FURNITURE DESIGN TOOLKIT

FOR DOMESTIC FURNITURE

Key resources
for your design process





FIRA

Furniture Industry Research Association

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1.



Introduction

1.1. Publishing and copyright information

This Toolkit has been produced by FIRA International Limited on behalf of the Furniture Industry Research Association.

The FIRA copyright notice displayed in this document indicates when the document was last issued.

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All efforts have been made to ensure that the document is accurate at the time of publication. European and National regulations and Standards are frequently revised and therefore the data provided must be used with caution. The authors cannot be held responsible for any actions resulting from the use of this Toolkit. It is not intended as a substitute for project specific legal advice, which should always be sought where required.

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

Images from front and back cover courtesy of:

Meadowmead
Teal
Simon Pengelly Design
Ercol

1.2. Foreword



Outstanding, well-designed furniture, be it for the domestic or commercial market, requires innovation, design, ergonomics and engineering in equal measure in order for it to be both safe, comfortable and aesthetically pleasing, as well as fit for purpose and sustainable.

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

This need has fuelled the way for the Furniture Design Toolkit for Domestic Furniture, 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 as appropriate and provides designers with 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 environment through their design

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



Michael Powell,
Furniture Industry Research Association Chairman,
January 2016

1.3. Introducing the Furniture Design Toolkit

Furniture design needs to be good, as it involves a product that comes into direct contact with people. 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 second part of the Furniture Design Toolkit for Domestic Furniture, which does not dictate how to design, but aims to help advise design choices and improve efficiency in the development process. The guide complements the first Furniture Design Toolkit, which looked at office, educational and contract furniture, and has sole focus on domestic furniture.

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 that are not covered by the 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 considered 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.

1.3.1. Scope

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

- Bedroom
- Living and dining areas
- Domestic products for the elderly
- Bariatric furniture

The Toolkit itself should help to design:

- Seating
- Bedroom furniture
- Work surfaces, including tables and desks
- Storage items

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



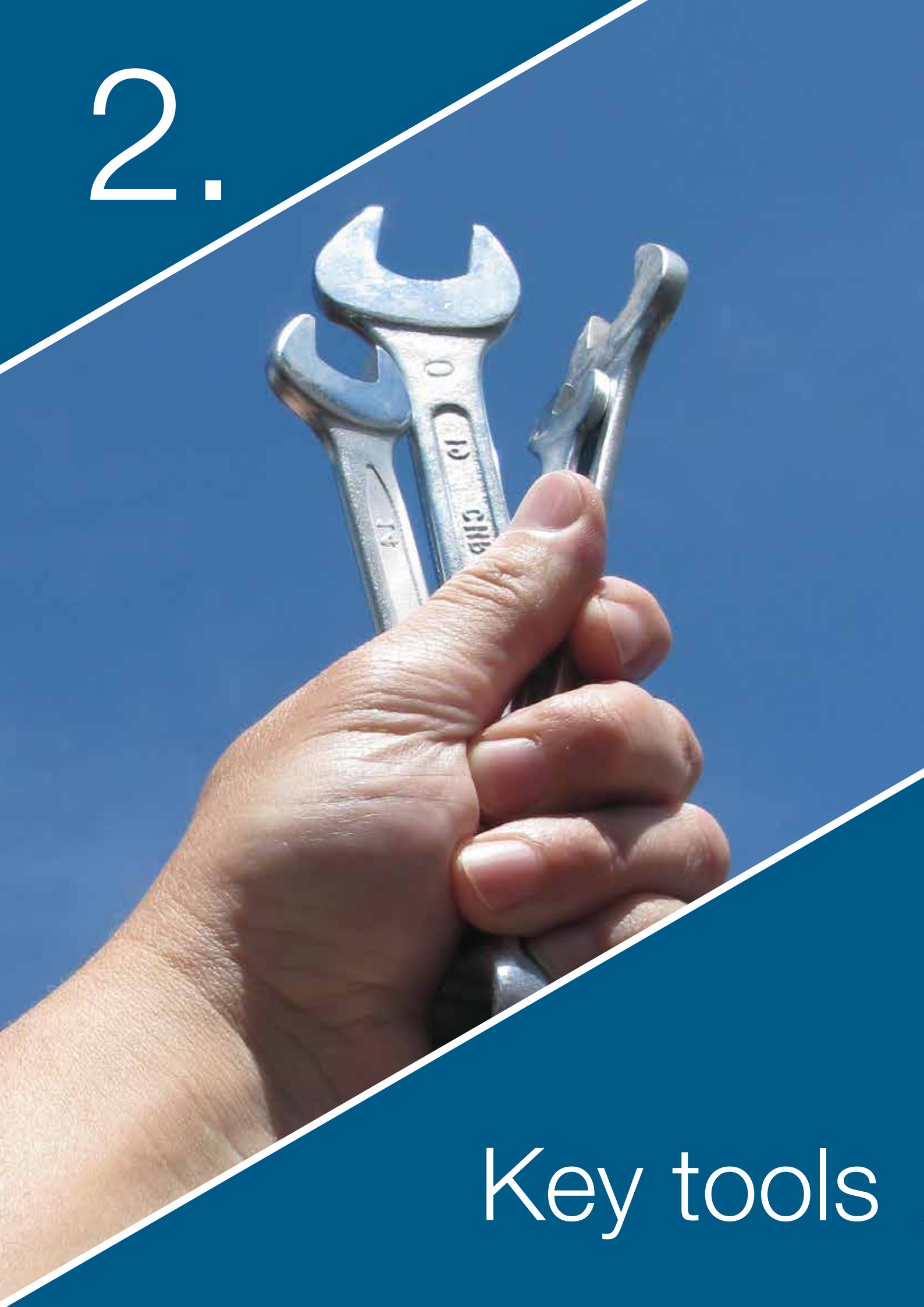
1.4. The toolbox

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:

Ergonomics and anthropometrics	What it is and how to use it Links to the best sources of data	**p.11**
Task analysis	Improving products by meeting needs	**p.28**
User trials	Improving products by testing with real people	**p.34**
Domestic furniture	Specific advice for designers Relevant legislation and Standards	**p.45**
Bedroom Furniture Design	Specific advice for designers Relevant legislation and Standards	**p.48**
Lounge/Dining Furniture Design	Specific advice for designers Relevant legislation and Standards	**p.56**
Home Office Furniture Design	Specific advice for designers Relevant legislation and Standards	**p.64**
Designing for the Elderly	Specific advice for designers Relevant legislation and Standards	**p.75**
Bariatric furniture	Specific advice for designers Relevant legislation and Standards	**p.84**
Other resources	Materials and processes Environmental consideration	**p.91**

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 products work in complete harmony. As such equipment and tasks should be aligned to human characteristics to reduce the stresses on users. In many cases, people can adapt to unsuitable conditions, but such adaptation often leads to inefficiency, errors or physical and mental cost. Designing products to improve posture and ease the load on the body can reduce instances of injury such as repetitive strain injury and upper limb disorder, which, if unchecked, can in extreme cases, result in musculoskeletal disorders.

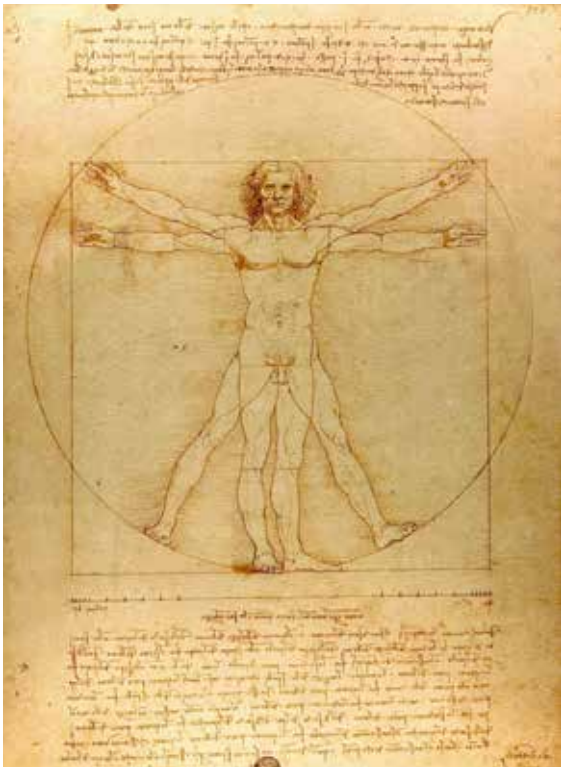
The application of ergonomics in the design of furniture products is important. Good ergonomics is an important factor in the overall health, safety and well-being of individuals. Good, ergonomically designed furniture occurs when it has been designed with both the intended user(s) and the intended use in mind.



2.1.1. Important factors

The ergonomic design of furniture has to take into account 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 using a product (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
- The ability of users being able to move freely 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

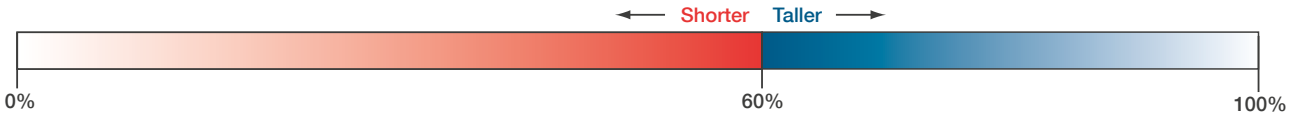
At the core of any real life product should be its function. For furniture, this involves how well it fits the user. While there may be dimensional Standards for a particular product, it is important to understand why these dimensions have been chosen and for this it is necessary to understand anthropometrics.

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:

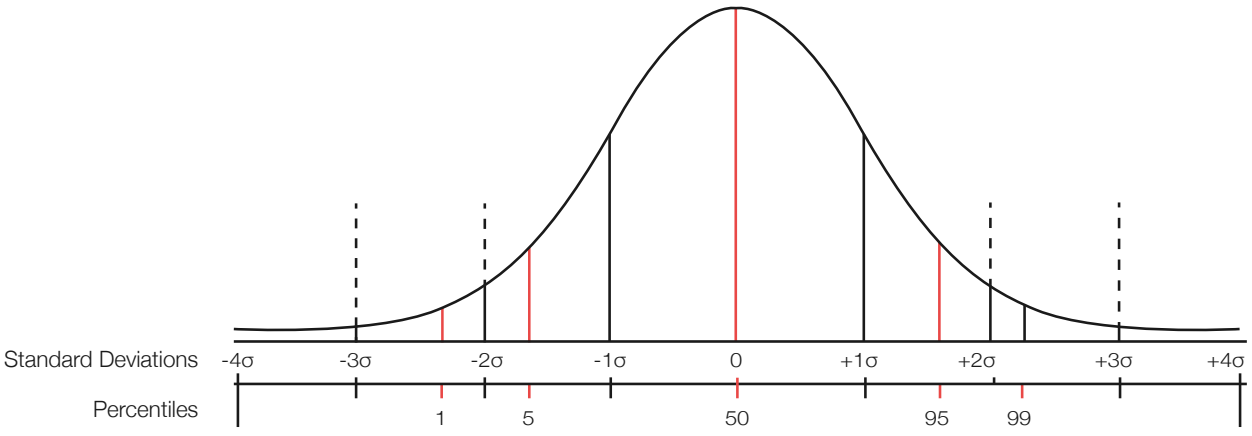
If data told us that the 60th percentile stature of UK males was 1777mm, it would mean that 60% of the population were shorter than this, and 40% were taller than this.



