Including plus size people in workplace design

by

Annabel Masson

Doctoral thesis submitted in partial fulfillment of the requirement for the award of Doctor of Philosophy of Loughborough University

© Annabel Masson, 2017

Loughborough University

CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this thesis, that the original work is my own except as specified in acknowledgments or in footnotes, and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

……………………………………………. (Signed)

……………………………………………. (Date)

Abstract

Over 60% of the adult population in the United Kingdom is now overweight or obese or classed as ‘plus size’. This is higher than almost all other developed countries in the world. Even with numerous public health interventions, the incidence of being plus size continues to rise potentially changing the demographics of the working population. This presents a challenge to those involved in workplace design as the design process relies upon the utilization of appropriate anthropometric data to establish the percentage of the user population that will be accommodated by the design. The aim of this thesis is to identify issues affecting plus size people in the working environment, not previously explored within the literature. Furthermore, by understanding the size and shape of this population via the collection of key anthropometric data, this will help inform the design of safe, comfortable, inclusive and productive working environments for plus size people within the United Kingdom.

A first stage Scoping Study (n=135) found that fit (equipment, tools, furniture, uniforms and personal protective equipment) and space (circulation and shared spaces within the working environment) were issues of concern to plus size people. This suggests that aspects of the current design of the workplace are not suitable, and may even exclude plus size people. A better understanding of the anthropometric requirements of plus size workers is therefore required.

Self-reported anthropometric data is an acceptable way of studying large and geographically diverse populations and may assist in accessing the hard to reach plus size working population. A validation study (n=20) established that self measurement of 14 key anthropometric measurements, using a self measurement instruction guide, was a feasible and acceptable data collection method for a larger scale anthropometric study to further understand the body size and shape of plus size people at work. A unique measure of knee splay (for a non-pregnant population) was included. Defined as the distance between the outer borders of the knees whilst seated

in the preferred sitting position it represents the observed sitting postures of plus size individuals – not captured in existing anthropometric data sources.

The larger scale Plus Size Anthropometry Study (n=101) collected anthropometric data of plus size working age people via self measurement. The findings indicated that the study population was substantially larger in circumference, depth and breadth measurements than the population of existing anthropometric data sources. Knee splay was also identified as a key anthropometric variable for plus size people, however, it is not included in any datasets or literature relating to plus size people at work. These factors may contribute to high exclusion rates from current design practices that seek to accommodate the 5^{th} to 95^{th} or 99^{th} percentile of users and may explain the high incidence of fit and space issues reported by participants with a BMI over $35kg/m^2$.

Finally, semi structured interviews with stakeholders (n=10) explored how they would like the data from the plus size anthropometry study communicated and any additional requirements of a resource aimed at supporting stakeholders in meeting the needs of plus size people within the working environment. The primary concern from stakeholders was the lack of existing data on the size and shape of the plus size working population and the importance of access to such data in whatever format. A range of ideas were suggested including case studies, guidance and access to training which may assist them in understanding the needs of their end users ultimately supporting the inclusion of plus size people in workplace design.

Acknowledgements

Firstly, I would like to offer a massive 'thank you' to my supervisors Professor Sue Hignett and Dr Diane Gyi and my internal assessor, Dr Russell Marshall. Your wealth of knowledge and dedication is inspirational and your support, guidance, patience and ability to say exactly the right thing at exactly the right time has been invaluable. Thank you so very much.

I would like to offer my gratitude to the individuals and organisations that have spared their valuable time to participate in my research studies. Without each and every one of you, this wouldn’t have been possible. Special thanks to Tracey Carr for showing such an interest and for her many contacts.

To my wonderful mum, who has seen more of my children than I have for the past three years. Your unquestionable support, despite my best attempts to take the path of most resistance has been appreciated beyond words.

To my twin sister, Juliet. You have enabled me to follow my dream. No words can say thank you enough but I am so grateful and so proud of what you have achieved.

And finally, to my beautiful daughters Freya and Thea. Mummy is nearly there!!! I know my favourite saying has become 'when I've finished my PhD we can……….' You have waited so patiently to go on holiday, have friends to play and go out for the day so now is your time. Everyone has a lucky star. I have two.

Publications / Conference Proceedings

Masson, A. Hignett, S. Gyi, D. (2014) Exploring workplace issues for plus size people. *Proceedings of 3rd International Conference on Wellbeing at Work*. Copenhagen, 26-28 May 2014.

Masson, A. Hignett, S. Gyi, D. (2014) Exploring and describing workplace Issues for plus size people. Proceedings of the *3rd International Conference on Ergonomics Modelling, Usability & Special Populations / 5th International Conference on Applied Human Factors and Ergonomics*. Krakow, Poland. 21- 25 July

Masson, A. Hignett, S. Gyi, D. (2015) Anthropometric Study to Understand Body Size and Shape for Plus Size People at Work. *Procedia Manufacturing* Procedia Manufacturing, 3, pp. 5647-5654.

Masson, A. Hignett, S. Gyi, D. (2015) Anthropometric Study to Understand Body Size and Shape for Plus Size People at Work. Proceedings of the *4th International Conference on Ergonomics Modelling, Usability & Special Populations / 6th International Conference on Applied Human Factors and Ergonomics*. Las Vegas, USA. 26- 30 July

Masson, A. Hignett, S. Gyi, D. (2016) Plus size anthropometry: is designing for the 95th percentile enough? *Proceedings of Ergonomics and Human Factors Conference*. Daventry, UK. 19-21 April

Kosten, L. Gyi, D. Masson, A. (2016) Plus size and inclusivity in design. *Proceedings of Ergonomics and Human Factors Conference*. Daventry, UK. 19-21 April

Masson, A. Hignett, S. Gyi, D. (2016) Including Plus Size People in Workplace Design – who are we designing for? *Proceedings of 4rd International Conference on Wellbeing at Work*. Amsterdam, 29-31 May 2016

Table of Contents

List of Figures

List of Tables

1. Introduction

Overweight and obesity is defined as an "*abnormal or excessive fat accumulation that may impair health"* (WHO, 2016) and is recognised as a major health problem in many countries of the world (Wearing et al., 2006). The majority of the adult population (61%) in the United Kingdom is now either overweight or obese (DoH, 2015) or classed as 'plus size'. This is higher than almost all other developed countries in the world. Despite numerous public health interventions such as 'Change4Life' (NHS, 2009), food labelling systems (for example the Traffic Light System *www.nhs.uk/Livewell/Goodfood/Pages/food-labelling*) and widespread weight management guidance (NICE, 2014) the incidence of being plus size continues to rise, leading to changes in the demographic of the working population.

The economic consequences of an increased percentage of plus size workers are well documented and include increased absence from work (Han et al., 2009) and reduced productivity (Bhattacherjee et al., 2003). Being plus size has also been identified as a major risk factor for permanent early retirement (Shrestha et al., 2016). The issues associated with plus size workers are of concern as increasing employment, supporting people into work and maintaining people at work are key elements of the UK Government's public health and welfare reform agendas (DWP, 2015). There are economic, social and moral arguments that work is the most effective way to improve the well-being of individuals, their families and their communities and there is a strong evidence base showing that work is generally good for physical and mental health (Burton and Waddell, 2006).

Despite the increasing worldwide prevalence of overweight and obesity and the benefits of employment, the literature is limited on the characteristics of the plus size worker in terms of anthropometry, and physical / psychological strengths or limitations. Further research is required to determine the key anthropometric data to enhance comfort, safety and user satisfaction within the working environment and reduce the risks of absenteeism, reduced productivity and early retirement.

1.1 Research aim

This research aims to explore issues affecting plus size people in the working environment and identify the preferences of stakeholders for a resource to support inclusion. It is proposed that the current evidence based guidance may be inadequate for the design of the working environment, such as products (chairs, desks, and toilets), clothing (uniform, personal protective equipment) and workspaces (door widths, corridors) as a result of the changing size and shape of the working population.

1.2 Research questions

In order to achieve the research aim the following research questions have been identified;

- Are there any issues affecting plus size people in the working environment?
- What are the anthropometric measurements of the plus size working population? (either currently or previously working)
- Is self-measurement a feasible and acceptable method for collecting anthropometric measurements in the plus size working population?
- What are the preferences for a resource used to support stakeholders in meeting the needs of plus size people within the working environment?

1.3 Research objectives

In order to support more inclusive, healthier and safer working environments for plus size people, the objectives of this research are therefore:

1. To undertake a literature review to understand the context of a plus size workforce;
2. To explore the methodologies appropriate for the study of plus size people in the working environment;
3. To conduct a study to explore the issues affecting plus size people within the working environment;
4. To conduct an anthropometric study to understand the body size and shape of the plus size working (or previously working) population via the collection of key anthropometric measurements;

5. To conduct stakeholder interviews to explore the preferences for a resource to support inclusion.

1.4 Thesis outline

This thesis presents information and data regarding plus size people at work.

Chapter 2 begins by reviewing the literature relating to the physical and psychological factors associated with plus size people at work. It continues with a review of the available anthropometric data, including its application and limitations for design.

Chapter 3 details the research methodologies used to address the research aims and objectives.

Chapter 4 presents the results of the **Scoping Study** exploring workplace issues for plus size people. This includes discussion of the main findings (identification of fit and space issues), and how the results inform subsequent research.

Chapter 5 presents the findings of the **Anthropometric Measurement Validation Study.**

Chapter 6 reports the results of the larger scale **Plus Size Anthropometry Study.**

Both these studies established a better understanding of the anthropometric requirements of plus size workers via the collection and analysis of anthropometric data specific to the workplace.

Chapter 7 discusses the methodology and results of **Stakeholder Interviews** in order to identify the preferences of a resource that will be used to support stakeholders in meeting the needs of plus size people within the working environment.

Chapter 8 summarises the findings of the research and the contribution to knowledge. The main conclusions of the research and their implications within the wider literature are discussed.

The structure of the thesis is detailed in Figure 1.1

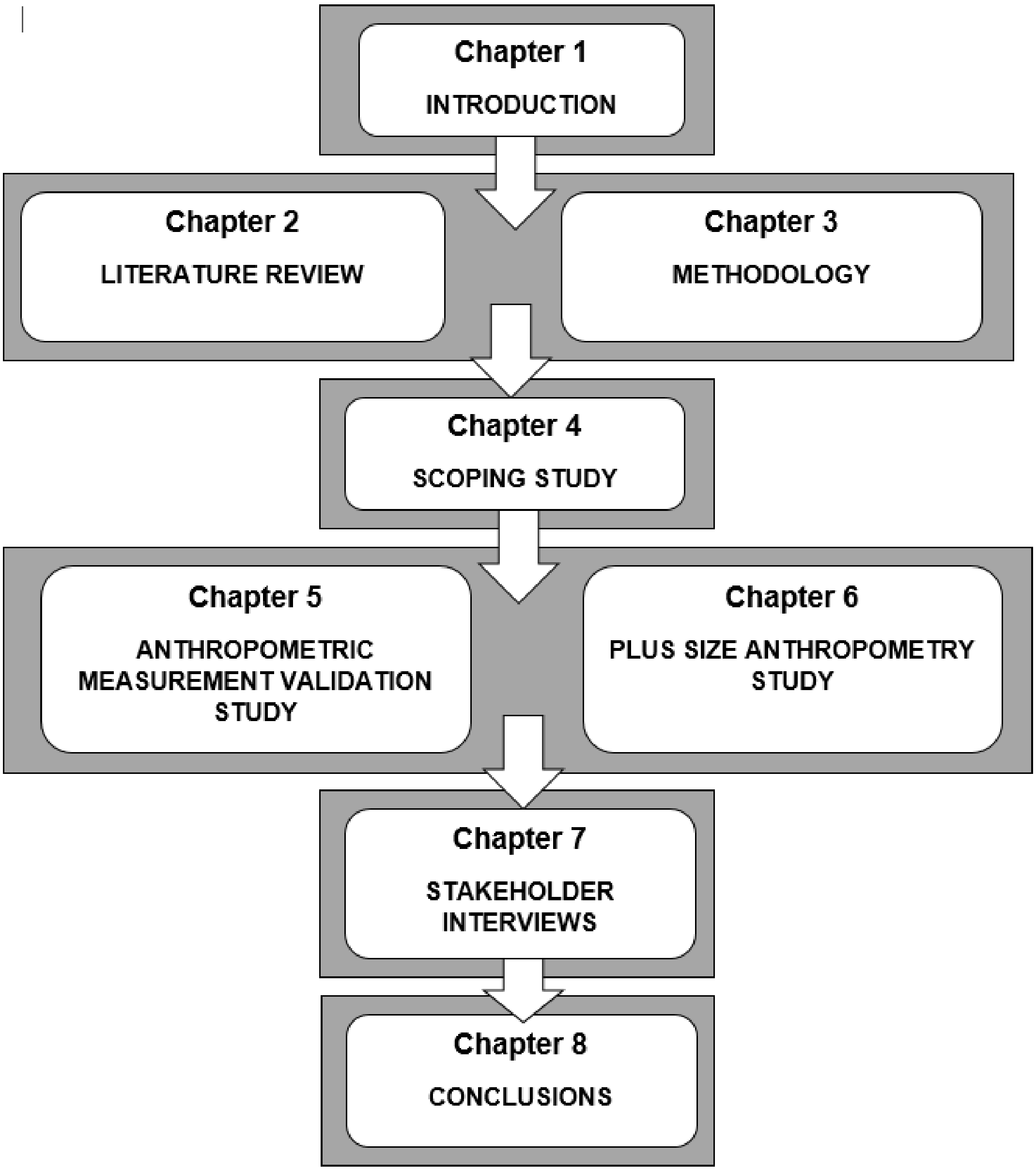


Figure 1.1 Thesis structure

2. Literature Review

2.1 Introduction

The primary objective of the literature review is to understand the context of a plus size workforce. This necessitates understanding previous research on plus size individuals (including individuals defined as overweight and obese) in terms of physical and psychological function and anthropometry, and also of issues that they have experienced within the working environment. There is an extensive body of literature that exists surrounding the health implications of being plus size and of strategies to reduce overweight and obesity from a public health perspective. Whilst acknowledging the importance of this view, this is only discussed briefly as it falls outside of the scope of this thesis. In order to understand the aims of the proposed research the following topics were explored:

- Measures of body composition and size
- Issues affecting plus size people at work
- Plus size and function
- Workability
- Ethical, legal and social issues

2.1.1 Search strategy

A search strategy was developed using journals and specific search criteria. Google Scholar was the primary source of journal papers, in combination with the Loughborough University Library Catalogue Plus and individual subject databases. An example of the databases and terminology searched, including exclusion and inclusion criteria combined with the number of references selected for review can be found in Appendix 2.1**.** References from pertinent research were recorded and retrieved to further 'snowball' the search strategy. RefWorks was used to store all references.

2.1.2 Critical appraisal of the literature

Following, the identification of relevant research for review, a systematic critical approach of the each reference was undertaken based upon the 'Mixed Methods Appraisal Tool (MMAT) version 2011 (Pluye et al., 2011).

See Appendix 2.2 for an example of this appraisal. This approach was selected because it enabled the appraisal and description of the three main methodological approaches; qualitative, quantitative and mixed methods utilised within the literature excluding the need for three different appraisal tools. Prior to inclusion, all studies were required to meet the screening criteria in that there was a clear research question or objective and the data collected enabled the research question or objective to be addressed.

2.2 Measures of body composition and size

There are many ways of measuring body composition and classifying body size including Body Mass Index (BMI), waist circumference, anthropometry, waist to hip ratio, 'A Body Shape Index' (Chang et al., 2015) and Body Roundness Index (Tian et al., 2016). Within the literature, three main measures of plus size have been identified and are discussed in more detail.

2.2.1 Body Mass Index

Body Mass Index (BMI) is a summary measure of an individual's height and weight, calculated by dividing weight in kilograms by the square of height in metres. It is the most frequently used method of estimating whether a person is overweight (Wearing et al., 2006) and as it allows weight to be standardised for the individuals height it enables individuals of different heights to be compared. (DoH, 2009). A number of research studies (Visscher et al., 2001, Twells et al., 2012, Kouvonen et al., 2013) have demonstrated a significant relationship between increasing BMI and increasing risk of illness or mortality. For Caucasian adults an individual's weight status is categorised according to the level of BMI (Table 2.1).

BMI (kg/m^2)	**Weight Status**
Below 18.5	Underweight
18.5 to 24.9	Healthy Weight
25.0 and above	Overweight
30.0 and above	Obese

Table 2.1 Classification of BMI (DoH, 2009)

Measurement of BMI is advantageous; it is cheap and non-invasive and enables comparisons to made between areas, across populations and over time (WHO, 2016). However, the extensive use of BMI as a measure of plus size has many limitations. BMI is only a proxy measurement of body composition (Park et al., 2009). As it is a calculation solely dependent on the total weight and height of the individual, it does not consider or differentiate between the distribution of fat, muscle or bone mass. Therefore, there is a potential risk of overestimating 'fatness' in individuals with high muscle mass, such as athletes, and underestimating the fat deposit in those with less lean body mass, such as the elderly (Frontera et al., 1991) which might lead to functional implications. Similarly, as BMI cannot fully adjust for the effects of height or body shape, individuals with the same BMI may have very different anthropometric measurements as shown in body scan data for eight females each with a BMI of 30kg/m^2 (Figure 2.1).

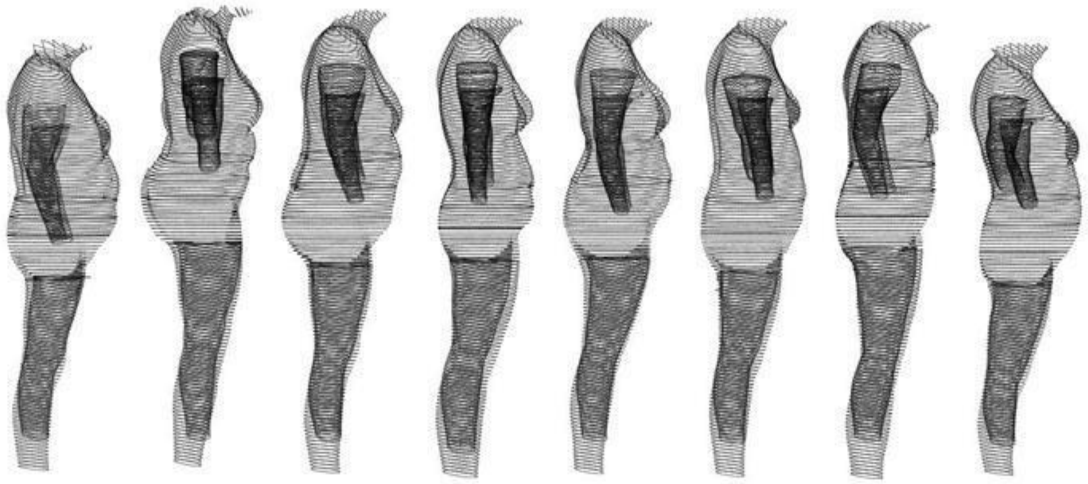


Figure 2.1 Eight females with BMI of 30kg/m^2 (image courtesy of Richard Barnes – Select Research)

The range within a single BMI classification as illustrated in Figure 2.1, combined with the reliance of BMI in the literature regarding issues affecting plus size people within the working environment makes it difficult to compare research within the field. This limitation applies throughout the literature review as all the included studies rely on BMI classification to define plus size.

2.2.2. Waist circumference

Waist circumference, as a measure of plus size, is rarely cited alone in the literature relating to plus size people at work. Waist circumference, measured at the level of the navel, indicates the degree of central adiposity and is defined as *"the accumulation of fat in the lower torso around the abdominal area"* (Karine et al., 2015). There are well documented links between high levels of central adiposity and the risk of developing obesity related conditions such as heart disease and hypertension (Pischon et al., 2008). A waist circumference of 94 centimetres or above for men and 80 centimetres for women is commonly used as an indicator of increased risk of these obesity related health conditions (Wang et al., 2005). As waist circumference is a measure of excess fat rather than excess weight it is useful when used in combination with BMI to determine whether BMI's in the overweight or obese category are likely to be due to excess body fat or high muscle mass (which has implications for function). Additionally, waist circumference is a valuable dimensional measurement in workplace design (Park et al., 2010).

2.2.3 Anthropometry

Anthropometry is the science of human body dimensions (Peebles and Norris, 1998). Each individual has a unique set of body measurements in different proportions that determines their body shape. Therefore, across the working population there is great variability in size and shape. It is important to determine how, and to what extent, people vary in order to ensure that products and environments are designed to suit and fit as many people as possible (Pheasant and Haslegrave, 2006). Table 2.2 gives examples of how anthropometric measurements may be used within the working environment and the range of variability that should be accommodated by the design.

Design Condition	Design Aim	Workplace Example	Range to Accommodate
Fit	• User –product match • For appropriate/effective use	Seats, toilets seats, uniform, PPE, seatbelts	Maximum range of the population (commonly 5th to 95th percentile)
Reach	• Placement to ensure access • For appropriate/effective use	Controls, objects on a workstation	Smallest of the population (commonly 5th percentile)
Clearance	• Placement to ensure undesirable or unintentional contact	Doorways, desk seat gap, space between rows of seats in lecture theatre of cafeteria	Largest of population (commonly 95th percentile)
Posture	• Design to ensure comfortable and safe working postures are adopted	Working surface height, controls, VDU placement	Maximum range of the population (commonly 5th to 95th percentile)
Strength	• Design to ensure operability	Machine controls, seat controls, door opening system	Smallest of the population (commonly 5th percentile)
Entrapment	• Design to avoid unintentional retention of whole body or body parts	Ladders, railings	Largest of population (commonly 95th percentile)
Exclusion	• Design to ensure Inaccessibility and inoperability	Guards, railings, barriers	Maximum range of the population (commonly 5th to 95th percentile

Table 2.2 Use and accepted variability of anthropometric dimensions (adapted from Peebles and Norris, 1998)

There are several anthropometry data sets available to support the design process such as Adultdata (Peebles and Norris, 1998), BodySpace (Pheasant and Haslegrave, 2006) and PeopleSize (Open Ergonomics, 2008). Because anthropometry data is so expensive to collect, surveys are conducted very rarely amongst civilian populations, so the majority of anthropometric dimensions are not taken from their original source (Khadem and Islam, 2014). For example, in Adultdata (Peebles and Norris, 1998), it is difficult to determine the original source of the data because only the secondary sources such as compilations or national standards are cited. This has implications in terms of usefulness for designers who may be trying to design for a specific population. In addition, the majority of values in data sets rely on ratio scaling methods to create estimates for many anthropometric variables from stature. The rapid increase in the prevalence of plus size people in working population may not be fully accounted for in these scaling methods (Bridger et al., 2013) in terms of mass and in terms of the proportion of each dimension that is body shape.

Anthropometric data sets are typically displayed in tables, listing the dimension, the 5th, 50th and 95th percentile ranges and standard deviation. However, it is not possible to ascertain the proportion of the measurements for one individual, which may have limitations in the design of functional activities, for example forward reach. Section 2.4.3 will discuss, how for example, the abdominal depth may reduce forward functional reach - a factor not addressed in data tables. More innovative design tools based on anthropometric data are documented in the literature (for example ‘HADRIAN’, Marshall et al., 2010) but these rely on small data sets which may also not account for the variability of plus size people.

No publications were found that provide an up to date and comprehensive anthropometric database for the current plus size UK working population. The need to further understand the anthropometry of the current plus size working population is therefore identified. Incorrect adjustments for, or the omission of anthropometric data in product or workplace design has been associated with work related psychological discomfort (Mokdad, 2003) and increased risk of work related musculoskeletal disorders (Viester et al., 2013). This knowledge is essential for a safe, comfortable and productive working environment.

2.3 Issues affecting plus size people at work

There are a multitude of workplace health and safety legislation and industry specific guidelines in place to maximise the safety and wellbeing of people at work. Examples include the Management of Health and Safety at Work Regulations (HSE, 1992), Personal Protective Equipment at Work Regulations (HSE, 1992) and the Provision and Use of Work Equipment Regulations (HSE, 1998). Despite this legislation and guidance, accidents at work still occur. This is now discussed in relation to plus size individuals at work.

2.3.1 Falls

In the year 2013 to 2014, falls, slips and trips accounted for more than half of all reported major injuries and almost a third of over seven day injuries to employees in the United Kingdom (HSE, 2015). An estimated three million working days in the UK were lost due to falls, slips and trips during this period.

A fall can be defined as " *unintentionally coming to rest on the ground, not as a result of an overwhelming hazard"* (Tinetti et al., 2008) and evidence from epidemiological studies suggest that plus size individuals have a greater incidence of falling than non plus size individuals. Fjeldstad et al., (2008) surveyed 200 participants and found that obese individuals (with a BMI of over 30kg/m^2) had a higher prevalence of falls in the preceding year than normal weight individuals (with a BMI between 18.5-24.9 kg/m^2). Ambulatory stumbling, that is "*a loss of balance that was restored before a fall occurred*" (Fjeldstad et al., 2008) was also greater in the obese group (32%) compared to the normal weight group (14%). However, the mean age of participants was 60 years of age so findings can only be generalised for the middle to older working age adult.

2.3.2 Types of traumatic injuries

Finklestein (2008) and Kouvonen et al., (2013) suggested that plus size individuals not only fall more frequently, but also have an increased incidence of sustaining a workplace related traumatic injury compared with normal weight individuals. In a large prospective study of 70,000 male and female employees Kouvonen et al., (2013) sought to examine whether being plus size was a predictor of recorded occupational injuries in Finland. The large sample size enabled the control of confounding factors such as age, gender, socio economic class, type of job, and health behaviours. In a seven year period, a total of 12,000 employees (18%) experienced at least one traumatic occupational injury. Of this percentage, 19% were overweight and 21% were obese. Analysis showed that being 'plus size' with a BMI of over $25kg/m^2$ increased the risk of only some types of occupational injury (dislocations, sprains and strains and bone fractures) supporting earlier findings by Pollack et al., (2007). Significant associations were found between being obese (BMI $30kg/m^2$ or above) and injuries to the upper and lower extremities with interestingly significant associations found between injuries to the spinal complex starting at a lower BMI of $25kg/m^2$. Previous studies by Low et al., (1996) and Myers et al., (1999) had not found any significant association between BMI and back injuries. However, methodological omissions, small sample sizes and no reported confidence intervals suggest caution in interpretation of the results. Several possible explanations why being plus size would increase the risk of occupational injury have been highlighted in the literature such as fatigue whilst at work (Salminen et al., 2010) and poorer mental health (Virtanen et al., 2011). However Kouvonen et al., (2013) found adjustments for mental health and fatigue made no difference to the results, thus weakening these explanations.

2.4 Plus size and function

Despite the increasing number of plus size individuals within the working environment over the past few decades, it is only recently that the functional implications of being plus size have started to be researched (Finklestein et al., 2008).

2.4.1 Balance

Balance defined as the "*ability to maintain the line of gravity of a body within the base of support with minimal postural sway*" (Nichols, 1995) is a major intrinsic factor associated with falling. Therefore, it is important to assess the impact of how being plus size affects balance in order to understand the risk of falling within the working environment. Research exploring the effect of being plus size on the balance in working age adults is limited and has primarily focused on static postural balance rather than dynamic tasks experienced within the working environment.

Hue et al., (2007) assessed the postural stability of 59 male subjects with BMI's ranging from 17.4 to 63.8 kg/m^2 using a force platform. A decrease in postural stability was strongly correlated to an increase in body weight; a view supported by McGraw (2000). These studies are limited by only including male participants. Blaszczyk et al., (2009) assessed a group of female participants consisting of 100 obese female working age adults with a mean BMI of 37.2kg/m^2 and 33 normal weight females. The methodology was similar to the studies by Hue et al., (2007) and McGraw (2000) in that all used a force plate to evaluate postural stability with participants being asked to maintain a stable posture while fixating on a predetermined reference point although the results disagreed with Blaszczyk et al., (2009) reporting that postural stability was significantly better in the obese group. However, it should be noted that in the study by Blaszczyk et al., (2009) the postural sway (small horizontal movements that occur even when standing still) of the normal weight control group were four times higher than those of the obese group and indeed of participants in other cited literature. A certain degree of sway is essential and inevitable but excessive sway is a predictor for risk of falling (Zech, 2010). This suggests that the postural stability was significantly better in the obese group because the control group used in this study had poor static postural balance.

Few studies have explored the effect of more functional, dynamic tasks on the balance of plus size working age individuals. Berrigan et al., (2006) examined the combined effect of balance and movement in a reaching task between normal weight and obese male subjects. Eight normal weight (BMI 20.9-24.9kg/m^2) and nine obese individuals (30.5 – 48.6kg/m^2) with no pre-existing co morbities were required to point at a target as fast and as accurately as possible whilst standing. The degree of displacement from the centre of pressure (location on the supporting surface where the resultant vertical force vector would act if it could be considered to have a single point of application) of each subject was recorded using a force platform. The task speed was repeated with four target sizes – the smaller the target the more difficult the task. Results showed that the obese participants exhibited more forward displacement (4.6cms) compared with the normal weight group (1.9cms). As the task difficulty increased (by aiming at smaller targets) displacement in all directions increased within the obese group whilst no change was recorded in the normal weight group. This suggests that postural instability increased in the obese participants as the task became more difficult. Similar findings were also reported by Hamilton et al., (2015) in another small parts assembly task. For male and female participants with a BMI of over 30kg/m^2, anterior–posterior sway was significantly larger than the normal weight group anterior–posterior sway. The results indicated that the displacement in the anterior–posterior direction was also significantly larger for time-paced tasks than for self-paced tasks. Once again, suggesting that as task difficulty increases so does postural instability. In both studies, different movement patterns were also identified between the two groups. Berrigan et al., (2006) observed that obese participants aimed at the target moving their whole body forward whilst those of a normal weight predominantly utilised elbow extension combined with shoulder flexion to reach the target. Hamilton et al., (2015) also reported more movement in obese participants compared to normal weight participants but instead in a posterior direction finding that obese participants tended to lean backwards in the sagittal plane while performing assembly tasks. This may be to counterbalance the gravity pushing them forward. This may be an important observation when designing workstations and working practices. However, the generalisation from such small sample sizes should be treated with caution.

The literature reviewed to this point has explored the effect of being plus size on postural stability and suggests that body weight may be an important risk factor in falling due to decreased postural stability. Further studies are required to provide a more complete understanding of the effect of being plus size on balance including how the distribution of adipose tissue may affect balance (Hao et al., 2016) and also to examine a variety of work related tasks and conditions, such as repetitive dynamic tasks, static endurance tasks or varying working loads.

2.4.2 Muscular capacity

The literature relating to the effect of being plus size on muscular capacity is conflicting and inconclusive. Muscular capacity includes muscle strength, that is the ability to exert a near maximal force for example in lifting, and muscular endurance which is the muscle's ability to exert a submaximal force repeatedly over time, which is required in repetitive tasks (Cavuoto, 2013). Hulens et al., (2001) found that knee extension strength (quadriceps muscle) was significantly greater in obese women (BMI over 30kg/m^2) compared to the normal weight group. These findings have since been supported in additional studies by Maffiuletti et al., (2008) and Abdelmoula et al., (2012) which have used male participants. This seems understandable as the quadriceps muscle is imperative for walking and standing and in order to move a greater body mass the quadriceps should be stronger due to the training effect (Cavuoto et al., 2013). Back extensor and flexor muscle strength followed the same trend in that obese women (BMI over 30kg/m^2) were stronger than normal weight women (Hulens et al., 2001). Back extensor and flexor muscles are required not only for movement of the trunk but are also responsible for maintaining trunk posture. Once again, this supports the suggestion that the postural and anti-gravity muscles undergo a training effect in plus size individuals increasing absolute strength, due to the constant demands of a larger mass.

However, these initial results suggesting that plus size individuals have greater muscle strength in the lower limb and trunk (Hulens et al., 2001, Maffiuletti et al., 2008, Abdelmoula et al., 2012 and Cavuoto, 2013) may be misleading. Although the studies matched the control and obese group for age and activity levels, when fat free mass was corrected for using an allometric scaling method (Hulens et al., 2001), obese participants were 6-7% weaker in quadriceps strength, and 8-10% weaker in trunk muscles than the normal weight group. This suggests that although the added body mass of plus size individuals includes some additional muscle mass which accounts for the greater absolute muscle strength of the weight bearing muscles (Cavuoto, 2013), the force required to move a larger body mass actually means that relative strength is less.

Despite limitations (such as obesity only considered by category (over 30 kg/m^2 or normal weight), no studies included BMI of between 25-29 kg/m^2, and results were based on laboratory based experiments) muscle efficiency is a key factor in a variety of work related activities from walking to lifting. Inadequate muscle strength has been associated with early muscle fatigue (Pollack et al., 2007), reduction in work performance and efficiency, and an increased risk of injury.

2.4.3 Range of movement (ROM)

The flexibility of the plus size individual is measured in terms of the angular ranges of motion of the joints (Pheasant and Haslegrave, 2006). The range of movement (ROM) available at joints greatly affect individual physical capabilities, activities of daily life and work (Verbrugge and Jette, 1994; Kee and Karwowski, 2002) and are an important consideration in the design of products and workplaces (Kee and Karwowski, 2002; Zhang, 2005).

Park et al., (2010) examined body joint ROM of 20 obese and non-obese individuals with a mean BMI of $44kg/m^2$ (obese) and $22kg/m^2$ (non-obese). 30 movements occurring at the shoulder, elbow, knee, ankle and lumbar and cervical spine were recorded. The effect of obesity on joint ROM was found to vary in that obesity significantly reduced ROM for only 9 of the 30 ranges (Table 2.3).

Joint	Movement	Mean difference (obese - non obese, %)
Right Shoulder	Extension	-20.5%
	Adduction	-35.9%
Left Shoulder	Extension	-22.0%
	Adduction	-38.9%
Lumbar Spine	Extension	-21.7%
	Left Lateral Flexion	-20.0%
	Right Lateral Flexion	-18.4%
Right Knee	Flexion	-11.1%
Left Knee	Flexion	-12.3%

Table 2.3 ROM significant differences between obese and non-obese groups

From Table 2.3 it can be seen that, when expressed as a percentage of the mean, the largest and second most significant reductions in ROM were for left and right shoulder adduction. Adduction, defined as movement towards the midline of the body (Levangie, 2001) is vital for completing tasks that involve working with two hands, reaching or driving (Pheasant and Haslegrave, 2006). Park et al., (2010) suggests that the reduction in ROM may be due to the excess fat in the plus size body obstructing the movement. This is also known as soft tissue apposition. In the case of shoulder adduction, the circumference of the chest and abdomen would limit any further movement across the body. Very small and highly non-significant differences were found at the cervical spine, elbow and ankle joints which would support this finding as apposition would not be as critical. However, this study examined each joint range in isolation, in a non-functional task which may not be applicable to the working environment. Advantageously, the flexibility of one joint may be influenced by the posture of another joint for example hip flexion is much greater when accompanied by knee flexion. Adaptations in movement strategies may therefore enable plus size individuals to complete work related tasks.

