appropriate scheme and Chain of Custody from plantation/forest to immediate supplier
h. Reuse fit for purpose components and piece parts
i. Use 100% reclaimed for reuse materials
j. Use recycled fit for purpose components and piece parts
k. Use 100% recycled or part recycled materials
l. Use recyclable materials which allow optimisation of quality, energy, waste and emissions in the recycling process
m. Use recyclable materials and components for which collection for recycling is well established for the product customer group (commercial, household), or which customers can recycle on site or easily despatch for recycling
n. Use recyclable materials and components for which there is a prospect of collections being established
o. Avoid pigmented plastics (for easier recycling) where possible
p. Use chemical additives (including metals) which are environmentally and physiologically benign
q. Use chemical additives (including metals) which are less environmentally and/or physiologically toxic or polluting than the current additives for the product category

6.4.1. Standards

BS EN 8887-1:2006 Design for manufacture, assembly, disassembly and end-of-life processing (MADE). General concepts, process and requirements
Link: Available on the BSI shop
Description: In addressing end-of-life requirements, BS 8887-1:2006 extends beyond specification for the manufacture and assembly of products to incorporate recommendations on how best to incorporate into the documentation, guidance on the ultimate reuse, recovery, recycling and disposal of the components and materials used.

6.4.2. Web resources

Design with Intent Toolkit
Link: http://requisitevariety.co.uk/design-with-intent-toolkit/
Description: It's applicable across product, service, interaction and architectural design, aimed at socially and environmentally beneficial behaviour change.

6.4.3. Books

Cradle to Cradle. Remaking the Way We Make Things, Braungart and McDonough
ISBN: 978-0099535478
Description: 'Reduce, reuse, recycle' urge environmentalists; in other words, do more with less in order to minimize damage. But as architect William McDonough and chemist Michael Braungart point out in this provocative, visionary book, this approach only perpetuates the one-way, 'cradle to grave' manufacturing model, dating to the Industrial Revolution, that creates such fantastic amounts of waste and pollution in the first place. Why not challenge the belief that human industry must damage the natural world? In fact, why not take nature itself as our model for making things? A tree produces thousands of blossoms in order to create another tree, yet we consider its abundance not wasteful but safe, beautiful and highly effective.

6.5 CAD resources

CAD Drawings are an important aspect of product design. Without high quality drawings, a design can be manufactured poorly or just incorrectly. The links and references below introduce some of the key resources available on the quality of drawings.

6.5.1. Standards

BS 8888:2011 Technical product documentation and specification
Link: Available on the BSI shop
Description: BS 8888 helps to make better use of the ISO system of product specification because it covers more than just engineering drawing: instead all aspects of technical product specification, including, for instance, the use of 3D CAD models to define component geometry are demonstrated.

BS 1192:2007 Collaborative production of architectural, engineering and construction information. Code of practice
Link: Available on the BSI shop
Description: BS 1192 establishes the methodology for managing the production, distribution and quality of construction information, including that generated by CAD systems, using a disciplined process for collaboration and a specified naming policy. BS 1192 is applicable to all parties involved in the preparation and use of information throughout the design, construction, operation and deconstruction throughout the project lifecycle and the supply chain.

6.5.2. Web

Cadsetterout.com
Link: http://cadsetterout.com/technical-drawing-standards/
Description: Website helping CAD users to ensure that their drawings can meet the required Standards. Based on BS 8888.

6.5.3. Books

Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards
ISBN: 978-0080966526
Description: Now in its 4th edition, “Manual of Engineering Drawing” is a long-established guide for practicing and student engineers to producing engineering drawings and annotated 3D models that comply with the latest BSI and ISO Standards of technical product specifications and documentation.

Image courtesy of Orangebox

7.

Image courtesy of Orangebox

Appendices

7. References

1. Pheasant, S. & Haslegrave, C. M. Bodyspace: Anthropometry, ergonomics and the design of work. (CRC, 2005).

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10. Parcells, C., Stommel, M. & Hubbard, R. P. Mismatch of classroom furniture and student body dimensions: Empirical findings and health implications. Journal of Adolescent Health 24, 265–273 (1999).

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12. BSI. BS EN 16139:2013 Furniture. Strength, durability and safety. Requirements for non-domestic seating. (2013).

13. Adler, D. Metric handbook: planning and design data. (Elsevier, 2006).

14. Panero, J. & Zelnik, M. Human Dimension and Interior Space: A Sourcebook of Design Reference Standards. (Architectural Press, 1979).