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.

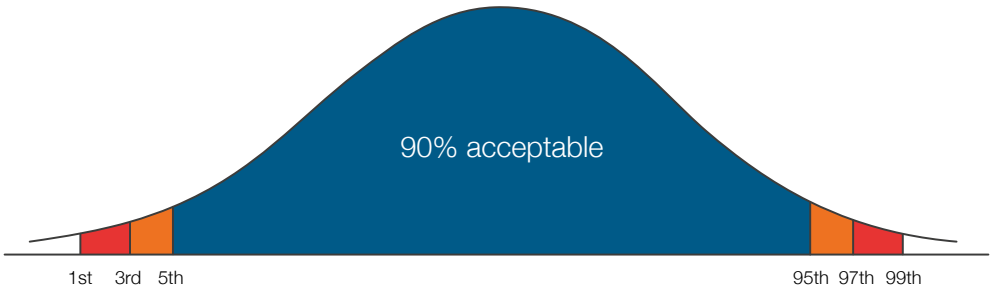
2.2.2. Why no one is average…

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.

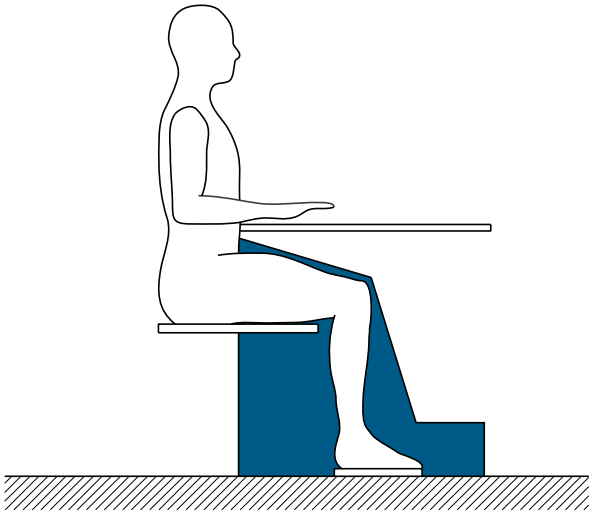
2.2.4. What percentile should you be designing for?

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 fixed height table, it is important to ensure that there is enough space under the table to accommodate a tall man. By designing the clearance under a table to the 95th percentile male, then the rest of the population, who have shorter legs, will have plenty of space under the table.



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, the rest of the population, who have longer reach, can operate the lever without difficulty. For example, if a lever on a recliner lounge chair is too far back then some users my struggle to reach round in order to operate it.



Image courtesy of Orangebox

2.2.4.3. Posture

This refers to the relationship between the dimensions of the furniture or space 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.

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 (formerly the Department for Trade and Industry -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 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 (taken from BS EN ISO 7250-1) and table 2.2.7 gives examples of how these measurements can be used.

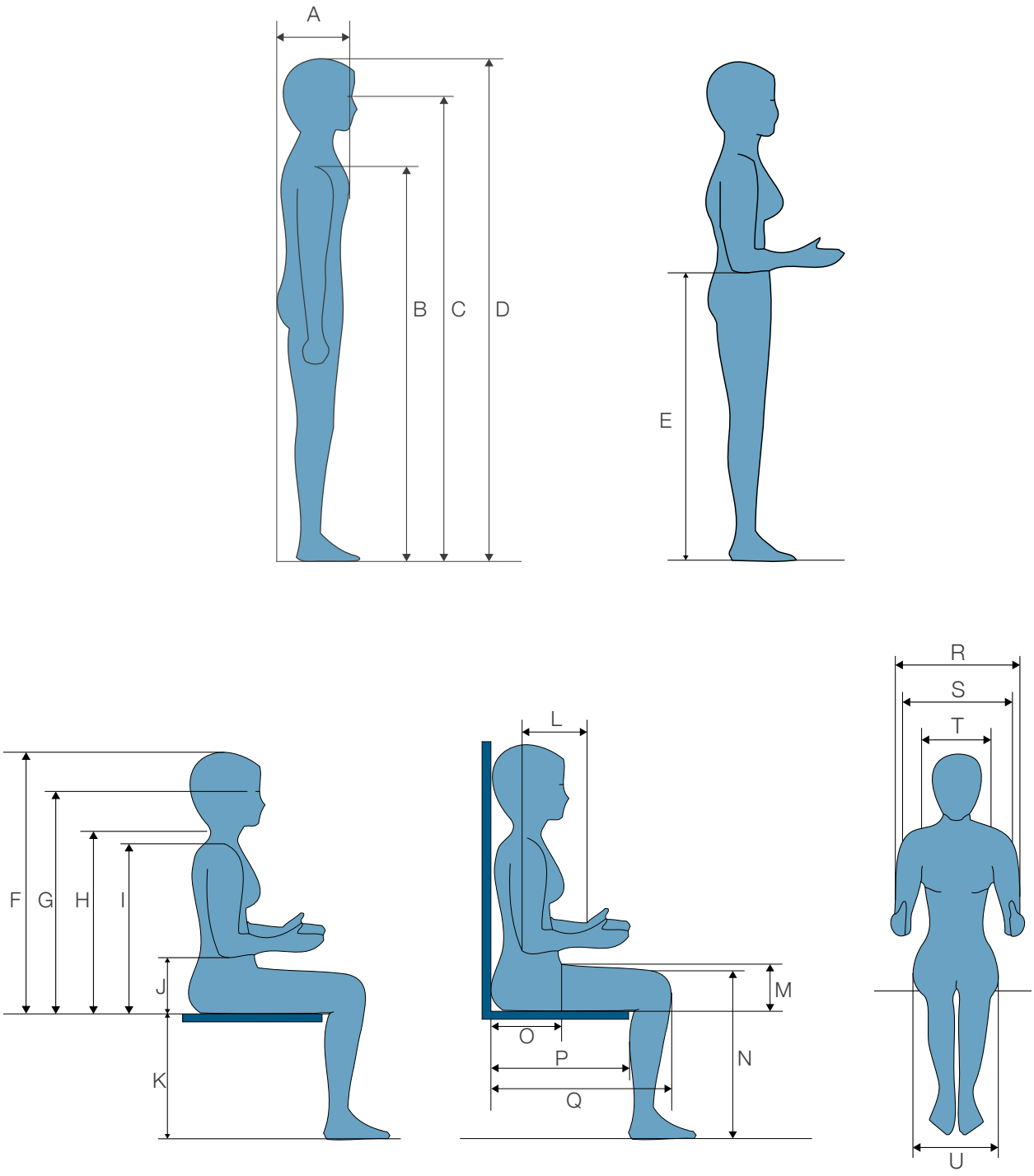
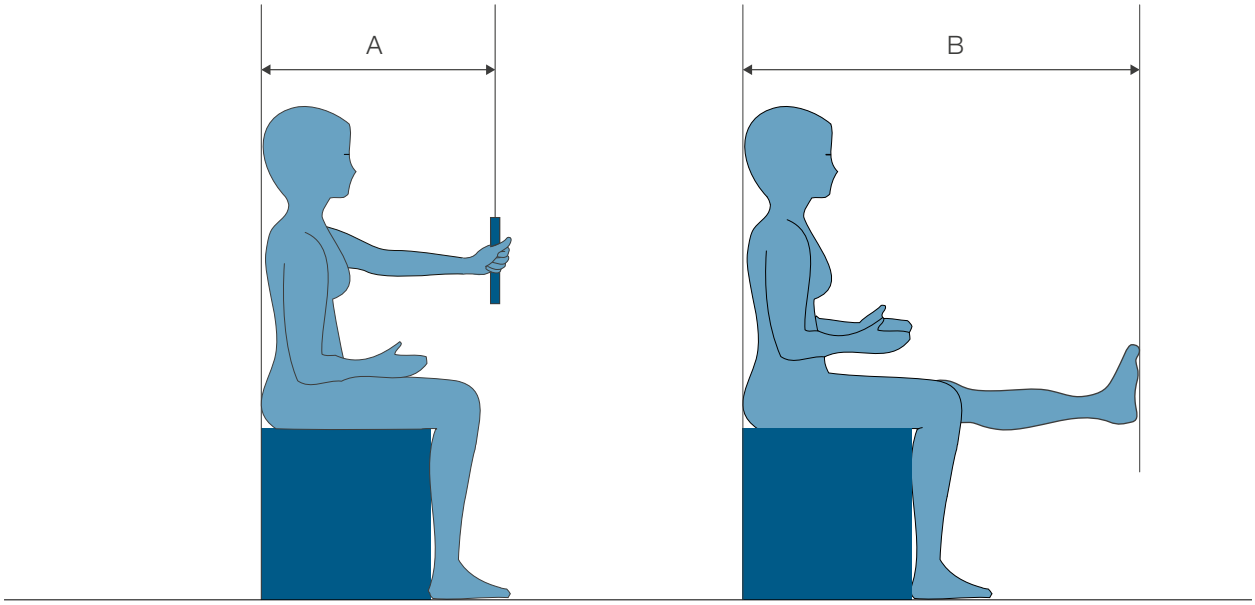


Table 2.2.7.

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. Dynamic anthropometric data

There are a number of dimensions that can show designers various dynamic postures. For example ‘grip when reaching in a standing position’. These can be useful when thinking about hanging height in a wardrobe or cupboard and a person’s ability to be able to grip a hanger and reach to put it in the wardrobe.



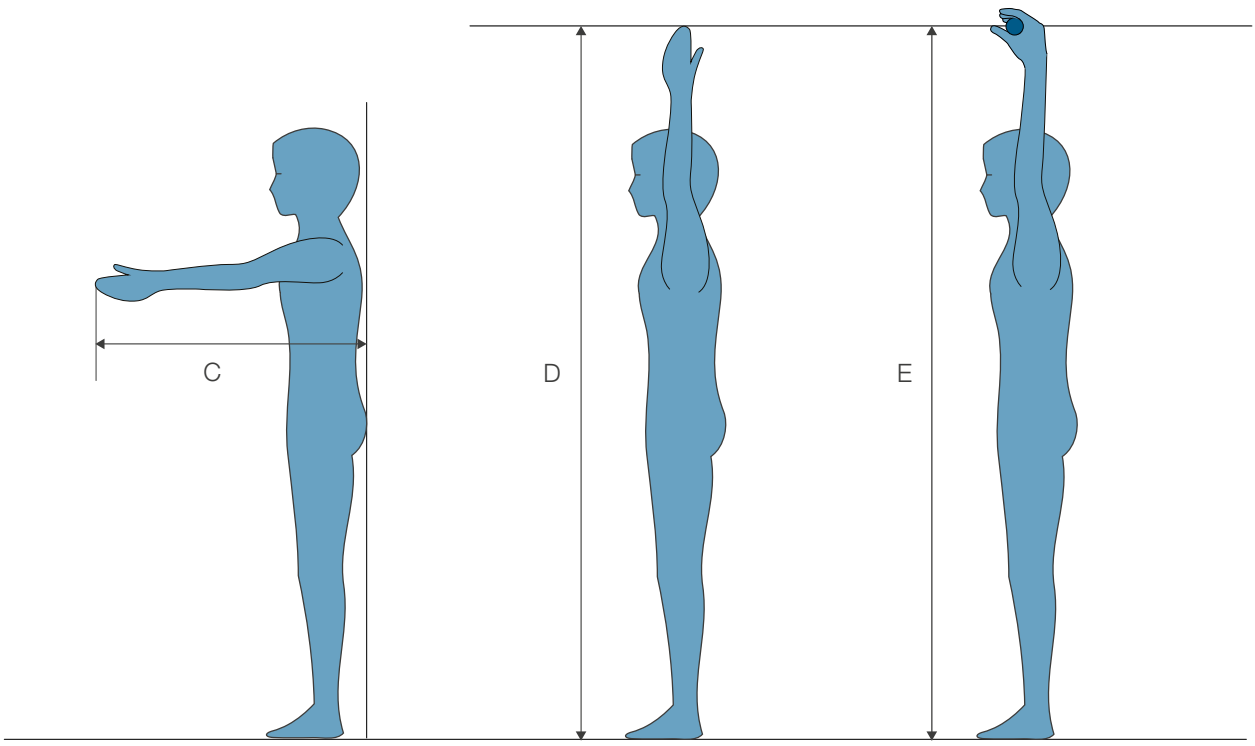


Table 2.2.8.