Gilleard and Smith (2007) found that obese participants adopted a more flexed trunk posture and concomitant increases in hip joint angle and hip to bench distance during a standing work task. This was primarily because they had positioned themselves further back from the work bench initially, possibly because their body dimensions had prohibited them from standing closer. Similar adaptations were found by Hamilton et al., (2013) who compared the maximum frontal functional reach zone between normal weight (BMI 23kg/m^2), overweight (BMI 27kg/m^2), and three categories of obese participants – obese class 1 (BMI 32kg/m^2), obese class 2 (BMI 38kg/m^2) and obese class 3 (BMI 44kg/m^2). During a simulated small parts assembly task, BMI was found to significantly affect maximum frontal functional reach with the reduction greater as BMI increased. This was primarily because obese participants had to stand further back from the workstation in order to accommodate a larger abdominal circumference therefore reducing their available reach zones. Over reaching in the plus size population has been associated with increased pelvic tilt and flexion of the sacro iliac joints increasing the risk of lumbar spine disorders (Garg and Kapellusch, 2009).

Capodaglio et al., (2010) found that during self-paced flat walking, compared to normal weight individuals, plus size individuals displayed greater hip abduction during the late stance phase of the gait cycle and reduced ankle plantar flexion throughout the whole cycle. Although Capodaglio et al., (2010) attributed the increase in hip abduction to the larger thigh breadth, reduced ankle plantar flexion was in response to a reduction in hip flexion. These findings support previous observations by Spyropolos (1991). Sibella et al., (2003) examined the movement strategy adopted by 40 obese males and females (mean BMI of 38 kg/m^2) compared to 10 non obese males and females (mean BMI 23kg/m^2) completing a sit to stand from a chair for 10 repetitions. Obese individuals demonstrated a reduction in trunk flexion coupled with posterior placement of their feet and reduced ankle dorsiflexion to reduce the loading of the lower back.

Notwithstanding the limitations of small and gender specific sample sizes, these examples suggest reductions in joint range primarily due to soft tissue apposition and altered modified movement patterns to accommodate the plus size body. This may result in certain movements being more difficult to achieve and maintain, therefore increasing the associated postural stress. Postural stress, especially repetitively or over prolonged periods, is a documented risk factor in the development of work related musculoskeletal disorders (Viester et al., 2103).

2.4.4 Work related musculoskeletal disorders (WMSD)

The term musculoskeletal disorders covers any injury, damage or disorder of the joints or other tissues (including muscle, ligaments, tendons, nerves) of the upper or lower limbs or trunk (Petty and Moore, 2004). Different from traumatic workplace injuries, in that they tend to be cumulative and not identifiable to one specific incident, musculoskeletal disorders represent a considerable health problem in the working age population due to symptoms including pain and limitations to activities of daily living. Additionally, WMSDs have consequences for the wider organisation as they have frequently been cited as the most common reason of absence from work (Andersson 1999, Park et al., 2009) with associated costs of absenteeism and loss of productivity.

In addition to the documented risk factors (age, female gender, temperature, vibration, repetition, posture; Oha et al., 2014) being plus size may also increase the risk of suffering from a WMSD (Copodaglio et al., 2010). Due to the complexity of WMSD, there are few epidemiological studies that have explicitly studied the combined effects of work, being plus size and musculoskeletal disorders. Disorders of the upper limb, especially Carpal Tunnel Syndrome, have been significantly associated with being plus size (Kortt and Baldry, 2002) with Ohnari et al., (2007) suggesting that the risk of developing carpal tunnel syndrome is four times greater in the plus size individual compared to normal weight. Knee osteoarthritis has also been associated with increased BMI in studies that control for work and non-work risk factors (Holmberg et al., 2005).

Awkward, stressful working postures are recognised as increasing the risk of WMSD (Armstrong 1993, Wearing et al., 2006) .In order to reduce the potential for WMSD, postural stresses need to be accurately assessed, typically via postural analysis tools and controlled as necessary, through appropriate workplace interventions. Park et al., (2009) suggested that postural stresses may be significantly affected by the physical condition, including weight status of individuals. From a biomechanical perspective and as discussed in Sections 2.4.2 and 2.4.3 on muscular capacity and ROM respectively, excess body weight may increase load through weight bearing joints and increases muscular exertions resulting in an increase in postural stress.

Park et al., (2009) also empirically examined the effect of being plus size on postural stress during static maintenance tasks. 20 obese individuals (males and females) mean BMI of 46 kg/m^2 (SD 4.99 kg/m^2) and 20 non obese males and females with a mean BMI of 22 kg/m^2 (SD 1.79 kg/m^2) performed static box holding for a set of 80 working postures defined based on the Ovako Working Posture Analysis System (OWAS; Karhu et al., 1977). Participants were required to rate their subjective levels of postural stress using the Rating of Perceived Exertion Scale (RPE; Borg, 1990) during each posture. Obese and non-obese participants found the same postures most difficult, but obesity was found to significantly increase the perceived postural stress across each of the 80 postures compared to the non-obese group. The working posture of a non-straight back, elevated arm or both arms and bent leg or legs was the most stressful posture reported for both groups but the degree of perceived stress was significantly higher for the obese participants. This has implications for workplace design in that working postures rated as low stress and acceptable, based on OWAS for non plus size individuals may be rated as high stress and unacceptable for plus size individuals. This would necessitate immediate workplace redesign to minimise the risk of developing WMSD (Ramachandran, 2006). Singh et al., (2013) suggested that due to altered biomechanics of the plus size body such as soft tissue apposition and decreased relative muscle strength plus size individuals may have a smaller range of feasible body postures that they can adopt compared with non plus size individuals. This would further increase the risk of having to adopt postures of high stress. However, the obese participants in the study by Park et al., (2009) were extremely obese in that the mean BMI was 46 kg/m^2 and potentially suffering from comorbities (such as Type II diabetes, hypertension or joint pathology) which are prevalent in this group (Kouvonen et al., 2013). This is likely to have affected the results but there are no other studies within this field for direct comparison.

2.4.5 Psychological aspects

The literature suggests a bidirectional relationship between being plus size and mental health problems such as depression (Luppino et al., 2010) but prevalence rates specifically related to the plus size working population are rare. Proper et al., (2012) aimed to determine the prevalence of chronic psychological complaints and emotional exhaustion amongst plus size workers. Based on self-reported BMI, workers were classified into underweight, healthy weight, overweight and obese groups and a questionnaire was used to explore levels of chronic psychological complaints and emotional exhaustion. Of the entire study population (n=43,928), 2.8% reported chronic psychological complaints and 12.5% were emotionally exhausted. However, compared to the healthy weight group levels of emotional exhaustion was significantly higher for overweight and obese males and females. This was true for all subgroups which were defined by age, type of work and education level. This study included only Dutch participants so it is unclear whether the results could be generalised to other populations. Also, other potential covariates such as activity levels or relationship status that may impact on the results were not controlled for. Despite this, considering the high level of plus size employees in the working population and the significant association between psychological conditions, this is likely to have a substantial impact in terms of absenteeism and productivity (Atlantis and Baker, 2008).

Risk factors that increase vulnerability to psychological conditions such as depression within the working environment, have not been established, but it has been suggested that weight stigmatisation may be one of those factors

(Wadden et al., 2007). Qualitative studies suggest that perceptions of weight based employment discrimination are frequent amongst plus size individuals. Puhl et al (2006) in a survey of plus size women (n=2249) found that 25% of participants reported experiencing job discrimination they attributed to their weight. 54% and 43% reported experiences of weight stigma from their colleagues or managers respectively which included inappropriate comments and differential treatment such as not being promoted. Roehling et al., (2008) in a similar scale, nationally representative sample of American adults (18-74 years) found that employment discrimination was reported as 12 times more likely by overweight respondents, 37 times more likely by obese respondents and 100 times more likely by severely obese respondents than normal weight respondents. Additionally, women were 16 times more likely to report discrimination than men. These findings were supported by Puhl et al., (2008) who found that experiences of weight discrimination were repetitive, and included not being employed for a job, failure to achieve promotion and wrongful termination. Weight discrimination may also help to explain longitudinal studies that reported lower rates of employment for plus size individuals (Klarenbach et al., 2006) and lower salaries (Maranto, 2000).

2.5 Workability

The literature has suggested a range of issues that may affect plus size people in the working environment. Work demands that are not sufficiently attuned to the physical and mental capacity of the plus size worker may increasingly cause health problems and subsequently displace them from the workforce (Stattin, 2005). Ilmarinen (2005) suggests that workability is determined by the individual's resources and work demands. The basis for workability are functional capacity and health, but workability is also affected by knowledge and skills, motivation and the work itself (van de Berg et al., 2008). Workability can be measured via a single question asking respondents to rate their current workability on a ten point scale (Bobko, 2002) or via 'The Workability Index' questionnaire (Tuomi et al., 1998). Assessing workability aims to identify early stage health risks of the employees and therefore risk of early retirement. Once identified strategies such as health promotion and job redesign can be implemented to counteract these risks. Very limited research has been reported on the impact of being plus size on workability. Being overweight was positively associated with low workability in studies by Fischer et al., (2006) and Pohjonen (2001), but in these studies workability related to health care workers in physical demanding roles which included shift work. Participants also reported a low level of job control, poor management and often experiencing conflict with patients which have all been associated with low levels of workability (Tuomi 1998; Lindberg, 2006).

More research is therefore required to ascertain if there is an effect from being plus size on workability. This will add to the knowledge of the determinants of workability which is important when designing interventions aimed at maintaining and improving productivity and presenteism at work (Bridger and Bennett, 2011).

2.6 Ethical, legal and social issues

To protect all workers, employers are responsible for providing workplaces that are free from recognised hazards (Schulte et al., 2007). From the literature, there is evidence to suggest that being plus size increases the risk of adverse health effects from the working environment such as traumatic injuries, WMSD's and postural stress. However, there is a lack of literature that suggests solutions to these issues without using approaches that may be deemed prejudiced, discriminatory or stigmatising (Luppino et al., 2010). Inclusive design strategies may help to overcome these issues.

2.6.1 Inclusive Design

'Inclusive Design' focuses on making products and services suitable for as many people as possible without the need for the individual to use specialised adaptions (Goodman-Deane et al., 2014). According to the Commission for Architecture and the Built Environment (2010), inclusive design's purpose is to *“remove the barriers that create undue effort and separation enabling everyone to participate equally, confidently and independent in everyday activities”* (p1) and this can be achieved via five key principles:

1. People – place people at the heart of the design process
2. Diversity – acknowledge diversity and difference
3. Choice – offers choice where a single design solution cannot accommodate all users
4. Flexibility – provides flexibility in use
5. Convenience – design building and environments that are convenient and enjoyable for use for everyone

Historically driven by the integration of disabled people into mainstream society and population ageing (Clarkson and Coleman, 2013) adoption of these principles may go some way to ensure inclusivity for plus size people within the working environment without drawing attention to the plus size person as requiring specialised adaptations. Clarkson and Coleman (2013) suggest that inclusive design is not a new concept or a separate specialism and in line with other design approaches the emphasis is very much upon an explicit understanding of users. Therefore, understanding the physical, functional and mental capacity of the plus size working population is paramount.

2.7 Limitations of the literature

Despite the majority of the population in the UK being classed as plus size (61%), literature addressing the issues affecting plus size people in the working environment is limited. Small scale, primarily laboratory based studies have identified a number of potential functional limitations affecting plus size people at work. However, these findings would need to be replicated using larger sample sizes and include work based measures before they could be used for workplace design. Larger scale epidemiological studies have identified further workplace issues affecting plus size people such as increased risk of workplace injury and work related psychological conditions but have failed to adequately control for potential confounding variables (such as medical history) that may offer an alternative explanation for the findings.

Perhaps the largest limitation in the literature however, is the reliance on BMI for classifying plus size. A large number of the studies reviewed compare non plus size people (control groups) with participants who have a BMI over 30kg/m^2 but even higher BMI's of 35kg/m^2 are commonly cited. Therefore, the literature currently provides very little information on the effects of overweight and moderate obesity. This needs addressing as Bridger et al., (2013) report that the direct and indirect employment costs associated with increasing BMI increase rapidly for employees with a BMI from 27kg/m^2.

2.8 Summary

Apart from stature, weight and waist circumference there is a lack of up to date anthropometric data pertinent to plus size people in a working environment. This establishes the need for the research question 'What are the anthropometric measurements of the current plus size working population?' Functional efficiency, ease of use, comfort, health and safety and quality of working life for plus size people is all dependent on this data (Pheasant and Haslegrave, 2006).

No research has been identified that explores the issues affecting plus size people in the working environment via qualitative methods, by asking plus size people what affects them at work. Understanding the requirements of the user is vital in any design process and therefore emphasises the importance of the research question 'Are there any issues affecting Plus Size People in the Working Environment?'

Methodological considerations to addressing these research questions are explored in Chapter 3 (Figure 2.2)

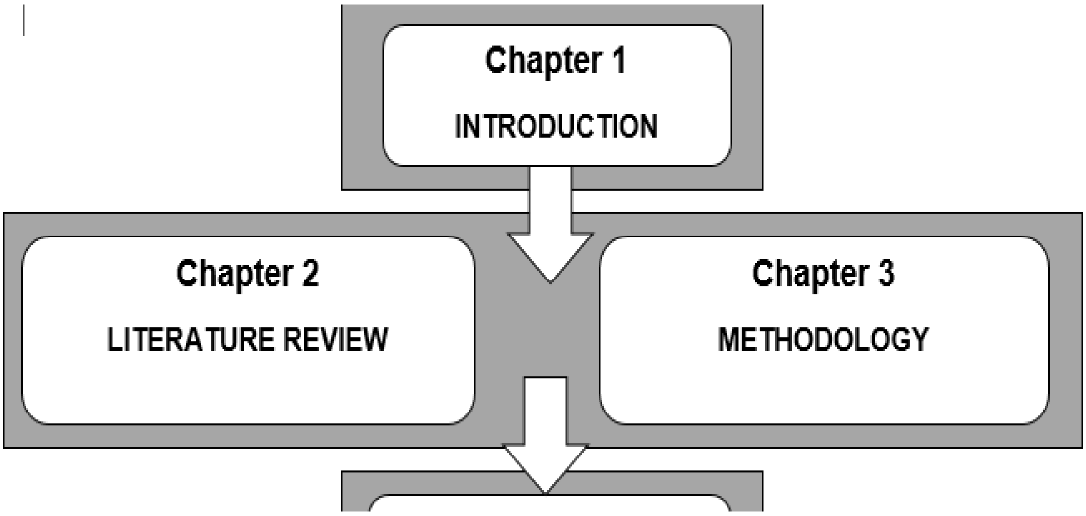


Figure 2.2 Relevant structure of thesis

3. Research Methodology

3.1 Introduction

This chapter presents the possible research approaches and strategy adopted in order to achieve the aims and objectives presented in Chapter 1. In addition, an outline of the selected methods is provided specifically:

- Qualitative data collection – surveys and questionnaires, interviews
- Anthropometric data collection

Detailed discussion of the equipment used and analysis techniques specific to each study are given in the relevant chapters.

3.2 Research approach

Research studies are designed to acquire knowledge in order to fill a gap in the literature or address a specific research question (Robson, 2011). However, the selection of the appropriate research techniques to obtain this data signifies only the final decision in the research design process (Saunders et al., 2012). Using the metaphor of the 'Research Onion' (Figure 3.1), the outer layers of the research onion, such as research philosophy, methodological choice and strategy all need to be considered in order to provide the context and boundaries within which data collection techniques and analysis procedures can selected.

3.3 Research philosophy

Four main research philosophies (Figure 3.1) have been identified by Saunders et al., (2012). The philosophy for this thesis are rooted within positivism in that, the role of the researcher is to propose theories and collect data to further understand the research area rather than reflecting the researchers own views and opinions. However, the philosophy of pragmatism is also adopted, in that the importance of the research is in the findings practical consequences. As discussed in the Literature Review (Chapter 2), research into the plus size working population is relatively unchartered,

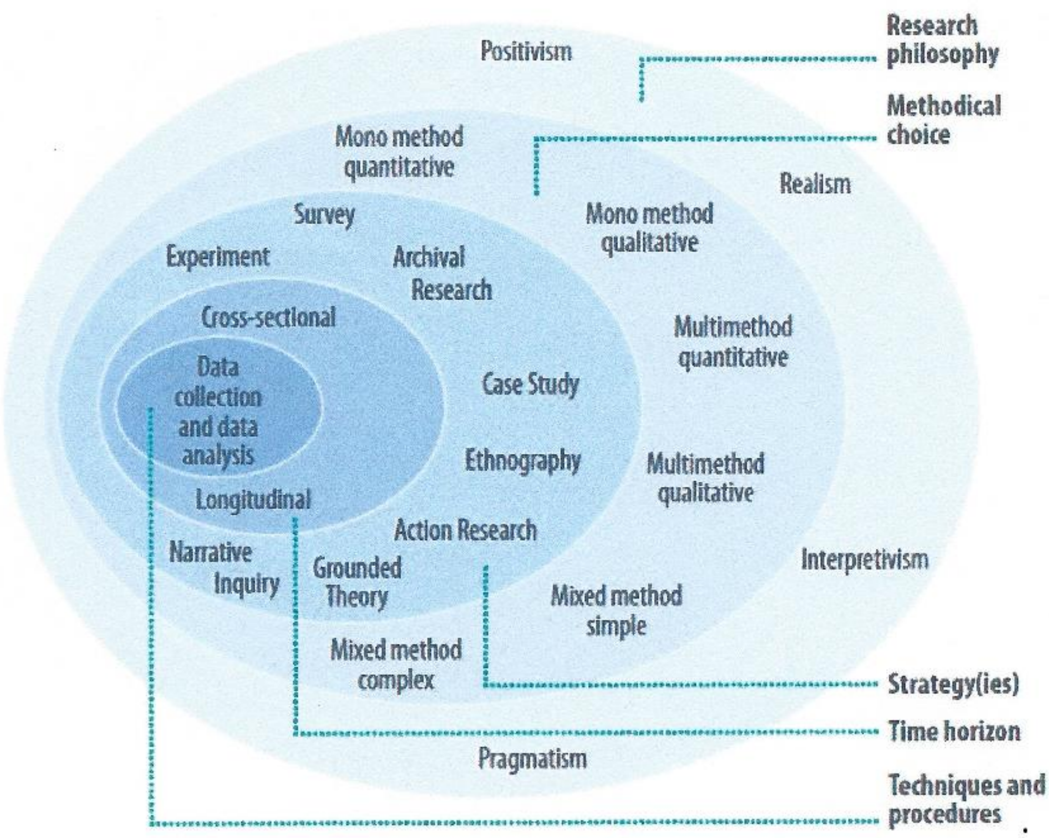


Figure 3.1 Research Onion paradigm (Saunders et al., 2012)

with very limited research having been identified that explores the size and shape of this population and issues affecting them in the working environment. It is therefore vital that the research design should enable credible, reliable and relevant data to be collected that supports the subsequent action of supporting inclusion for plus size people at work.

3.4 Methodological choice

Research has historically been divided into two types; qualitative and quantitative (Creswell, 2013). More recently, a mixed methods approach has also been documented (Pluye, 2011). In quantitative research, links between two or more variables can be analysed to support an existing hypothesis (Golafshani, 2003). It usually involves collecting and converting data into numerical form so that statistical calculations can be made and conclusions drawn (Sale et al., 2002). However, some criticise quantitative research for failing to be applicable to real world situations (Robson, 2011).

In contrast, qualitative research emphasises the socially constructed nature of reality. It is concerned with recording, analysing and attempting to uncover the deeper meaning and significance of human behaviour and experience. Researchers are interested in gaining a rich and complex understanding of people's experience and not in obtaining information which can be generalized to other non-specific larger groups (Golafshani, 2003).The mixed methods approach, involves using the method which appears best suited to the research problem (Morgan, 2007). Mixed methods researchers may therefore use methods, techniques and procedures typically associated with both quantitative and qualitative research. Different techniques may be used simultaneously or consecutively as appropriate.

This thesis aims to identify issues affecting plus size people in the working environment and understand the size and shape of this population. In addition, it explores stakeholder preferences for a resource aimed at supporting inclusion (Chapter 1). This is achieved using a mixed methods approach to emphasize the research problem, to understand human experience and investigate potential solutions using a range of applications to do so (Cresswell, 2013). The adoption of a mixed methodology may also improve the validity of the research (Robson, 2011). Defining validity as the extent to which the findings of the research are based on truth (Walliman, 2006), the combination of both qualitative and quantitative data, constitutes a triangulation process.

Table 3.2 details the three different classifications of carrying out research regardless of the approach adopted as identified by Robson (2011). As research into the plus size working population is a relatively new area of enquiry, identification of issues using a mixed methods approach is unique in the current literature. The nature of this research therefore, has been exploratory in that it has investigated emerging issues combined with an element of descriptive enquiry into the working environment for plus size people.

Classification	Objective
Exploratory	To investigate emergent issues and seek new insights
Descriptive	To portray a situation or issue
Explanatory	Discussion and explanation of situation or issue

Table 3.2 Classification of enquiry

3.5 Research strategy

Moving inwards, the next layer of the 'Research Onion' (Saunders et al., 2012) is the research strategy. This layer indicates that researchers can use one or more strategies within their research design in order to answer or address the research question. Robson (2011) suggests that there are a number of research strategies available as either fixed in design or of a flexible design (Table 3.3). The mixed methods exploratory nature necessitates a flexible strategy, where the research is designed as a unique process aimed at answering each specific question rather than a predetermined and rigid process as followed in a fixed design strategy (Morgan, 2007).

Fixed Design Strategies	Flexible Design Strategies
Experimental Design • Researcher actively manipulates the variables to measure the outcomes • Selection of samples from known population • Testing of formal hypotheses	**Case Study** • One study of a specific case or small number of related cases • Takes context into account • Detailed collection of information via a range of data collection methods
Non Experimental Design • No manipulation of variables • Selection of samples from known population • Testing of formal hypotheses	**Ethnographic Study** • Interest is in the experiences of a group or community • Immersion of the researcher in the setting • Use of participant observation **Grounded Theory Study** • Generation of a theory from data collected • Applicable to range of phenomena • Systematic but flexible

Table 3.3 Possible research strategies (adapted from Robson, 2011)

3.6 Thesis specific research strategies

In order to achieve the objectives of the research a number of methods are documented in the literature which may be applicable. The main points for each potential method, including advantages and disadvantages are mapped against the relevant objective and research question in Table 3.4.

Research Question	Research Objective	Potential Methods	Selected Method	Reasons for Selection
Are there any issues affecting plus size people in the working environment?	**1. To undertake a literature review to understand the context of a plus size workforce**	Unstructured MMAT CASP tools	Mixed Method Appraisal Tool (MMAT)	Enabled the appraisal and description of the three main methodological approaches; qualitative, quantitative and mixed methods utilised within the literature excluding the need for three different appraisal tools
	2. To conduct a study to explore the issues affecting plus size people within the working environment	Questionnaire based survey – self or researcher led completion. Postal or internet based Focus Groups/Interviews Observation	Questionnaire based survey – self completion. Online distribution	Allow anonymity Collection of large amount of data Low cost, short time period. Large geographically spread. Identify unknown issues/emerging areas for further research
Is self measurement a feasible and acceptable method for collecting anthropometric measurements in the plus size working population? **What are the anthropometric measurements of the plus size working population?**	**3. To conduct an anthropometric study to understand the body size and shape of the plus size working population via the collection of key anthropometric measurements**	Standard protocol – utilising anthropometer, stadiometer and tape measure 3D body scanner Self-measurement	Self-Measurement – utilising self-instruction guide and tape measure Questionnaire	Validated for population group (see Chapter 5) Allows anonymity Facilitates larger participant number Triangulation – to promote validity
What are the preferences for a resource used to support stakeholders in meeting the needs of plus size people in the working environment?	**4. To conduct stakeholder interviews to explore the requirements of a toolkit to support inclusion**	Questionnaire based survey – self or researcher led completion. Postal or internet based Focus Groups Interviews – structured, semi structured, flexible	Interview – Semi Structured Questionnaire	Flexible and adaptable method. Enables follow up/expansion of points of interest and truer assessment of respondent beliefs. Identify unexpected answers/area Triangulation – to promote validity

Table 3.4 Potential and selected research strategy for each objective

3.6.1 Questionnaire based survey

A questionnaire based survey method (Chapter 4) was adopted in order to address the second research objective:

- To conduct a study to explore the issues affecting plus size people within the working environment.

Consisting of a series of questions and other prompts these are a widely used social research method for collecting data from and about people (Sharples and Cobb, 2015). The questionnaire may be either self-administered via post or internet, or may be delivered face to face or telephone based by the researcher known as an interview survey. Many advantages and disadvantages are associated with questionnaire based surveys (Robson, 2011) including:

Advantages

- Provide a straightforward approach to the study of attitudes, beliefs and motives.
- Collect generalised information from almost any human population.
- High amount of data standardisation.
- Acceptable at providing large amount of data at relatively low cost, in a short period of time (for self-administered questionnaire based surveys).
- Allow anonymity which may encourage participation and openness (for self-administered questionnaire based surveys).

Disadvantages

- Memory, knowledge, experience motivation and personality of respondents will influence data.
- Participants may report incorrect information regarding their beliefs or attitudes which can cause bias in the data.
- Potential for non-representative sample.
- Misunderstandings/ambiguity of the questions may not be detected.

A number of questionnaires based within surveys have been documented in the literature as being relevant to the individual at work in terms of work ability, wellbeing at work, absenteeism/presenteism and pain (Table 3.5).

	Author	Year	Measure	Sample includes plus size
Work Ability	Eskelinen et al	1991	Work Ability Index (WAI)	Yes
	Fischer et al	2006	Work Ability Index (WAI)	
	Gharidia et al	2016	Work Ability Index (WAI)	Yes
	Kaleta et al	2006	Work Ability Index (WAI)	
	Laitenen et al	2006	Work Ability Index (WAI)	Yes
	Martinez and Latorre	2006	Work Ability Index (WAI)	
	Monteiro et al	2006	Work Ability Index (WAI)	
	Pohjonen	2001	Work Ability Index (WAI)	Yes
	Punakallio et al	2004	Work Ability Index (WAI)	
	Sjogren –Ronka et al	2002	Work Ability Index (WAI)	
	Tuomi et al	2001	Work Ability Index (WAI)	Yes
Role Functioning at Work	Altshuler et al	2002	Life Functioning Questionnaire (LFQ)	
	Amick et al	2000	Work Role Functioning (WRF)	
	Beaton et al	2005	Work Limitations Questionnaire (WLQ)	
	Burton et al	2004	Work Limitations Questionnaire (WLQ)	
	Feuerstein et al	2005	Workstyle Scale	
	Feuerstein et al	2006	Workstyle Scale	
	Gignac et al	2004	Work Activity Limitations Scale (WALS)	
	Osterhaus et al	2009	Work Activity Limitations Scale (WALS)	
	Van Roijen	2007	Short Form Health Labour Questionnaire (SF- HLQ)	
Pain in Work Activities	Caberlon et al	2013	Nordic Questionnaire for Analysis of Musculoskeletal Symptoms (NMQ)	Yes
	Larsson	2001	Nordic Questionnaire for Analysis of Musculoskeletal Symptoms (NMQ)	Yes
	Viester et al	2013	Nordic Questionnaire for Analysis of Musculoskeletal Symptoms (NMQ)	Yes
Quality of Life	Caterson et al	2009	Health Related Quality of Life Short Form – 36 (HRQL SF-36)	Yes
	Wang et al	2013	Health Related Quality of Life Short Form – 36 (HRQL SF-36)	Yes

Table 3.5 Questionnaires utilised in existing literature

These questionnaires have been used for general populations (which may or may not include plus size as part of this population). However, as discussed in Chapter 2, no research has been identified that explores the issues affecting UK plus size people in the working environment via qualitative methods, that is asking the plus size individual what affects them at work. Therefore, although using a previously published questionnaire may improve the validity and reliability of the data obtained, it would not suffice to address the research objective of this proposed research.

Detailed methodology relating to the development and piloting of the questionnaire based survey as part of a scoping study to explore issues affecting plus size people within the working environment are described in Chapter 4.

3.6.1.1 Observation as an alternative method to the questionnaire based survey

Observation is a method of gathering data by watching behaviour, events or noting physical characteristics in their natural setting (Creswell, 2013). Direct observation, that is watching interactions, processes or behaviours as they occur was also considered as a potential method to explore the issues affecting plus size people within the working environment (Objective 2). A number of advantages and disadvantages are associated with observation (Robson, 2011; Saunders et al., 2012; Cresswell, 2013) including:

Advantages

- Directness – watch and listen rather than asking people about views, feelings or attitudes
- Collect data where and when an event or activity is occurring
- Technique is not dependent on memory, knowledge, experience, motivation and personality of respondents – inherent to other methods such as questionnaires and focus groups.
- Can be used to complement information obtained from other methods

Disadvantages

- Impact of reactivity – that is the extent to which the presence of the observer affects the situation under observation
- Time and resource intensive especially for widely dispersed or unknown populations

- Non-physical issues more difficult to detect and record
- Does not increase understanding of why people behave as they do
- Potential for non-representative sample

Despite the documented advantages of this method and its use in previous design based studies (Molenbroek et al., 2011) observation was rejected in favour of the questionnaire based survey. This was due to accessing the widely dispersed and relatively unknown working environments of plus size people and importantly the negative effect that direct observation may have on the plus size individual (Puhl et al., 2009). In addition, because no research has been identified that explores the issues affecting UK plus size people in the working environment observation may result in failing to acknowledge the non-physical issues that are unknown to the researcher but experienced by the plus size individual.

3.6.2 Methods for the collection of anthropometric data

Anthropometry is the study of the physical, dimensional measurement of humans (Delleman et al., 2004) which can then be applied to the design of products and environments to ensure that they accommodate as many people as possible. Anthropometry of the user population is necessary to define many fundamental aspects of the working environment such as seating, working heights, equipment, and uniform as well as shared spaces such as corridors and toilets (Tokmakidis et al., 2012). How to use this anthropometric data, as well as access to existing anthropometric data sources and their limitations have been presented previously in Chapter 2. This section will focus on the potential methods for the collection of anthropometric data in a plus size population, in order to fulfil the fourth research objective:

- To conduct an anthropometric study to understand the body size and shape of the plus size working (or previously working) population via the collection of key anthropometric measurements.

Two main methods for the collection of anthropometric data are well documented in the literature;

- Traditional method – utilising stadiometer, anthropometer, tape measure.

- Three dimensional method (3D) - utilising body scanners.

These methods require standardised measurement protocols to improve the consistency of the measurement and reporting of anthropometric data. ISO: 7250 'Basic Human Body Measurements for Technical Design' (International Standardisation Organisation, 2015) standardises the language and measurements methods used in anthropometry. In addition, ISO:15535 (2012) 'General requirements for establishing anthropometric databases' provides the necessary information, such as characteristics of the user population, sampling methods, measurement items and statistics, to make international comparison possible among various anthropometric databases.

Other methods such as photography and videos to measure body dimensions (in 2D or 3D) were also considered. These were rejected due to lack of available literature for comparison and being unacceptable to the targeted plus size population primarily as they wished to remain unseen (Masson et al., 2014).

3.6.2.1 Traditional methods

Traditional methods of collecting anthropometric data focus on the manual measurement of distances between bony or soft tissue landmarks whilst the subject adopts a standardised seated or standing posture (Kouchi et al., 2011). Distances are measured using a variety of equipment; a stadiometer (height measure), an anthropometer; a tool having a rod and a sliding perpendicular arm to measure depths, widths or height, callipers; having two curved ends to measure curved body parts such as shoulder breadth and a tape measure to measure circumferences. These instruments provide measurements in one dimension (for example, buttock to front of knee length) or a two dimensional body feature along a plane, such as hip circumference.

Advantageous of the traditional method of collecting anthropometric data include lower equipment cost when compared to 3D methods utilising body scanners, ability to transport equipment between locations (Pheasant and

Haslegrave, 2006) and in the case of this proposed research the flexibility to incorporate non-standardised measurements such as knee splay to represent the observed sitting position of plus size individuals (Sibella et al., 2003). However, Kouchi et al., (2011) identified that the accuracy of manual measurements using traditional approaches were dependent on the expertise of the measurer and that there can be difficulty in identifying the correct position of bony landmarks which may reduce the accuracy of measurements. This may be particularly relevant in the plus size population due to an increase in adipose tissue masking the palpation of the bony landmarks (Olds and Honey, 2005).

3.6.2.2 Three dimensional methods (3D)

In contrast to traditional methods, 3D methods for collecting anthropometric data can be expensive, problematic to move and may require additional software to make use of the information. However, Sims et al., (2012) suggest that 3D body scanners may offer the opportunity to remove some of the inaccuracies of traditional anthropometric measurements. There are many types of 3D scanners in use (Table 3.6) but typically, a whole body scanner is an optical 3D measuring system that produces a digital copy of the surface geometry of the human body without physical contact with that body (Arezes et al., 2016). The subject being scanned usually wears standardised form fitting clothing during the process removing the need for physical contact during the measuring process; which is a disadvantage associated with the use of traditional techniques. However, this standardised clothing may be inappropriate for plus size individuals which itself may be prohibitive and additionally raise concerns with regards to privacy of data collection and storage.

Company	Product	Country	Technique
Cyberware	WBX	USA	Laser Line
4ddynamics	EX Pro	Belgium	Structured Light Projection
4ddynamics	Gotcha	Belgium	Structured Light Projection
Vitronics	Vitrus Smart	Germany	Laser Line
TC2	KX-16	USA	Infrared
Size Stream	3D body Scanner	USA	Infrared
Space Vision	Cartesis	Japan	Laser Structured Light

Table 3.6 Available 3D scanners

A number of studies have compared traditional anthropometry data collection methods with data collected via 3D body scanners and are summarised in Table 3.7 However, no studies have been identified that compare traditional versus 3D measurement techniques that include all of the proposed anthropometric measurements required for this thesis. Interesting, some studies suggest that an increased body fat leads to greater differences between 3D and traditional measurements especially on torso and circumference dimensions. This impacts on the reliability of 3D methods for collecting anthropometric data in this proposed research due to the target population being plus size and a measurement set which includes torso (abdomen, chest) dimensions and circumference measurements.