15. BS 8887-1:2006 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) General concepts, process and requirements

7.1 Standing vs. seated posture and the effect on the spine[11]

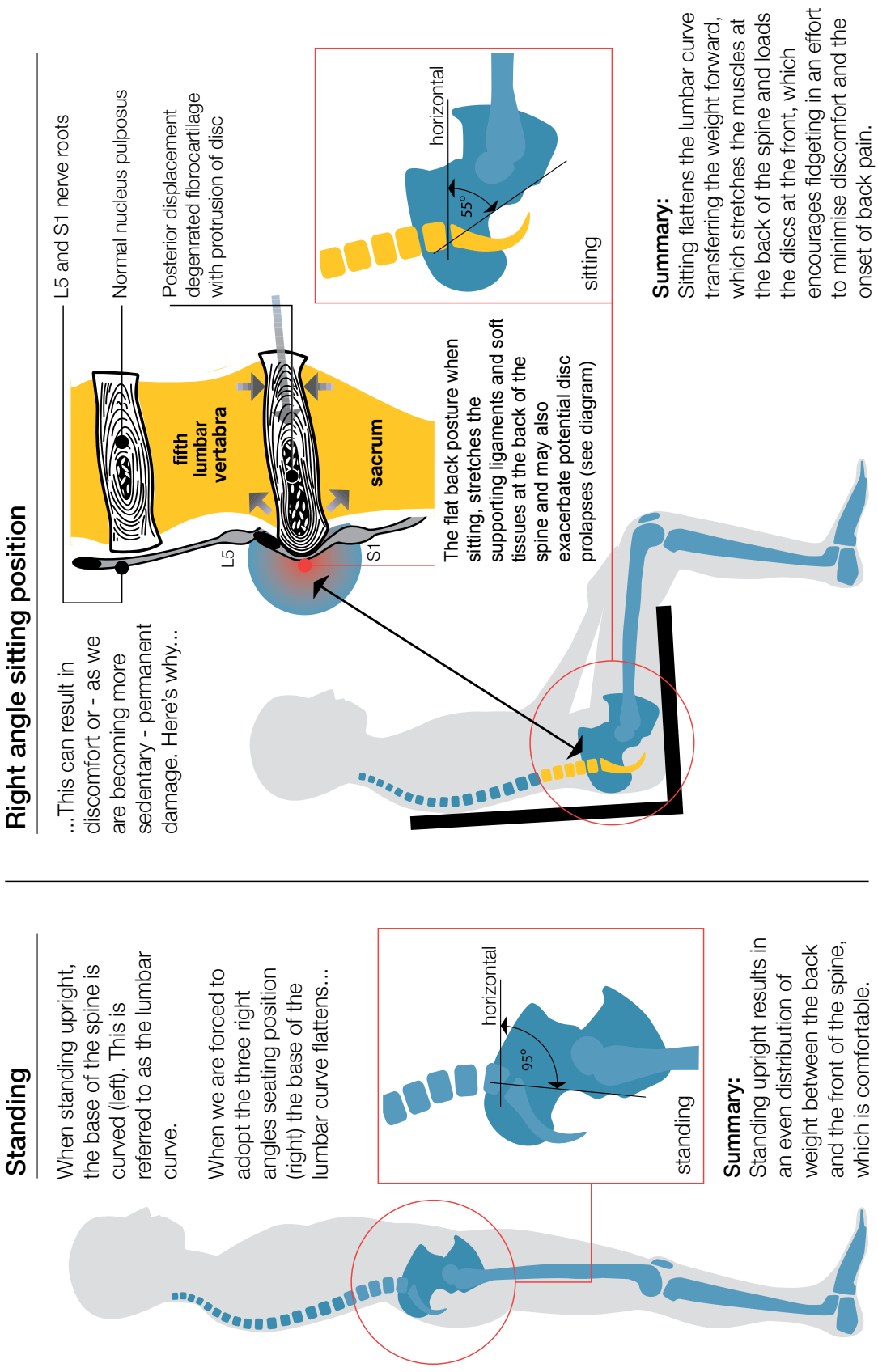


Image courtesy of Aalborg DK

7.2 Sample evaluation for user trials

CHAIR EVALUATION BY USING BODY DISCOMFORT RATING

Name of chair: ……

Name of person sitting on the chair: ……

Date: ……

Please use the seat for at least 30 minutes and after intervals of

5 minutes
15 minutes
30 minutes
45 minutes

rate any sensations you feel in each area indicated on the figure by the scale shown below.

0 NO SENSATION
(Comfortable)

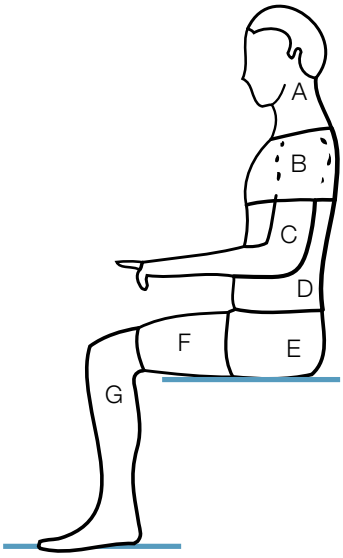
1 AWARE OF LITTLE SENSATION
(neither comfortable nor uncomfortable)

2 SENSATION OF SOME DISCOMFORT
(a little uncomfortable)

3 FEELING OF TINGLING OR NUMBNESS
(uncomfortable)

4 ACHING
(very uncomfortable)

5 PAIN
(can not sit any longer)



Body Areas	5 mins	15 mins	30 mins	45 mins
A Neck				
B Shoulders				
C Arms (right/left)				
D Trunk – including lower back				
E Buttocks				
F Thighs				
G Lower legs (right/left)				

What is your overall rating for the chair from 1(worst) to 10 (best)? ……

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