Key	Measurement	Uses
A	Forward grip reach	The user can put all four fingers around the object and use force in a pulling motion. For example, opening cabinet doors or drawers.
B	Overall sitting leg length	Minimum distance needed to support legs especially on recliner chairs
C	Forward fingertip reach	Maximum distance in front that the user can touch without exertion from other areas of the body. E.g, leaning over a counter to reach a high cabinet.
D	Overhead fingertip reach	Absolute maximum height user can touch. For example, the back of the top shelf in a wall mounted cabinet.
E	Overhead grip reach	This should be the maximum distance for operations that may require strength. For example, opening cabinet doors or drawers.



Image courtesy of Henderson Russell

2.2.9. 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:

2.2.9.1. 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://www.bodysizeshape.com/

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/

2.2.9.2. 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

2.2.9.3. 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

2.2.9.4. 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 Henderson Russell

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 activity and the way in which the individual uses the information and equipment provided.

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.



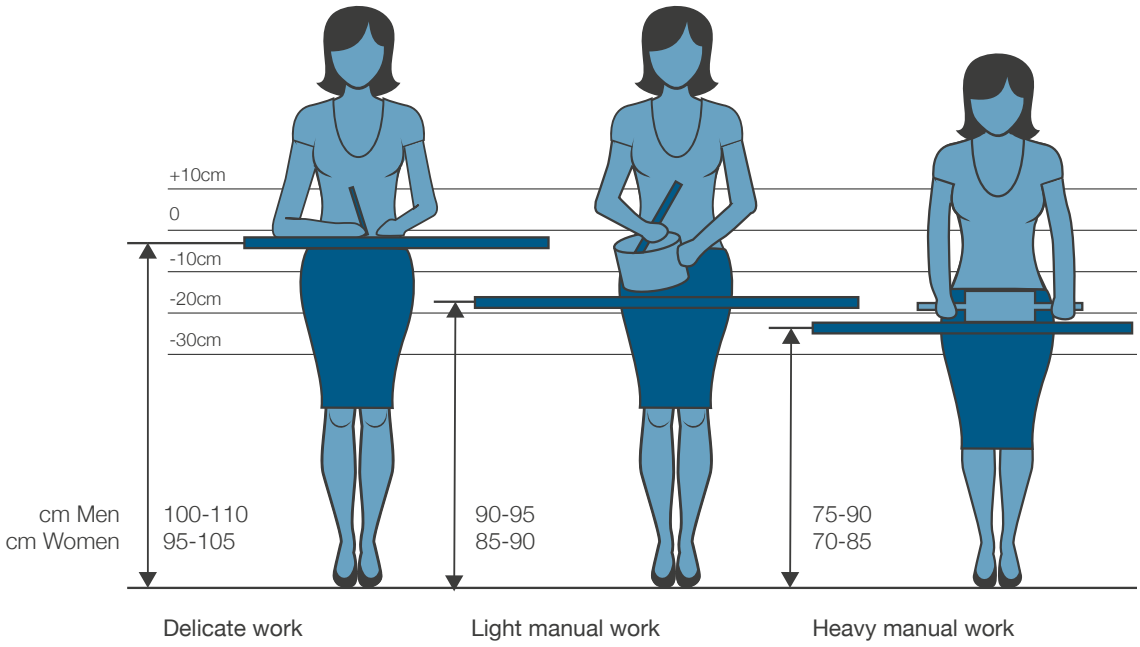
Image courtesy of Henderson Russell

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

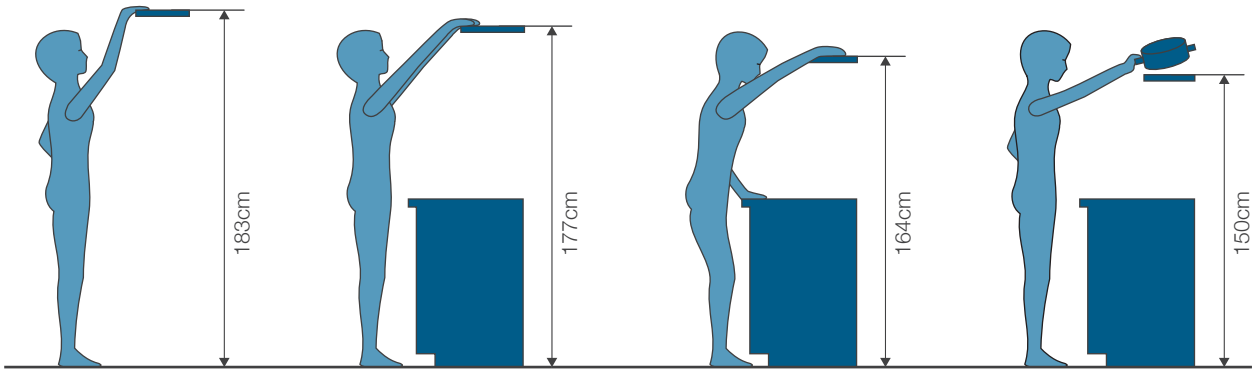
By applying task analysis during the design process, it ensures that a product is easy to use and meets the user's needs. Even if two or more people complete the same task, the way in which they complete it may be very different. Task analysis can help to ensure that each person is taken into account.

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.

Task analysis is very important for example when defining the height of a work surface in the home. As the force required to carry out the task increases, the lower the work surface should be. Task analysis can help to define the nature of the tasks and therefore determine what height would be suitable.



This is also true in how people reach for things when there are obstructions. Task analysis can define the appropriate reach height depending on what obstruction they have to reach over.



Consider how fast technology is advancing and how this is impacting on home environments. It is clearly vital to examine how people are working now. Tasks and equipment are changing and older solutions are no longer compatible. One important area is how to help people to achieve better postures when using portable devices. This is very important in the home environment as technology is used from the moment we wake up to when we go to sleep at night. We use it sat on our sofas or when lying in bed. Technology such as handheld devices and laptops are taken with us everywhere. It is important to understand how people use them and how we can help to encourage good posture when they are in use. 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. home: task description, associated equipment, frequency/duration of use?

The inter-relationship between tasks

- E.g. home: need to use technology? Interaction with other people?

Visual attention areas

- E.g. home: friends and family, screens, tablets, paper, books, work space?

Support equipment

- E.g. home: location, frequency, enough space?
  Storage of furniture when not in use?

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

- E.g. home: relaxed, lying down, sitting up, writing, reaching?

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 way in which we live in our home. For instance, relaxing, entertaining, working, sleeping and eating will have significantly different task requirements. The amount of time individuals spend doing their day-to-day tasks 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 during that time.

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

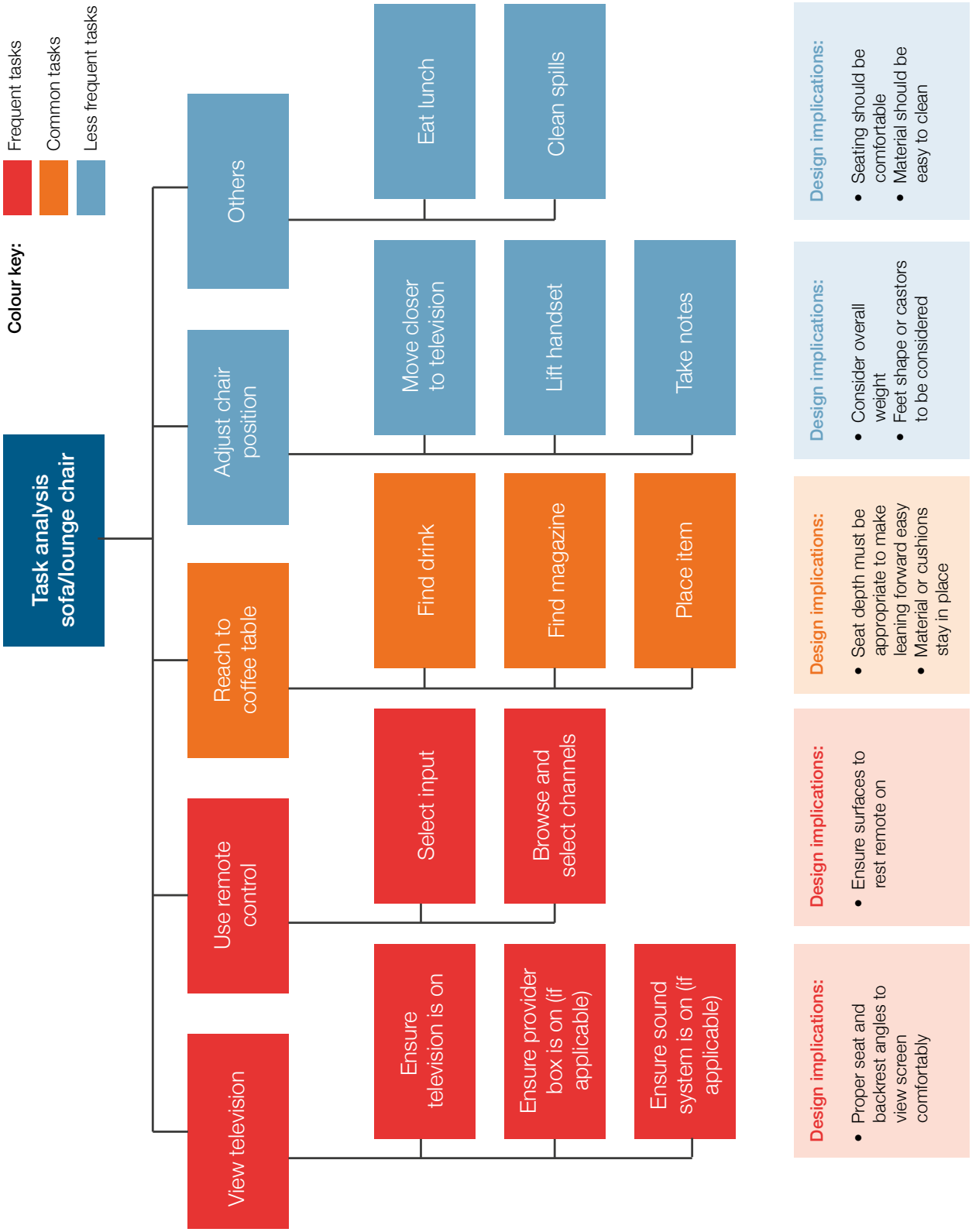
Using the data collected, create a list of the overall tasks that are frequently completed using the product. Some tasks may have more than one sub-task. These tasks should then be made into a diagram or table to show the flow.