Author	Title	Year	Main Aim	Sample	Findings	Comments
Brooke Wavell et al	Reliability and repeatability of 3D body scanner measurements compared to traditional anthropometry	2004	Comparison of LASS measurements with anthropometric measurements and examines intra- and inter-observer differences of both techniques.	n=10 (male and female). 7 body dimensions measured	Small but significant ($p < 0{\cdot}05$) differences at some sites. Females: neck and chest circumference, waist width depth and height. Males: waist depth. Repeatability of 3-D measurements was no better than that from traditional anthropometric measurements	Small sample size, 7 dimensions studies. Not plus size specific Acknowledges multiple uses of 3D scan data Suggests differences were due to difficulties in making horizontal tape measurements, and by differences in site location on LASS scans due to imperfect site markers
Han et al .	Comparative analysis of 3D body scan measurements and manual measurements of size in Korean women	2010	Determine the differences between manual measurement and 3D body scan measurements.	n= 1704 females between 20-75 yrs of age from Korean Sizing survey 14 body measurements recorded	Torso circumferences differed significantly between measurement methods. Increase BMI resulted in increase in differences of all circumferences.	Effect of BMI on 3D measurements due to landmark identification. Female only subjects Korean sample.
Sims et al	Collection of anthropometry from older and physically impaired persons: traditional methods versus TC 3-D body scanner	2011	Determine the differences between manual measurement and 3D body scan measurements in less able individuals	n=54 males and females. 18 years and above Able bodied or degree of disability.	Significant differences found for 5 out of 7 body measurements.	Broad representative sample of ability BMI not documented. Only 7 measurements compared. Landmark limitations. Noted practicalities of using 3D scanner for less able bodied is problematic.
Zwane et al .	A preliminary comparative analysis of 3D body scanner, manually taken body girth measurement and size chart measurements	2010	Comparison of scanned and traditionally measured body girth measurements	n=56 females	Significant differences in waist and hip circumferences between scanned and measured methods. Differences increased with increasing body fat.	No discussion of role of scanning garments in compression of soft tissue and change of landmarks. Only hip and waist circumference compared.

Table 3. 7 Example of comparison studies between traditional and 3D anthropometry measurement methods

3.6.2.3 Rationale for the data collection method selected

Following a review of the literature, the traditional method for the collection of anthropometric data (using stadiometer, anthropometer and tape measure) was thought most suitable for the studies in Chapters 5 and 6. An emerging potential method for the collection of anthropometric data is self-reported measurement using traditional techniques (Rastrollo, 2011, Kouvonen, 2013). Although literature is limited and focuses on primarily stature and weight rather than a range of dimensional measurements, this method will be considered as a way of collecting anthropometric data from the plus size population due to preferences expressed by the target population and the potential for the advancement of knowledge in this area. This is discussed in Chapter 5.

In summary, the reasons for using the traditional method include:

- Access to equipment required.
- Portability of equipment – important due to widespread location of population and to increase participation rates.
- Reliable/valid method for plus size population – when researcher is experienced in plus size landmark identification.
- Reduces issues of data protection/privacy inherent with shared equipment/ software.
- No upper limit to shape or size of participants due to limitations of equipment (3D scanners are enclosed and require changing areas).
- Potential to explore self measurement using traditional methods - an emerging issue raised in scoping study.
- Knee Splay – possible to include new measure of knee splay into measurement set and this is measured using an anthropometer.

Detailed methodology relating to the anthropometric measurements selected, sampling, equipment and data collection procedure are discussed for each study in the relevant chapters – Chapter 5 and Chapter 6.

3.6.3 Semi structured interview

Semi structured interviews were used to meet the fifth research objective:

- To conduct stakeholder interviews to explore the preferences for a resource to support inclusion for plus size people in the working environment.

Structured, and unstructured interview techniques were also considered (Figure 3.2). However, the flexible and adaptable nature of the semi structured approach enabling the researcher to modify the line of enquiry in response to interviewee comments was deemed beneficial in capturing the broad and potentially unknown requirements of the stakeholder.

Structured Interview:
Predetermined questions with fixed wording, delivered in a pre-set order. Answers can be reliably aggregated and comparisons made with confidence between participants. Similar to survey based questionnaire although may include more open response questions.

Unstructured Interview:
Interviewer states area of interest. Non standardised, open ended and in depth. Let conversation develop and may be informal.

Semi Structured Interview:
Used widely in multi strategy designs. Interviewer has certain topics/questions and seeks to get responses from them but freedom to modify sequence, adjust wording and change amount of time given to each question depending on answers given.
Appropriate when researcher has knowledge of subject matter/research process.
Schedule typically involves;

- Welcome/introductory comments
- List of topic headings – questions
- Set of prompts for each topic heading
- Closing comments

Figure 3.2 Types of interview structure

Focus groups were also considered as an alternative method of capturing stakeholder views. This is an efficient technique for qualitative data collection as the amount of data is increased by collecting from several individuals simultaneously with the advantage of assessing the extent to which there is a shared or consistent opinion (Robson, 2011). However, the logistics of timetabling focus groups to accommodate busy professionals was deemed prohibitive. To assist with facilitating participation, it was decided that the option would be given to participate in either a telephone based or face to face semi structured interview. Detailed methodology relating to the development, structure and piloting of the semi structured interview are discussed in Chapter 7.

3.7 Timescale

The final layer of the Research Onion (Saunders et al., 2012) before reaching the centre, highlights the time horizon over which the researcher undertakes the research. Where research is undertaken to answer a question or address a problem at a particular time (as in this thesis), rather than studying individuals or interventions over a long period of time, the research can be deemed as cross sectional or giving a 'snapshot' of the current situation. Specific timescales for each study are given in the relevant Chapters.

3.8 Sampling strategy

The design of a sampling strategy for quantitative and qualitative research is vital as a well-defined strategy that utilises an unbiased and robust frame can provide unbiased and robust results (Golafshani, 2003). The sampling strategy of the research process is linked with the external validity of the findings, which enables the findings to be generalised from the study sample to the population (Robson, 2011). There are a number of different sampling strategies defined in the literature (Table 3.8).

Sampling Strategy	Description
Simple random sampling	• Random selection of subjects for the sample from a population list. • Each subject has equal chance of being selected • Strong chance of getting a representative sample of the population
Systemic sampling	• Selecting every 'nth' name form a population list Depending on sample size needed • List should be organised in a way not related to the study aims/objectives • Relies on true and complete population list
Stratified Random Sampling	• Dividing the population into a number of groups called strata • Subjects in each strata share characteristic e.g. gender, age range, • Random sampling of each strata to select subjects • Used when it is though that characteristics of a group may have an effect of the data being collected
Cluster sampling	• Dividing the population into a number of clusters, each of which has individuals with a range of characteristics • Clusters are then randomly selected and then the sub population within the cluster is identified • Useful when a full population list is not available
Quota sampling	• Aims to obtain representatives of various sections of the population in relative proportions to how they occur • Within each category convenience sampling is applied • Subject to bias
Convenience Sampling	• Choosing the most convenient people to act as respondents (e.g. nearest, known to researcher) • Process continued until sample size is reached • Subject to bias but widely used
Purposive Sampling	• Subjects chosen based on researchers judgement of their suitability • Enables researcher to satisfy specific needs of the research • Subject to bias but widely used
Snowball Sampling	• Researcher selects individual from population of interest • Then used as informants to identify other members of the required population • Useful when population is hidden or unknown

Table 3.8 Summary of sampling strategies utilised in research (adapted Robson, 2011)

For the studies reported in this thesis, a selection of non probability sampling strategies were used. Non probability sampling is adopted when it is not possible to specify the probability that any person will be included in the sample (Saunders et al., 2012). Because there are no up to date population lists accessible to the researcher that are relevant to the study (in terms of body and shape and size) the magnitude of the population is relatively unknown. In addition, to maximise response rate in the scoping study of plus size workers (Chapter 4) and participation in the two measurement studies (Chapter 5 and Chapter 6) convenience sampling with a combination of purposive and snowball sampling was used. The interviews in Chapter 7 also adopted purposive sampling in order to fulfil the inclusion criteria within the constraints of the timescale of the research. Specific details of the sampling strategies and discussion of the implications on the findings of the research including limitations are given in the relevant chapters.

3.9 Summary

Designing research to answer a question or address a problem is constrained both by what is practicable and of equal importance, what is ethical (Saunders et al., 2012). This chapter has identified and summarised the methods selected for this thesis (Table 3.4) and has discussed why other potential methods for example observation have been discounted. This has helped to ensure that the data collection techniques and analysis procedures used in the research undertaken are both appropriate and coherent to the aim of the proposed research.

4. Scoping Study

4.1 Introduction

The measurement of body composition and size, combined with the effects of being plus size on function and workability have been reviewed in Chapter 2. Methodological approaches for including plus size people in workplace design using a mixed methods approach have been discussed in Chapter 3. It has been determined from the literature, that although there is an increasing amount of research concerning the functional differences and limitations between a non plus size and plus size person performing an isolated work task (for example, forward reaching) no studies have been identified that explore issues affecting plus size people specifically at work utilising qualitative methods. This chapter presents the methodology and results of a scoping study which aims to explore workplace issues for plus size people. It will seek insights for further research.

4.2 Aims and objectives

The focus of this chapter is to understand the experiences of plus size people at work. To achieve this, a questionnaire based survey was conducted with the following objective:

- To explore issues affecting plus size people within the working environment.

4.3 Research method

4.3.1 Questionnaire based survey design and rationale

The questionnaire titled 'plus size people at work questionnaire' (Appendix 4.1) was developed to explore issues affecting plus size people within the working environment. It was developed from information gained and questions raised from the literature review in Chapter 2.

The questionnaire had six sections with each section having a specific focus (Figure4.1).

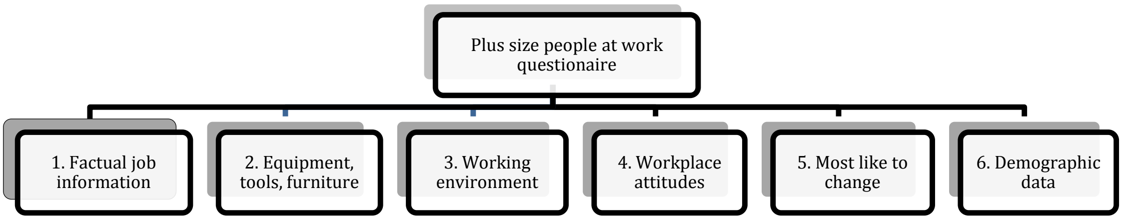


Figure 4.1 Focus areas of plus size people at work questionnaire

Section one, was designed to obtain factual information about the participant's main job, including job title, size of organisation/company, main place of work (home or site based). These questions were asked to gain an insight into the type of work that they were undertaking, to ascertain the spread of employment sectors (for example healthcare, retail) and to explore whether any issues were more prevalent in different types of organisations. In addition, participants were asked about home based working as previous research suggests that such individuals are able to adapt their environment to suit their needs without the constraints of an organisation (Wells et al., 2007).

No literature has been identified asking plus size people whether they have any issues with the equipment, tools or furniture they interact with within their working environment. Therefore, this question was the focus of Section two. Specific options related to seat size, height of desk, space in working area and fit of uniform or PPE (such as high visibility jacket) were included as they cover the main physical aspects of the working environment (Pheasant and Haslegrave, 2006; HSE, 2013; Feathers et al., 2015). The potential to have a degree of control over an individual working environment, such as selecting a chair or organising the immediate working area is also an important factor in employee satisfaction and comfort (Wells et al., 2013).

Section three, focused on issues experienced by the plus size person interacting with the wider working environment and shared spaces. This included seat size in shared spaces, corridors, stairways, lifts and toilet cubicle size. A separate question was also asked on temperature in the main work area. Although being an important factor in workplace design (Wells, et al., 2013; HSE, 2013), the literature lacks consensus; being plus size is linked to both a reduction in core body temperature (Grimaldi et al., 2015) and a higher perceived body temperature and excessive sweating (Casa et al., 2005). Thermal comfort is very difficult to define, as you need to take into account a range of environmental, work-related and personal factors when deciding what makes a comfortable workplace temperature. Therefore, a four part question was included to identify as far as possible, if any issues with temperature were due to the individual (too cold or too hot regardless of the weather) or the working environment.

Section four focused on workplace attitudes towards plus size people. Using statements identified in the literature as being relevant to plus size people at work including organisational issues (stigma, opportunities for job advancement) and workability issues (fatigue, productivity, absenteeism), participants were asked to indicate the extent to which they agreed or disagreed with each of the statements. A question directly related to how the respondent felt plus size people were viewed at work from different viewpoints was included (Puhl, 2008). A further question related to workability or how able they felt to complete the physical and mental demands of their job was also included. This question was taken from the 'The Workability Index' questionnaire (Tuomi et al., 1998.)

The fifth section of the survey enabled participants to indicate up to three aspects of their work they would like to change. The aspects were based on the findings from the literature review and on top level issues covered in the previous sections of the questionnaire. Ten options were listed, focussing on both the physical and non-physical elements of the working environment, for example 'seating (chairs, stools or car seats)', 'fit of uniform provided' and 'attitudes of colleagues / managers to plus size'. The eleventh option was to choose 'other' and comment as necessary. As questionnaires frequently raise a significant number of areas for further investigation (Robson, 2011) selecting three issues was incorporated to determine which issues were of most concern to the respondents and enable issues to be prioritised in future research.

The final section, consisted of questions to collect demographic data. As it is suggested that most respondents would prefer not to give their personal details when completing questionnaire based surveys (Robson, 2011) participants were not required to give their name or date of birth. Tick boxes were instead used to indicate gender and age range (18-24, 25-44, 45-64, 65 or older). Age ranges were based on ranges used in existing anthropometric sources such as Bodyspace (Pheasant and Haslegrave, 2006). Country of residence was asked as the sampling strategy would potentially extend outside of the United Kingdom (UK). All participants were asked to give a UK based clothes size and a comprehensive size conversation chart was included to enable participants from outside of the UK to do this. Clothes size was asked to gain an understanding of the size of the participants. Clothes size was used instead of asking for weight, or Body Mass Index (BMI) as requesting participants to indicate their weight has been found to reduce response rate to questionnaire based surveys (Hidiroglou et al., 1993). In any case, weight is frequently under reported and height over reported (Kouvonen, 2013) which may subsequently result in inaccurate BMI's. Therefore, to maximise response rate and ease of completion for participants, clothes size was deemed appropriate to gain an understanding of body size.

The questionnaire was designed to take between five and ten minutes to complete. The wording avoided leading questions as far as possible, and participants were reassured prior to completing it that there were 'no right or wrong answers' encouraging them to respond freely and honestly. Mainly closed response questions and rating scales were used to encourage responses and assist in the analysis of results (Robson, 2011). There was the option to respond as 'not applicable' to questions in order to improve response accuracy. All sections included an option to select 'other' and space for respondents for expand upon their answer. This was to capture as many issues as possible that affect plus size people within the working environment. Throughout the questionnaire, participants were prompted to respond based on their current shape and size and in their current working environment to explore issues that were specific to being plus size. Although no identifying personal details were required from the participants, there was an option to give their contact details to receive the results of the study or be involved in further research activities.

An online questionnaire via Survey Monkey was considered the most appropriate method for this large scale data collection. As well as allowing participants the opportunity to complete the questionnaire at a convenient time thus minimising interviewer effect (Robson, 2011), an online questionnaire offers statistically shorter response times and faster data collection combined with lower monetary and time costs than other potential data collection methods such as focus groups, interviews or observational studies. The ‘plus size people at work questionnaire’ was reviewed and granted ethical approval by Loughborough Design School, Loughborough University (December 2013).

4.4 Pilot study

The questionnaire was tested in a pilot study to check the:

- clarity of the wording of the questionnaire
- structure of the questionnaire
- responses were as anticipated
- time taken to complete the survey
- data analysis strategy

4.4.1 Participants

A convenience sample of 10 plus size participants (5 male, 5 female) completed the pilot study. Convenience sampling is seen as an acceptable sampling method for a pilot study (Robson, 2011).

4.4.2 Findings/modifications

The responses were appropriate and minor changes were made to the wording of one question. The average time taken to complete the questionnaire was 6.5 minutes (range from 3-15 minutes). For a copy of the final questionnaire see Appendix 4.1.

4.5 Data collection

The questionnaire was distributed using an online survey tool, Survey Monkey over a 3 month period concluding on 31st March 2014. All respondents were informed of the background and purpose of the scoping study and how the results would be used prior to indicating their consent.

4.5.1 Sampling strategy

Various sampling techniques were considered for use in this study and are discussed in Chapter 3. Due to the target population being relatively unknown and potentially so widely dispersed, the questionnaire based survey took on a non-probability sampling strategy using a combination of 'purposive' and 'snowball sampling' (Robson, 2011). From the literature and via personal contacts, a number of individuals were identified and approached to complete the online questionnaire and then act as informants to identify other plus size people and snowball the questionnaire. Links to the questionnaire were also placed on several online forums;

- www.bigmatters.co.uk
- www.ukbigpeople.co.uk
- www.netmums.co.uk
- www.fatlotsheknows.co.uk

This enabled individuals who fulfilled the inclusion criteria, to complete the questionnaire via self-selection.

The inclusion criteria for recruitment were that participants were:

- Aged 18 years of age or above

  Rationale: younger than 18 years of age were considered vulnerable populations by Loughborough University Ethical Advisory Committee (LUEAC).

- Working (or had worked in the 12 months prior to the study) either on an employed or self-employed basis
  Rationale: (1) experience of interacting with workplace equipment, products, tools and recall issues/challenges in the workplace.
  (2) distinguish between bariatric hospital based community and plus size individuals at work.
- Self-Classification of as ‘plus size’ or ‘larger than average’
  Rationale: to identify factors related to being plus size.

With the aim of collecting a wide range of responses, and difficulty in controlling snowball sampling, participants from outside of the UK were not excluded. Due to the sampling strategy, it is possible that the sample is not fully representative of the plus size working population. Although accepting that the interpretation of results should be viewed with caution it was seen as an acceptable sampling technique as the scoping study focus was on exploring the topic rather than making statistical generalisations and specific recommendations.

4.6 Data analysis

The majority of questions were quantitative, closed questions and therefore were analysed using descriptive statistics such as percentages and frequencies. Two questions were open ended; these responses were coded thematically to identify recurring issues affecting plus size people within the working environment.

Responses were received from 135 people although not all the participants completed all questions on the questionnaire based survey (response rate is indicated for each question). Incomplete questionnaires were still included to explore the extent, range and nature of the issues affecting plus size people within the working environment.

4.7 Results

This section details the demographics and findings from the survey presented via the main themes of;

- equipment, tools and furniture
- the working environment
- workplace attitudes
- workability
- aspects most like to change.

4.7.1 Demographics

96% of participants were female (n= 129) and 4% of participants were male (n=6). 71% of participants were in the 25-44 year age range. 5% were aged between 18 -24 years and 24% aged between 45- 65 years (Figure 4.2). No participants were over 65 years of age.

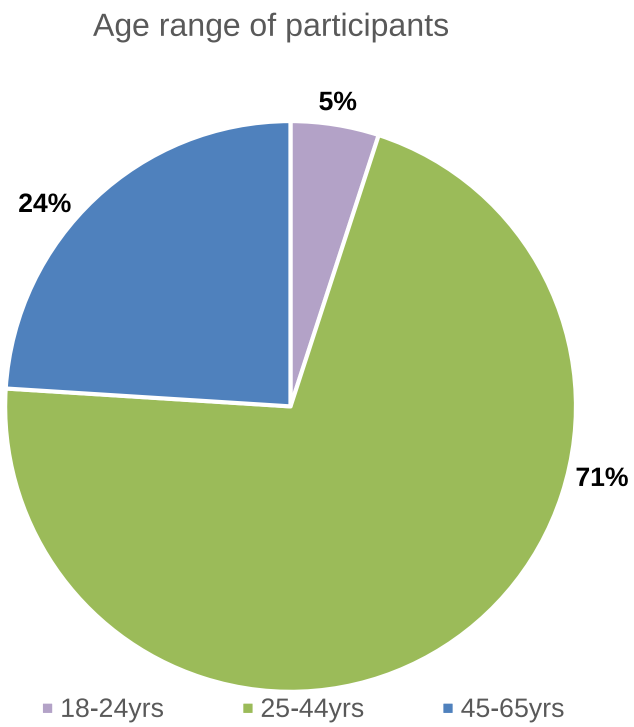


Figure 4.2 Age range of participants (n=93)

Online responses were received from 9 different countries. 79% of participants were from the United Kingdom (Table 4.1). 11% of participants (n=14) worked mainly from home. Only 6% of participants (n=8) stated the size of the organisation they worked for; 2 participants worked for an organisation with between 10-49 employees, 2 participants worked for an organisation with between 500-2499 employees, 2 participants worked for an organisation with over 2500 employees, with a single participant working for an organisation with less than 9 employees and a single participant worked alone.

Country	Sample Size	% of participants
United Kingdom	79	79%
United States (USA)	10	10%
Sweden	2	2%
Germany	2	2%
Ireland	2	2%
United Arab Emirates	2	2%
Canada	1	1%
Qatar	1	1%
New Zealand	1	1%

Table 4.1 Country of residence of participants (n=100)

100% of respondents were in either full time of part time work and 100% classified themselves as plus size. Female participants ranged in UK clothes size from size 18 to size 36 (Figure 4.3). The mode was clothes size 22 with 31% reporting generally wearing this size.

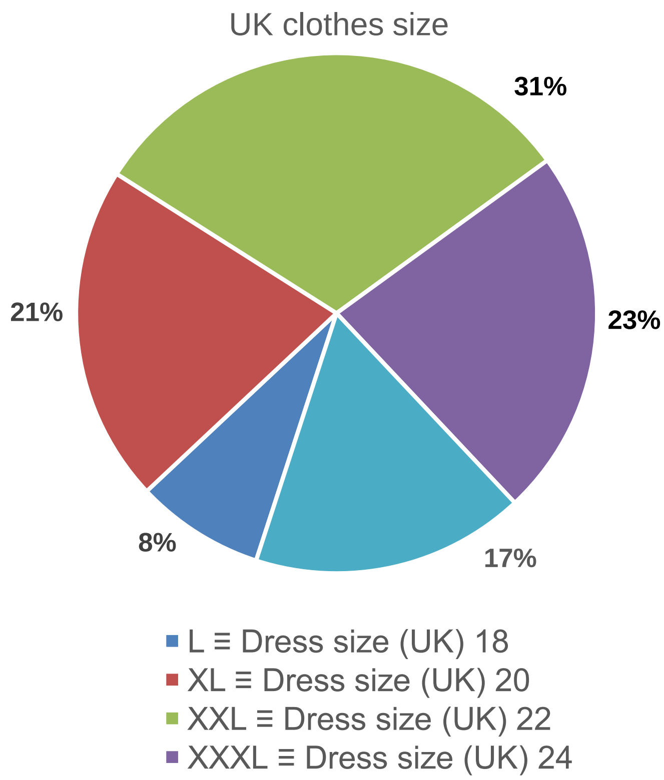


Figure 4.3 Clothes size of female respondents (n=75)

Of the six male participants, 68% (n=4) generally wore UK size 3 extra large (3XL), 16% (n=1) wore 4XL and 16% (n=1) wore 6XL.

Female participants who indicated their height (n=89) ranged from 1490mm to 1709mm. Male participants who indicated their height (n=6) ranged from 1740mm to 1830mm.

Despite the relatively large sample size of 135, due to the small response rate of male participants (n=6), the results from males and females have been combined and will be discussed in the subsequent sections.

4.7.2 Equipment, Tools and Furniture

Participants were asked if they were currently experiencing any problems with the equipment, tools and furniture used at work; specifically related to seat size, height of working surfaces, space in working area, fit of uniform and fit of personal protective equipment (PPE).

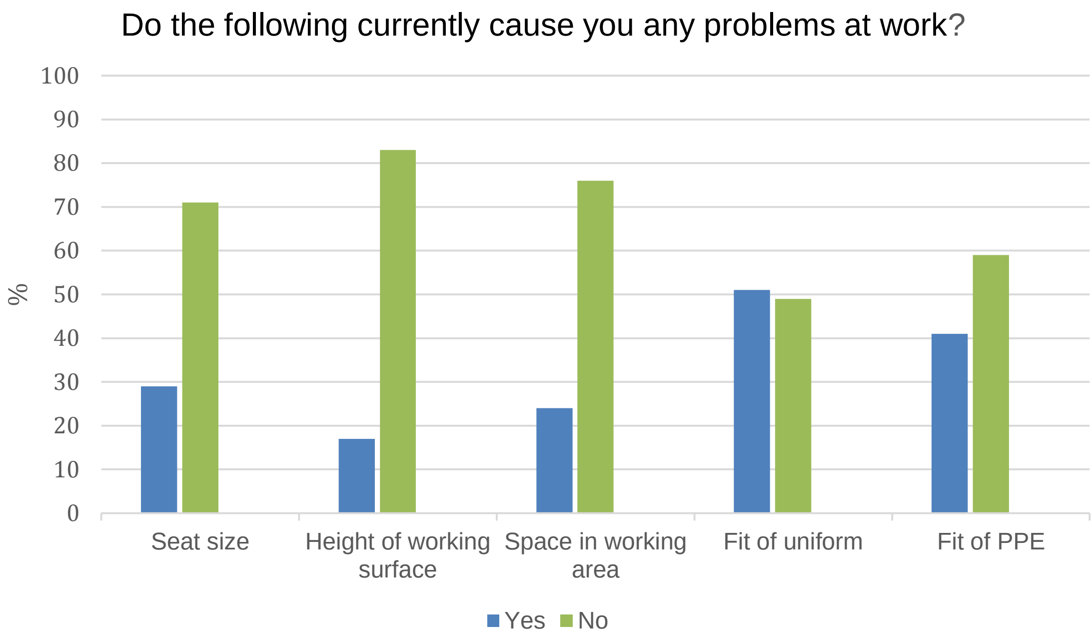


Figure 4.4 Currently causing problems at work (n=115)

29% of participants reported problems with the seat size, for example, chairs, stools or car seats utilised within the working environment (Figure 4.4). Nearly a quarter of the participants (24%) indicated concern about space in their working area impacting on their ability to move around without hindrance. The height of working surface (required for legroom clearance) was reported by 17% of participants as problematic.

Although fit of uniform was not applicable to all participants, 51% of those required to wear uniform (27 out of 53) supplied by their organisation reported that this caused them problems. Similarly, 41% of plus size people (23 out of 56) reported the fit of PPE such as high visibility jackets and gloves in the workplace as a cause for concern. Of the responses to the open ended question, ‘Do you have any other comments, questions or concerns relating to being a plus size person at work?’ 20% of the responses related to fit of uniform and PPE. For some participants (n=4) their company did not use a stockist supplying uniform in plus size. The tight fit of high visibility jackets, a form of PPE, resulted in 2 participants being unable to wear them at work leading to concerns over worker safety.

4.7.3 Working environment

Only a small percentage of participants reported experiencing problems with the width of staircases (8%), width of lifts (9%) and size of lifts (10%). 30% of participants identified that seat size (in shared areas) were causing problems and similarly 29% reported problems with seat size in individual working areas. This suggests that for the participants, problems with seat size are present within different areas of the working environment. Toilet cubicle size was reported as the most problematic for these participants with 42% expressing that it was currently an issue (Figure 4.5).15% of respondents (n=9) indicated that 'other' elements of working environment were causing problems at work. These related to inability to fasten the seat belt in the company car (n=9), space in photocopier room (n=2), orientation of arm rests reducing usable seat size (n=2), difficulty moving between rows of fixed seats (n=2) and the height of the toilet seat (n=1).

When asked about the temperature in the main working area, 33% of participants strongly agreed and a further 42% agreed that they were often too hot in warm weather (75% in total). In comparison, only 11% either disagreed or strongly disagreed that they were often too hot in warm weather.

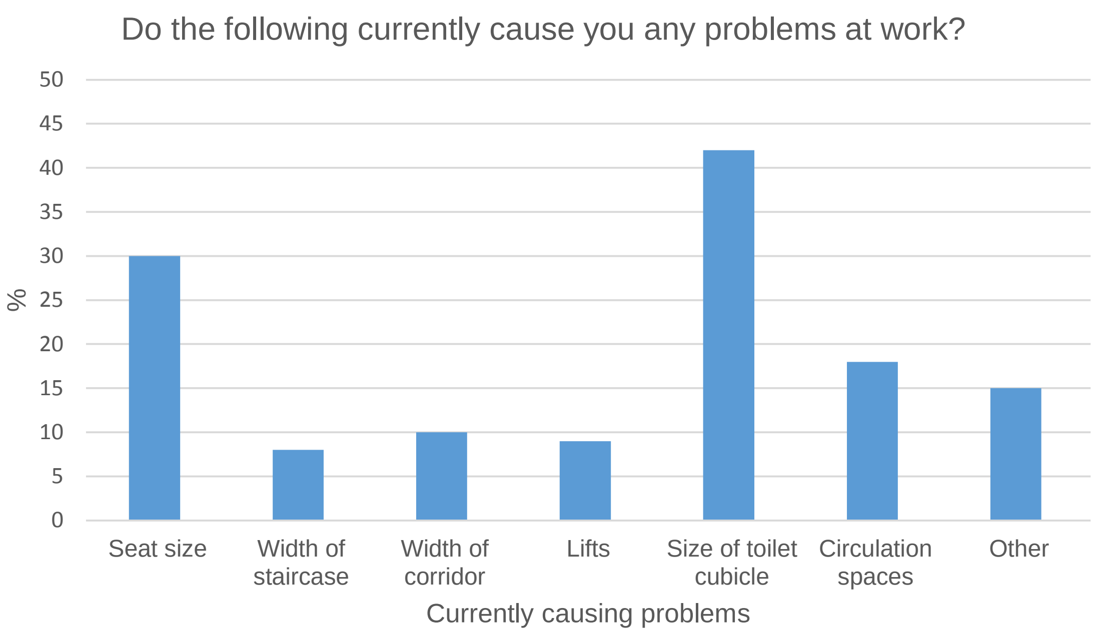


Figure 4.5 Currently causing problems at work (n=105)

Due to the complex nature of measuring thermal comfort a further three questions relating to temperature were asked and the responses are shown in Table 4.2.

	Response				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I am often too hot in warm weather	32%	42%	14%	10%	2%
I am often too hot in cold weather	12%	21%	23%	40%	4%
I am often too cold in warm weather	1%	5%	23%	47%	24%
I am often too cold in cold weather	9%	21%	28%	32%	10%

Table 4.2 Temperature in main work area (n=105)

Only 30% of participants reported being too cold in cold weather suggesting that being too hot is more prevalent in the working environment for these participants. Indeed 33 % of respondents reported often feeling 'too hot' even in cold weather.

Of the responses to the open ended question, 'Do you have any other comments, questions or concerns relating to being a plus size person at work?' 3 responses reported that finding work wear suitable for plus size people in warmer weather was problematic. Therefore, this may be a contributory factor to thermal comfort.

4.7.4 Workplace attitudes

Perceptions of attitudes towards plus size people from both internal sources (such as colleagues, managers) and sources external to their organisation (such as customers or suppliers) were reported. 98 participants replied to the question about whether as a plus size person, they felt they were viewed positively by colleagues, line managers and senior managers within their organisation. Nearly half (46%) disagreed or strongly disagreed that they were viewed positively by colleagues. In addition, 42% disagreed or strongly disagreed that they were viewed positively by line managers and 47% disagreed or strongly disagreed that they were viewed positively by senior managers. With respect to attitudes towards plus size people by those outside of their organisation/company, 39% disagreed or strongly disagreed that they felt they were viewed positively by the customer. This was similar for suppliers and/or external organisations with 34% disagreeing or strongly disagreeing that they were viewed positively. However, the respondents indicated that in relation to customers (45%) and suppliers/external organisations (55%) they neither agreed nor disagreed with the statement that plus size workers were viewed positively suggesting a neutral attitude Less positive attitudes were therefore perceived to be more prevalent in colleagues and managers within the participants own organisations rather than from external contracts.

4.7.5 Workability

Perceived workability (as defined in Chapter 2 and discussed previously in section 4.3.1) rated highly amongst participants in terms of the physical and mental demands of their job (Figure 4.6). 41% rated their work ability as very good and 36% as rather good with respect to the physical demands of their job compared with only 2% and 5% reporting work ability as very poor or poor respectively. This trend was similar for the mental demands with 84% reporting it as very good or rather good.

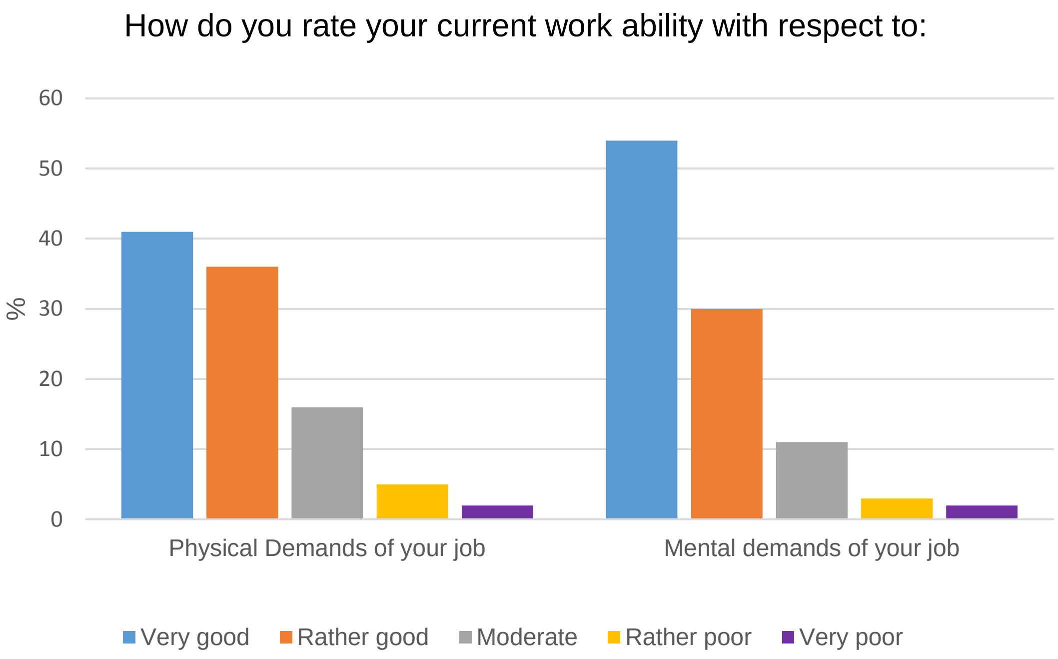


Figure 4.6 Workability (n=98)

Despite high levels of work ability, nearly half of respondents (44%) felt they tired more easily because of their shape/size. However, the question did not explore whether this was due to the physical or mental demands of their job or other additional factors and how if at all, this impacted on their job.

4.7.6 Aspects participants would 'Most Like to Change'

In the final question, participants were asked to indicate up to three aspects of their work that they would like to change (Figure 4.7). Participants were requested to leave this question blank, if there were no aspects of their work they would change. No participants chose this option.

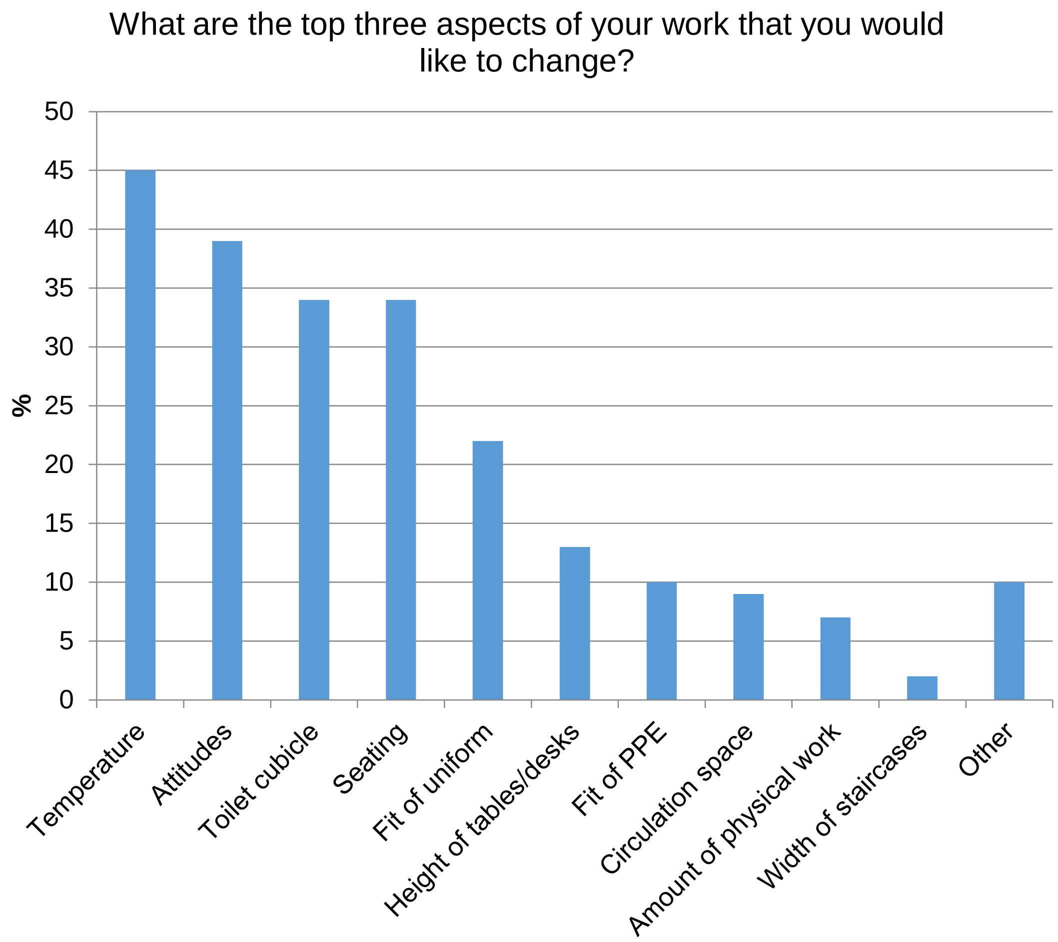


Figure 4.7 Aspects most like to change (n=98)

- 45 % of participants would like to change the temperature of their working environment.
- 39% of participants would like to change the attitudes of colleagues and managers within their working environment.
- 34% included the size of the toilet cubicle and/or seating size (for example, chair, stools, car seat) as aspects they would most like to change.
- 22% and 10% of participants included fit of uniform and PPE respectively. From the 62 participants who identified uniform and PPE as relevant, 40% (n= 25) included it as an aspect they would most like to change.

Other aspects included as most like to change were lack of space in the working environment specifically the photocopier room, squeezing past rows of seats and desks which resulted in embarrassment and the fit of the seat belt in the company car.

4.8 Discussion

The aim of the scoping study was to explore issues affecting plus size people at work and within the working environment. The results highlight some interesting issues that concur with the literature review such as workplace attitudes experienced by plus size people. However, a number of new areas of interest such as the fit of workplace equipment, uniforms and PPE and the issue of space at work were also identified.

4.8.1 Issues relating to fit

Seat size within the individual working area and the seat size of toilets and in shared spaces such as cafeterias, meeting rooms and company cars were reported as problematic. The purpose of a seat is to provide stable bodily support in a posture that is comfortable, physiologically satisfactory and appropriate to the task (Pheasant and Haslegrave, 2006). Seat design relies upon understanding the anthropometric data of users but these results suggest that the current anthropometric data in use may not reflect the working population. Although no anthropometric measurements were collected in the scoping study (apart from stature), participants were asked to provide their UK clothes size. This was asked in preference to weight, to indicate size/shape and to promote participation in the survey as requesting weight has led to a lower response rate in previous research (Proper et al., 2012). The most frequent female clothes size, was size 22 which correlates to a waist circumference of 1050mm and a hip circumference of 1305mm. These measurements are substantially greater than the measurements detailed in anthropometric data tables for the 95th percentile female of 957mm and 1157mm respectively (Peebles and Norris, 1998). Therefore, the majority of the female participants (71%) in this scoping study would have potentially been excluded from design. When considering benches or other seats where people sit in a row, for example cafeterias and lecture theatres, Pheasant and Haslegrave (2006) suggests that the breadth of a 95th percentile couple is less than twice that of a 95th percentile individual. This is because the probability of two 95th percentile individuals sitting together is less than one in four hundred. However, with the majority of the UK population (61%) being overweight or obese (DoH, 2015) and classed as plus size, this probability would be significantly increased suggesting that this scenario is no longer valid. The stature of all of the participants that indicated their height (n=95), fell within the existing 5th to 95th percentile range (Pheasant and Haslegrave, 2006). This suggests that the desire to see improved seating was not due to excessive stature but instead due to being plus size. There is therefore a requirement to further understand the anthropometric measurements of the plus size working population in order to reduce the risks of inadequate seating such as increased postural stress and WMDS (Park et al., 2009) and increase user satisfaction and comfort.

The fit of uniform and PPE was an issue for participants and 40% (for whom it was applicable) wanted to see changes. Schulte et al., (2007) suggested that if PPE is poorly fitting, this will impact on compliance in use and fail to provide the protection as intended. Both have serious safety implications. This was highlighted by comments made in the scoping study questionnaire such as;

> "*my high visibility jacket is so small I can't move in it, so I take it off*"
> (female, aged 25-44)

In addition, a number of additional comments related to the fit of the uniform or the poor availability of 'employer provided' plus size work wear, were raised by participants. Uniforms can make employees feel that they are part of a team, which can foster a sense of pride in their jobs and the company (Kaplan, 2000). However, if the uniform provided does not fit the plus size worker or is not available to order in their size, this may lead to the opposite effect where these employees feel outside of the team. This goes against the aims of inclusive design and may increase the risk of weight stigma (Section 2.4.5) which has been shown to impact on emotional health and wellbeing (Lewis et al., 2011). Similar to the design of workplace equipment, tools and furniture, the provision of well-fitting PPE and uniform also requires a comprehensive understanding of the anthropometry of the plus size working population.

4.8.2 Issues relating to space

Places where people work, including shared areas should have enough free space to allow people to move about with ease (Management of Health and Safety at Work Regulations; HSE, 1992). However, respondents reported that circulation spaces such as cafeterias and meeting rooms, and space within their own working areas were problematic. In order to avoid unintentional contact, for example when walking between rows of tables in a cafeteria, the design criteria is commonly set at accommodating the largest of the population, 95th percentile user (Peebles and Norris, 1998). However, as mentioned previously, 71% of the participants exceeded the current 95th percentile measurement for waist circumference. This may be even more apparent in environments where there is fixed furniture as highlighted by comments in the questionnaire;

> *"Lecture theatres are incredibly problematic as they tend to have fixed desks - either in long rows or attached to each chair. These rarely accommodate larger bellies and so I often either cannot use the desk, or in worst case scenarios cannot fit comfortably into the row of seats"* (female, aged 18-24)

> *"there is a pillar in the way and I have to squeeze past my boss' chair to get out of our bank of desks – that's uncomfortable and embarrassing"* (male, aged 45-64)

This again highlights that the design of the working environment based on currently used but outdated anthropometric data may result in exclusion for the plus size person.

The literature (Section 2.4) has highlighted that plus size people may adopt altered working postures and movement strategies in order to achieve the task demands, for example a wider stance in standing and during the stance phase of the gait cycle (Capodaglio et al., 2010). This may offer some explanation as to the reasons why space within the respondents own working area was reported as problematic. In order to accommodate a larger abdomen, plus size individuals typically positioned themselves further away from their working surface (Vismara et al, 2010). This immediately increases the amount of space required by the plus size person to achieve the task. An appreciation of the functional requirements of the plus size person in combination with anthropometric data is urgently needed.

4.8.3 Temperature at work

Nearly half (45%) of the participants reported they would like to change the temperature of their working environment. Thermal comfort is a complex issue as it depends upon environmental factors (such as humidity and sources of heat in the workplace) combined with personal factors (such as the clothing being worn, age, gender and how physically demanding the work is) (HSE, 2013). From the questionnaire it was not possible to ascertain whether dissatisfaction with the temperature of the working environment was due to being plus size or other factors. HSE (2014) recommend that the best that you can realistically hope to achieve is a thermal environment that satisfies the majority of people in the workplace. It considers that satisfying 80% of occupants is a reasonable limit for the minimum number of people who should be thermally comfortable in an environment. Due to 45% of respondents in the scoping study being unsatisfied, more research exploring thermal comfort of plus size people within the working environment is indicated. However, due the specialised resources required and the scope of this potential research this will not be explored further in this research.

4.8.4 Attitudes of others

Another aspect identified in the questionnaire as problematic was the perceived attitudes of others at work. Puhl et al., (2009) believes plus size people are highly stigmatised and face multiple forms of prejudice and discrimination both at work and elsewhere. The results have identified that weight stigma is a significant problem for the plus size respondents. Very high levels of workability, that is perceived ability to meet the physical and mental demands of their job, were reported by the participants in the study. This is in contrast to the common weight based stereotypes in the literature indicating that plus size people are lazy, not able to do their job and are less emotionally stable (Roehling et al., 2008). Weight stigma is a multi-factorial issue which requires specialised attention. However, issues relating to poor fit of uniform/PPE, inadequate workplace design in terms of fit of seat size including toilets, lack of space and accessibility constraints as previously discussed will all contribute to create barriers that cause additional effort and separation. This can inhibit equal participation within the working environment and in turn contribute to stigmatisation. Therefore, indirectly weight stigma will be addressed by better understanding the body size and shape of the plus size working population.

4.9 Limitations

The scoping study is unique in that it explores the issues experienced by plus size people at work and in the working environment. However there are some limitations. The results are based upon a limited sample size (mainly female) with only 6 male participants. This is a documented disadvantage with online questionnaires (Wright, 2005). The limited number of responses to some questions notably, 'how many people work within your organisation?' (n=8) and 'do you work mainly from home?' (n=14) did not enable any analysis to be undertaken exploring the influence of home working or organisational size on issues reported.

In addition, participants were recruited via non probability sampling methods and therefore, it is possible that the sample is not fully representative of the plus size working population. Although accepting that the interpretation of results should be viewed with caution and not considered indicative of a wider population, it was seen as an acceptable sampling technique; the focus of the scoping study is on clarifying a complex concept and refining subsequent research inquiries rather than making statistical generalisations and specific recommendations.

The questionnaire wording was designed to avoid leading questions as far as possible, and respondents were reassured prior to completing it that there were ‘no right or wrong answers’ encouraging them to respond freely and honestly. However, the majority of the questionnaire used closed questions so it was not possible to explore the reasoning behind the responses. In addition, no comparisons were made with respondents from a non plus size working population. This would have helped to confirm whether differences between non plus size and plus size were due primarily to size and not other variables. On the other hand, due to the wide variety of potential compounding variables such as medical history, it would have been difficult to utilise a control group to address this.

4.10 Conclusions

The results support the following conclusions:

- Plus size individuals report a range of issues at work and in the working environment.
- Fit - of equipment, tools and furniture specifically seating, uniform and PPE has been identified as problematic and has been identified as an area of work/working environment that participants would like to change.
- Space - circulation and shared spaces within the working environment has also been raised as an issue. Toilet cubicle size was reported as an issue for almost half of the participants.
- Non-physical aspects of the working environment such as temperature and 'attitudes of others towards plus size people' were also raised as issues. Physical aspects of work/working environment such as inappropriate uniform or isolation due to poor workplace layout were reported by some participants as contributing to the these non-physical aspects.
- Despite these issues, plus size people perceive their ability to achieve the physical and mental requirements of their roles as very good or good.

The overall objective of the scoping study has been achieved in that the extent, range and nature of the issues affecting plus size people within the working environment have been explored. The following main issues have been identified for further exploration:

- Fit - of equipment, tools and furniture specifically seating, uniform and PPE
- Space - circulation and shared spaces within the working environment

Both issues necessitate a better understanding of the anthropometric measurements of plus size working age individuals which has been identified as limited. Measurement of the anthropometry of plus size workers will be the focus of Chapter 5 (Figure 4.8).

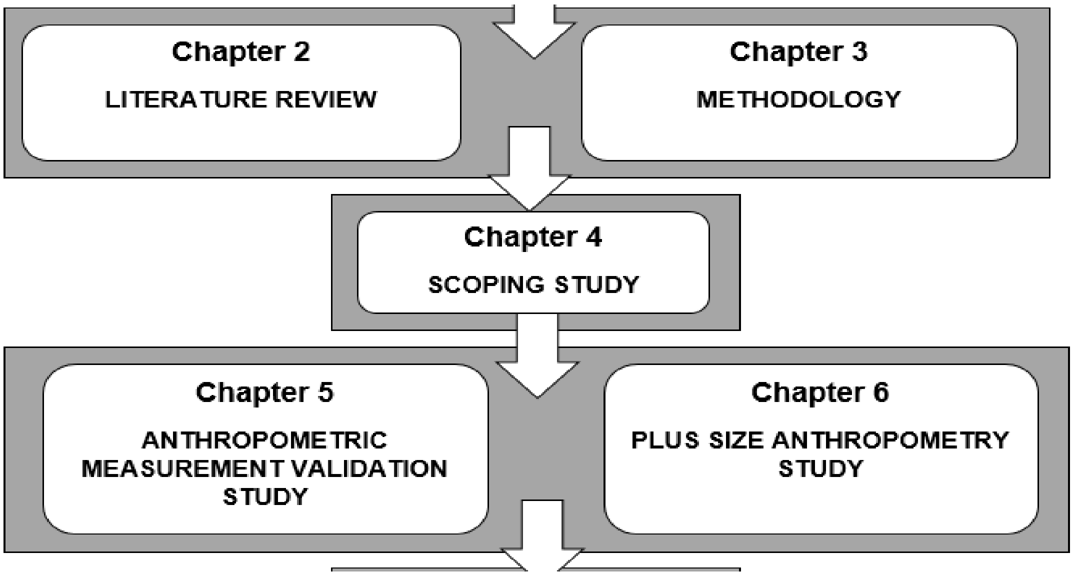


Figure 4.8 Relevant structure of thesis

5. Anthropometric Measurement Validation Study

5.1 Introduction

The design process relies upon the utilization of anthropometric data to maximise the percentage of the user population that will be accommodated by the design. The scoping study (Chapter 4) concluded that fit (equipment, tools, furniture, uniforms and personal protective equipment) and space (circulation and shared spaces within the working environment) were issues of concern to plus size people. This suggests that aspects of the current design of the workplace may not be suitable for, and may even exclude plus size people. In addition, the literature review (presented in Chapter 2) revealed a lack of current and comprehensive anthropometric data for the plus size UK working population and a need to further understand the anthropometry of this population. Incorrect adjustments for, or the omission of anthropometric data in product or workplace design has been associated with work-related psychological discomfort (Mokdad, 2003) and increased risk of work related musculoskeletal disorders (Viester et al., 2013). Therefore, more knowledge is essential to design safe, comfortable and productive working environments

Methodological approaches for the collection of anthropometric data such as manual measurement via anthropometer and three dimensional body scanning have been reviewed in Chapter 3. Although self-reported anthropometric data is an acceptable way (in terms of cost and resources) of studying large and geographically diverse populations and may assist in accessing the hard to reach plus size working population, previous studies validating the use of self-reported anthropometry (Kouvonen, 2013) have focused primarily on stature and weight. No studies have been identified that include anthropometric measurements required for workplace design and/or that are specific to plus size people. The focus of this chapter is to explore this knowledge gap with the findings impacting upon the methodology for the subsequent chapter.

5.2 Aim and objectives

The aim of the anthropometric measurement validation study is to establish whether self-measurement of anthropometric data in a plus size working age population is feasible and acceptable as the data collection method for a larger scale survey. This will be achieved through the following objectives:

- Identification of a set of anthropometric measurements relevant to workplace design;
- Development of a self-measurement instruction guide to enable participants to self-measure;
- Comparison of the self-measured (using the guide) and researcher measured anthropometric measurements relevant to workplace design.

If self-measurement of anthropometric data is determined to be feasible and acceptable, this validation study will also act as the pilot study for a larger scale anthropometric study (Chapter 6).

5.3 Research method

5.3.1 Development of anthropometric measurement set

34 anthropometric measurements were identified in the literature as being applicable to workplace design (Appendix 5.1) and had been used in previous studies cited in Chapter 2. It was considered that including all of the 34 measures would result in poor recruitment of participants and low completion rates (Robson, 2011). Weight and Stature were considered vital to include as they enable comparison across populations and in combination determine BMI for each participant. Additionally, the scoping study (Chapter 4) identified issues with:

- Fit - of equipment, tools and furniture specifically seating, uniform and PPE.
- Space – workplace layout, circulation and shared spaces within the working environment

The final measurement set therefore needed to include sufficient measures to understand the size and shape of the individual in order to explore the issues identified in the scoping study.

5.3.1.1 Seating

Pheasant and Haslegrave (2006) recommends that designing a seat relies upon understanding the anthropometric measurements of:

- Sitting height
- Sitting shoulder height
- Shoulder breadth
- Hip breadth
- Buttock to knee length
- Popliteal height

As seating (within individual working areas, shared areas and toilet seats) was a key issue from the scoping study, these 6 measurements were all considered to be appropriate for inclusion in the set of anthropometric measurements relevant to workplace design. However, sitting height can also be derived from stature and sitting shoulder height (Peebles and Norris, 1998) so to avoid duplication for participants sitting height was not included in the measurement set. Shoulder breadth can be measured horizontally between the bony tips of the shoulders; known as acromion shoulder breadth. Alternatively, it can be measured horizontally between the points of maximum protrusion of the deltoid muscles on the upper, outer borders of the arm and shoulders; known as bideltoid shoulder breadth. Bideltoid shoulder breadth was chosen for inclusion in this study as the acromion can be difficult to locate for untrained individuals (Levangie et al., 2001) and may be further complicated by the excess of adipose tissue associated with being plus size.

5.3.1.2 Uniform/PPE

Issues with the fit of uniform and PPE, specifically high visibility jackets and vests was identified in the scoping study. Stature, combined with chest, waist and hip circumferences are used within the clothing industry to determine the basic shape and size of the individual (Gupta et al., 2014). Circumference measurements, are also important in determining whether or not a garment can be fully closed (zipped, buttoned or Velcro) which is required to maximise the benefits of PPE. Chest, waist and hip circumference measurements were therefore required to be included in the final measurement set. The correct position for measuring waist circumference is midway between the uppermost border of the iliac crest and the lower border of the costal margin (Pheasant and Haslegrave, 2006). In practice it may be difficult for plus size individuals to accurately palpate these bony landmarks in which case placing the tape measure at the level of the navel is recommended (WHO, 2015). This is more accurately termed abdominal circumference.

5.3.1.3 Workplace layout (reach and clearance)

The ability to grasp and operate controls within the working environment, use a keyboard on a desk, or manipulate items on a working surface is determined by the ability to reach the required distance. This is known as functional reach and is an important element of workplace layout. The anthropometric measures of forward grip reach and forward fingertip reach can be used to measure reach. Both measures require the arm to be raised horizontally forward at shoulder level; in forward fingertip reach the distance is measured from the back of the scapula to the tip of the middle finger, in forward grip reach measurement is taken from the scapula to the centre of the rod gripped in the hand. To avoid the requirement for participants to find a suitable rod, forward fingertip reach was selected to be included in the final measurement set. Functional reach is also affected by the distance the individual stands or sits away from the working surface (Feathers et al., 2015). In a plus size individual, abdominal depth measured horizontally from the rear vertical plane to the maximum protrusion on the front of the relaxed abdomen may dictate this distance. Abdominal depth was therefore selected for inclusion in the final measurement set.

Workplace clearances are affected by the heights, widths and depths underneath and around the workstation's work surface (Feathers et al., 2015). The provision of adequate vertical, lateral and forward leg room in a range of situations (such as seated at a desk, cafeteria or lecture room seating, driving) is essential if the working individual is to adopt a satisfactory posture (Pheasant and Haslegrave, 2006). Vertical leg room requirements must give clearance for the thighs and the knees requiring the anthropometric measurements of popliteal height and thigh thickness to be included in the measurement set. Buttock to front of knee length was included in order to address the forward leg room requirements. Lateral leg room must give clearance for the thighs and knees and therefore hip breadth was included to identify the clearance required at seat level. Consideration was given to including knee breadth, which is measured horizontally between the outer borders of the knees with the knees and legs together. However a unique measure of knee splay (in a non-pregnant population) was included based on the observations of Sibella et al., (2003) and the comments raised in the scoping study such as;

> *"I'm uncomfortable when someone sits next to me. They're too close and our knees touch",* (female, 18-24)

5.3.1.3.1 Knee Splay

Knee splay (Figure 5.1) is defined as the distance between the outer borders of the knees whilst seated in the preferred sitting position (Serpil and Weeks, 2006) and represents the observed sitting postures of plus size individuals (Sibella et al., 2003).

Figure 5.1 Knee Splay. Measured horizontally between the outer borders of the knees in preferred comfortable posture.

The measurement of knee splay is taken with the participant seated, their feet flat on the floor, knees bent at 90 degrees with the upper leg parallel to the floor and their preferred posture for angle between the thighs and distance between the knees. Knee splay is an important novel measure to include in this measurement set as the size and shape of the plus size individual may influence workplaces clearances, particularly in a lateral direction, both within the individual working area and shared spaces. This may impact on both safety and comfort.

5.3.1.4 Final anthropometric measurement set

Following review, 14 measurements were selected for inclusion in the anthropometric measurement set for this study (Table 5.1). This number of measures was sufficient to understand the size and shape of participants without being a barrier to participation in terms of participant time or expertise required to complete the measurements. The definition and application to workplace design for each of the selected fourteen measurements are tabulated in Appendix 5.2.

Anthropometric Measure	
Standing	**Seated**
Height	Sitting shoulder height
Weight	Abdominal depth
Chest circumference	Hip breadth
Abdominal circumference	Thigh thickness
Hip circumference	Buttock to front of knee length
Shoulder breadth (bideltoid)	Popliteal height
Forward fingertip reach	Knee splay

Table 5.1 Anthropometric measurements in final measurement set

5.3.2 Development of self measurement instruction guide

A self measurement guide (Appendix 5.3) was developed to enable participants to collect the self-measured data for the 14 anthropometric measurements contained in the final anthropometric measurement set. The self measurement guide had 5 sections (Figure 5.2)

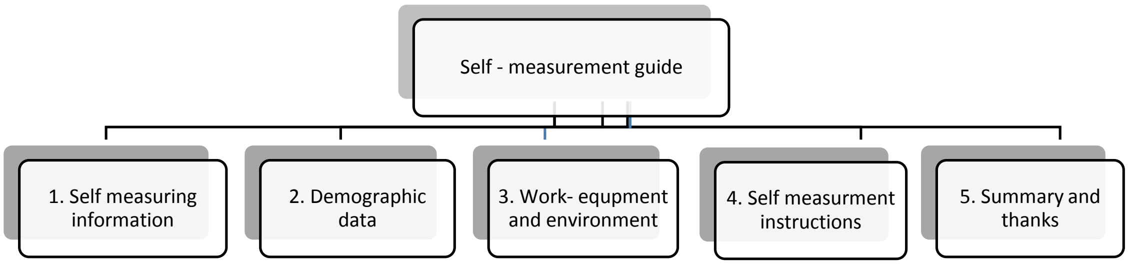


Figure 5.2 Structure of self measurement guide

Section one provided participants with information on equipment and time required, how to measure and how to submit the information. Statements on how to measure, for example placement and tautness of the tape measure and clothing requirements were aimed at standardising the measuring process as much as possible. This was to enable comparison between the participants in the study and also enable comparison to existing anthropometric datasets. The statements replicated guidance contained within ISO: 7250 Basic Human Body Measurements for Technical Design (International Standardisation Organisation, 2015) but were presented using simplified language to aid understanding. Participants were given four ways of submitting their measurement data (phone, in person, post or online via Survey Monkey) to facilitate completion of the study.

Section two consisted of questions to collect demographic data. Participants were asked to indicate their gender, ethnic group and date of birth to demonstrate the spread of the sample. Participants were also asked to give their weight (without shoes) in either metric or imperial units. Finally, participants were required to indicate their body shape. Five body shapes (Figure 5.3); straight, pear, apple, cone and hourglass were depicted using pictures (Connell et al., 2006 and Lee et al., 2007). This was asked to gain an understanding of the body shapes of the study plus size working and the frequency of each shape occurring in the study population.

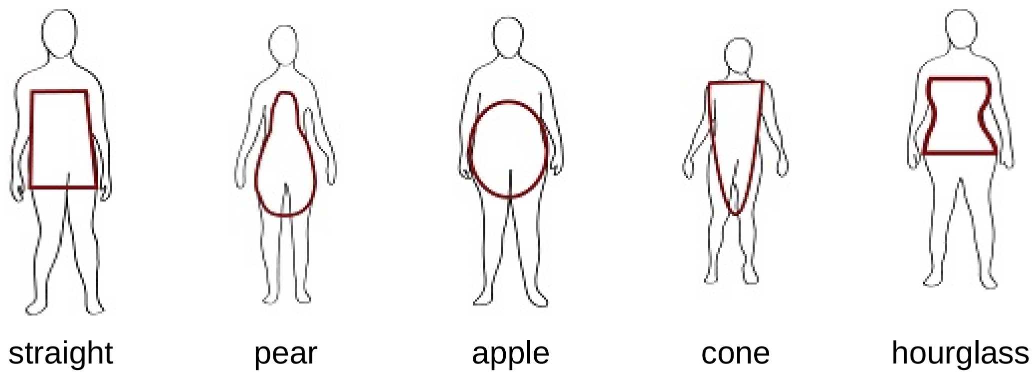


Figure 5.3 Body shape depicters

Section three focussed on aspects of the participant's work. Information was requested about job title and main place of work to gain an insight into the type of work and whether they were home or site based. Participants were then asked to indicate whether any of the previously identified (see Section 4.8) aspects of the working environment currently caused them any problems at work.

- Seat sizes – chairs, stools, car
- Height of desk or working surface
- Space in your working area
- Fit of uniform
- Fit of PPE
- Size of toilet cubicle
- Shared circulation spaces – café or meeting rooms
- Width of stairways or corridors

.

Section four gave instructions on how to complete the self measurement of the 14 anthropometric measurements. The purpose of this section was to both standardise the measurement process to increase the accuracy of the measurement data and to simplify the measurement process to reduce the time required to complete the measures.

The 14 anthropometric measurements were renamed (simplified) to relate more to the body part being measured (Table 5.2).

Title of Anthropometric Measurement	
Existing datasets Adultdata (Peebles and Norris, 1998) and Pheasant (2006)	**Self measurement guide**
Stature	Height
Weight	Weight
Chest circumference	Full chest
Abdominal circumference	Stomach
Hip circumference	Hips
Shoulder breadth (bi deltoid)	Shoulder width
Forward fingertip reach	Forward reach
Shoulder height (sitting)	Sitting shoulder height
Abdominal depth	Stomach depth
Hip breath	Hip breadth
Thigh depth	Thigh thickness
Buttock to front of knee	Buttock to front of knee
Knee splay *	Between knee width
Popliteal height	Back of knee height

*not documented within existing datasets

Table 5.2 Title of anthropometric measurements used in self measurement guide compared to existing datasets

A photograph was included of a plus size volunteer (consent was granted), wearing light clothing and no footwear, in the posture required for each anthropometric measurement. For the measurements where it was possible to self-measure without assistance (chest, stomach and hip circumference), the photograph showed the model completing the measurement to highlight the position of the tape measure and improve accuracy. For the remaining measures, the photographs were annotated to show the line of measurement. A plus size model was used for the photographs in preference to a diagram form (Figure 5.4) common in existing anthropometric sources. This was to assist participants by using real people rather than diagrams as this supports engagement in research activities (NIHR, 2009).

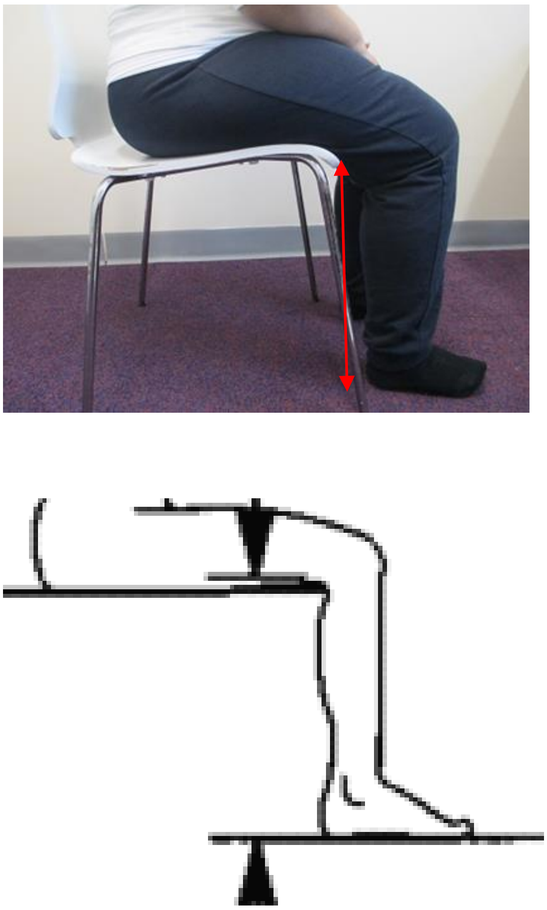


Figure 5.4 Example of self measurement photograph compared with diagram form

A set of concise and easy to follow instructions detailing how to complete the measurement accompanied each photograph. The instructions were based upon the protocols described in ISO: 7250 Basic Human Body Measurements for Technical Design (International Standardisation Organisation, 2015), Adultdata (Peebles and Norris, 1998) and Pheasant and Haslegrave (2006). Each set of instructions started with a statement of the starting position; either standing or sitting

Standing – look forward, shoulders relaxed, arms by your side

Sitting – on a hard surface. Feet should be supported and thighs horizontal. Sit upright, look ahead. Hands in your lap.

The starting point and end point and direction (horizontally or vertically) was then given for each measure. Points to check included ‘be careful not to compress the thigh when measuring’, ‘do not hold your stomach in’ and ‘ensure the tape measure is in a straight line’. Participants were then requested to recheck the measurement and record the data on the guide.

Participants were also asked to describe the clothing they were wearing during the self measurement (e.g. jogging bottoms and t shirt, or suit trousers and shirt). This was required to enable comparison of the data obtained via self measurement and researcher-measured. An open question asked about the participant's experience of self measurement and concluded the section.

The final section of the self measurement instruction guide, section five, thanked the participants for completing the guide. The self measurement instruction guide was reviewed and granted ethical approval by Loughborough Design School, Loughborough University (November 2014).

5.4 Pilot study

The self-measurement guide was tested in a pilot study to check the:

- structure of the questionnaire
- clarity of the instructions
- clearness of the photographs
- responses
- time taken to complete the study
- data analysis strategy

5.4.1 Participants

A convenience sample of 6 plus size participants (2 male, 4 female) completed the pilot study. Convenience sampling is an acceptable sampling method for a pilot study (Robson, 2011).

5.4.2 Findings/modifications

The responses were appropriate but minor changes were made to the instructions of 2 anthropometric measures. The average time taken to complete the questionnaire was 19 minutes (range from 16-21 minutes). The final self-instruction guide is shown in Appendix 5.3.

5.5 Data collection for the Validation Study

5.5.1 Sampling strategy

20 plus size participants, 10 males and 10 females, were recruited via a non-probability sampling strategy using a combination of 'purposive' and 'snowball sampling'. The sample size was selected to allow statistical analysis (Howell, 2007) and meet the profile of potential end users (age and gender). Purposive sampling was used with participants recruited from the scoping study (who expressed an interest in being involved in further research) and personal contacts.

The inclusion criteria for recruitment were that participants were:

- Aged 18 years of age or above

  Rationale: younger than 18 years of age are considered a vulnerable populations by Loughborough University Ethical Advisory Committee (LUEAC)
- Resident in the UK

  Rationale: to enable researcher measured component and focus on UK data
- Working (or had worked in the 12 months prior to the study) either employed or self-employed

  Rationale: (1) experience of interacting with workplace equipment, products, tools and recall issues/challenges in the workplace; (2)distinguish between bariatric hospital based community and plus size individuals at work
- Self-Classification of as 'plus size' or 'larger than average'

  Rationale: to identify factors related to fit/space

5.5.2 Data collection procedure

Potential participants identified through the sampling strategy were contacted by phone or email to discuss:

- participation in the study
- self-measurement component
- appointment time and location for the researcher-measured component

5.5.2.1. Self-measurement component

An information sheet (Appendix 5.5) was sent to the participant with the self-measurement instruction guide and a standardised 300cm fabric tape measure. An informed consent form (Appendix 5.6) was also signed by the participant. Participants were requested to complete the self-measurement form by following the instructions in the guide. Once completed, the participants were requested to place the completed self-measurement instruction guide into a sealed envelope. The self-measurement component was completed before the researcher-measured component for each participant to avoid any learning bias. None of the participants had previous experience of collecting anthropometric data. The self-measurement data was not reviewed by the researcher until the end of the data collection period. Participants were requested to wear the same clothing for both the self and researcher measurements.