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 sofa/lounge chair
View television
Use remote control
Reach to coffee table
Adjust chair position
Others
Ensure television is on
Select input
Ensure provider box is on (if applicable)
Browse and select channels
Ensure sound system is on (if applicable)
Place item
Find drink
Find magazine
Take notes
Move closer to television
Lift handset
Eat lunch
Clean spills
Design implications:
• Proper seat and backrest angles to view screen comfortably
Design implications:
• Ensure surfaces to rest remote on
Design implications:
• Seat depth must be appropriate to make leaning forward easy
• Material or cushions stay in place
Design implications:
• Consider overall weight
• Feet shape or castors to be considered
Design implications:
• Seating should be comfortable
• Material 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 Teal

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 10.2

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:

- Sit on the sofa in a comfortable position for you
- Reach and hang up this item of clothing in the wardrobe

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.



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

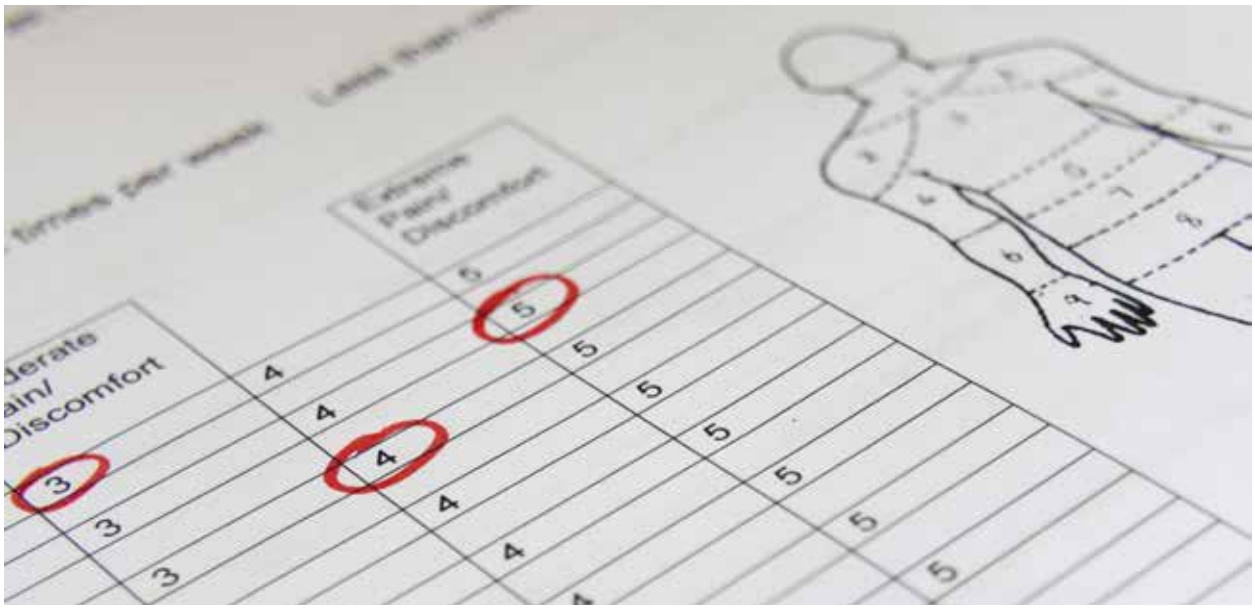
It is often necessary to include both objective and subjective measures in a trial. For example, use objective measures like accuracy, physical fit and workload, then subjective measures for convenience, ease of use and comfort.

Examples for objective measures:

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

Examples for subjective measures:

- 'Rate out of ten 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 were 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
- 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 10.2 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 National Furniture Specifications. 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: www.nfs.uk.com

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 sister company Exova BM TRADA, via their website http://bookshop.bmtrada.com/. Members of the Furniture Industry Research Association can benefit from a 20% discount from the full price of the Standard.

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.

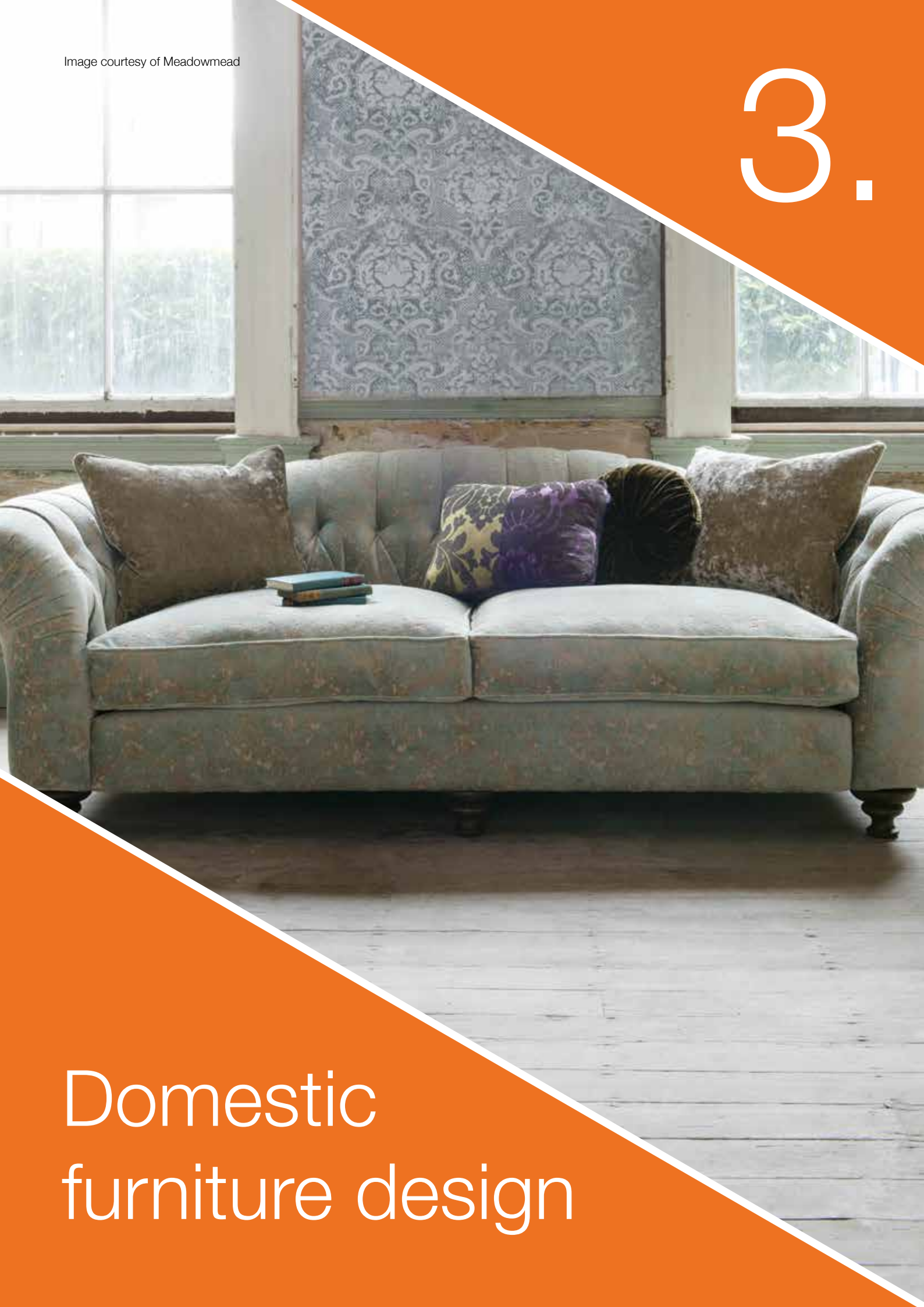
Below are some key points in ensuring that products are ergonomically excellent:

- 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.

Image courtesy of Meadowmead



3.

Domestic furniture design

3.1 Introduction

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

It explores the following categories:

- Bedroom
- Lounge/dining room
- Home office
- Elderly design
- Bariatric furniture

One of the main challenges for today's domestic designer is designing cost effective products with good aesthetics, while still being comfortable and simple for people to use.

The domestic furniture industry is growing and consumers expect well designed, safe products for use in their homes. People want products that will last, as well as being comfortable and so, ergonomics and good design are essential for a comfortable and efficient domestic environment.



3.2. Legislation and Standards

3.2.1. Legislation for domestic furniture

Legislation relating to the home includes many regulations. While not exhaustive, the following have a direct impact on the design of furniture, although it should be noted that different legislation may be applicable if the furniture contains moving parts, electrical equipment or is considered a medical device for the disabled.:

General Product Safety Regulations (2005)

The latest version of the General Product Safety Regulations came into force in October 2005. The purpose of this document is to ensure that producers shall only put safe products on the domestic market. The regulations introduce a presumption of conformity if a product conforms to a voluntary European standard, but only as far as the risks are covered by that standard. National legislation (e.g. Flammability Regulations) takes precedence and, should there be no European standards, then National standards apply. It is important, however, to realise that compliance with a standard does not imply that a product is totally safe, especially where the standard itself does not provide an acceptable level of safety.

Even though in some cases failure to meet a standard does not always mean that a product is unsafe, enforcement bodies such as Trading Standards will use these standards as benchmarks for compliance. Hence, failure to meet the standard is taken as indication of an unsafe product and the onus is on the producer to prove that the product is safe.

Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993 and 2010)

All upholstered products that are sold in the uk must also comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993). The tests applied will be determined by the types of fillings used.

4.



Image courtesy of Teal

Bedroom furniture design

4.1 Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for bedroom environments. Style, comfort and practicality are all very important when designing pieces of furniture for the bedroom. Aesthetically it has to look appealing for consumers but must also be comfortable and easy to use.

4.2. Legislation and Standards

You should be aware of other items that come within the General Product (Safety) Regulations 2005, and which have implications for furnished accommodation. For example:

- Furniture incorporating glass, should comply with FIRA/FRQG G0001: 2010 (covers the use of glass in all furniture including cabinets, shelving systems and wall hangings, such as free standing mirrors)

BS EN 747-1:2012+A1:2015
Furniture. Bunk beds and high beds. Safety, strength and durability requirements

BS EN 747-2:2012+A1:2015
Furniture. Bunk beds and high beds. Test methods

BS EN 1129-1:1995
Furniture. Foldaway beds. Safety requirements and testing. Safety requirements

BS EN 1129-2:1995
Furniture. Foldaway beds. Safety requirements and testing. Test methods

BS EN 1725:1998
Domestic furniture. Beds and mattresses. Safety requirements and test methods

BS EN 14749:2005
Domestic and kitchen storage units and worktops. Safety requirements and test methods.

BS EN 1957:2012
Furniture. Beds and mattresses. Test methods for the determination of functional characteristics and assessment criteria

BS 4875-7:2006
Strength and stability of furniture. Domestic and contract storage furniture. Performance requirements

BS EN 13759:2012
Furniture. Operating mechanisms for seating and sofa-beds. Test methods

BS EN 14072:2003
Glass in furniture. Test methods

BS EN 1334:1996
Domestic furniture. Beds and mattresses. Methods of measurement and recommended tolerances

BS 7177:2008+A1:2011
Specification for resistance to ignition of mattresses, mattress pads, divans and bed bases

BS EN 14976: 2005
Textiles, Mattress tickings. Specification and test methods

FIRA 6250:2005 Specification
Furniture materials – interior.