5.5.2.2. Researcher measured component

For the researcher-measured component, the 14 anthropometric measurements were collected using standard methods (including weight scales, stadiometer, modified sitting height table and anthropometer) following protocols described in Section 5.3.2 and in Adultdata (Peebles and Norris, 1998) and Pheasant and Haslegrave (2006). All equipment was calibrated prior to each usage and the researcher was experienced in taking anthropometric measurements. Data was recorded on a data collection sheet (Appendix 5.7).

5.6 Data analysis

Statistical Package for the Social Sciences (SPSS) software for Windows (release 22.0 SPSS, Inc, 2015) was used for analysis. Demographic data (age, gender, employment) were analysed descriptively using means and frequencies. The Kolmogorov-Smirnov statistic was used to understand the spread of the sample for stature in combination with the descriptive analysis of the sample. These were compared to existing datasets to determine whether a self-classification of plus size was due to stature or other anthropometric measurements.

T-tests are useful to compare the mean scores of two tests on two different occasions with two groups when the data is interval and continuous in nature (Pallant, 2016). Paired comparison t tests were therefore used to compare the self-measured and researcher-measured data for each anthropometric measurement.

5.7 Results

The results are presented for:

- demographic data including the gender and age ranges and employment details.
- issues experienced by plus size people at work.
- quantitative analysis comparing the self-measured and researcher-measured data for each anthropometric measurement.

5.7.1 Demographics

20 participants (10 males and 10 females) in employment completed the study (Table 5.3).

Age Range	Number of Participants	
	Male	Female
18-24 years	2	2
25-44 years	4	4
45-64 years	2	4
65 years and above	2	0

Table 5.3 Sample group – age and gender distribution (n=20)

13 participants classed their ethnic group as ‘white’, 5 as ‘Asian’ and 2 as ‘Black or Black British’. There were no Chinese or mixed ethnicity participants (Figure 5.5).

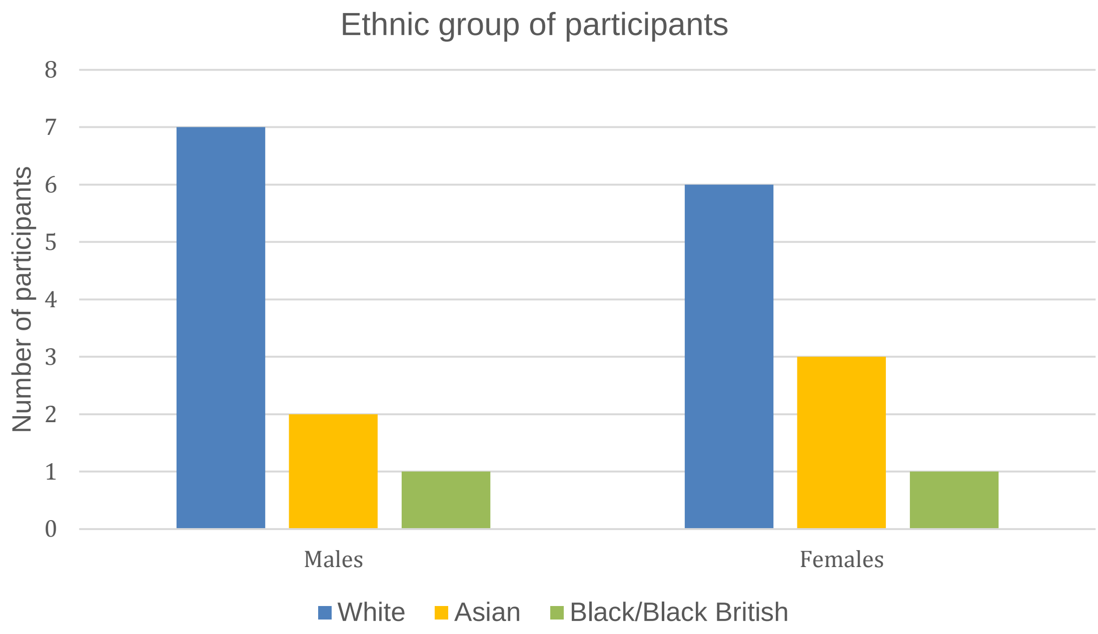


Figure 5.5 Ethnicity of participants (n=20)

All participants were currently employed; 1 participant worked mainly from home. Employment sectors are shown in Figure 5.6. All participants (n=20) were resident in the United Kingdom and classed themselves as plus size.

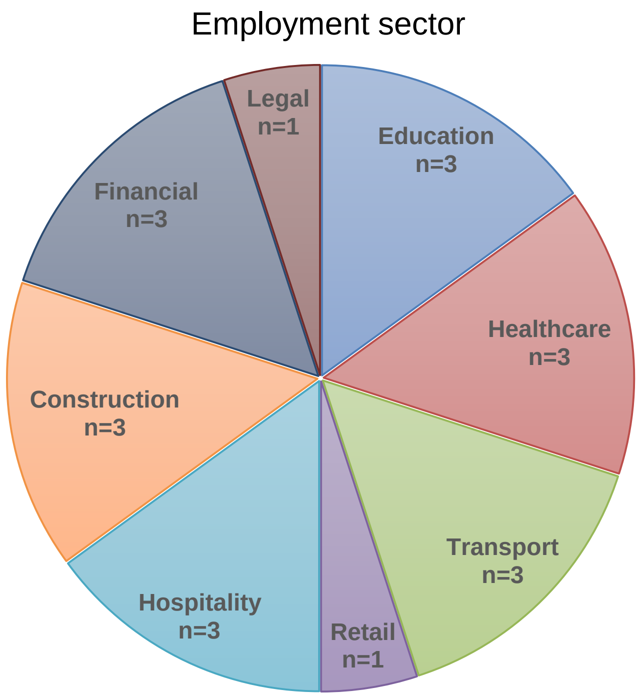


Figure 5.6. Employment sectors of participants (n=20)

5.7.2 Issues at work

Participants were asked if they were currently experiencing any issues with the equipment they used at work; specifically seat sizes, height of desk or working surface, or fit of uniform and PPE (Figure 5.7). 55% of participants (n=11) reported issues with seat size including chairs, stools or car seats. 25% of participants (n=5) expressed concern about the height of their working surface (required for legroom clearance). Fit of uniform was not applicable to the majority of the participants (60%). However, 7 participants required to wear uniform reported problems with the fit and 5 out of the 6 using PPE also reported problems.

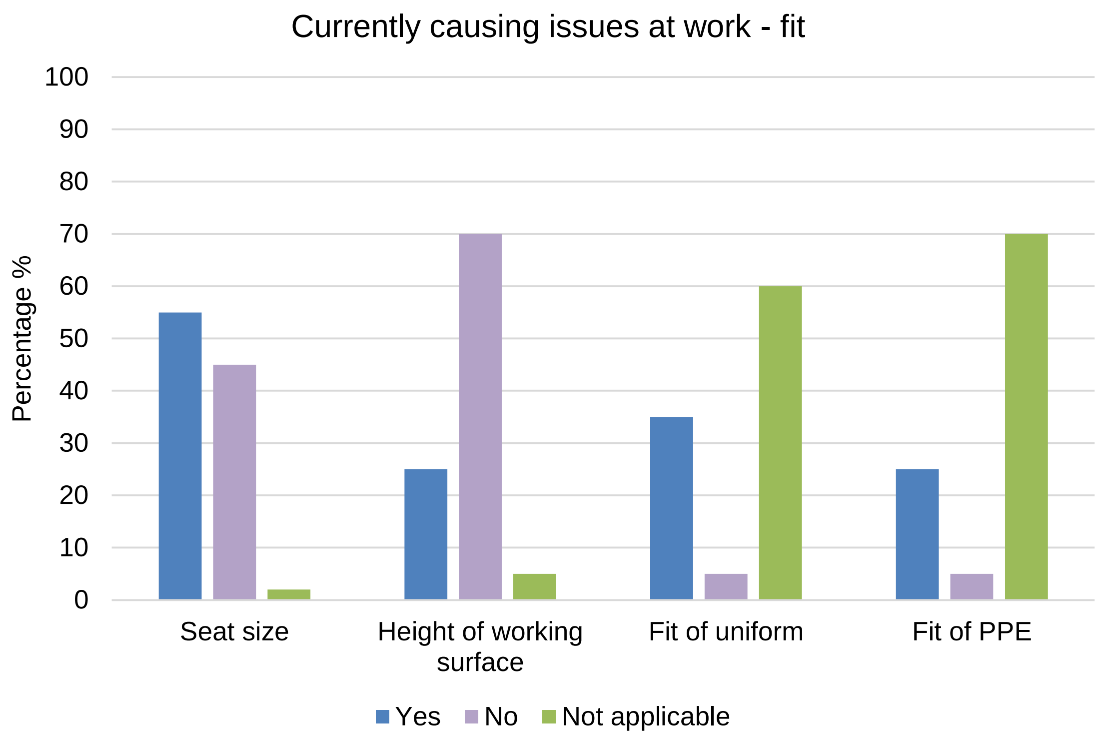


Figure 5. 7 Fit issues - currently causing issues at work

45% (n=9) of participants reported issues with the space in their direct working environment which affect their ability to move around without hindrance. 55% (n=11) identified toilet cubicle size as an issue with 35% (n=7) indicating that space in shared areas such as meeting rooms and cafeterias were currently causing them problems. 1 participant experienced issues with the width of staircases and corridors within their working environment (Figure 5.8).

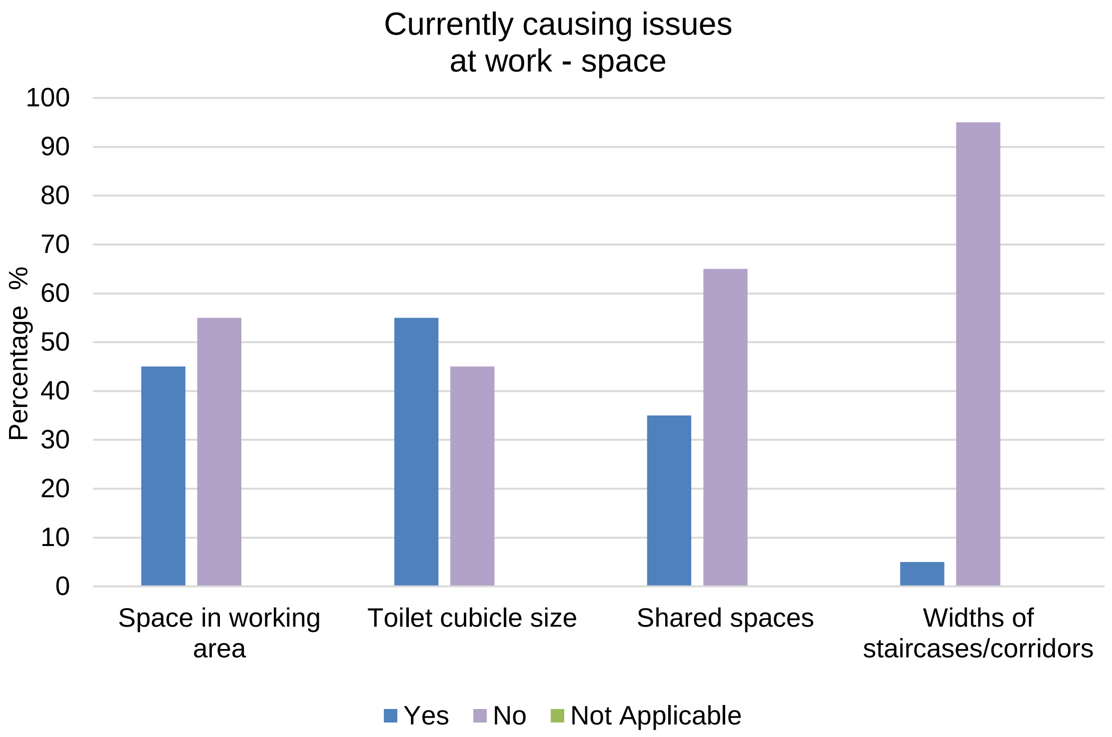


Figure 5. 8 Space issues - currently causing issues at work

5.7.3 Stature

The mean stature was 1763mm (SD 43mm) for males and 1567mm (SD 77mm) for females. This is similar to the mean values documented in existing datasets (Pheasant and Haslegrave, 2006) and therefore demonstrates a good spread of stature across the sample.

	Male		**Female**	
	Study mean (SD 43mm)	Existing dataset mean (SD 70mm) (Pheasant, 2006)	Study mean (SD 73mm)	Existing dataset mean (SD 62mm) (Pheasant, 2006)
Stature	1763mm	1755mm	1567mm	1620mm

Table 5.4 Comparison of Study mean height and existing dataset mean height (n=20)

The normality of the distribution of stature for this data set was assessed using the Kolmogorov-Smirnov statistic. A non-significant result (sig. value of more than 0.05) was found for male and female stature data (Table 5.5) indicating normality.

	Kolmogorov-Smirnov		
	Statistic	**df**	**Significance**
Height - Male	0.204	10	0.200
Height - Female	0.238	10	0.114

Table 5.5 Normality of distribution for height data (n=20)

5.7.4. Comparison of self-measured and researcher measured data

5.7.4.1 Anthropometric measurements

The data from the self-measured (using the self measurement guide) and researcher-measured components were collated (Table 5.6 and Table 5.7).

Anthropometric Measurement	Participant																			
	1		2		3		4		5		6		7		8		9		10	
	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res
Weight (kgs)	143	147	130	129	125	127	107	107	101	106	97	99	96	97	95	98	106	106	117	120
Height (mm)	1830	1800	1810	1820	1720	1730	1760	1740	1830	1800	1770	1750	1780	1770	1730	1710	1820	1810	1740	1700
Chest Circumference (mm)	1590	1590	1430	1410	1400	1400	1320	1310	1440	1460	1190	1200	1360	1360	1260	1240	1320	1320	1270	1320
Abdominal Circumference (mm)	1540	1560	1300	1270	1420	1430	1370	1360	1340	1350	1380	1390	1350	1370	1400	1410	1250	1270	1290	1260
Hip Circumference (mm)	1630	1630	1300	1340	1260	1260	1310	1320	1300	1310	1100	1090	1240	1260	1270	1290	1150	1160	1340	1320
Shoulder Breadth (Bideltoid) (mm)	630	640	660	670	550	590	480	470	600	590	490	750	500	490	450	470	730	720	600	590
Forward Fingertip Reach (mm)	840	840	1000	1000	910	930	790	790	810	820	740	750	810	800	770	790	810	800	810	830
Sitting shoulder Height (mm)	650	640	640	620	670	680	600	610	600	610	600	590	620	610	570	590	600	610	630	640
Abdominal Depth (mm)	590	590	490	480	530	470	500	510	570	580	620	640	500	530	540	520	540	520	500	560
Hip Breadth (mm)	640	640	580	580	490	490	590	570	600	600	580	580	540	540	500	510	500	490	520	510
Thigh Thickness (mm)	400	400	340	370	320	310	290	270	270	290	290	300	250	270	250	260	250	270	300	290
Buttock to Front of Knee (mm)	630	630	660	660	630	640	610	610	620	640	600	590	620	610	580	560	600	610	620	630
Popliteal Height (mm)	470	470	460	470	410	430	450	440	450	460	430	440	450	460	440	430	480	480	440	440
Knee Splay (mm)	640	640	570	560	560	570	570	590	590	580	590	590	580	580	570	560	600	600	580	590

Table 5.6 Self and Researcher Measured Anthropometric Measurements for Male Participants (Self=Self Measured Res=Researcher Measured)

Anthropometric Measurement	Participant																			
	1		2		3		4		5		6		7		8		9		10	
	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res	Self	Res
Weight (kgs)	91	93	106	108	106	109	92	94	145	143	134	136	120	121	97	100	99	102	92	97
Height (mm)	1570	1550	1640	1610	1580	1560	1440	1450	1690	1670	1570	1560	1570	1560	1500	1500	1710	1690	1560	1520
Chest Circumference (mm)	1160	1170	1270	1270	1320	1330	1020	1000	1250	1230	1280	1290	1250	1260	1270	1270	1300	1280	1220	1260
Abdominal Circumference (mm)	1160	1160	1220	1220	1430	1430	1170	1190	1600	1600	1230	1230	1270	1260	1190	1200	1200	1210	1260	1280
Hip Circumference (mm)	1220	1220	1310	1320	1170	1180	1120	1130	1390	1410	1310	1300	1250	1250	1260	1250	1260	1270	1460	1470
Shoulder Breadth (Bideltoid) (mm)	570	600	580	590	600	600	490	500	600	570	490	500	480	480	520	520	510	500	470	440
Forward Fingertip Reach (mm)	790	800	830	830	700	700	870	860	890	900	750	750	730	730	700	710	740	740	720	730
Sitting shoulder Height (mm)	580	570	580	580	580	590	600	570	700	730	560	550	530	540	510	500	540	560	530	540
Abdominal Depth (mm)	410	420	470	480	500	500	430	440	630	650	480	490	530	540	460	440	430	440	470	490
Hip Breadth (mm)	580	580	680	700	630	630	550	540	610	630	560	560	520	530	500	510	500	500	510	510
Thigh Thickness (mm)	220	220	330	330	270	290	190	190	270	240	230	240	220	230	220	200	190	200	240	260
Buttock to Front of Knee (mm)	640	640	620	620	690	690	590	570	630	640	620	630	600	610	590	590	600	600	560	570
Popliteal Height (mm)	450	440	430	400	400	410	380	370	580	580	420	420	410	420	410	400	480	490	420	410
Knee Splay (mm)	490	490	580	580	620	630	470	470	680	680	510	520	510	510	470	480	510	500	580	570

Table 5.7 Self and Researcher Measured Anthropometric Measurements for Female Participants (Self=Self Measured, Res=Researcher Measured)

Two dimensional scatterplots were created to visualise the differences between the self and researcher values for each of the 14 measurements. Examples of these are shown for Weight (Figure 5.9), Height (Figure 5.10), Hip Breadth (Figure 5.11) and Thigh Thickness (Figure 5.12).

Figure 5.9 Relationship between Self and Researcher Measurement of Weight (n=20)

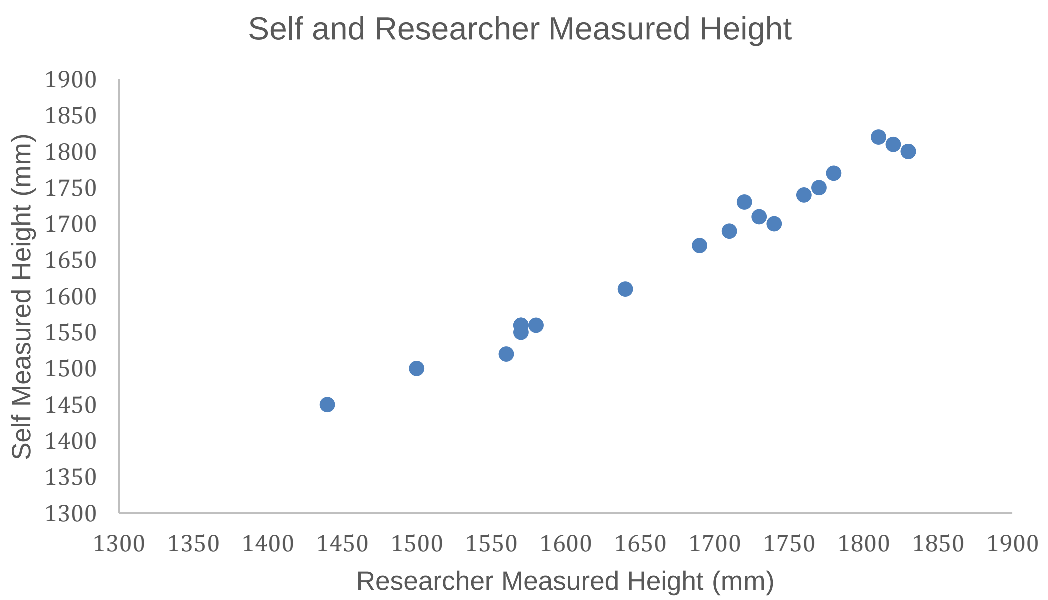


Figure 5.10 Relationship between Self and Researcher Measurement of Height (n=20)

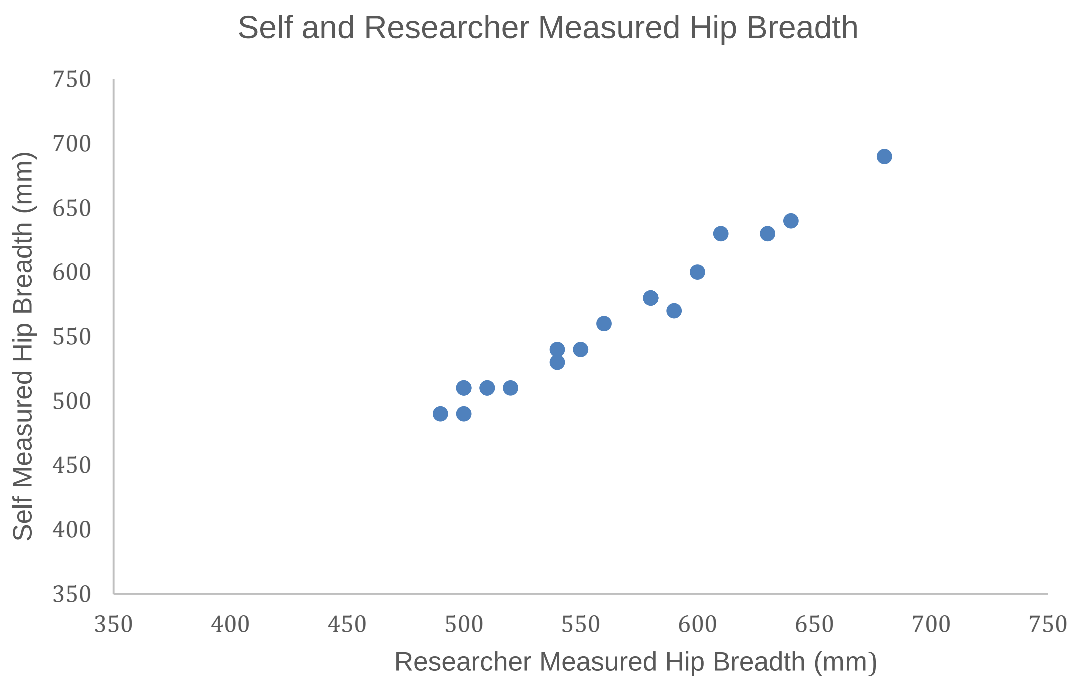


Figure 5.11 Relationship between Self and Researcher Measurement of Hip Breadth (n=20)

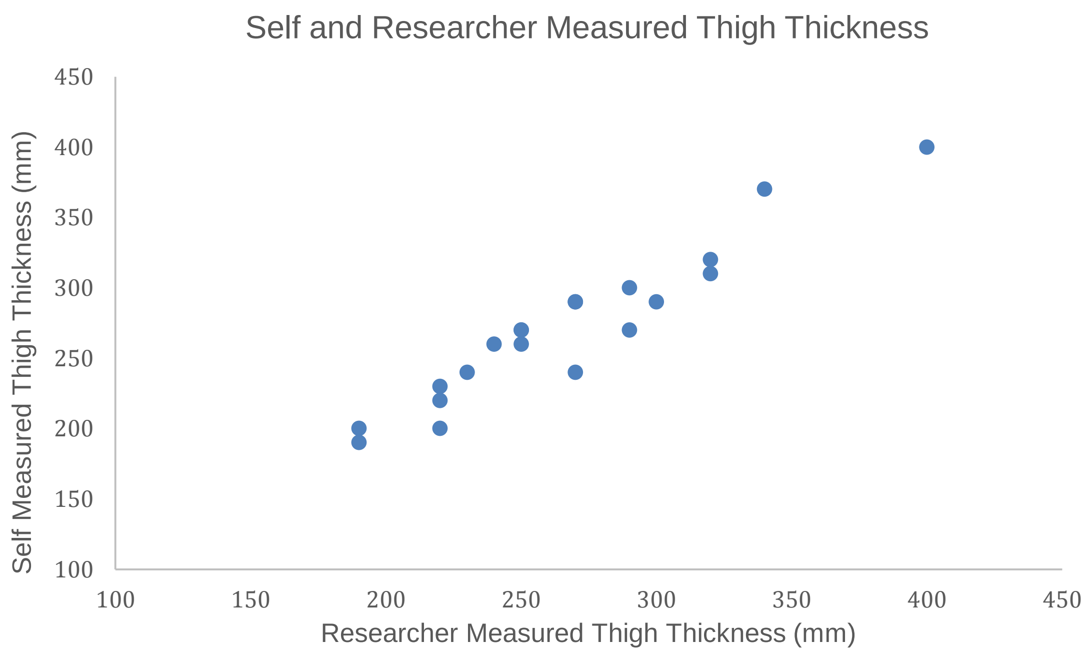


Figure 5.12 Relationship between Self and Researcher Measurement of Thigh Thickness (n=20)

The data from the self-measured and researcher-measured components were then entered into SPSS. Paired comparison t tests were used to compare the self-measured and researcher-measured data for each of the 14 anthropometric measurements. The analysis found that 11 out of the 14 measurements taken via self-measurement were comparable to those obtained via the researcher-measured technique with no significant differences between the measures ($P \leq 0.05$). However 3 anthropometric measurements differed significantly (Table 5.8): stature ($P \leq 0.001$), weight ($P \leq 0.001$), and hip circumference ($P \leq 0.05$).

Anthropometric Measure	Paired Differences		t	df	Sig. (2 tailed)
	95% Confidence Interval of the Difference				
	Lower	Upper			
Weight	-2.675	-1.045	-4.778	19	**0.000**
Height	0.898	2.302	4.767	19	**0.000**
Chest Circumference	-1.110	0.410	-0.960	19	0.349
Abdominal Circumference	-1.100	0.302	-1.192	19	0.248
Hip Circumference	-1.281	-0.189	-2.156	19	**0.044**
Shoulder Breadth (Bideltoid)	-4.230	1.430	-1.035	19	0.314
Forward Fingertip Reach	-0.813	-0.131	-1.926	19	0.069
Sitting shoulder Height	-0.892	0.611	-0.295	19	0.772
Abdominal Depth	-2.232	2.432	0.090	19	0.929
Hip Breadth	-0.365	0.465	0.252	19	0.804
Thigh Thickness	-1.201	0.301	-1.254	19	0.225
Buttock to Front of Knee	-0.675	0.075	-1.674	19	0.110
Popliteal Height	-2.136	0.136	-1.842	19	0.081
Knee Splay	-0.469	0.269	-0.567	19	0.577

Table 5.8 Anthropometric measures showing significant and non-significant differences between self- measurement and researcher measured techniques (n=20)

5.7.4.2 Body shape

The description of body shape was also compared between self-classification and researcher classification. 6 participants classified themselves as ‘apple’, 5 participants choosing ‘pear’, 5 indicating ‘hourglass’ and 4 participants describing themselves as ‘straight’. The researcher classification resulted in ‘apple’ being the most frequent classification (n=16) with the remaining participants being classified as ‘pear’ (Table 5.9). It was not possible to undertake paired t tests on these results due to the categorical nature of the data. However, self-classification and researcher classification of body shape only matched for 10% of participants (n=2). This difference is discussed in Section 5.8.1.4.

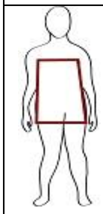
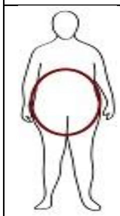
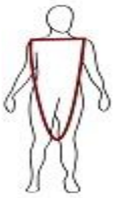
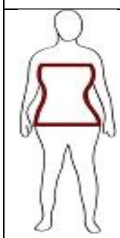
Body Shape	Frequency		Number of matches (between self and researcher measured)
	Self-measured	Researcher measured	
 **Straight**	4	0	0
 **Pear**	5	4	1
 **Apple**	6	16	1
 ***Cone***	0	0	0
 **Hourglass**	5	0	0

Table 5.9 Comparison of body shape classification between self and researcher measured

5.8 Discussion

This chapter has described the validation study to establish if self-measurement of anthropometric data is feasible and acceptable as the data collection method for a larger scale anthropometric survey. In this section, the most significant findings are discussed followed by the limitations and the conclusions.

5.8.1. Comparison of self-measured and researcher measured data

The anthropometric measurements with a significant difference were weight, stature and hip circumference and these will be reviewed and discussed in the following sections.

5.8.1.1 Weight

The possible reasons for misreporting of weight and stature are many and complex (Gorber et al., 2006). The difference being self and researcher measured weight was significant at the $P \leq 0.001$ level. Both male and female participants underreported their weight with a mean of 112 kgs self-measured weight for males compared with 114 kgs by the researcher. For females the mean self-measured weight was 108kgs compared to 110 kgs by the researcher. These findings are similar to Stommel et al., (2009) who found that the degree of difference between self-reported and objective measurement of weight is strongly influenced by the participants body size; heavier people (BMI of over 25kg/m^2) are likely to underestimate weight than normal weight individuals (BMI of 18.5-24.9kg/m^2). O'Neill et al., (2013) reported similar findings in a large scale study using female participants. However, both of these studies had a delay in the weight comparison with participants recruited from epidemiological studies many months earlier. Cash et al., (1990) discusses the pattern of significant differences in such methodologies, suggesting that the difference may be due to prolonged time between self-measurement and researcher-measurement as weight changes can occur over short periods (Gorber et al., 2007).

In this validation study, the time between measurements was controlled with a maximum of three days between the self and researcher measured components. It is therefore suggested that under-reporting of weight amongst the study participants may be due to other reasons. Stommel et al., (2009) suggest that some plus size individuals may avoid weighing themselves and therefore may report their weight less accurately and Gorber et al., (2007) suggest that although individuals might be aware of their weight, issues around body image and social acceptance may result in consciously under reporting their weight. Both explanations are reasonable but the design of the self-measurement guide and the objectives of the study do not enable any further clarification.

5.8.1.2 Stature

Self-measured stature in combination with weight, is also frequently suggested as an alternative to researcher measurement primarily due to financial limitations and/or time constraints (Spencer et al., 2002). In this study, the difference between self and researcher-measured stature was significant at the $P \leq 0.001$ level. Both male and female participants over-reported their stature with a mean self-measured stature of 1779mm for males compared to 1763mm by the researcher. For females the mean self-measured stature was 1583mm compared to 1567mm by the researcher. DelPrete (1992) and Allison (1998) found similar results. DelPrete (1992) reported a mean difference of 18mm between self- and researcher-measured stature for a sample of 82 adults (male and female). Allison (1998) found an over reporting in height of 17mm. In both studies the self-measurement component occurred first to minimise the learning effect (bias) by participants and there was less than two weeks between measurements.

As stature declines with age by up to 2cm per decade after the age of 30, Shields et al.,(2008) hypothesises that loss in stature may not be perceived by the individual which results in reporting of stature from previous years rather than actual stature at the time of the self-measurement. However, Dekkers et al., (2008) found no difference in the over-reporting of stature between older or younger participants, with all participants over reporting. Additionally, in an UK adult population, Bolton-Smith et al., (2000) found no trend in the over-reporting of stature based on age up to 65 years.

Disparity between self- and researcher- measured data can also occur when researchers do not use standard procedures or consistent guidelines. The order of measurement, clothing worn, and the elapsed time between measurements (Tokmakidis et al., 2102) were all standardized as far as possible during the validation study but it is possible that participants may have estimated their weight and height rather than taking actual measurements or reduced their weight and increased their height consciously.

5.8.1.3 Hip circumference

Hip circumference was also under-reported for self-measurement compared to researcher measurement although to a lesser extent than weight. This may be due to difficulties in identifying the maximum protrusion for measurement (anatomical landmarks) or again due to conscious under reporting. No studies were identified which compare self and researcher measured hip circumference but it is interesting that weight, height and hip circumference are measures that are generally ‘known’ to the participant, for example through clothing sizes. Tokmakidis et al., (2102) suggests that self-reported data has a trend of bias towards the ideally expected value. In developed countries such as the UK, with the ideology of being tall and slim, this could result in reported measures being closer to ideal values rather than actual measures.

However, although the measurement differences for weight, stature and hip circumference are statistically significant, they are relatively small as illustrated by the 95% confidence interval. The advantages of self-measurement in terms of access to the plus size working population, cost and resources combined with the lack of significant difference between self and researcher measurements leads to a conclusion that self-measurement (utilizing the self-measurement guide) is adequately feasible and acceptable as the data collection method.

5.8.1.4 Body shape

There was a considerable different in the self-classification of body shape by participants and the researcher, with only 10% (n=2) agreement. The question was asked to firstly explore the body shapes of plus size worker and secondly consider the frequency of each shape as this was identified as a knowledge gap by Park et al., (2013). However, the results suggests that self-classification is not a valid method to ascertain the frequency of particular body shapes.

Body shape misperception is common amongst the general public and is a core factor in eating disorders and related conditions (Zaccagni et al., 2014). The majority of the literature focusses on specific populations such as adolescents, eating disorder clinics or bariatric units rather than the general working population. This makes the comparison of these findings to existing literature difficult. Apple and pear body shapes are the most frequently reported body shapes in the plus size literature (Park et al., 2013) and this was found by the researcher classification with 80% of participants classified as apple (n=16) and 20% as pear (n=4). However the participant's classification was much more varied with straight, hourglass, apple and pear shapes being reported almost equally. As the researcher classification took place with the participants wearing light clothing it may be that body shape was masked by clothing. However, similar to weight, stature and hip circumference measurements it is possible that participants are biased towards their ideally expected shape as suggested by Tokmakidis et al., (2102). The lack of agreement between self- and researcher classification of body shape reinforces the need for empirical anthropometric measurements of the UK plus size working population to understand the extent of the body shape variability among plus size individuals.

5.9 Limitations

The anthropometric measurement validation study explores the use of self-measurement as an alternative method of collecting anthropometric data. The limitations include firstly a small sample size with only 10 male and 10 female participants and secondly, participants recruited via non-probability sampling methods. Due to the sampling strategy, it is possible that this could be unrepresentative of the plus size working population. Participants may have been highly motivated to provide accurate measurements as they were aware that the researcher would repeat and compare the measurements. Although interpretation of the results should be viewed with some caution, it was concluded that this was an acceptable sampling technique for a larger scale data collection study.

Due to the small sample size it was not possible to ascertain whether the age group and/or ethnicity would affect the accuracy of the self-measurements. Also no female participants over 65 years of age were included in this study so it is unknown whether self-measurement is valid within this group.

Although not identified in the pilot study, the chair depicted in the photographs used throughout the self measurement guide (Appendix 5.3) had a slightly curved seat. This may have affected the measurements taken in a seated position, for example sitting shoulder height, thigh thickness and back of knee height as they rely upon the thighs being horizontal, which may be affected by a curved seat. However, despite the potential for error, there were no statistical significant differences between the self and researcher measured values for these dimensions suggesting that for this study any impact was insignificant. However, further use of this self measurement guide beyond this thesis would benefit from a photograph depicting a non-curved seat surface.

Only 14 measurements were selected for inclusion in the anthropometric measurement set. Although the measurements were carefully selected as being crucial to workplace design they do not provide a complete data set for workplace design as found in other data sets such as Adultdata (Peebles and Norris, 1998), BodySpace (Pheasant and Haslegrave, 2006) and PeopleSize (Open Ergonomics, 2008). The validation of this self-measurement technique cannot be extended to other measurements not included in this study.

In addition, as discussed in Section 5.8.1, the statistically significant differences found between weight, stature and hip circumference measurements recorded via self-measurement and researcher measured is itself a limitation of this study. As BMI is calculated using weight and stature, any misreporting of weight or stature may result in an incorrect calculation of BMI. However, due to the under reporting of weight by a mean of 2kgs and the over reporting of height by a mean of 14mm in this study, this would have a minimal effect on BMI classification.

5.10 Conclusion

The results support the following conclusions:

- Self-measurement, using a specifically developed guide is a feasible and acceptable method of collecting data for 11 anthropometric measurements relevant to workplace design; stature, weight, chest circumference, abdominal circumference, hip circumference, shoulder breadth (bi deltoid), forward fingertip reach, shoulder height (sitting), abdominal depth, hip breath, thigh depth, buttock to front of knee, knee splay and popliteal height.
- Although statistically significant differences were found between weight, stature and hip circumference measurements recorded via self-measurement and researcher measured these differences were small and highlight known limitations of self-measurement including misunderstanding of questions and response bias.

The objectives of the validation study have been achieved by developing an anthropometric measurement set pertinent to workplace design. A self-measurement instruction guide has been developed and tested. Self-measured and researcher measured anthropometric measurements relevant to workplace design have been compared.

It is concluded that self-measured anthropometric data for a plus size working age population is feasible as the data collection method for the subsequent (Chapter 6) larger scale plus size anthropometric study (Figure 5.13).

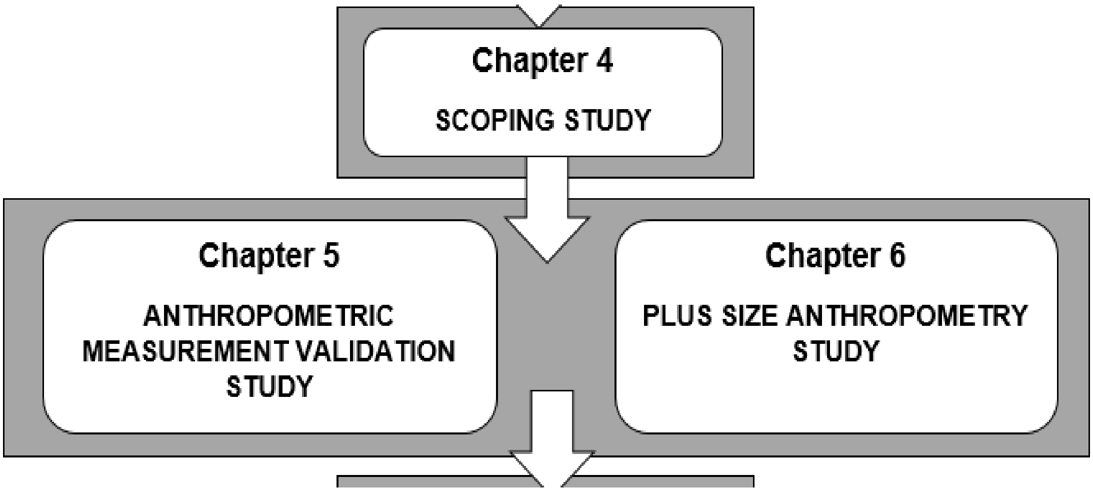


Figure 5.13 Relevant structure of thesis

6. Plus Size Anthropometry Study

6.1 Introduction

The prevalence of overweight (BMI ≥ 25kg/m^2) and obesity (BMI ≥ 30kg/m^2) and being classed as plus size has been increasing in the UK and worldwide over the past few decades (James 2004; Caballero 2007; WHO 2015). As a result of this increase, plus size individuals now make up the majority (61%) of the population (Baker and Bate, 2016). Despite this prevalence, anthropometric characteristics of plus size individuals have not been widely studied. Chapter 2 revealed a lack of current or comprehensive anthropometric data for the plus size UK working population and Chapter 4 highlighted fit and space related issues in the working environment. This suggests that the increasing prevalence of plus size carries with it potential challenges that may have a significant impact on the design of the working environment.

Self-reported anthropometric data is an acceptable way (in terms of cost and resources) of studying large and geographically diverse populations. The anthropometric measurement validation study (Chapter 5) concluded that self measurement using a specifically developed guide, was a feasible and acceptable method of collecting anthropometric measurement data from the current plus size UK working population. As a result, this method may assist in overcoming the barriers historically associated with anthropometric data collection surveys such as cost, access to non-civilian populations and the use of scaling methods (which may not fully account for the increasing incidence of a plus size population). The focus of this chapter is to report on a larger scale anthropometric study involving self reported anthropometric data. This will lead to a better understanding of the plus size population relevant to workplace design.

6.2 Aim and objectives

The aim of this study is to identify the body size and shapes of plus size working age people to inform the design of safe, comfortable and productive working environments.

This will be achieved through the following objectives:

- Collection of anthropometric data of plus size working age people pertinent to workplace design.
- Identification of any key anthropometric variables that explain body size and shape of plus size working age people.
- Identify any issues related to fit or space which affect plus size people in the working environment.
- Comparison of this newly acquired anthropometric data to existing datasets.

6.3 Research method

6.3.1 Collection of anthropometric measurement data

The self-measurement instruction guide (Appendix 6.1), developed and piloted for use in the anthropometric measurement validation study (Chapter 5), was utilised in this larger scale anthropometric study in an online format. The development of this guide was detailed previously in Section 5.3 and is summarised in Table 6.1. The guide had five main sections for use in the validation study, but an additional section providing background information to the study was added for the online version (Figure 6.1).

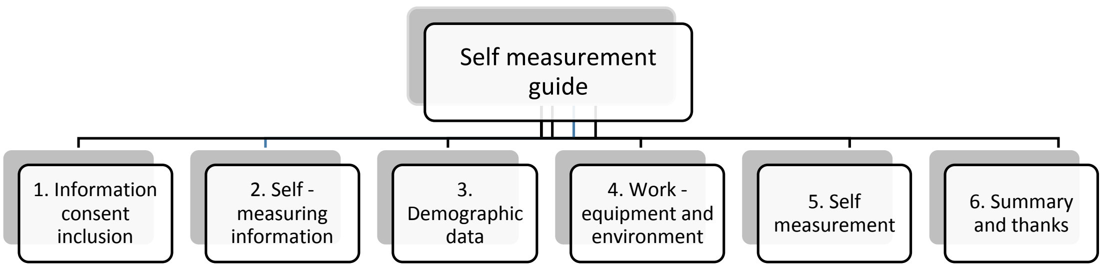


Figure 6.1 Structure of self-measurement guide

Stage Description	Rationale
Identification of anthropometric measurements recorded in literature relating to workplace design	Relevant to current workplace design literature. Usable to stakeholders.
Identification of functional measures recorded in literature relevant to plus size individual	To include novel functional measures identified in the literature but currently not included in existing datasets.
Selection of final measurement set based on stages 1 and 2	Sufficient measures to understand size and shape of participants. Limit to measures to encourage participation in research without being prohibitive in terms of participant time or expertise.
Development of self measurement guide	To enable self-measurement. Concise instructions and accompanying pictures to aid completion. (Robson 2013).
Pilot and revision of self measurement guide	To identify any systematic errors or unexpected problems with instruction guide and/or protocol.

Table 6.1 Stages of development of the self instruction guide

Section one provided a summary of the background information for the research including the purpose of the study and how the data would be used and stored. This was to enable participants to indicate their informed consent prior to undertaking the study.

Three qualifying questions were also asked; ‘Are you aged 18 years or older?’, ‘Are you plus size or larger than average?’ and ‘Are you working (or have you worked in the past 12 months)’? This was to ensure that all participants fulfilled the inclusion criteria for the study.

The content for the remaining sections were unchanged from the piloted version of the self-measurement guide (Chapter 5) with the exception of 2 questions in section three. A question was added requiring participants to disclose which country they lived in. Although the study aimed to collect anthropometric data from UK residents, due to the online format of the study and difficulty controlling snowball sampling as a result, non UK based participants would be able to complete it. However, non UK based participants could be excluded from analysis as appropriate. The question asking participants to indicate their body shape from 5 options (straight, pear, apple, cone and hourglass) depicted using pictures was omitted as the results from the validation study suggested that self-classification of body shape was not valid (see Section 5.8.1.4). The 14 anthropometric measurements (Table 6.2) remain unchanged from the validation study.

Anthropometric Measure	
Standing	**Seated**
Height	Sitting shoulder height
Weight	Abdominal depth
Chest circumference	Hip breadth
Abdominal circumference	Thigh thickness
Hip circumference	Buttock to front of knee length
Shoulder breadth (bideltoid)	Popliteal height
Forward fingertip reach	Knee splay

Table 6.2 Anthropometric measurements in final measurement set

Online access to the self-measurement instruction guide via Survey Monkey was considered the most appropriate method for data collection. As well as allowing participants to complete the measurements in a convenient location and at a convenient time it also improves response rate and reduces response time (Robson, 2011). The self-measurement instruction guide was reviewed and granted ethical approval by Loughborough Design School, Loughborough University (February 2015).

6.3.2 Comparison of plus size anthropometric measurement data to existing datasets

The anthropometric data collected was compared with data contained within the existing anthropometric datasets of Adultdata (Peebles and Norris, 1998) and BodySpace (Pheasant and Haslegrave, 2006). Consideration was given to other datasets for example, Tilley and Dreyfuss, (2002); PeopleSize (Open Ergonomics, 2008) but these were selected because of their;

- accessibility - open access, non-subscription based
- utilisation in industry/by stakeholders
- wide range of dimensions included
- most recent databases fulfilling the above criteria

ISO 15535:2012 General requirements for establishing anthropometric databases (International Standardisation Organisation, 2012) acknowledges the difficulties in comparing anthropometric measurements from different datasets due to differences in methodology, sampling technique or lack of description. As the potential sample size and sampling strategy in the proposed study are different from the existing datasets, the purpose is to gain an understanding of the new data in the context of the existing datasets, rather than providing a like for like direct comparison.

6.4 Pilot study

As the larger scale anthropometry study was designed to be distributed online, the self-measurement guide (Appendix 6.1) was piloted to check the;

- online structure of the self-instruction guide
- clarity of the instructions – particularly section one
- clarity of the photographs
- responses
- time taken to complete
- data analysis strategy

6.4.1 Participants

A convenience sample of 4 plus size participants (1 male, 3 female) completed the pilot study. Convenience sampling is an acceptable sampling method for a pilot study (Robson, 2011).

6.4.2 Findings/modifications

The responses were appropriate and no changes were made to the online self-instruction guide. The average time taken to complete the self measurement and submit the responses via the online questionnaire was 24 minutes (range 19-29 minutes). The final online self-instruction guide is in Appendix 6.1.

6.5 Data collection for the Anthropometry Study

The self-instruction guide was distributed using Survey Monkey over a 6 month period concluding on 31st October 2015. All respondents were informed of the background and purpose of the research and how the findings would be used prior to indicating their consent.

6.5.1 Sampling strategy

Various sampling techniques were considered for use in this study and are discussed in Chapter 3. Due to the target population being relatively unknown and potentially so widely dispersed, the self-instruction guide took on a non-probability sampling strategy using a combination of 'purposive' and 'snowball sampling' (Robson, 2011). From the literature and via personal contacts, a number of individuals were identified and approached to complete the online self-instruction guide and then act as informants to identify other plus size people and snowball the guide. Links to the study were also placed on several online forums;

- www.bigmatters.co.uk
- www.ukbigpeople.co.uk
- www.netmums.co.uk
- www.fatlotsheknows.co.uk

This enabled individuals who fulfilled the inclusion criteria, to complete the guide via self-selection.

The inclusion criteria for recruitment is that participants were:

- Aged 18 years of age or above.
- *Rationale:* younger than 18 years of age are considered a vulnerable population by Loughborough University Ethical Advisory Committee (LUEAC).
- Working (or had worked in the 12 months prior to the study) either employed or self-employed.
  Rationale: (1) experience of interacting with workplace equipment, products, tools and recall issues/challenges in the workplace; (2) distinguish between bariatric hospital based community and plus size individuals at work .
- Self-Classification of as 'plus size' or 'larger than average'
  Rationale: to identify factors related to being plus size.

6.6 Data analysis

Statistical Package for the Social Sciences (SPSS) software for Windows (release 22.0 SPSS, Inc, 2015) was used for analysis. Demographic data (age, gender, employment) were analysed descriptively.

Descriptive statistics (range, mean and standard deviation) will presented for each of the 14 anthropometric measurements collected via self-measurement. Correlations are useful to describe the strength and direction of a linear relationship between two variables (Tabachnick and Fidell, 2007). Pearson product-moment correlation coefficient was used to explore the relationship between each of the 14 anthropometric measurements taken. It was appropriate for use in this analysis due to the interval nature of the data.

Chi square is used to test for an association between two variables and answers the question "are the differences between the 'observed' and 'expected' cell counts large enough to infer an association in the tested population?" (Pallant, 2016). In addition to descriptive analysis, Chi square was used to test for associations between BMI and reported issues within the working environment related to fit and space; such as seat size, uniform and toilet cubicle size. There was no obvious dependent variable so multiple regression analysis was not appropriate.

The exclusion rate (Weekes et al., 2010) was investigated for each measurement. Typically design practice is to accommodate from the 5^{th} percentile up to the 95^{th} percentile of the target population - that is aiming to accommodate 90% of the population. Additional safety tolerances may be added to the design limits, for example when design situations involve a risk of injury, necessitating design to accommodate a larger proportion of the population, for example the 1^{st} to 99^{th} percentile - that is to accommodate 98% of the population. Therefore, exclusion rate is calculated as the percentage of the study population that might potentially be excluded by a design that accommodates the 5^{th} to the 95^{th} percentile or the 1st to the 99^{th} percentile for a particular dimension according to existing datasets.

6.7 Results

The results are presented for:

- demographic data including gender and age ranges, ethnicity and employment details, Body Mass Index (BMI) classification.
- anthropometric measurement data of plus size working age people (n=101).
- issues experienced by plus size people at work.
- comparison of the study anthropometric measurement data to existing datasets.

6.7.1 Demographics

113 responses were received. 12 responses were rejected following data cleansing due to missing weight or height data resulting in a sample size of 101. 101 participants (47 males and 54 females) in employment completed the study (Table 6.3).

Age Range	Number of Participants	
	Male (n=47)	Female (n=54)
18-24 years	7	9
25-44 years	18	24
45-64 years	22	21

Table 6.3 Age and gender distribution (n=101)

62 % of participants classed their ethnic group as 'White; 22% as Asian and 13% as Black or Black British'. 5% classed themselves as 'Mixed' ethnicity participants. All participants (n=101) were currently employed in 9 main employment sectors (Figure 6.2). The healthcare industry employed the highest percentage of participants (19%). All participants (n=101) were resident in the United Kingdom and classed themselves as plus size.

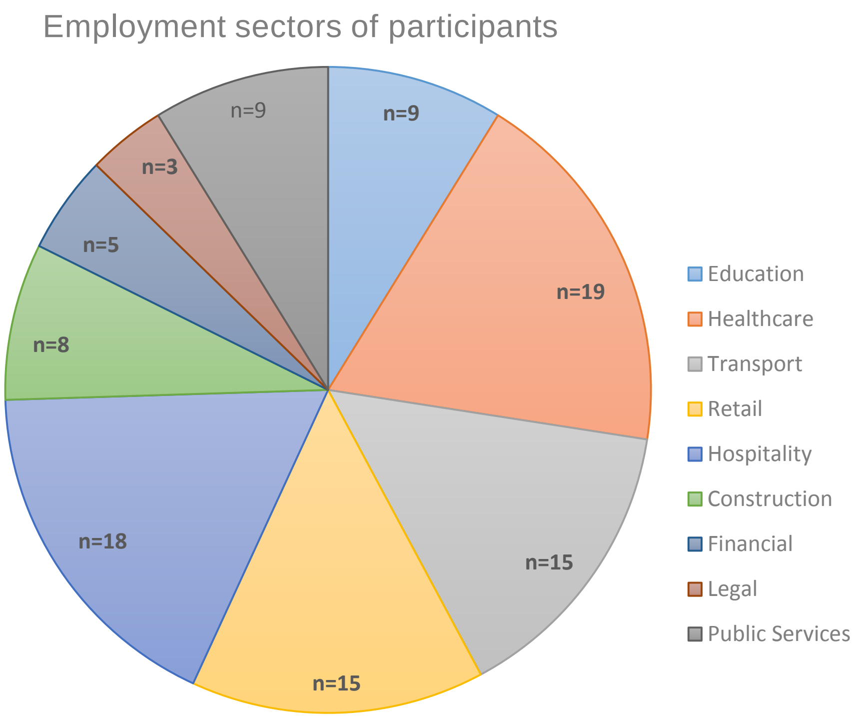


Figure 6.2. Employment sectors of participants (n=101)

Based on the self-measured stature (cm) and weight (kg) values, BMI (kg/m^2) was calculated (Table 6.4) for each participant using;

$$Body\ Mass\ Index\ (BMI) = \frac{Mass\ (kg)}{Stature(m)^2}$$

Figure 6.3 BMI calculation (Keys et al., 1972)

Mean BMI for males was 40.3 kg/m^2 (SD 8.4 kg/m^2) and mean BMI for females was 43.5 kg/m^2 (SD 8.5 kg/m^2).

	Body Mass Index (BMI) kg/m^2							
	≤ 29.9	30-34.9	35-39.9	40-44.9	45-49.9	50-54.9	55-59.9	≥ 60
Male (n=47)	1	13	12	6	8	3	3	1
Female (n=54)	1	4	11	21	5	7	1	4
Total (n=101)	2	17	23	27	13	10	4	5

Table 6.4 BMI classification (n=101)

6.7.3 Anthropometric data of plus size working age people

The range, mean, and standard deviation for each of the 14 anthropometric measurements collected in this study were determined. The results for male participants (n=47) are shown in Table 6.5 and female participants (n=54) in Table 6.6.

Anthropometric Measurement	N	Range		Mean	Standard Deviation
		Minimum	Maximum		
Weight (kgs)	47	93	207	125	27
Height (mm)	47	1560	1860	1752	62
Chest Circumference (mm)	47	1100	1650	1341	130
Abdominal Circumference (mm)	47	1110	1760	1375	134
Hip Circumference (mm)	47	990	1650	1296	157
Shoulder Breadth (Bideltoid) (mm)	47	420	760	570	104
Forward Fingertip Reach (mm)	47	720	1000	812	55
Sitting shoulder Height (mm)	47	540	770	634	59
Abdominal Depth (mm)	47	280	840	537	113
Hip Breadth (mm)	47	390	880	590	109
Thigh Thickness (mm)	47	230	460	334	59
Buttock to Front of Knee (mm)	47	540	880	633	70
Popliteal Height (mm)	47	390	570	453	53
Knee Splay (mm)	47	460	770	588	71

Table 6.5 Descriptive statistics for study anthropometric measurements – male (n=47)

	N	Range		Mean	Standard Deviation
		Minimum	Maximum		
Weight (kgs)	54	88	200	113	24
Height (mm)	54	1430	1800	1604	86
Chest Circumference (mm)	54	1000	1700	1303	149
Abdominal Circumference (mm)	54	970	1620	1308	137
Hip Circumference (mm)	54	1060	2000	1345	162
Shoulder Breadth (Bideltoid) (mm)	54	350	800	537	90
Forward Fingertip Reach (mm)	54	450	920	735	80
Sitting shoulder Height (mm)	54	490	970	592	80
Abdominal Depth (mm)	54	320	890	498	111
Hip Breadth (mm)	54	460	960	609	113
Thigh Thickness (mm)	54	190	450	310	70
Buttock to Front of Knee (mm)	54	490	850	618	69
Popliteal Height (mm)	54	320	500	386	34
Knee Splay (mm)	54	450	820	577	89

Table 6.6 Descriptive statistics for study anthropometric measurements – female (n=54)

6.7.3.1 Normality of distribution

To assess the normality of the distribution of scores for each measurement the Kolmogorov-Smirnov statistic was calculated. For male participants, the scores for chest, stomach and hip circumference, shoulder breadth, forward fingertip reach and abdominal depth (Figure 6.4) were all non-significant (Sig. value of more than 0.05) indicating normality.

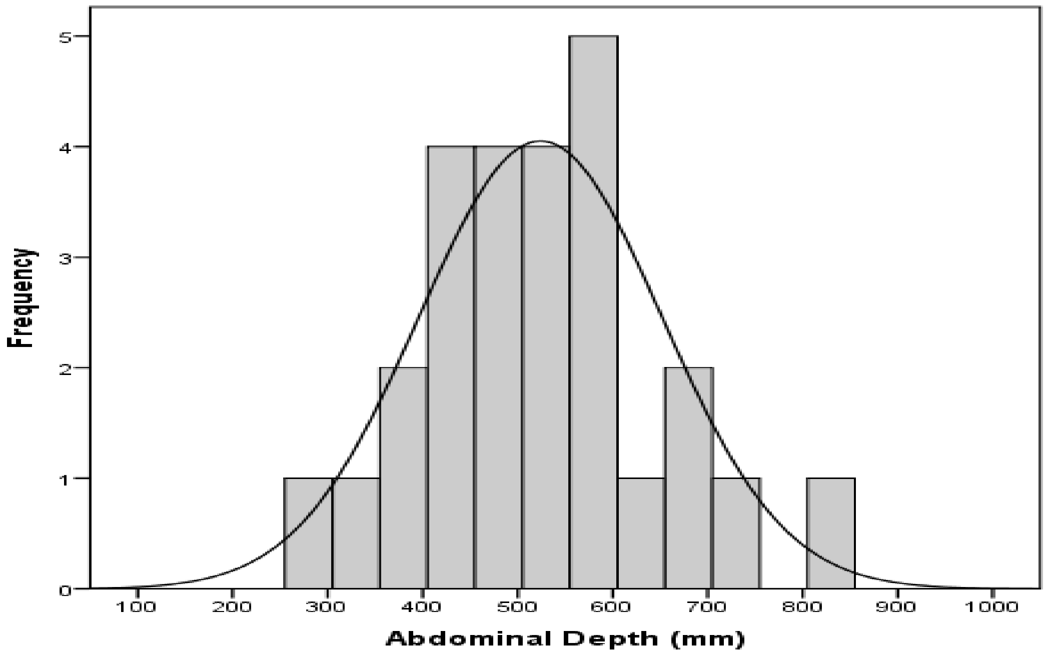


Figure 6.4 Distribution of abdominal depth measurements for male participants (n=47)

Weight, sitting shoulder height, hip breadth, thigh thickness, buttock to front of knee length, popliteal height and knee splay showed a significant result suggesting a violation from the assumption of normality. Skewness score for these measurements were all positive indicating a positive skew where scores are clustered to the left at lower values. The results for height also suggested a deviation away from a normal distribution, but skewness was negative indicating a negative skew where scores are clustered to the right at higher values (Figure 6. 5).

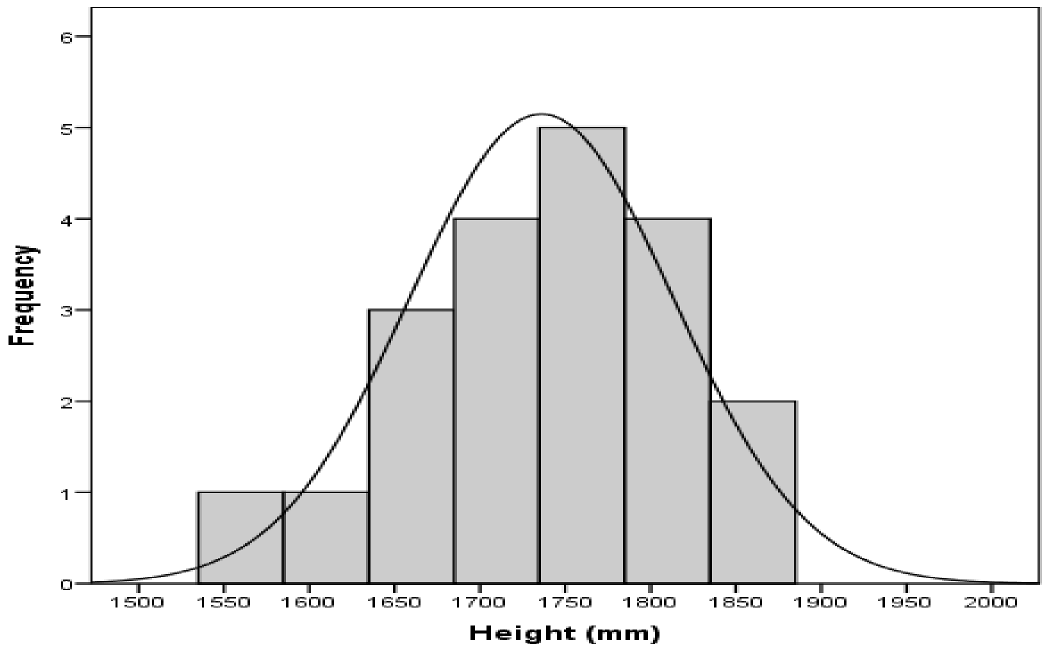


Figure 6.5 Distribution of height measurements for male participants (n=47)

Further analyses of distribution utilising Normal Q-Q graphs were performed. A reasonably straight line was achieved for all of the measurements which had statistically not shown normality, suggesting some agreement between the observed value for scores plotted against the expected value from the normal distribution.

For female participants (n=54)**,** the normality of the distribution scores for height (Figure 6.6), hip circumference, thigh thickness and popliteal height were all non-significant (Sig. value of more than 0.05) indicating normality.

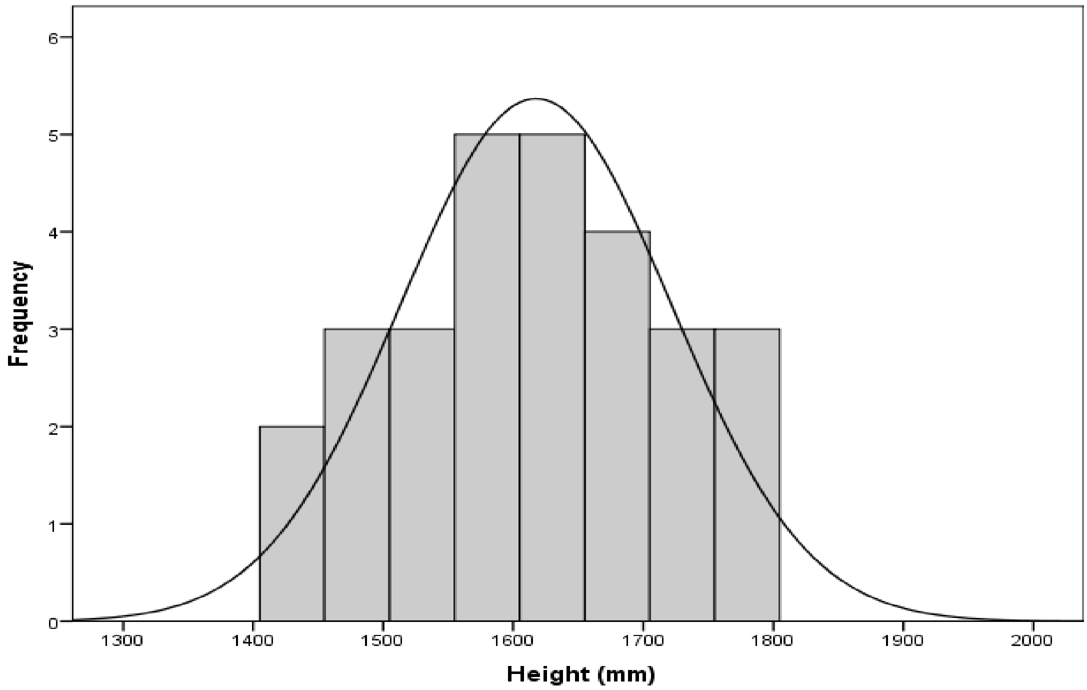


Figure 6.6 Distribution of height measurements for female participants (n=54)

Weight (Figure 6.7), chest circumference, abdominal circumference, shoulder breadth, forward fingertip reach, sitting shoulder height, abdominal depth, hip breadth, buttock to front of knee length and knee splay showed a significant result suggesting a violation from the assumption of normality. Apart from forward fingertip reach, skewness scores for these measurements were all positive indicating a positive skew where scores are clustered to the left at lower values. For forward fingertip reach, the skewness value was negative indicating a negative skew where scores are clustered to the right at higher values.

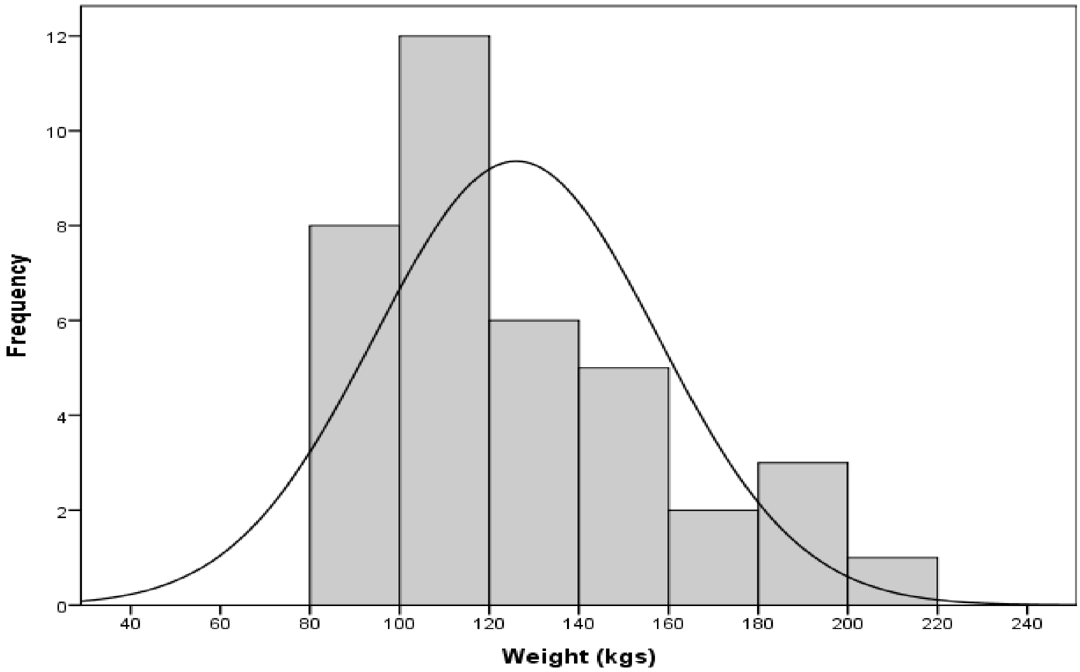


Figure 6.7 Distribution of weight measurements for female participants (n=54)

Similar to males, further analyses of the distribution utilising Normal Q-Q graphs were performed. A reasonably straight line was achieved again for all of the measurements which had statistically not shown normality, suggesting some agreement between the observed value for score plotted against the expected value from the normal distribution.

6.7.3.2 Correlation analysis of anthropometric data

For males and females, the relationship between the 14 anthropometric measurements collected in this study was investigated using Pearson product-moment correlation coefficient (r value). Preliminary analyses were performed to ensure no violation of the assumptions of linearity and homoscedasticity (the error term is the same across all values of the independent variables). The strength of each relationship (Appendix 6.2 and 6.3) was interpreted using guidelines suggested by Cohen (1988);

Small (S)	r= 0.10 to 0.29
Medium (M)	r= 0.30 to 0.49
Large (L)	r= 0.50 to 1.0

For males, there was a large, positive and significant correlation between 27 pairs of anthropometric measurements n=47, p≤0.01 (Table 6.7). The strongest correlations were between; hip breadth and abdominal depth r= 0.77, hip breadth and knee splay r= 0.77 and hip breadth and buttock to front of knee r= 0.75. Chest circumference and hip circumference were also strongly correlated r= 0.72. Weight, hip breadth and knee splay showed strong associations with the highest proportion of other variables for male participants.

For females, there was also a large, positive and significant correlation between 27 pairs of anthropometric measurements (Table 6.8) n=54, p≤0.01. The strongest correlations were between; weight and abdominal depth r= 0.77, chest circumference and hip circumference r= 0.74, knee splay and abdominal depth r=0.71 and hip breadth and shoulder breadth r= 0.70. Chest circumference, abdominal depth and knee splay showed strong associations with the highest proportion of other variables.

For each of the large, positive and significant correlations the coefficient of determination was calculated (r^2) to assess the shared variance between the measurements. For males (Table 6.7), hip breadth could help to explain over 50% of the variance in the participant's buttock to front of knee length, knee splay and abdominal depth measurements, and chest circumference and hip circumference also had over 50% of shared variance. For females (Table 6.8) abdominal depth could help to explain over 50% of the variance in the participants weight and knee splay measurements, and similar to the male data, chest circumference and hip circumference also had over 50% of shared variance.