BS 2543:2004
Upholstery fabrics for end use applications. Classification

4.3. Ergonomic design principles

Comfort
An important factor when designing furniture for the bedroom is to consider the comfort of the end user. Beds, chairs or mattresses must all be 'comfortable', as the bedroom is a place for relaxation and rest. For example, the slats on a bed must be spaced in a way that provides enough support for the mattress not to dip otherwise it would cause pain and discomfort.

Safety
Furniture should be structurally sound and fit for purpose, so not to cause danger or injury. It should also be free from sharp edges or potential finger entrapments. For example, if a bed has sharp corners, then an individual might walk into it which would cause injury. Where possible, edges should be rounded and smooth.

4.3.1. Mattresses

Mattresses used in domestic settings should be assessed to determine their durability, fire safety and user comfort. There are a number of ways these can be tested and these are discussed below.



4.3.1.1. Durability

To test for durability, the main Standard used is EN 1957:2000 Domestic furniture - Beds and mattresses - Test methods for the determination of functional characteristics

This Standard determines the durability using the mattress roller and seat loading pad. It also determines the hardness of mattresses and fully erected beds with mattresses. It includes a method of the determination of the firmness rating of a mattress or bed correlating to the subjective assessment made by people.

Other Standards that are applicable to mattresses are:

EN ISO 1856:2001
Flexible cellular polymeric materials – determination of compression set

BS EN 12945-2
Pilling test for mattress covers

4.3.1.2. Flammability Testing

Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993 and 2010).

If mattresses are sold in the UK, fillings of mattresses must comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993 and 2010). The tests applied will be determined by the types of fillings used. In order to comply with the Regulations, everything should be tested in accordance with the Regulations and the relevant schedules in it.

In addition, mattresses should meet BS EN 7177 low hazard. This means the mattress as a finished product must pass EN 597:1995 part 1 and 2 and all fillings must fully comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993 and 2010).

4.3.1.3. Optional tests

If the mattresses fail to comply with the EN 1957: 2000, we would recommend testing to EN ISO 3385:1995 Flexible cellular polymeric materials — Determination of fatigue by constant-load pounding. This is a foam pounding test which is generally used by manufacturers to determine if their foam is suitable for mattresses.

4.3.1.4. Comfort evaluation and pressure mapping

In order to determine the comfort of a mattress it can be assessed in two ways. It can be firstly analysed with pressure mapping to determine if the distribution of pressure is even and if the mattress gives optimum support. It can also undergo subjective assessments by users taking part in controlled user trials. Then an overall comfort rating can be given based on both the findings of the pressure mapping and the user trials.



Examples of some of the questions used to determine user comfort for a mattress are shown below.

1. Sit on the edge of the bed

How do you find the support when sitting on the mattress	Much too firm	Too firm	Just right	Too soft	Much too soft
	◯	◯	◯	◯	◯

2. Lay on your back on the bed. Place your hand under the small of your back.

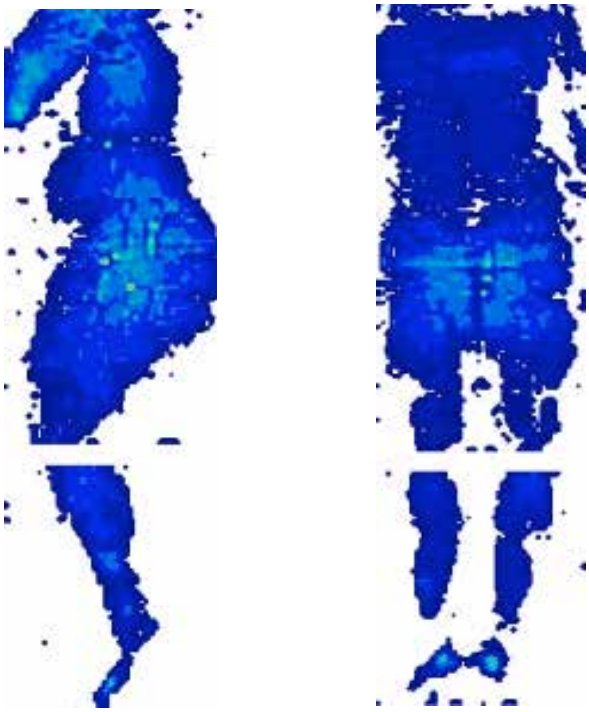
How large is the gap?	Cannot get hand through	Can just pass hand through	Can pass hand through gap
	◯	◯	◯

3. Lay on your side on the bed. Place your hand under your body above your waist.

How large is the gap?	Cannot get hand through	Can just pass hand through	Can pass hand through gap
	◯	◯	◯

4.3.2 Pressure mapping

Pressure mapping can show the weight is distributed and if the mattress can offer even and well distributed support to the user. FIRA's Ergonomics Department has completed many studies to look at this distribution and what makes a comfortable mattress. Below are some example shots of a mattress pressure mapping study.



4.4. Dimensional recommendations

As there are no dimensional Standards for domestic bedroom furniture, anthropometric data should be used to determine the correct heights, for example, dressing table heights. For guidance for dimensions on tables the principles found in BS EN 527-1 can be used and for chairs BS EN 16139, Annex C

4.4.1. Reach

Within a bedroom environment it is important for users to be able to reach important features of the furniture. For example, within a wardrobe it is vital that a shorter individual can reach the hanging rails in order to hang up their clothes. If the rail is too high, they will struggle to reach upwards which could strain in the back and arms. It is therefore important to incorporate the ability to adjust the height of the hanging rail during assembly. This means the individual can place it at a suitable height for their needs.

4.4.2. Grip

The handles used on domestic furniture, such as wardrobe doors or drawers should also be carefully considered. It is important that they are easy and comfortable to grip for the majority of the population, including the elderly and those who may have dexterity problems. Very thin or small handles can be difficult to grip and could cause problems. Below is anthropometrics data than be used to determine suitable handle sizes. The largest percentiles are used.

British male 18-64 95th percentile	**mm**
Thumb-index finger grip diameter	47
Thumb-middle finger grip diameter	56
Hand breadth including thumb	116
Hand breadth across finger knuckles	95
Hand depth at the middle finger knuckle	33
Horizontal grip reach (from e.g. seat back/wall)	811
Vertical pinch-grip reach, standing	2291

Finger proximal joint depth (for distance between handle and door)	**mm**
Index	20
Middle	21
Ring	18
Little	17
Thumb	26

5.



Lounge/Dining furniture design

5.1. Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for lounge and dining environments. In modern consumer homes aesthetics are often put above all else when designing new pieces of furniture, although users can be greatly spread across the form versus function spectrum. It is finding this key balance of comfort and desirability that is the great aim of all good furniture design for the home.

5.2. Legislation and Standards

You should be aware of other items that come within the General Product Safety Regulations 2005, and which have implications for furnished accommodation. For example:

- Furniture incorporating glass, should comply with FIRA/FRQG G0001: 2008 (covers the use of glass in all furniture including cabinets, shelving systems and wall hangings, such as free standing mirrors)

BS EN 1022:2005
Domestic furniture. Seating. Determination of stability

BS EN 1728:2012
Furniture. Seating. Test methods for the determination of strength and durability

BS 2543: 2004
Upholstery fabrics for end use applications. Classification

BS EN 13336:2012
Leather. Upholstery leather characteristic. Guide for selection of leather furniture

BS EN 4875-7:2006
Strength and stability of furniture: Domestic and contract storage furniture. Performance requirements

BS EN 8474:2013
Furniture: Chairs with electrically operated support surfaces. Requirements

BS EN 12520:2010
Furniture. Strength, durability and safety. Requirements for domestic seating

BS EN 12521:2009
Furniture. Strength, durability and safety. Requirements for domestic tables

BS EN 14749:2005
Domestic and kitchen storage units and worktops.
Safety requirements and test methods.

BS EN 1730: 2012
Furniture. Tables. Test methods for the determination of stability, strength and durability

BS EN 13759:2012
Furniture. Operating mechanisms for seating and sofa-beds. Test methods

FIRA 6250:2005 Specification
Furniture materials – interior.

BS 3379:2005+A1:2011
Combustion modified flexible polyurethane cellular materials
for loadbearing applications. Specification.

BS 4723:2002
Stretch covers for upholstered furniture. Specification

BS 6261:1982
Method for evaluating the application of and interaction
between components in upholstered furniture

BS 6608:1985
Specification for cattle hide leathers for upholstered furniture

BS 7376:2009
Inclusion of glass in the construction of tables and trolleys for domestic use

5.2.1. Flammability

All upholstered products that are sold in the uk must also comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993). The tests applied will be determined by the types of fillings used. All upholstery for domestic furniture has to meet these Regulations. In order to comply, everything should be tested in accordance with the Regulations and the relevant schedules in it.



5.3. Ergonomic design principles

Though it is often overlooked by designers seeking to create sleek shapes and unique concepts, ergonomics can be useful in all design projects. The principles of ergonomics can be applied all over the home when furniture interacts with users.

Many of the same values used in ergonomic office furniture design can be applied to domestic furniture. Although domestic furniture normally implies a more relaxed posture, it is still important to consider these different postures that users will adopt in their home. Many posture analysis studies have found that a static position can impact musculoskeletal health, so it is important for the user to change position regularly. This reduces the effect of pressure points over the body.

5.3.1. Encourage movement

Holding the same position for a long period can cause a lot of pain and fatigue. This is known as static load and can have long term effects on the body if the user is persistently exposed to it. Careful design can encourage the user to change position every 3-4 minutes. Normally users will change position as soon as they begin to feel discomfort, but some adverse health risks can arise before any pain can be felt. Furniture that is able to subtly morph and move with the user is ideal for promoting movement.

5.3.2. Ensure comfortable shape fitting to the user

The human spine has a natural s-shape when standing which most chair designers seek to maintain for a user in a seated posture. The degree of this shape varies between each individual and the natural resting shape itself can actually be altered by years of improper sitting. For this reason it is important that domestic furniture accommodates a lot of different postures and adequate support in the correct places.

In the home, users may use their furniture in a number of different ways, and are unlikely to sit in a lounge chair or sofa in a proper, upright position at all times. They may slouch or lie down over time. For this reason it is common for lounge furniture to have deep, soft padding which can mould around the user to spread pressure over their body. This can help to reduce any unwanted pressure points. A sofa that is too soft or low can be uncomfortable for some users and can be more difficult for users to get themselves up and into a seated position.

Designers must find a balance of form and function in order to appeal to the greatest number of users. Harder surfaces can be beneficial to posture but psychologically if a sofa is too hard, some users may feel it to be uncomfortable and not suitable for relaxation.

5.3.3. Accepted misuse

It cannot always be assumed that a product will be used in the way intended by the designer; there is an accepted level of misuse that a designer must be aware of. You must consider the tasks carried out on furniture and the postures that result from them. A user lying across a sofa browsing the web with a tablet is likely to find upper back or neck pain after a short time. This would be due to the strain being put on their neck by laying their body flat and resting their head against the arm rest. Actions taken to reduce these angles can greatly improve user comfort in these positions. This would be accepted misuse.

In terms of dining furniture, it is a common habit for users to lean back on their dining chairs onto the rear two legs when relaxing. Similarly users may bring their weight forward to the front of the seat, lifting the rear two legs off of the ground, possibly in order to get closer to their food. In order to reduce any hazards in this case, careful consideration of the leg structure and weight distribution across the chair would be required to make it stable.

Furthermore, users are less likely to tip onto the rear or front legs if the chair and table are properly sized to them. While it is known by most users that this type of misuse is generally inappropriate, due to it potentially causing harm, it is to the benefit of both the user and the designer to integrate special design considerations to make the product safer even when being misused.

5.3.4. Consider human variance

Consider providing additional product accessories that allow it to be used by other demographics. For example, having the options for larger back cushions to reduce seat depth can make it easier for older people to stand up from a seated position. Design considerations for elderly users are discussed in more depth in section 7.

5.3.5. Adjustability

Having adjustable furniture is always an advantage and allows optimum fit for as many users as possible. But In some cases it is not practical or desirable to incorporate adjustability. For example, on a sofa. Here a fixed height armrest will never be able to be set at an optimal height for the majority of the population, but it is not practical to have an adjustable arm rest. Therefore compromise has to be made. Fixing armrest height higher than for an average person will be less risky than having armrests too low, in which case users will have to bend their trunk side ways to use a single armrest or slouch to use both armrests.



5.4. Dimensional recommendations

Within the home environment, there is less guidance about table height. It is therefore recommended that designers consider using a Standard such as BS EN 527-1 as guidance. It is also important to consider the relationship between the height of the table and the height of the intended seat it is to be used with. If this is considered, then a comfortable sitting posture can be adopted by the user. For example, when designing a dining table, it should be noted what size chairs will be used with it. If these are to be taller bar stools, then the table height should be designed accordingly.

Design needs to use body dimensions found in anthropometric data sources as there are no Standards for dimensional requirements for domestic furniture. These data sources can help to design correct and comfortable seat height and depths. Dining or other domestic tables shall be 740 ±20mm high, when measured from floor to top surface of table.



Image courtesy of Henderson Russell

Chair dimension	Recommended dimensions for dining chairs and other chairs used for upright postures	Recommended dimensions for relaxing chairs	Recommended dimensions for sofas
Seat height	420-490	420-450	400-450
Seat depth	450±10	475±25	475±25
Gap between arms min	116	460-510	N/A
Armrest height	200-250	200-250	200-250
Seat pad width min	400	460	N/A
Height of backrest	400	500	500
Seat angle	+3° to –5°	-2° to -7°	-2° to -7°
Angle between seat and back*	90° to 100°	100° to 120°	100° to 120°

*It should be noted that as the angle between the seat and back increases, there is a need to support the upper torso and head. For example, a short backrest of a 120° with a reclining back seat would force the user to slouch by sliding forward and resting their neck on the upper edge of the backrest. For high reclined backrests, consider moveable neck supports. One neck rest does not suit everybody, therefore it is important that it is moveable.

6.



Home Office furniture design

6.1. Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for home office environments. Similar requirements that are applicable to a work office should be applied to furniture that could also be used in a home office.

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 whilst working has benefits to health and efficiency 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 the increase of home working and many employers allowing flexible and remote working patterns for their employees, ergonomics and good design is essential for a comfortable and efficient working environment.

It is important that furniture designed for a home office does not look like typical office furniture. It should blend into the home environment and not look too industrial. For example, the adjustments offered should be fewer and less complicated than a typical office chair.



6.2. Legislation and Standards

There is no legal requirement to comply with Standards, however under the General Product Safety Regulations; it is advisable to comply with any available safety Standards to ensure that the product is safe and fit for purpose.

Tables and chairs that are to be used in home office environments tend to be the same or very similar to those tables and chairs used in offices. Because of this, it is recommended that the dimensions of home office chairs and tables should be in line with those stated in office chair and desk Standards. Although, it is not essential for all the dimensions stated in these Standards to be fulfilled.

Below is a table that shows what is considered to be the essential dimensions. Dimensions for additional features such as lumbar support height can be determined from the requirements in BS EN 1335-1 and dimensions such as recommended table height can be found in BS EN 527-1.

Recommended dimensions in mm

Chair dimension	Fixed	Adjustable	Minimum range
Seat height	420-490	430-480	80
Seat depth	450±10	430-450	50
Gap between arms min	460	460-510	N/A
Armrest height	200-250	N/A	N/A
Seat pad width min	400	N/A	N/A
Lumbar zone (50mm high zone within the specified range)	180-300	200-250	N/A
Seat angle	+3° to –5°	-2° to -7°	N/A
Angle between seat and back	>90°	>90°	>90°

For safety, strength and durability, these chairs and tables should comply with domestic furniture Standards such as BS EB 12520 which is the strength, durability and safety requirements for domestic seating and BS EN 12521 which set out the requirements for domestic tables.

6.2.1. Legislation for home office furniture

You should be aware of other items that come within the General Product Safety Regulations 2005, and which have implications for furnished accommodation. For example:

- Furniture incorporating glass, should comply with FIRA/FRQG G0001: 2012 (Covers the use of glass in all furniture including cabinets, shelving systems and wall hangings, such as free standing mirrors)

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.

6.2.2. Standards for home office furniture

BS 6206:1981
Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings

BS EN 12150-1:2000
Glass in building. Thermally toughened soda lime silicate safety glass. Definition and description

BS EN 12150-2:2004
Glass in building. Thermally toughened soda lime silicate safety glass. Evaluation of conformity/Product Standard

BS EN 12520:2010
Furniture. Strength, durability and safety. Requirements for domestic seating

BS EN 12521:2009
Furniture. Strength, durability and safety. Requirements for domestic tables

BS EN 12600:2002
Glass in building. Pendulum test. Impact test method and classification for flat glass

BS EN 14749:2005
Domestic and kitchen storage units and worktops. Safety requirements and test methods.

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 requirements

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 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. Test methods

BS EN 4875-7: 2006
Strength and stability of furniture: Domestic and contract storage furniture. Performance requirements.



6.2.3. Flammability

All upholstered products that are sold in the uk must also comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989 and 1993). The tests applied will be determined by the types of fillings used. All upholstery for domestic furniture has to meet these Regulations. In order to comply, everything should be tested in accordance with the Regulations and the relevant schedules in it.

6.2.4. Fire safety requirements

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

6.3. 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.

6.3.1. 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 >7mm and <18mm and no holes >5mm and <12mm.

6.3.2. Height of the armrests above a seat

It is important to ensure that the armrests of a chair can be lowered or arm pads pushed back 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.



Image courtesy of Boss Design

6.4. 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:

6.4.1. 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 12.1 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.

6.4.2. 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.



6.4.3. 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.

6.4.4. 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!

6.4.5. 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.

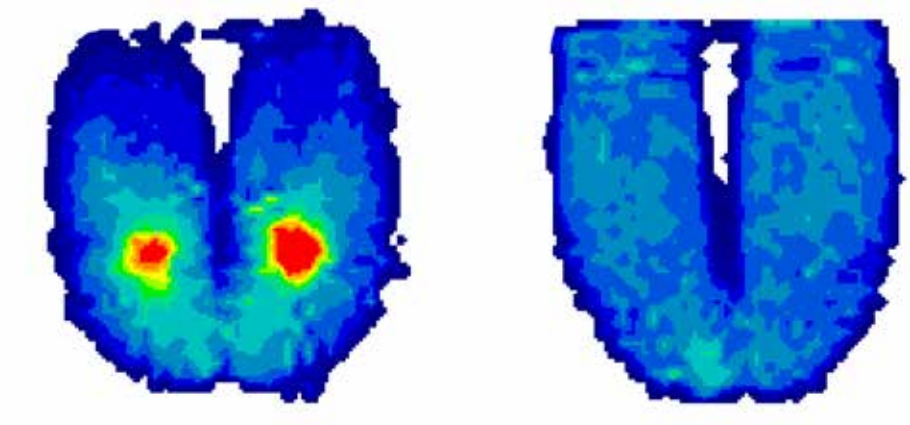


Image shows two examples of pressure mapping results on seated users, one showing high pressure points (left)

6.5. Posture when working with computers

The traditional posture for working with computers 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 for both in the office and at home, 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.

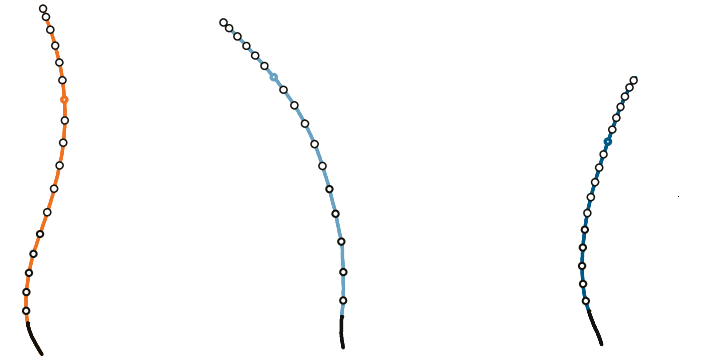
In today's workplace the multitude of digital devices like laptops, smartphones and tablets in use means that the classic work posture is no longer applicable. Research is underway into how to take these new devices into account in the office environment. For example, see Steelcase's recent study resulting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

6.6. Spinal tracing and pressure mapping

6.6.1. 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.

Image courtesy of Orangebox



6.6.2. 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.

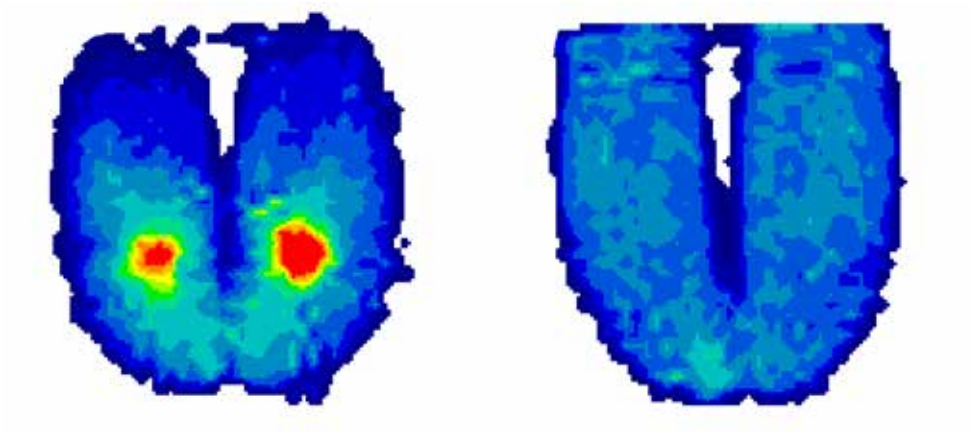


Image shows two examples of pressure mapping results on seated users, one showing high pressure points (left)

6.6.3. FIRA expertise

These tools require expert interpretation in order to get meaningful results. FIRA's 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.



Image courtesy of Teal

7.

Designing for the elderly

7.1. Introduction

This section of the Toolkit is intended to give an introduction to designing for the elderly and the disabled. On Census Day 2011 there were 1.25 million people aged 85 or over who were usually resident in England & Wales (The National Archives, 2013). This compared to 1.01 million in 2001 and by 2015, nearly 1 in 5 of us will be aged 65 or over. These statistics show that our population is ageing and that designers should be designing products to include this larger percentage of the population.

Over a billion people, about 15% of the world's population, have some form of disability and between 110 million and 190 million adults have significant difficulties in functioning. These rates of disability are increasing due to population ageing and increases in chronic health conditions, among other causes. www.who.int/mediacentre/factsheets/fs352/en/



Image courtesy of Teal

7.2. Legislation and Standards

You should be aware of other items that come within the General Product Safety Regulations 2005, and which have implications for furnished accommodation and electrically operated seating (e.g. recliners, riser recliners).

Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989,1993 and 2010)

All upholstery for domestic furniture has to comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989,1993 and 2010. In order to comply with the regulations, everything should be tested in accordance with the regulations and the relevant schedules in it.

Fillings of mattresses sold in the UK must also comply with these regulations 1998 (amended 1989, 1993 and 2010).The tests applied will be determined by the types of fillings used. In order to comply with the Regulations, everything should be tested in accordance with the Regulations and the relevant schedules in it.

BS EN 1970:2000

Adjustable beds for disabled persons. Requirements and test methods

BS 4467:1991

Guide to: Dimensions in designing for elderly people

BS EN 8474:2013

Furniture: Chairs with electrically operated support surfaces. Requirements

BS EN 60601-2-52:2010

Medical electrical equipment. Particular requirements for basic safety and essential performance of medical beds

PD CEN/TR 15894:2009

Building hardware — Door fittings for use by children, elderly and disabled people in domestic and public buildings—A guide for specifiers

CEN/ISO TR 22411:2008
Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities

ISO/IEC Guide 71 (CEN / CENELEC Guide 6):
Guide for addressing accessibility in Standards. New version out for consultation, and publication of the revised Guide 71 by ISO assumed to take place on 15th October 2014

European Commission adopted on 15 November 2010, the new European Disability Strategy 2010 - 2020: A Renewed Commitment to a Barrier-Free Europe

European Accessibility Act – will this be proposed by European Commission to further develop the Single Market for accessible products and services?

7.3. Ergonomic design principles

There are number of factors that can have design implications when thinking about the capabilities of the elderly or disabled. As an individual ages, a number of their capabilities reduce or diminish over time. This means they may have different needs when using a product compared to a younger individual. These are discussed below:

7.3.1. Vision

As people age, the muscles that control pupil size and reaction to light lose some strength. This means the average 60 year old eye requires three times as much light as a 20 year old eye, but simply increasing illumination can result in unacceptable levels of glare.

Other precautions in furniture design must be taken in order to simplify the visual environment for the elderly user, such as more solid, definite shapes or highly contrasting colours or shades. It can be difficult for the elderly to tell where an object in the foreground ends and the background begins, meaning their spatial awareness is reduced and increasing the possibly for an accident. High contrast is therefore needed in order to be able to distinguish between close and distant objects.

7.3.2. Hearing

Age induced hearing loss is known as ‘presbyacusis’. Higher tones are the first affected as an individual ages. These can become difficult to hear or may even be uncomfortable. As a result, if the product uses any audio stimulus then tones below 2000 Hz must be used. Furthermore, with age the ability to discriminate between similar frequencies can be reduced even with amplification.

This mainly affects the user’s ability to understand speech, however it can have design implications on products that use signals or alarms. In these products a large contrast in the frequency of tones is recommended, as well as a capability for the user or carer to adjust the sound, as these effects vary greatly between people.

7.3.3. Dexterity

A person of 65+ can achieve only about 75% of earlier capacities in strength and endurance. This means the user’s ability to grip onto objects is diminished and combined actions can be even more difficult so the user would struggle with a joint pushing and twisting motion. The design impact of this is to consider the size and shape of all user operated controls. Controls should be large and blunt, allowing the user to apply more force on a larger area. Despite the size, controls should be light to activate.

Gripping tasks are easiest when the wrist is in a neutral position, so these areas must not be placed at awkward locations. Handles and areas designed with space to hold can be provided to help grip. Twisting motions should be avoided as they can cause pain in those with particularly bad muscle damage or arthritis cases. However, if a twisting motion is essential to the design then the control must be easy to activate and have a well considered angle of motion for optimal force to be provided.



Image courtesy of Teal

7.3.4. Touch

As an individual ages, they have reduced sensitivity in their fingers and extremities. There is a reduction in the user's ability to dense vibration, pressure, temperature and pain. These effects can impact furniture design in some ways that may alter the way unique functions work. For instance it is common to find the tips of the armrests of a chair in a home for the elderly to be made of wood. This is because the wood provides a more solid surface than an upholstered or foam covered area and is much easier for the elderly user to feel, which helps them to lift out of the chair. In terms of pressure, elderly users may be unable to tell or communicate that the furniture they are sitting on is too tough.

Elderly users bruise more easily due to a weakening of the skin structure and reduced muscle and fat mass, meaning prolonged sitting on hard surfaces can push the skin and muscle against the bone creating discomfort. Therefore, it is advised to test the seat surface for pressure mapping amongst the targeted users to make sure pressure is properly distributed.

7.3.5. Cognition

If older people have to deal with a lot of information, they are likely to take longer to perform a task and choice reaction time is degraded. The user's ability to problem solve begins to deteriorate from as early as 50. Therefore elderly users may need more time to complete a task accurately and they should be given more control over the speed in which they learn and rehearse a piece of information. Objects and furniture should be designed in a way that implies their intended use. Stereotypes for controls should be implemented where possible, such as large surfaces for buttons or dials with arrows for direction indication on twisting controls.

7.3.6. Reach

People tend to shrink with age in terms of stature and most other body measurements. The muscle groups of the body also become less flexible, leading to a reducing in reach distances. In addition to this there is an increased likelihood of the development of a health condition such as arthritis. For situations in which reach would be an issue to users, use anthropometric reach data for guidance that is specific to older users.

Generally within inclusive design, areas of the products features are simplified to aid the user. These factors should all be considered when designing furniture for the domestic market. Furniture in the home can be used by individuals of any age and so it is important that they are simple to use by all users. Due to the change in demographics within the country, some of the future challenges facing users are dementia, obesity and ageing.

7.4 Specialised furniture

7.4.1. Armchairs

In order for an elderly person to get in and out of a seat easily, it is helpful to have higher and longer armrests than in a standard chair. This provides a strong support for the hands to press off from.

Dimensions of the chair are also very important. The seat height must be appropriate and relative to the user's popliteal height to allow a 90º knee angle. If the seat is too low then it will be more difficult for the user to rise out of the chair, and if it is too high their feet will dangle and the seat will cause pressure and obstruct blood circulation.

Armchairs for the elderly are recommended to have a high back to support all the way up to the shoulders and a headrest is also beneficial. For proper ergonomic posture the backrest should be shaped to give lumbar support and allow the whole back to be rested without causing pain or pressure on the lower spine and pelvis. Additionally, the design of the chair may include head supports at the sides of the backrest for the elderly user to rest their head against to sleep.



Image courtesy of Teal

7.4.2. Riser recliners

Rising from a chair can be very difficult for an elderly user as it requires strength and movement which may be restricted due to problems faced through the process of aging.

The reclining feature is common and is seen in many modern lounge sofa or armchair designs. This provides a comfortable and supportive position for an individual to relax in. The rising feature then assists the user in bringing them upright and allows them to slowly transfer their weight from their buttocks and backs of the thighs to their feet. In a standard chair, assistance from others may often be needed to help the person rise. The riser recliner reduces the need for this assistance and can enable some users to stand independently.

As the individual ages, it is likely that they may find a weakening of muscles and pain in their body which can make it very hard for them to get out of a regular bed unassisted. As muscles weaken, it can become difficult for an individual to change from a lying position to a seated position. Electronically raising beds do the hard work for the user and help them to lift their torso up to a sitting position.





7.5 Techniques for when designing for the elderly or disabled

There are a number of techniques that can be used to assess how well a product may work for those who are older or have a disability. Personas and empathic modelling techniques can be very useful in allowing a designer to 'step into the shoes' of an individual. Personas are created to include the following information:

- Name
- Profession
- Age
- Location
- Gender
- Attitudes (e.g. to money and time)
- Activities
- Influences
- Workflow or key tasks
- Pain points and frustrations
- Task and experience goals

Other techniques empathic modelling examples

- AGNES- Age Gain Now Empathy System (MIT Age lab)
- Loughborough University SKInS Sensory and Kinaesthetic Interactive Simulations
- Adam Rouilly Age Simulation Set
- Mobilstrictor
- GERT Age Simulation Suit

7.6. Dimensional recommendations

As an individual ages, their dexterity capabilities begin to reduce. This makes it more difficult to grip objects, especially small and thin items, such as cupboard handles. If a handle is designed to be long and thin, then there must be adequate space behind it for an individual to place their fingers behind it and pull open using their hand. It may be too difficult for users with reduced dexterity to grip the thin handle if there is not enough space to slide their fingers through.



Image courtesy of Teal

8.



Bariatric furniture design

8.1. Introduction

This section of the Toolkit is intended to give an introduction to designing furniture for bariatric individuals.

Bariatrics is the branch of medicine that deals with the causes, prevention, and treatment of obesity. In a non medical sense, these individuals are often referred to as 'plus sized'. This can be anywhere from around 150kg to 300kg with many differences in body shape and where the weight is distributed on the body. For example, some individuals may have most of their weight around their stomach and hips, whereas others may have a larger percentage on their bottom. This is often referred to as a 'gluteus shelf' and can dramatically range in size.

FIRA's Ergonomics Department met with and interviewed a number of plus sized individuals in order to discuss how they use their furniture and any issues they have with it. One individual took part in a pressure mapping study so it could be observed where the weight and pressure points are distributed when seated.

All of this information gathered has shown us that we have to design furniture differently for plus sized people. It needs to have added strength and be carefully designed so that dimensionally it is suitable. In some data, we have observed seated dimensions of individuals range from 51cm to 119cm. This shows that when designing a piece of furniture for larger people, it must be carefully and well designed so that it can be used comfortably by as many people as possible. Features such as foldable arm rests are useful as some individuals may use them to aid themselves getting in and out of the chair. Whereas others may find them too constricting and so can fold them down and out of the way.

The Bariatric Standard, written by FIRA, can be used to test both structurally and dimensionally, furniture for plus sized people. It also includes well thought out design considerations that were gathered from interviews and meetings with plus sized individuals who encounter issues with different types of furniture on a daily basis.

8.2. Legislation and standards

ANSI/BIFMA X5.11- 2015
General- Purpose Large Occupant Office Chairs- Tests

FS0 56:2011
FIRA test. Furniture - Bariatric Seating - Requirements for strength, stability and durability

BS 5852:2006
Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources

Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989,1993 and 2010).
If mattresses are sold in the UK, fillings of mattresses must also comply with the Furniture and Furnishings (Fire) (Safety) Regulations 1998 (amended 1989,1993 and 2010). The tests applied will be determined by the types of fillings used. In order to comply with the Regulations, everything should be tested in accordance with the Regulations and the relevant schedules in it. Il upholstery for domestic furniture has to meet these regulations.



8.3. Ergonomic design principles

After speaking with healthcare professionals and plus sized individuals, it was clear that there are a number of design and ergonomic considerations that should be taken into account. These are discussed further below:

8.3.1 Foam

Firmer foam should be considered when designing some seating. This allows the weight to be distributed more evenly and the pressure to be reduced. Memory foam should also be considered where possible. This gives the user comfort and support. Other options include gel cushions, Roho cushions or a high dynamic cushion if the patient is at risk of tissue damage.

8.3.2 Lumbar support

A traditional approach to lumbar support is not applicable when designing furniture for larger users. This is due to the lumbar area itself being dramatically reduced by the gluteus shelf. Therefore, cushioning above the lumbar is needed to support this area of the back above the shelf. Designers should consider options such as waterfall effect backs to allow the user some degree of manipulation in the position of the support. These horizontal cushions could have different density foams or loose fillings that can be adjusted and moved by the user.