Correlation test Males	**Pearson correlation coefficient (r value)**	**Coefficient of determination (r^2 value)**	**% variance**
Abdominal depth vs Hip breadth	0.77	0.59	59%
Hip breadth vs Knee splay	0.77	0.59	59%
Hip breadth vs Buttock to front of knee length	0.75	0.56	56%
Chest circumference vs Hip circumference	0.72	0.52	52%
Abdominal circumference vs Hip circumference	0.67	0.45	45%
Abdominal depth vs Knee splay	0.66	0.44	44%
Weight vs Hip breadth	0.64	0.41	41%
Chest circumference vs Knee splay	0.63	0.39	39%
Weight vs Abdominal circumference	0.62	0.38	38%
Sitting shoulder height vs Hip breadth	0.62	0.38	38%
Abdominal circumference vs Knee splay	0.61	0.37	37%
Chest circumference vs Abdominal circumference	0.61	0.37	37%
Sitting shoulder height vs Buttock to front of knee length	0.61	0.37	37%
Weight vs Hip circumference	0.61	0.37	37%
Weight vs Chest circumference	0.61	0.37	37%
Hip breadth vs thigh thickness	0.60	0.36	36%
Hip circumference vs Knee splay	0.59	0.34	34%
Forward fingertip reach vs Buttock to front of knee length	0.59	0.34	34%
Sitting shoulder height vs thigh thickness	0.59	0.34	34%
Weight vs Knee splay	0.59	0.34	34%
Weight vs Thigh thickness	0.58	0.33	33%
Forward fingertip reach vs Sitting shoulder height	0.58	0.33	33%
Thigh thickness vs Buttock to front of knee length	0.56	0.31	31%
Chest circumference vs Hip breadth	0.54	0.29	29%
Knee splay vs Popliteal height	0.54	0.29	29%
Hip circumference vs Hip breadth	0.53	0.28	28%
Hip circumference vs Thigh thickness	0.52	0.27	27%

Table 6.7 Pearson correlation coefficient and coefficient determination for male anthropometric variables (n=47)

Correlation test Females	**Pearson correlation coefficient (r value)**	**Coefficient of determination (r^2 value)**	**% variance**
Weight vs Abdominal depth	0.77	0.59	59%
Chest circumference vs Hip circumference	0.75	0.56	56%
Abdominal depth vs Knee splay	0.71	0.50	50%
Shoulder breadth vs Hip breadth	0.70	0.49	49%
Weight vs Chest circumference	0.69	0.48	48%
Chest circumference vs Abdominal circumference	0.68	0.46	46%
Hip breadth vs Buttock to front of knee length	0.68	0.46	46%
Weight vs Hip circumference	0.67	0.45	45%
Abdominal circumference vs Hip circumference	0.66	0.44	44%
Shoulder breadth vs Buttock to front of knee length	0.66	0.44	44%
Chest circumference vs Knee splay	0.62	0.38	38%
Chest circumference vs Abdominal depth	0.61	0.37	37%
Weight vs Abdominal circumference	0.61	0.37	37%
Hip circumference vs Abdominal depth	0.61	0.37	37%
Weight vs Knee splay	0.59	0.35	35%
Weight vs Hip breadth	0.59	0.34	34%
Abdominal depth vs hip breadth	0.58	0.33	33%
Hip breadth vs Knee splay	0.58	0.33	33%
Chest circumference vs Hip breadth	0.58	0.33	33%
Abdominal circumference vs Abdominal depth	0.58	0.33	33%
Abdominal circumference vs Knee splay	0.57	0.32	32%
Knee splay vs height	0.57	0.32	32%
Weight vs Buttock to front of knee	0.55	0.30	30%
Chest circumference vs Thigh thickness	0.55	0.30	30%
Chest circumference vs Buttock to front of knee length	0.55	0.30	30%
Hip circumference vs knee splay	0.53	0.28	28%
Abdominal depth vs Buttock to front of knee length	0.51	0.26	26%

Table 6.8 Pearson correlation coefficient and coefficient determination for female anthropometric variables (n=54)

6.7.3 Issues at work

Participants were asked if they were currently experiencing any issues with the equipment they used at work; specifically seat sizes, height of desk or working surface, or fit of uniform and PPE (Figure 6.8).

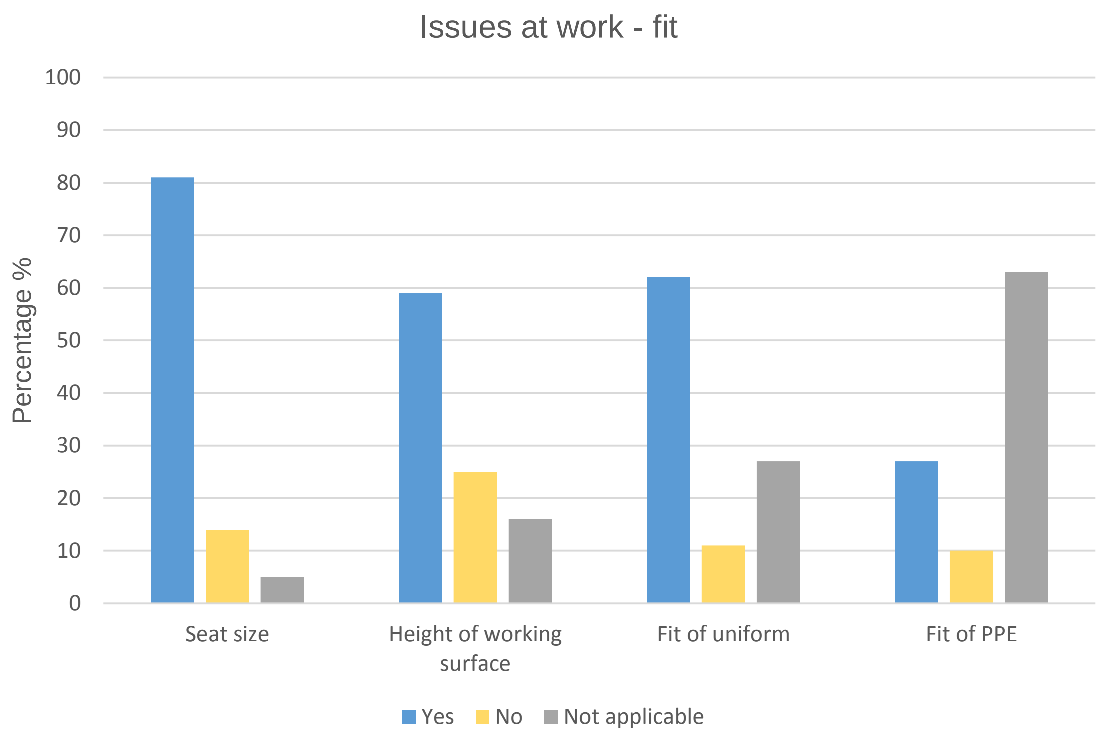


Figure 6.8 Fit issues - currently causing issues at work (n=101)

81% of participants (n=81) reported issues with seat size for example chairs, stools or in the in the car. 59% of participants (n=59) expressed concerns about the height of their working surface (required for legroom clearance). 62% of participants had an issue with the fit of uniform. Uniform was not applicable to another 27% of participants with the remaining 11% (n=11) reporting no concern. For the majority of participants (63%) the fit of PPE was not applicable. However, of the 37% that utilised PPE over half reported problems.

62% (n=63) of participants reported issues with the space in their direct working environment affecting their ability to move around without hindrance. 73% (n=74) identified toilet cubicle size as an issue with 49% (n=50) indicating that space in shared areas such as meeting rooms and cafeterias were currently causing them problems. 43% of participants were experiencing issues with the width of staircases or corridors within their working environment (Figure 6.9).

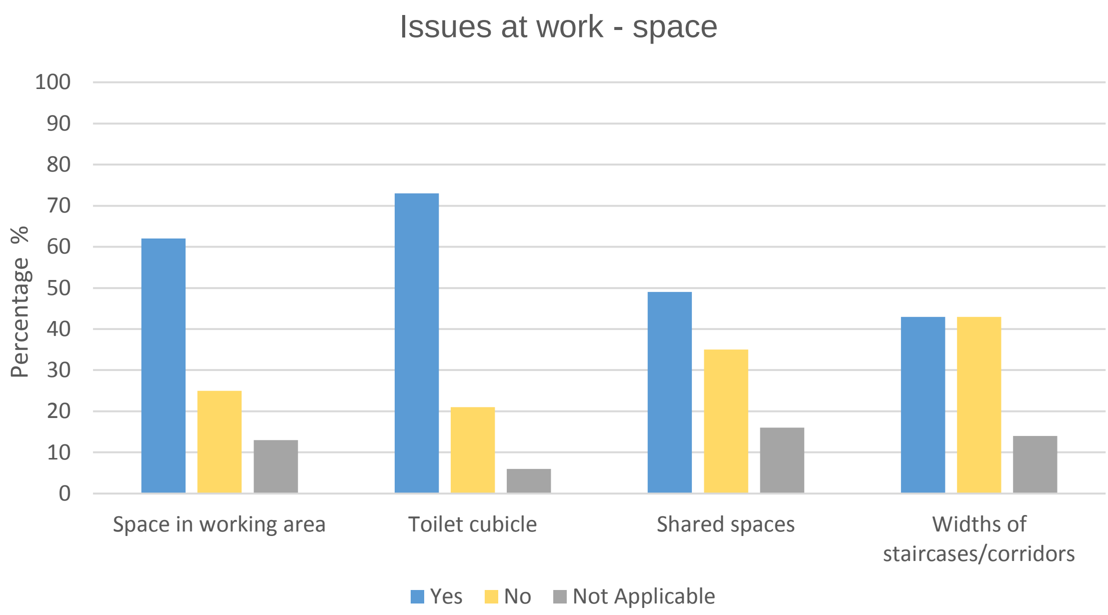


Figure 6.9 Space issues - currently causing issues at work (n=101)

6.7.3.1 Relationship between BMI and issues at work

The percentage of participants within each BMI category reporting issues relating to fit, such as seating, height of working surface, uniform, PPE is shown in Table 6.9. The majority (71%) of participants with a BMI between 30-34.9 kg/m^2 reported issues with seat size with the percentage increasing as BMI increased. All participants with a BMI over 50Kg/m^2 raised seat size as an area of concern. No participants (n=2) with a BMI of under 30 kg/m^2 reported issues with the height of their working surface but similar to seat sizes the majority of participants in each BMI category over 30kg/m^2 reported issues. The fit of uniform and PPE followed in a similar pattern to seat size and height of the working surface, although issues were reported by a higher number of participants (for whom it was relevant) at the lower BMI range. For participants with a BMI above 35kg/m^2, 92% and 89% reported issues with the fit of uniform and PPE respectively.

BMI (kg/m²)	ISSUE											
	Seat size			Height of desk/table (clearance)			Fit of uniform			Fit of PPE		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Less than 29.9 (n=2)	1 (50%)	1 (50%)	0	0	2 (100%)	0	1 (50%)	1 (50%)	0	0	1 (50%)	1 (50%)
30-34.9 (n=17)	12 (71%)	5 (29%)	0	10 (59%)	5 (29%)	2 (12%)	7 (42%)	5 (29%)	5 (29%)	2 (12%)	5 (29%)	10 (59%)
35 -39.9 (n=23)	18 (79%)	4 (17%)	1 (4%)	11 (48%)	10 (43%)	2 (9%)	16 (70%)	3 (13%)	4 (17%)	5 (22%)	2 (8%)	16 (70%)
40-44.9 (n=27)	20 (74%)	4 (15%)	3 (11%)	14 (52%)	7 (26%)	6 (22%)	22 (82%)	2 (7%)	3 (11%)	8 (30%)	0	19 (70%)
45-49.9 (n=13)	12 (92%)	0	1 (8%)	9 (69%)	1 (8%)	3 (23%)	6 (46%)	0	7 (54%)	5 (38%)	1 (8%)	7 (54%)
50-54.9 (n=10)	10 (100%)	0	0	8 (80%)	1 (10%)	1 (10%)	6 (60%)	0	4 (40%)	3 (30%)	0	7 (70%)
55-59.9 (n=4)	4 (100%)	0	0	3 (75%)	0	1 (25%)	2 (50%)	0	2 (50%)	2 (50%)	0	2 (50%)
Above 60 (n=5)	5 (100%)	0	0	4 (80%)	0	1 (20%)	3 (60%)	0	2 (40%)	2 (40%)	0	3 (60%)

Table 6.9 Fit issues reported by plus size participants categorised by BMI (n=101)

The percentage of participants within each BMI category reporting issues relating to space, such as space in working area, toilet cubicle size, shared circulation spaces and width of stairways and corridors is shown in Table 6.10. No participants with a BMI of under 30 kg/m^2 (n=2) reported any issues related to space at work. Only 5 participants with a BMI between 30-34.9kg/m^2 (n=17) raised shared circulation spaces (for example in café or meeting rooms), as an issue and this number was even lower for issues with the width of stairways or corridors with only 2 participants identifying issues (n=17). Space in the work area, that is space to move unhindered and toilet cubicle size were reported as an area of concern for half of the participants with a BMI under 35kg/m^2. Issues with toilet cubicle size increased sharply for participants with a BMI of between 35-39.9kg/m^2 with 78% (n=18) compared to 13% (n=3) finding it a problem.

Generally, this descriptive analysis suggests that there was an increase in issues reported by plus size people with a BMI over 35 kg/m^2. This observation was confirmed by a Chi squared test for independence, which indicated a significant association between the prevalence of issues reported by participants with a BMI of 34.9kg/m^2 and under, and participants with a BMI of 35kg/m^2 and over, for all fit (seat size, height of working surface, uniform and PPE) and space issues (space in working area, toilet cubicle size, shared spaces, corridors/stairways). (n=101, $p \leq 0.05$). This suggests that the issues reported by participants with a BMI of 34.9kg/m^2 or under were significantly less than those with a BMI of over 35kg/m^2.

Due to the small number of participants with a BMI of less than 30kg/m^2 (n=2) and the constraints of the Chi squared analysis if was not possible to explore this area further.

BMI (kg/m^2)	ISSUE											
	Space in work area e.g. space to move unhindered			Size of toilet cubicle			Shared circulation spaces e.g. in café or meeting room			Width of stairways or corridors		
	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A	Yes	No	N/A
Less than 29.9 (n=2)	0	2 (100%)	0	0	2 (100%)	0	0	2 (100%)	0	0	2 (100%)	0
30-34.9 (n=17)	9 (53%)	6 (35%)	2 (12%)	10 (59%)	6 (35%)	1 (6%)	5 (29%)	10 (59%)	2 (12%)	2 (12%)	13 (76%)	2 (12%)
35 -39.9 (n=23)	10 (43%)	12 (53%)	1 (4%)	18 (78%)	3 (13%)	2 (9%)	13 (57%)	9 (39%)	1 (4%)	10 (43%)	13 (57%)	0
40-44.9 (n=27)	17 (63%)	5 (19%)	7 (26%)	18 (67%)	8 (30%)	1 (3%)	12 (45%)	9 (33%)	6 (22%)	12 (45%)	7 (25%)	8 (30%)
45-49.9 (n=13)	11 (84%)	1 (8%)	1 (8%)	10 (77%)	2 (15%)	1 (13%)	5 (38%)	4 (31%)	4 (31%)	5 (38%)	4 (31%)	4 (31%)
50-54.9 (n=10)	8 (80%)	1 (10%)	1 (10%)	9 (90%)	0	1 (10%)	7 (70%)	1 (10%)	2 (20%)	8 (80%)	2 (20%)	0
55-59.9 (n=4)	3 (75%)	0	1 (25%)	4 (100%)	0	0	3 (75%)	0	1 (25%)	3 (75%)	1 (25%)	0
Above 60 (n=5)	5 (100%)	0	0	5 (100%)	0	0	5 (100%)	0	0	4 (80%)	1 (20%)	0

Table 6.10 Space issues reported by plus size participants categorised by BMI (n=101)

6.7.4 Comparison of anthropometric measurement data to existing datasets

6.7.4.1 Comparison of means

The mean for each of the 14 anthropometric measurements collected in this study was compared to the mean for each of the corresponding measurements contained within two existing datasets, Peebles and Norris, (1998) and Pheasant and Haslegrave (2006) as shown in Table 6.11.

In males (n=47), 7 measurements were substantially larger for the study population. Mean weight (kgs) was 46kgs heavier than the mean weight of the two existing datasets. Circumference measurements of the waist and hips were larger by 390mm and 250mm respectively and breadth measurements were also larger in the study population; shoulder breadth by 73mm and hip breadth by 197mm. Depth measurements of the abdomen and thigh were larger by 256mm (abdominal depth) and 167mm (thigh thickness). Only one measurement, forward fingertip reach, was substantially less by 92mm in the study population compared to the two datasets. Male chest circumference is not recorded for British adults aged 18-65 year olds in either of these datasets so was not included for comparison.

For female participants (n=54), 8 measures were substantially larger in the study population compared to existing datasets. Abdominal circumference (+467mm) abdominal depth (+228mm), and hip circumference (+308mm) and hip breadth (+228mm) demonstrated the largest differences (Table 6.11). The mean weight of female participants was heavier by 45kgs. Similar to male participants, only one measurement, forward fingertip reach, was substantially less (-72mm) in the study population when compared to the two datasets.

Knee Splay

As knee splay is a novel measure (for a non pregnant population), it is not possible to make direct comparisons with these datasets. However, as it is a breadth measurement pertinent to seating posture, the decision was taken to compare it with hip breadth and shoulder breadth (bideltoid) measurements which are commonly utilised to determine seating requirements (Section 5.3.1.1). For male participants, mean knee splay measurements were compared to mean shoulder breadth data in the two existing datasets and was larger by 91mm and compared to hip breadth was larger by 195mm. For females, mean knee splay measurements were larger than both mean shoulder breadth and hip breadth measurements by 166mm and 199mm respectively.

For interest, 1st, 5th, 50th, 95th and 99th percentile comparisons between the study population (males and females) were performed (Appendix 6.4 and 6.5). Due to the potential differences in sampling strategy and sample size between the current study and the two datasets, exclusion rates were more deemed appropriate to understand the potential match/mismatch between the current design guidance based on anthropometry and the study population.

Anthropometric Measure	Male			Female		
	Study Mean	Existing Dataset Mean	Difference	Study Mean	Existing Dataset Mean	Difference
Weight	125kg	79kg	**+46kg**	113kgs	68kg	**+45kg**
Height	1752mm	1755mm	+3mm	1604mm	1620mm	-16mm
Chest Circumference	1341mm	No male data for comparison		1303mm	1008mm	**+295mm**
Abdominal Circumference	1375mm	985mm	**+390mm**	1308mm	841mm	**+467mm**
Hip Circumference	1296mm	1046mm	**+250mm**	1345mm	1037mm	**+308mm**
Shoulder Breadth (Bideltoid)	570mm	497mm	**+73mm**	537mm	458mm	**+79mm**
Forward Fingertip Reach	812mm	906mm	-92mm	735mm	807mm	-72mm
Sitting shoulder Height	634mm	610mm	+24mm	592mm	573mm	+19mm
Abdominal Depth	537mm	281mm	**+256mm**	498mm	270mm	**+228mm**
Hip Breadth	590mm	393mm	**+197mm**	609mm	411mm	**+198mm**
Thigh Thickness	334mm	167mm	**+167mm**	310mm	154mm	**+156mm**
Buttock to Front of Knee	633mm	613mm	+20mm	618mm	588mm	+30mm
Popliteal Height	453mm	448mm	-5mm	386mm	398mm	-12mm
Knee Splay	588mm	393mm 497mm	**+195mm** (hip breadth) **+ 91mm** (shoulder breadth)	577mm	411mm 458 mm	**+166mm** (hip breadth) **+119mm** (shoulder breadth)

Table 6.11 Comparison of means between study anthropometric measures to existing datasets (n=101)

6.7.4.2. Exclusion rates

The percentage of the study population that might be excluded from design that accommodates up to 95th and the 99th percentile (British adult 18-65 year old data) as defined by anthropometric data currently available in the literature (Peebles and Norris 1998, Pheasant and Haslegrave, 2006) was calculated. A degree of exclusion, was found for 10 of the measurements (Table 6.12). For males, the exclusion rate for thigh thickness was 100% at the 95th percentile level and 99th percentile level. In addition, nearly all of the male plus size study population would potentially be excluded from design that based weight, abdominal circumference and depth, hip circumference or hip breadth at the 95th percentile design limit. However, the levels of potential exclusion was much higher for females. All (100%) of the study population would have been excluded from design in terms of weight, hip breadth, thigh thickness and abdominal circumference and depth that used the 95th percentile data from the two datasets.

Knee splay

Once again, because knee splay dimensions are not included in existing datasets, exclusion rates for knee splay were estimated by considering hip breadth and shoulder breadth measurements. When calculating the exclusion rate for knee splay using hip breadth measurements from existing datasets, 100% of the male and 99% of the female study population would potentially be excluded from design based on the 95th and 99th percentile design limits. Using shoulder breadth for comparison, 82% of male and 100% of female participants would potentially be excluded using the 95th percentile limit, and 79% and 99% respectively at the 99th percentile design limit.

Measurement	Exclusion Rate (95th percentile)		Exclusion Rate (99th percentile)	
	Male (n=47)	Female (n=54)	Male (n=47)	Female (n=54)
Weight	97%	100%	87%	99%
Chest Circumference	82%	79%	67%	59%
Abdominal Circumference	95%	100%	93%	98%
Hip Circumference	98%	92%	71%	78%
Shoulder Breadth (Bideltoid)	64%	92%	54%	80%
Abdominal Depth	96%	100%	95%	100%
Hip Breadth	99%	100%	97%	100%
Thigh Thickness	100%	100%	100%	98%
Buttock to Front of Knee Length	23%	47%	18%	21%
Knee Splay	***100%*** *(compared to hip breadth)* ***82%*** *(compared to shoulder breadth)*	***100%*** *(compared to hip breadth)* ***100%*** *(compared to shoulder breadth)*	***100%*** *(compared to hip breadth)* ***79%*** *(compared to shoulder breadth*	***99%*** *(compared to hip breadth)* ***99%*** *(compared to shoulder breadth)*

Table 6.12 Exclusion rate (%) determining the percentage of study respondents that might be excluded from design that accommodates up to 95th or 99th percentile (British 18-64 year old data) in existing datasets

6.8 Discussion

The plus size anthropometry study was conducted to collect anthropometric data from plus size working age people pertinent to workplace design and subsequently to understand this newly acquired data in the context of existing datasets. In addition, a further objective was to identify any issues related to fit or space which affect plus size people in the working environment and how these issues relate to body largeness in terms of BMI. The findings will now be discussed followed by the limitations of the study and conclusions.

6.8.1 Anthropometric data

For plus size males (n=47) and females (n=54), correlation analysis identified a strong and significant relationship between 27 pairs of anthropometric variables. Correlations differed by gender but all showed a positive correlation in that as one measurement increased so did the other. No measurements indicated a perfect correlation, in that the value of one measurement could be determined exactly by knowing the value on the other variable (Pallant, 2016) However, male hip breadth was strongly correlated with abdominal depth and knee splay (r=0.77, n=47, p≤0 .01) and buttock to front of knee (r=0.75, n=47, p≤0.01). This suggests that hip breadth may be a useful measure for forecasting the magnitude of these other measures , for example an individual with a 95th percentile hip breadth is also likely to be in the higher percentile for abdominal depth, knee splay and buttock to front of knee.

For females, abdominal depth was strongly correlated with weight (r=0.77, n=54, p=<0.01) and knee splay (r=0.71, n=54, p≤0.01) and 5 additional measures (chest circumference r=0.61, n=54, p≤0.01; hip circumference r=0.61, n=54, p=<0.01; abdominal circumference r=0.58, n=54, p≤0.01; hip breadth r=0.58, n=54, p≤0.01 and buttock to front of knee length r=0.51, n=54, p≤0.01) Again, this is a good indicator in terms of the largeness of these dimensions. Weight, was strongly and significantly correlated with all three circumference measurements (chest, abdominal and hip), and breadth measurements of hip breadth and knee splay for both males and females. In males, the relationship between weight (and thigh thickness was also strong. For females weight and abdominal depth, and buttock to front of knee showed strong relationships. This suggests, that an increase in weight does not relate to just one anatomical area. As weight increases so do measurements of circumference, depth and breadth affecting the torso and lower body. Due to the dearth of literature exploring the anthropometric characteristics of the plus size person it makes comparing the findings of this study difficult. However, the large correlation between many variables (in different regions of the body) suggests that simplistic descriptions of plus size shape as either ‘apple’ (body fat in abdominal area) or ‘pear’ (body fat in lower abdominal and buttock/upper thigh area) (Thoma et al., 2012) or ‘endomorphic’ (Olds et al., 2013) may be unrepresentative of the current plus size working population.

The diversity of the plus size shape across the study population is also apparent in the percentage of variance shared by pairs of anthropometric measurements. For males, just over half of the variation in abdominal depth, buttock to front of knee or knee splay can be explained by hip breadth. Similarly for females, abdominal depth accounts for half of the variation in weight and knee splay but there are likely to be other unknown factors involved. These findings, suggest that for each gender there exists significant shape variability among plus size individuals. This is a view supported by Park et al., (2012) who identified eight body types (including ‘large everywhere’, small torso and large lower body’ and ‘large torso surface’) for Korean plus size individuals. However, they acknowledged that there still remained a wide range of characteristics within each description of body shape. This important result potentially has impact on profiling the plus size body shape. The distribution of body fat may be help to explain such variation in the shape of plus size individuals. All participants in this plus size anthropometry self-classified themselves as plus size or larger than average. This was supported by the calculation of BMI which confirmed every participant was either overweight (BMI above 25 kg/m^2 or obese (BMI above 30 kg/m^2). Therefore, it is likely that participants had a high proportion of body fat and differences in the location and magnitude of body fat deposition may help to explain this variability in body shape.

6.8.2 Issues at work

A high proportion of the study population reported issues relating to both 'fit' and 'space' within their working environment.

> *" Nothing I use at work actually fits me. I squeeze into my chair, squeeze past my colleagues to then squeeze into my company car"* (male, aged 45-64 years)

Supporting the results from the scoping study (Masson et al., 2015) seat sizes was again reported as the biggest concern regarding the 'fit' of the working environment, with the majority (81%) of participants reporting issues. Despite claims that seating designers have responded to the increase in the populations weight by producing products that have more adjustments and support features that enable a broader range of people to sit comfortably (Bender et al., 2011), the findings suggest that plus size people are still experiencing issues;

> *" the plastic rim digs into my overhang"* (female, aged 18-24years)

> *"I can't use a seat with armrests – I know I won't fit. It's quite embarrassing"* (female, aged 45-65 years)

In a small (n=10) interview based study by Kösten et al., (2016) plus size people (mean BMI 37 kg/m^2) also identified seating as an area of concern. Participants reported facing seating options that were not appropriate for their weight and a fear of falling off/breaking a chair that will not withstand their size. Therefore, appropriate anthropometric data is paramount to seating design (Deros, 2015). Pheasant and Haslegrave (2006) recommends that designing appropriate seat sizes depends on understanding the anthropometric measurements of hip and shoulder breadth, sitting shoulder and popliteal height and buttock to popliteal knee length. Therefore understanding the anthropometry of the study population in the context of existing datasets may help to explain the issues surrounding seating. This is vital given that Benden et al., (2011) in a study of 51 office workers found that the more overweight the individual was, the more likely they were to spend most of the day seated. The same study also found that those with a BMI over 35kg/m^2 spent 20% more time seated per shift than those with a BMI of 34.9kg/m^2 or under. Although no reasons were cited in the study for plus size people spending more time seated, recent research has suggested workplace stigma (Kösten et al., 2016), fatigue (Benden, 2008) and functional limitations (Sibella et al., 2003) may be contributory factors. The findings of the current study also indicate that design of the working environment may be a factor, with 62% reporting issues with the space in their direct working area affecting their ability to move around unhindered. Half of the study population also reported issues with space in shared areas (meeting rooms, restaurants, corridors);

> *" I stay in one place because it's easier than moving around. Then I don't get stuck"* (male, 45-65 years)

> *" Space – I have no space. I fill the space"* (female, 25-44 years)

73% of participants reported toilet cubicle size as problematic. The findings are in line with Kösten et al., (2016) who found that 80% (n=10) of plus size people identified cubicle space as too small. Doors that open to the inside and reduce the space to enter or leave the cubicle, and hygiene concerns due to the probability of touching surfaces when manoeuvring were all cited as reasons for dissatisfaction with toilet cubicle size. One explanation for plus size people encountering difficulties interacting with the surrounding furniture, tools, clothes/uniform and space for example in shared areas and toilet cubicles is that they are all basically designed for normal weight (BMI 20.2 ±

1.0 kg/m^2) subjects (Menegoni et al., 2009). Design guidance, such as Regulation 10 of the Workplace, (Health Safety and Welfare) Regulations (HSE, 1992) and Building Regulations Part M (Department for Communities and Local Government, 2015) determine fit and space requirements based on existing anthropometric data. Circumferences determine turning circles (Pheasant, 2006), breadths, depths and lengths determine ingress and egress (Weekes, 2010) and individual space requirements are based on an average user (Perry, 2010). Any mismatch between the dimensions of the actual user and the design will result in dissatisfaction leading to issues (Brewis, 2014). This is further supported by the findings of this study comparing issues reported between groups of participants with different BMI's.

6.8.2.1 BMI

Although some issues were reported by participants with a BMI of 34.9kg/m^2 and under (especially with regard to seat size, fit of uniform and toilet cubicles sizes), there was a significant difference ($n=101$, $p \leq 0.05$) in the frequency of issues reported by individuals with a BMI of 35 kg/m^2 and over compared to a BMI of 34.9kg/m^2 and under. This was across all issues of fit (seat size, height of desk or working surface, fit of uniform and PPE) and space (direct working environment, toilet cubicle size, shared areas such as meeting rooms or staircases/corridors). This suggests that the working environment may be particularly unsuitable for plus size people with a BMI over 35 kg/m^2. The prevalence of individuals with a BMI of between 35-39.9 kg/m^2 has almost doubled between 1991 and 2013 to 24% for males and 22% for females (HSCIC, 2013). For individuals with a BMI over 40kg/m^2 the increase has been three fold to 2% for males and 4% for females and this rapid increase is expected to continue with prevalence predicted to rise to almost 3% in men and 6% in women by 2030 (Lobstein et al., 2007).The relationship between fit and space issues reported by plus size people in the working environment and BMI has not previously been explored in the literature. The findings therefore represent a useful insight into the extent of the problem for individuals with a BMI over 35 kg/m^2.

6.8.3 Comparison of Anthropometric Data to Existing Datasets

6.8.3.1 Comparison of means

By comparing the mean of each measurement collected in this plus size anthropometry study with the mean of the same measurement in existing datasets, it is identified that the study population is considerably larger. However, the results suggest that the participants are not larger all over; the largeness is related to circumference, breadth and depth measurements rather than the measurements related to length.

6.8.3.2 Measures of length

For both male and female participants the mean of the length related measures of height, sitting shoulder height, buttock to front of knee length and popliteal height were similar between the study data and existing datasets. However, interestingly, forward fingertip reach, was smaller for the study population by 92mm for males and 72mm for females. Measured horizontally from the wall to the to the tip of the middle finger with the person standing erect with arm stretched horizontally in front of them, this measure is vital for establishing reach envelopes. A few studies have previously reported on reduced reach for plus size participants compared with normal weight individuals primarily due to plus size participants adopting altered movement strategies to accommodate their size. For example, Hamilton et al., (2013) found that a high BMI significantly affected the maximal frontal reach during small parts assembly work. Plus size participants stood further away from the workstation in order to accommodate a larger abdominal depth. Gilleard and Smith (2007) also reported that plus size individuals positioned themselves further away from the working surface, possibly because their body dimensions had prevented them standing closer. However, neither of these studies reported on the length measure of forward fingertip reach being smaller. The shorter forward fingertip reach (compared with existing datasets) in combination with an increase in circumference, depth and breadth measurements (compared with existing datasets), may further compound the apparent reduction in reach of a plus size individuals.

6.8.3.3 Circumference, breadth and depth measurements

Although depth and breadths are simple linear measurements they tend to reflect volumetric body size (Annis, 1996). Circumference measurements are enclosed curvilinear measurements which say even more about body volume. As a result males and females might be expected to show an increase in depth, breadth and diameter measurements particularly in areas where fat tends to be deposited (Karine et al., 2015). However, the potential scale of this increase is less well known. All 7 of the mean circumference, breadth and depth measurements collected in this study (Figure 6.11) were larger than those in existing datasets. Mean abdominal circumference for males and females showed the greatest difference when compared to values within existing datasets; 390mm larger for males and 467mm larger for females. The depth measure with the greatest difference was abdominal depth (256mm larger for males and 228mm larger for females) suggesting that changes in the abdominal region of the plus size individual may be particularly relevant to accommodating plus size individuals. Park et al., (2012) reported that largeness of the abdominal region is a feature of plus size body shapes for both males and females.

The large difference in abdominal depth between the study population and existing datasets may be in part be explained by the interaction of body parts. In a seated posture, the 'spread effect' (Weekes et al., 2010) results in in the abdominal region being larger than in standing. In standing the abdomen has space around it and can take its natural shape under the influence of gravity. This occurs to some degree in all individuals. However, when a plus size individual sits down the space available below the abdomen is limited by the upper thighs. The thighs exert an upward pressure on the abdomen pushing it upwards and outwards. As the mean thigh thickness of the study population was bigger than the mean of existing datasets by 167mm for males and 156mm for females, the thighs would displace the abdomen further forwards increasing abdominal depth. This may be more problematic in instances where seats within the working environment slope backwards, for example in vehicle seats (company cars, lorries, buses) as the angle between the legs and the trunk is further decreased increasing contact between the abdomen and thighs.

Substantial differences between the study population and existing datasets were not limited to the abdominal region. Measurements of the chest, hip, shoulder and thigh regions were also found to larger; all areas for potential fat deposition. This suggests that the challenge of producing a modern dataset by updating existing older data lies almost entirely in the "fatty" dimensions (Open Ergonomics, 2008).

6.8.3.4 Exclusion

A common compromise in design is to select dimensions to accommodate the 5th percentile up to the 95th percentile (Bratmiller et al., 2004) that is to accommodate 90% of the population. In some safety critical arenas, the aim may be to accommodate 1st to 99th percentile of the population (see Section 2.2 for definition of percentiles). However, the findings from this study suggest that for the majority of measurements (excluding length based measures), the study population is substantially larger than the values (95th and 99th percentile) cited in most existing datasets. This is likely to result in plus size people being excluded and indeed this study identified that for 10 of the 14 anthropometric measurements a proportion of the study population would potentially be excluded from design in many working environments.