8.3.3. Size and adjustment

The size of furniture meant for bariatric users also has to change. The seat width needs to be larger to allow support for the user's shelf. Armrests should also be longer as the individual needs to use them to aid themselves moving from sitting to standing. This also means they must be a lot stronger than standard armrests. Some users suggested the idea of an armrest that would fold or drop lower when not in use to allow more room and space when sitting. When considering seat depth, it is critical to get the right dimensions. There is a lot of weight behind the spine in a plus sized individual which pushes them forward in the chair, meaning they need a larger seat depth. This also means that the back isn't very well supported and so additional attention to back support and lumbar region should be taken.

8.3.4. Structure

Due to the individuals using the furniture being heavier then the furniture must be structurally sound and safe to use. It was felt that webbed or sprung seat bases may be too weak and could break over time. Users also commented that strong support is needed at the front edge of a seat or bed as this will help users safety get up and down.

8.3.5 Design

There were a number of design considerations that were discussed when talking to users. It was felt that designers should think of ways to develop furniture that is suitable for bariatric people, where there may not be a big increase in price. This is especially important when it comes to users buying furniture for their own home. It allows it to be accessible and more affordable for all users. It was also noted that domestic furniture should be made to look domestic. If it is meant for the home, users do not want it to look clinical or industrial. It should be made to look as if it is for the home. Gaps and loops where excess tissue could get trapped should be avoided as this could be dangerous. Low level seating or anything that is sloping backwards slightly is difficult to enter and exit easily.

It is important to try and incorporate some flexibility into the design. For example, design seating that is multifunctional and usable by all. Benches or larger seats would allow a number of people to sit down and also give more choice for plus sized people, meaning there isn't just one seat they can sit on that is labelled for them.

Designers must consider overall size of furniture. It is likely to be larger than standard furniture and so it may be important to make it modular so that it can fit through doors in peoples' houses.

8.4. Dimensional recommendations

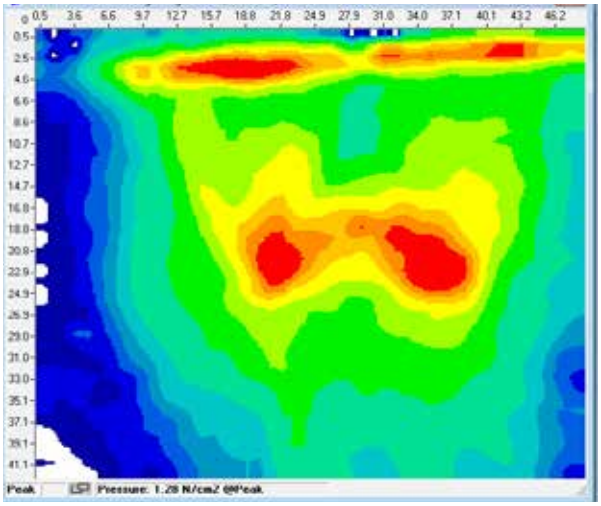
All dimensional recommendations can be found in FS0 56:2011 This shows suitable measurements for seating that will allow plus sized individuals to use comfortably.

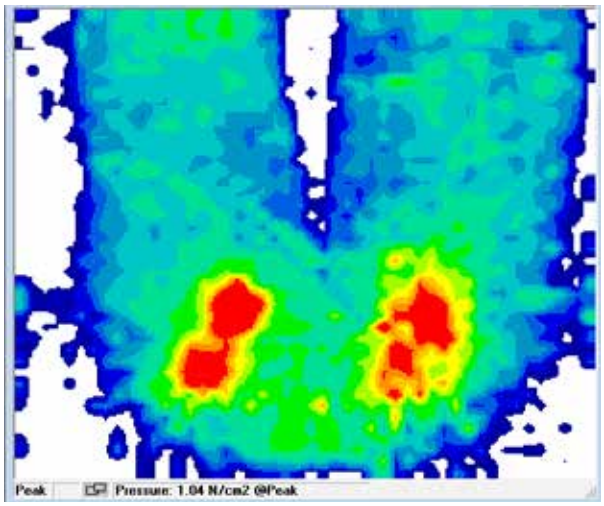
Table A.1 Dimensions of bariatric chairs

Seat dimension	Requirements (mm)
Seat height	450-500
Seat depth	500-600
Seat width (min)	700 (for an individual seat)
Gap between arms	>750 - <900 (for an individual seat)
Backrest height (min)	500
Armrest height (min)	250-300
Armrest width (min)	600
Armrest length (min)	400

8.4.1. Pressure mapping

Pressure mapping studies comparing plus sized individuals to average weight users has shown the different distributions of pressure and positions of ischial tuberosities when using the same seat. Below show screen shots of an individual weighing x180kg (plus sized, left) and an individual weighing 64kg (right).





9.



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.

9.1 FIRA resources

9.1.1. General services

FIRA Ergonomics

Link: http://www.fira.co.uk/commercial-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/commercial-services/testing
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.

9.1.2. Certification and award schemes

FIRA Gold Product Certification and FIRA Gold Installation Certification

Link: http://www.fira.co.uk/commercial-services/awards-and-certification/fira-gold
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/commercial-services/awards-and-certification/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/commercial-services/awards-and-certification/fira-innovation-award

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

9.1.3. Specific resources

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/guides

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



9.2 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.

9.2.1. 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.

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

9.2.2. 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.

9.3 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.

9.3.1. 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 Wiki Mixabest, 2008

9.4 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 'National Furniture Specifications' 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

9.4.1. 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.

9.4.2. Web resources

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

9.4.3. 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.



9.5 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.

9.5.1. 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+A1:2015 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.

9.5.2. 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.

9.5.3. 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.



10.



Image courtesy of Orangebox

Appendices

10. References

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2. Wilson, J. R. & Corlett, N. Evaluation of human work. (CRC, 2005).

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4. FIRA. Get up, stand up.. find a desk to suit your height. (2013). at <http://www.fira.co.uk/news/article/get-up-stand-up-find-a-desk-to-suit-your-height>

5. MacLeod, D. 10 Principles of Ergonomics. (2008). at <http://danmacleod.com/ErgoForYou/10_principles_of_ergonomics.htm>

6. FIRA. Safe seats of learning. (2008). at <http://www.fira.co.uk/document/safe-seats-of-learning.pdf>

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

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

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

11. Grandjean, E. Ergonomics of the home. (London: Taylor & Francis, 1973).

12. Characteristics of Older People , What does the 2011 Census tell us about the oldest old living in England and Wales? (2013) at http://webarchive.nationalarchives.gov.uk/20140721132900/http://ons.gov.uk/ons/rel/mortality-ageing/characteristics-of-older-people/what-does-the-2011-census-tell-us-about-the-oldest-old-living-in-england-and-wales-/index.html

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

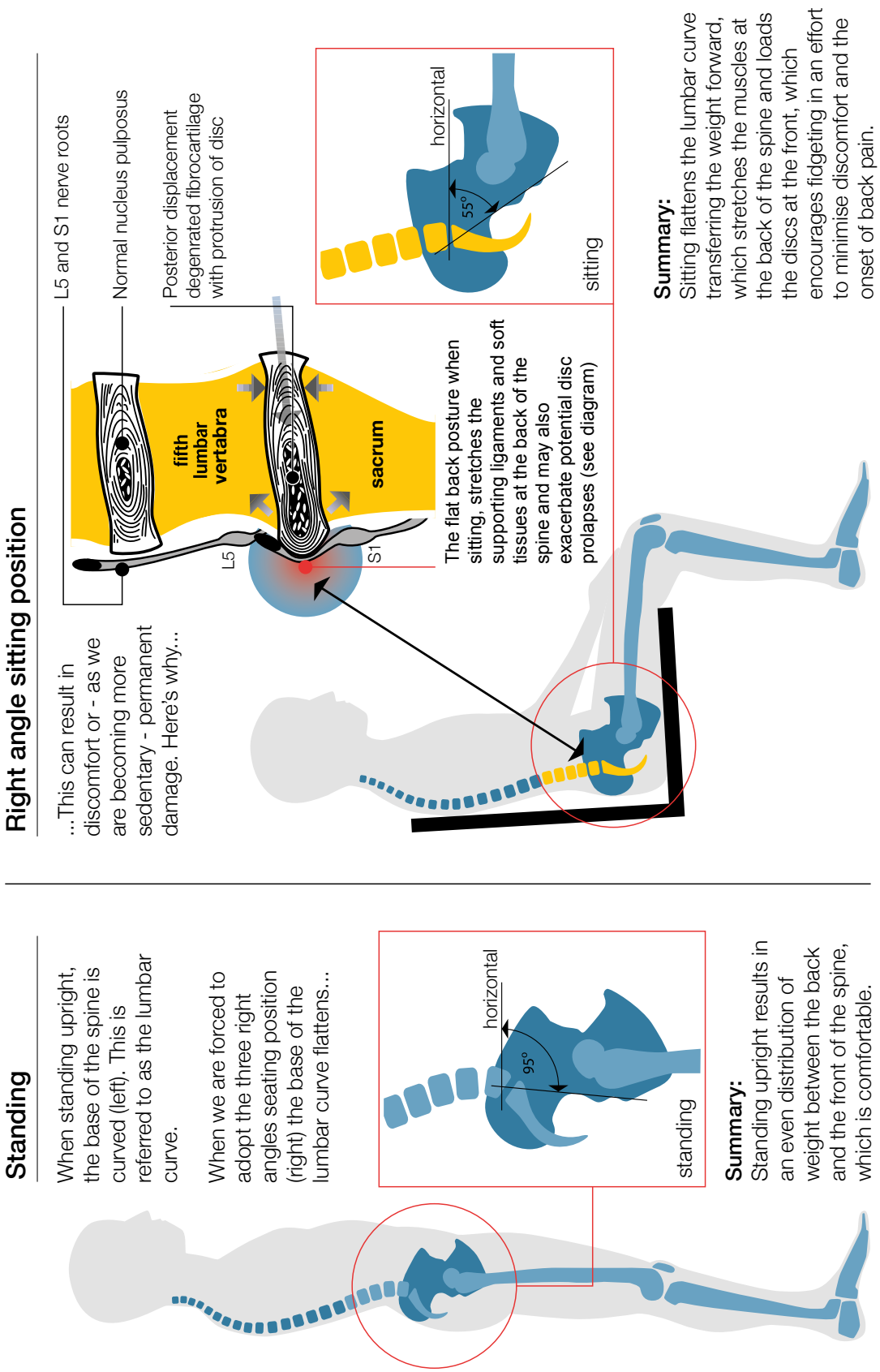


Image courtesy of Aalborg DK

10.2 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)

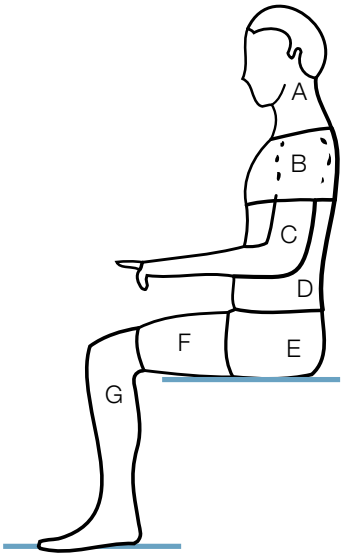
1 AWARE OF LITTLE SENSATION
(neither comfortable nor uncomfortable)

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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