Weight (kgs) is often used to determine acceptable user weight limits for a range of seating options, such as office chairs, communal seating and toilet seats and their associates components such as arm rests (Capodaglio et al., 2010). Although acknowledging that seating is tested to withstand a greater weight than its upper user limit (FIRA, 2016), 97% of males and 100% of females in the current study would be excluded if the 95th percentile value for weight was used. The average male weight was 39 kgs heavier than the 95th percentile from existing datasets. 87% of males and 99% of females would also be excluded from designs that accommodated up to the 99th percentile value in terms of weight (kg). These high exclusion rates for weight have obvious safety implications in that potentially the study population would be using equipment that was not designed to support their weight. This has been linked to accidents such as falls from height and ill health such as musculoskeletal injuries (HSE, 2013). Concerns with regard to safety and robustness due to weight limits were also documented by plus size participants in an interview study by Kösten et al., (2016) with some participants reporting chairs breaking underneath them and 'flimsy' or 'unstable' looking chairs were mentioned as worrying.

Measurements of hip breadth, abdominal depth and thigh thickness were also found to have high exclusion rates in this study - these measures are particularly relevant when designing for clearance. Thigh thickness is the clearance required between seat and underside of table or other obstacles (McKeown, 2011). All of the study population would be excluded if thigh thickness was used in the design at the 95th percentile level (the mean being 145mm larger than the 95th percentile in existing datasets). The exclusion rate was also 100% for males and 98% for females at the 99th percentile level. Lack of under surface clearance may result in individuals being held back from the work surface and unable to reach, requiring them instead to over lean to complete the task (Annis,1997) or needing to sit sideways and twist their upper body. This may be further compounded by findings of a study by Paul et al.,(1995) who observed that the working surface height of choice for pregnant women was lower than the standard height contained within guidance such as 'BS EN 1335-1:2000 Office furniture. Office work chair. Dimensions. Determination of dimensions (2000)' with Copodaglio et al., (2010) suggesting similar preferences would apply to plus size individuals. This kind of guidance could lead to an even greater mismatch between the anthropometric requirements and the preferences of the plus size working individual and the existing design of the working environment.

Hip breadth, indicative of lateral clearance for seating, is a key measurement in the design of chairs and other seating options and can be used for example, to determine how many people can fit onto a communal bench or shared seat in a workplace cafeteria. With regard to seating at work the Health and Safety Executive specify that the primary requirement of a work chair is to enable the user to adopt a comfortable position (HSE, 2011). The estimated exclusion rates for hip breadth were 99% for males (95th percentile limit) reducing slightly to 97% (99th percentile limit). All of the female study population would have been excluded at both limits – the difference was approximately 170mm. This suggests in terms of providing adequate clearance, the majority of participants in this study could have been excluded from current workplace design. The finding from the validation study, Masson et al., (2015) also previously highlighted seating as problematic for 55% of the plus size respondents. Interestingly, shared seating was seen as even more uncomfortable than individual seats by Kösten et al., (2016) due to the designated seating area for one person being described by participants as 'too small' and 'made worse by having to impose on the other person's space'. This once again highlights that when considering shared seating, previous guidance (Pheasant and Haslegrave, 2006) suggesting that the breadth of a 95th percentile couple is less than twice that of a 95th percentile individual may be need rethinking.

Abdominal depth, is used to determine the minimum clearance between the seat back and obstructions forward of the seat (McKeown, 2011) for example an office chair and the rim of the desk or a car seat backrest and the steering wheel. A design based on accommodating up to the 95th percentile male (Peebles and Norris 1998, Pheasant and Haslegrave 2006) would exclude approximately 96% of the male study population and 100% of females in terms of abdominal depth by approximately 193mm. Designs to include up to the 99th percentile still have an exclusion rate of 95% for these males and remains at 100% for the females. Abdominal depth, that is the most protruding point of the abdomen, influences an individuals posture at the work desk or work surface usually forcing the individual to be at a greater horizontal distance from the target (Capodaglio et al., 2010) and adopting a more flexed sitting or standing posture. As a result the working envelope is reduced. (Section 6.8.3.2). If the increased abdominal depth and subsequent reduction in reach is not taken into consideration in the design of the task or environment, this may increase the risk of musculoskeletal disorders associated with prolonged awkward postures (Wearing et al., 2006). This is important as plus size participants in a study by Park et al., (2009) demonstrated much higher levels of perceived postural stress across 84 different working postures than non plus size individuals demonstrating a lower threshold for acceptable working postures. The mean BMI in this study by Park et al., (2009) was 46 kg/m^{2,} similar to the study mean in the current study (40.3 kg/m^2 and 43.5 kg/m^2 for male and female participants respectively).

High exclusions rates from designs based on abdominal depth measurements may also have safety implications for example, proximity to the steering wheel or seatbelt usage. As transport was one of the largest sectors in which the study population was employed, and in addition, participants employed within other sectors such as public services, may be required to utilise company vehicles, these exclusion rates may be of concern. The mean abdominal depth of the study population exceeded the 95th percentile value from existing datasets by 195mm. In a situation where space is restricted, like a car, such a large difference may require the plus size driver to sit with their abdomen very close to the steering wheel. This is likely to go against the recommended 250mm distance between the sternum and the centre of the steering wheel (Segui-Gomez et al., 1999). Adopting a position close to the steering wheel has safety implications and has been associated with an increased risk of injury especially in relation to air bag activation (Hartgarten et al., 2010).

As well as abdominal depth impacting on space requirements in front of the abdomen, more space is required behind the individual to facilitate both sitting and standing and to egress and ingress. Accessibility to the working area and space to move around unhindered depends upon the design incorporating chest, waist and hip circumference measurements combined with hip breadth measures to ascertain turning circles and access (McKeown, 2011). The high exclusion rate for abdominal depth, combined with high percentages of the study population that would be excluded based on the circumference measures and hip breadth may further result in plus size individuals adopting awkward postures with the associated risks. In addition, this may also hinder participation in activities and social roles within the working environment (Jackson et al., 2014). This is particularly important as it violates the principle of equitable use in Universal Design (Mace, 1997) where the design should not disadvantage or stigmatise any groups of user. Also, the principle of size and space for approach and use, indicating that appropriate size and space should be provided for approach, reach, manipulation and use, regardless of the users body size, posture or mobility was also not met;

> *"I stay in my chair too long and it's too awkward to get up as I have to disturb too many other people" (*female, aged 18-24 years)

> *"I choose carefully, which training courses to go to. The location of some are impossible"* (male, aged 45-64 years)

Given the high exclusion rates for the majority of anthropometric measurements taken (10 out of 14) in this plus size population, it is not surprising that the participants reported substantial fit and space issues within their working environments.

6.8.4 Knee Splay

The measure of knee splay is defined as the distance between the outer borders of the knees whilst seated in the preferred posture (Serpil and Weekes 2006). It was included in this study because the standard anthropometric measurements of knee breadth and hip breadth, for seat width and clearance (chairs, toilet seats, shared seating, car seats), are measured with the knees together, a posture infrequently adopted by plus size individuals (Sibella, 2003). The measurement of knee splay in the plus size working population is important for investigation as it may influence an individuals comfort and safety in the working environment. This section discusses knee splay and its implications for design.

From the findings presented in Section 6.8.1, it is clear that being plus size results in dimension changes affecting all body areas. For both males and females, knee splay was strongly positively correlated with weight, chest, hip and abdominal circumference, hip breadth and abdominal depth - as knee splay increased the other measures also increased. This suggests that knee splay is a good predictor of overall largeness but as it has not previously been collected or applied to a non-pregnant population, there is no comparable data to explore in existing datasets. The only published data on knee splay (Weekes et al., 2010) relates to UK pregnant adults in the third trimester, who had a mean stature of 1664mm (SD 70mm). In this sample, mean knee splay was 353mm which is 234mm and 224mm smaller than the mean male and female data for the plus size study population. Concerning the wide knee splay adopted by the study population, Sibella (2003) suggested that this position is adopted due to an increased abdominal circumference and depth. In addition, Copodaglio et al., (2009) also suggesting, following a period of observation of 44 plus size individuals, observed that the knees tend to splay apart in the seated posture to facilitate trunk flexion and reduce weight on the pelvis. Finally, increases in adipose tissue may result in the thighs increasing in size (as suggested by thigh thickness measurements). In the seated position, the seat applies an upward pressure on the thighs and spreads the soft tissue horizontally, known as the spread effect (Weekes et al., 2010). This would lead to an increase in individual thigh breadth meaning the plus size individual has difficulty putting the knees together, resulting in an increase in knee splay. Plus size participants reported both discomfort;

> *“I drive a van for at least 8 hours a day. The seat doesn’t support my upper legs and my knees rest on the gear change one side and the door the other”* (male, 45-65 years)

and embarrassment;

> *"my nightmare is someone coming to sit next to me in the breakout room"* (female, 18-24 years)

and experienced a high prevalence of fit and space related workplace issues which may be influenced by the knee splay findings of this study. When compared to existing hip breadth data (Pheasant and Haslegrave, 2006), mean knee splay exceeded the 95th percentile values by 180mm for males and 108mm for females suggesting that current anthropometric datasets are not inclusive of plus size individuals when consideration is given to positions of comfort frequently adopted or indeed positions adopted due to anatomical or physiological necessity. Current design practices and data sets are likely to have excluded over 99% of the male study population and 100% of the female study population using both the 95th and 99th percentile criteria. Considering shoulder breadth (bideltoid) for comparison, 82% of male and 100% of female participants would potentially be excluded using the 95th percentile limit, reducing to 79% and 99% respectively at the 99th percentile design limit. These high exclusion rates may help to explain why plus size individuals in previous research by Kösten et al., (2016) found the width of the seating area much too small. Participants are also often forced to sit on the outside part of the seat so that there is more space between the individual and the other person.

There is strong evidence that;

- plus size individuals (by preference and necessity) adopt a different posture and sit with their knees widely spaced.
- knee splay measurements are substantially larger than existing hip breadth or shoulder breadth measurements.
- knee splay measurements are substantially larger than existing knee splay measurements documented for pregnant women.

- plus size individuals report high number of issues related to clearance (seat sizes – shared and individual , height of working surfaces, space to move around unhindered).
- there are high exclusion rates from existing design practices based on knee splay data.

Consideration should therefore be given to including the functional measure of knee splay in existing datasets and subsequent design activities to include plus size people in workplace design.

One of the knowledge gaps when designing to include plus size people is the lack of a current anthropometric dataset of the plus size population. The collection of anthropometric data is extremely time consuming and expensive (Pheasant and Haslegrave, 2006) and often data is estimated for this reason (Ward, 2011; Cavdar, 2014). In addition, it is known that secular changes can occur quite rapidly in populations (Park et al., 2013), but surveys are rarely repeated at frequent intervals leading to the use of outdated data which may be at best an approximation of the actual user population (Gupta et al., 2010). However, employers have legal duties to provide workplaces suitable for their employees (The Workplace; Health, Safety and Welfare) Regulations HSE, 1992). In December 2014, the EU highest court stated that being plus size can 'constitute a disability if it "hinders full and effective participation by the individual concerned in their professional life on an equal basis with other workers; (Equality and Human Rights Commission, 2015). This implies that whether or not a person could be classified as disabled could, among other things, be determined by the design of the workspace and the extent to which it includes the needs of the plus size individual.

6.9 Limitations

Although the sample size was appropriate in terms of age and gender spread, a larger sample size would have allowed a greater representation of the plus size working population and more confidence in the findings. The sample size fell short of a statistical power formula proposed in ISO 15535:2012 General requirements for establishing anthropometric databases

(International Standardisation Organisation, 2012) which suggests a sample size of closer to 300 to establish a database with the required level of accuracy. However, it was not an objective of the study to create a database. Participants were recruited to the study via a non-probability sampling strategy. It is therefore possible that the sample could be non-representative of the plus size population which may introduce other potential biases. Random or stratified sampling techniques were considered but to the relatively unknown population and the anticipated difficulty in recruiting participants they were not deemed appropriate.

Due to the relatively small sample size (n=101), the sampling strategy or potentially the construct that was being measured, the anthropometric data of the plus size working age people collected in this study was not normally distributed for all measurements. However, further analyses of distribution utilising Normal Q-Q graphs demonstrated a reasonably straight line for all of the measurements which had statistically not shown normality. Any deviation away from a normal distribution should be considered when interpreting the findings of this study and in particular comparisons with existing datasets.

The questionnaire element of this study collected quantitative data on the issues experienced by plus size people within the working environment. Apart from the last question, which enabled participants to make further comments related to issues affecting them at work, the questionnaire did not facilitate understanding the full context of the issues. Although this detail would have provided greater insight into the issues and knowledge to support stakeholders in meeting the needs of plus size people at work it would have substantially increased the time taken to complete the study impacting on response rate (Robson, 2011) and potentially accuracy of the measurement component.

Finally, only 2 participants with a BMI of 29.9kg/m^2 and under completed the study. It was therefore not possible to include them as a separate group for statistical analysis and therefore they were merged with participants with a

BMI between 30-34.9 kg/m^2. Bigger cell counts for lower BMI's would have enabled a better understanding of the anthropometric data and issues for these participants.

6.10 Conclusions

The results support the following conclusions:

- Plus size people are clearly larger, but not in all dimensions. Length measurements remain similar to existing datasets but measurements of breadth, circumference and depth are substantially increased.
- In males, hip breadth may be a useful measure for predicting the magnitude of other anthropometric measurements. In females, abdominal depth is useful for predicting largeness.
- There is much variability in the body shape of UK plus size working population. Although some variability can be explained by shared variance between anthropometric measurements two plus size individuals may have very similar hip breadth measurements for example, but very different abdominal depths. The reasons for this are unknown.
- Issues associated with workplace design are reported by a large number of plus size people. Seat sizes were found to be most problematic. Individuals with a BMI of 35kg/m^2 and over reported significantly more issues than individuals with a BMI of 34.9 kg/m^2 and under, suggesting that for these individuals current workplace design is inadequate.
- Exclusion rates, that is the percentage of the study population that may be excluded from design that accommodates up to the 95th or 99th percentile of existing datasets, were high for 10 out of the 14 measurements collected. These measurements once again relate to circumference, breadth and depth rather than measures of length. This suggests that anthropometric datasets often used may not be appropriate for ensuring inclusion of the plus size population. Findings suggest that this lack of appropriate data may be evident in the experiences of plus size people with components of design of their

environments. Participants frequently reported concerns about “not fitting into something”. This may impact on the safety, comfort and performance of these individuals.

- Knee splay, a novel measure in a plus size population was substantially larger than measurements for hip and shoulder breadth. Given the functional relevance of this measurement in terms of meeting the requirements of the plus size population, consideration should be given to using this to determine space and clearance requirements within the working environment.

The objectives of the plus size anthropometry study have been achieved by the collection of anthropometric data of plus size working age people pertinent to workplace design. This has enabled the identification of key anthropometric variables that explain body size and shape and also the identification of issues related to fit or space which affect plus size people in the working environment. Comparison of this newly acquired anthropometric data to existing datasets was also achieved, meeting the final objective.

7. Stakeholder Interviews

7.1 Introduction

This chapter will explore stakeholder preferences for the presentation (communication) of the data from Chapter 6 (Figure 7.1).

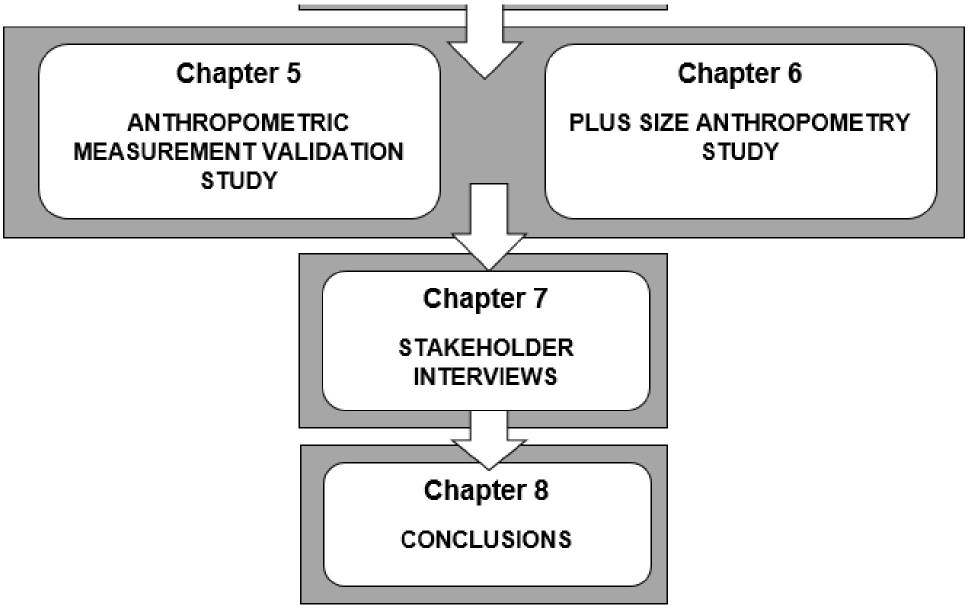


Figure 7.1 Relevant structure of thesis

Chapter 6 reported on an anthropometry study which collected measurement data for plus size working age people pertinent to workplace design. The findings indicated that the study population have substantially larger breadth, width and depth body measurements than populations in existing datasets. Knee splay was identified as a key anthropometric variable, however, it is not included in any datasets or literature relating to plus size people at work. These factors may contribute to high exclusion rates from current design practices that seek to accommodate the 5th to 95th or 99th percentile of users and may explain the high incidence of fit and space challenges reported by participants with a BMI over 35kg/m^2.

7.2 Aim and objectives

The aim of this chapter is to identify stakeholder preferences for a resource to support them in meeting the needs of plus size people within the working environment. This will be achieved by:

- Identifying a cohort of stakeholders
- Exploring how stakeholders would like the data from the plus size anthropometric study (Chapter 6) presented and accessed to support design decisions.
- Gaining an understanding of the additional information required to order support the inclusion of plus size people in workplace design.
- Producing of a summary specification of a resource to support stakeholders include plus size people in workplace design.

7.3 Research method

In order to present the anthropometric data (chapter 6) and identify the preferences of a resource to support the working methods of a wide range of stakeholders (Nicolle et al., 2005), and provide information that meets their needs in an accessible format (Kunak, 1990) stakeholders will be engaged via semi structured telephone interviews. Semi structured interviews have been shown to be successful in allowing participants to speak of their own experiences, whilst allowing the interviewer to cover any topics of interest that are not naturally raised in conversation (Golafshani, 2003 Robson, 2011).

Accepting the potential disadvantages of conducting an interview via the telephone rather than face to face such as lack of visual cues (Robson, 2011), unable to gather contextual information (Creswell, 2013) and the necessity for shorter interview length due to the earlier onset of participant fatigue (Robson, 2011), telephones interviews were deemed advantageous. This was in terms of reduced costs but primarily due to reducing the time demands placed on stakeholders completing the interview. Focus groups were also considered as a possible method to gain an understanding of the content and format of information required by the stakeholder in order support the inclusion of plus size people in workplace design but the practicality of carrying out focus groups was deemed prohibitive due to the time demands that it would place upon stakeholders (Wright, 2005).

7.3.1 Identification of a cohort of stakeholders

Groups of potential stakeholders were identified based on their involvement or vested interest in activities related to these issues (Figure 7.2).

Stakeholders were defined as ‘any individual, group, or institution who has a vested interest in the area of study and/or who potentially will be affected by study activities and have something to gain or lose’ (Hoffman et al., 2010)

Potential stakeholder groups

Equipment/tools/furniture

Ergonomist/Human Factors specialist
Designer
Physiotherapist
Occupational therapist
Occupational health professional
Health and safety/risk professionals
Employers
Procurement professionals

Uniform/PPE

Ergonomist/Human Factors specialist
Designer
Uniform manufacturer
Dressmaker
Procurement professionals
Employers

Space/workplace layout

Ergonomist/Human Factors specialist
Designer
Physiotherapist
Occupational therapist
Occupational health professional
Health and safety/risk professionals
Procurement professionals
Architect
Estates/building control
Employers

Figure 7.2 Potential stakeholder groups identified based on issues raised in previous studies

7.3.2 Preliminary questionnaire survey

The scoping study (Chapter 4) and plus size anthropometry study (Chapter 6) identified issues with:

- Fit - of equipment, tools and furniture specifically seating, uniform and PPE.
- Space – workplace layout, circulation and shared spaces within the working environment

A preliminary questionnaire with four sections (Figure 7.3; Appendix 7.1) was created for completion by stakeholders prior to the interview to collect demographic data and information about job role and level of expertise. The questionnaire was designed to immerse the participants in the topic, allowing them to reflect on their environments in preparation to the subsequent interview. Additionally, by collecting suitable information such as demographic data and preferences in advance utilising this preliminary questionnaire it would also reduce potential interview time. This information was further used to make the interviews more relevant and targeted.

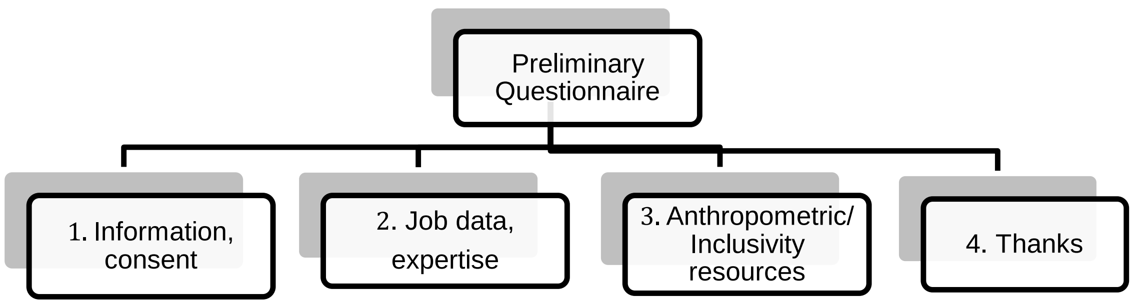


Figure 7.3 Structure of preliminary questionnaire survey

Section one provided a summary of the background information for the research including the purpose of the study and how the data would be used and stored. This was to enable participants to indicate their informed consent prior to undertaking the study.

Section two asked the participant to provide their first name to enable the questionnaire to be linked with the telephone interview. The participant was also asked to give their job title and level of expertise. Expertise was categorised using the Dreyfus model of skill acquisition (Dreyfus et al., 1980) as is therefore divided into five categories ranging from ‘novice’ to ‘expert’. It was important gain an understanding of the level of expertise of the participants as Johnson (1996) suggests that more experienced stakeholders will be able to provide a deeper insight into the areas of interest. This is a consideration for the sampling strategy.

Section three collected information about whether the participant utilises anthropometric data in their working practices (Yes or No). If yes, then participants were asked to indicate the extent of use for specific groups of resources;

- Tables e.g. Bodyspace,[1] Adultdata[2]
- Web based databases e.g. Peoplesize[3], DINED[4]
- CAD packages e.g. Sammie[5], JACK,[6] ErgoLink[7]
- Inclusive design websites
- Simulation tools e.g. Cambridge simulation glasses/gloves, bariatric suits

The above resources included the main anthropometric and inclusive design resources identified in Chapter 2.

---

[1] Pheasant and Haslegrave (2006);
[2] Peebles and Norris (1998)
[3] Open Ergonomics (2008)
[4] TU Delft (2004)
[5] Sammie CAD Ltd, Loughborough University (1995)
[6] Siemens (2011) http://www.siemens.com/tecnomatix
[7] Sun Group Design (2012)http://sungroupdesign.com

7.3.3 Interview schedule

The interview schedule was developed (Table 7.1 and Appendix 7.2) based on a review of previous literature and methodologies (Chapters 2 and 3), and to achieve the objectives of the study. Three main themes were used as broad discussion points;

- anthropometric data,
- information to assist in the understanding of issues experienced by plus size people in the working environment and
- resource requirements.

Interviews were designed to last approximately 20-30 minutes. This was an acceptable time according to Robson (2011); long enough to provide valuable information without making unreasonable demands on interviewees. Prompts were prepared for each topic from the preliminary questionnaire and used to encourage more depth to the interview (King and Horrocks, 2010)

The first theme 'anthropometric data' introduced the new dataset (reported in Chapter 6) explored whether such data will be useful to the stakeholder and their organisation. Participants were asked to give examples of how they might use such data, for example in current/recent projects to encourage participants to immerse themselves in thinking about their activities on a day to day basis. This theme also allowed the interviewee to explore the preferred format for the presentation of this anthropometric data in order to be of most use to stakeholders. Prompts and probes were used based on previous information they had given in the preliminary questionnaire based survey such as 'you mentioned in the questionnaire that you used Adultdata most often'. What features do you like? What features do you dislike?

Discussion Points	***Questions and prompts***
Introduction	*Purpose and nature of study, anonymity, consent for participation and recording, use of data, structure of interview*
Anthropometric data	*Usefulness of plus size data, give examples if necessary. Current use? Awareness? What you like/dislike? Unmet needs? Improvements? Relative importance? Preferred layout/delivery?*
Information to assist in the understanding of issues experienced by plus size people	*To encourage empathy/diversity – approaches you might use? Examples? How do you find out about end users? Positive/negative examples of design for plus size? What would need to be different to include plus size?*
Design resources to support inclusion for plus size people at work	*What would you like included? (case studies, persona, blogs, day in life) Current use? What you like/dislike? Unmet needs? Improvements? Format and access? Training/education needs? Have you received any training/education related to plus size? Need? Useful experiences of training? Accessing training.*
Conclusion and Thanks	*Additional comments not covered. Examples of resources not mentioned? Thanks for completing interview.*

Table 7.1 Summary of proposed questions and issues for discussion during interview

The second theme, 'information to assist in the understanding of issues experienced by plus size people' summarised the issues identified by plus size people in the scoping study (Chapter 4) specifically;

- Fit – seating (personal and shared), height of working surface, uniform, PPE

- Space – workplace layout, space to move round unhindered, toilet cubicle size
- Organisational issues – how plus size were perceived within the working environment.

Participants were asked about their ideas for information they would like including within a resource that would help them with understanding the issues affecting plus size people within the working environment. Organisational issues identified from the scoping study, for example how plus size are perceived within the working environment were included in the introduction to this theme to encourage stakeholders to think about empathy and diversity issues as well as physical issues (Allanwood and Beare, 2014). Due to the limited literature on plus size people at work (as discussed in Chapter 2) it is acknowledged that participants may have limited experienced of designing specifically to include plus size people. Therefore prompts and probes were included to draw upon experiences from designing for other groups of end users as appropriate.

The third theme ‘what stakeholders would like included in a resource aimed at including plus size people in workplace design broadly focussed on the topics of content of a resource, format and access and finally opportunities for education and training. This theme was included to explore aspects that are documented in literature as supporting design decisions and encouraging inclusion such as persona (Pruiitt and Adlin, 2006), case studies (Crowe et al., 2011), simulation tools (Gable et al., 2014) as well as exploring tools not know to the interviewer. This theme also allowed the interviewer to explore the preferred format for a potential resource aimed at supporting stakeholders in including plus size people in workplace design.

The interview schedule concluded with a question inviting participants to comment further on any themes as appropriate before thanking participants for their time and participation in the study. Ethical approval for the preliminary questionnaire survey and subsequent interview schedule was granted by Loughborough Design School, Loughborough University (November 2015).

7.4 Pilot study

A pilot study was performed to check the;

- online structure of the preliminary questionnaire
- clarity of the questions in the preliminary questionnaire
- structure and flow of the interview schedule
- prompts and probes
- responses
- time taken to complete the interview
- data analysis strategy
- reliability of the recording device

7.4.1 Participants

A convenience sample of 2 potential stakeholders (female) completed the pilot study. Convenience sampling is an acceptable sampling method for a pilot study (Robson, 2011).

7.4.2 Findings/modifications

The pilot found that the method was appropriate but additional prompts were needed for the second theme of ‘information to assist in the understanding of issues experienced by plus size people’ to encourage depth and breadth of responses related to designing to meet the needs of a range of end users. The interview time was 22-27 minutes.

7.5 Data collection for stakeholder interviews

7.5.1 Sampling strategy

It was deemed essential that stakeholders should have relevant experience or expertise in order to provide insightful contributions (Kirk et al., 2015). From the range of potential stakeholders profiled in Section 7.3.1 a non-probability sampling strategy was used as a combination of ‘purposive’ and ‘snowball sampling’. Purposive sampling was considered the most appropriate strategy given to meet the specific needs of the sample (Dolores and Tongco, 2007); participants were recruited from respondents who expressed in interest in being involved in research via generic emails to interest groups/forums and through personal contacts.

7.5.2 Sample Size

Kirk et al (2015) suggests that in practice, 4-6 participants selected to represent a good inclusive range of characteristics and contexts can provide a significant amount of information and evidence of issues that was not apparent beforehand. In addition, Virzi (1992) suggests that 80% of issues with the usability of resources can be detected by 4 or 5 participants and fewer new insights are revealed as the number increases. A sample size of 8-12 participants was deemed appropriate based on the;

- range of stakeholder profiles identified (10)

This was refined based on the point of theoretical saturation (Saunders, 2012).

All participants were aged 18 years and over with some experience of utilising anthropometric data and/or design resources/toolkits.

7.5.3 Data collection strategy

Potential participants identified through the sampling strategy were contacted by phone or email to discuss:

- Participation in the study
- Appointment time for stakeholder interview

7.5.3.1. Preliminary questionnaire

An information sheet detailing the purpose of the study and their right to withdrawn at any time (Appendix 7.3) was emailed to the participant along with the link for the online preliminary questionnaire. Participants were requested to complete and submit the online questionnaire prior to the pre-arranged date of the interview.

7.5.3.2 Stakeholder interview

The telephone Interview was conducted on a semi-structured basis and an audio record was taken using a digital voice recorder (Ultradisc DVR-7) and saved digitally. The interview followed the schedule detailed in Section 7.3.3 and participants were invited to ask questions as necessary throughout the process. The researcher also recorded the interview responses manually (pen and paper) during the interview.

7.6 Data analysis

Interview data was transcribed verbatim in Microsoft Word version 8 (2014). Each interview transcript was then uploaded into NVivo10 software, and coded thematically by the researcher within NVivo using quasistatistical analysis (Fereday, 2008). A quasi-statistical approach uses the frequency of references from participants to determine the importance of key themes within the interview. A template approach allows these key themes or 'nodes' (derived from an initial read of the data) to be used as a template for data analysis, which can change as analysis progresses. Main themes were identified and then further sub-coded to make them more specific. Quotes are used to support and illustrate the findings of the interviews.

7.7 Results/Discussion of findings

The results are presented for the preliminary questionnaire survey and subsequent interview study. Quantitative data from the questionnaire (Section 7.7.1) provides demographic data (gender, employment role and level of expertise of the participants) and the usage of anthropometric data. Qualitative data from the in-depth semi-structured interviews are reported in Section 7.7.3 in combination with a discussion of the findings.

7.7.1 Demographics

10 participants (6 males and 4 females) completed the study with 6 different employment roles (Table 7.2).

Employment Role	Number of Participants (n=10)
Ergonomist/Human Factors specialist	3
Health and safety/risk professional	2
Designer	2
Occupational health professional	1
Estates/building control	1
Occupational Therapist	1

Table 7.2 Employment roles of participants (n=10)

All participants classed their level of experience in their field as 'proficient' (n=7) or 'expert' (n=3).

7.7.2 Anthropometric data usage and resources

100% of participants (n=10) utilised anthropometric data in their working/design activities. Anthropometric data was most frequently accessed using tables such as Bodyspace (Pheasant and Haslegrave, 2006) and Adultdata (Peebles and Norris, 1998) with 9 participants using this method often (Figure 7.3). Web based databases such as PeopleSize (Open Ergonomics, 2008) were used often by 2 participants but 5 participants had never used this resource. The majority of participants had never used either CAD packages (n=9) or simulation tools (n=6). Inclusive design websites (*inclusivedesigntoolkit.com)* had been used rarely by half of the participants (n=5) with only 3 participants using them often (n=1) or occasionally (n=2).

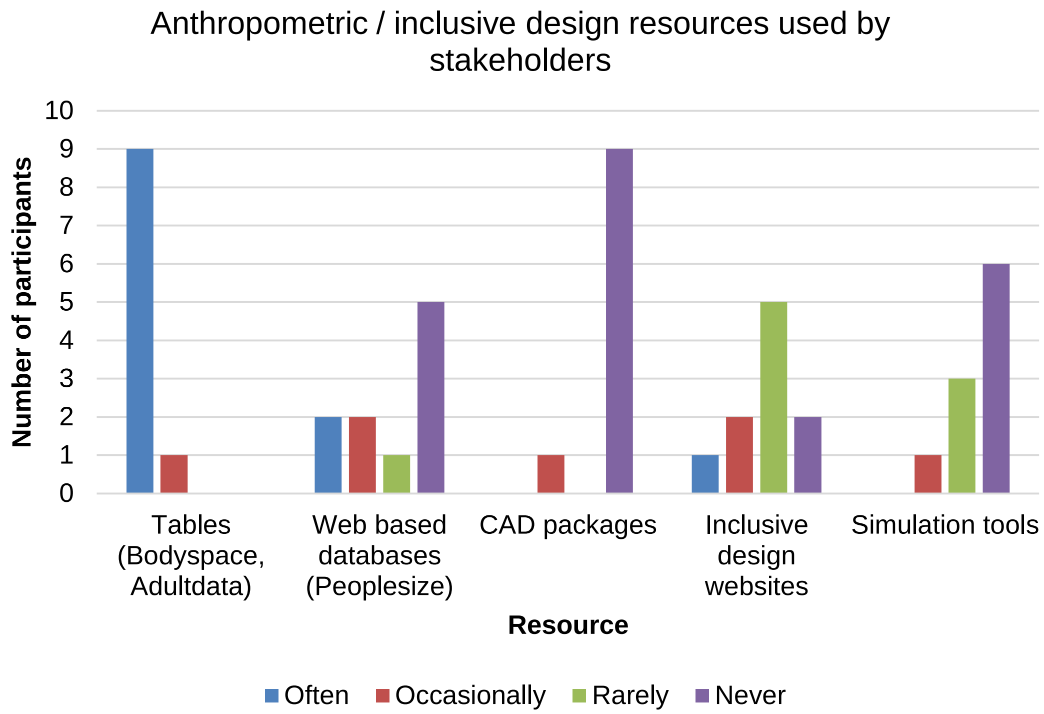


Figure 7.3 Resources used by participants (n=10) during working/design activities

Two comments relating to the accessibility and currency of resources in Figure 7.3 were reported by participants.

> *" I know there is a more up to date resource but I can't get access to it"* (participant 9)

> *" Its nearly older than me, the data must have changed"* (participant 1)

7.7.3 Qualitative analysis – Stakeholder Interviews

During the interview, three main themes (Section 7.3.3) were used as broad discussion points;

- anthropometric data,
- information to assist in the understanding of issues experienced by plus size people in the working environment and
- resource preferences

After reading through the interview transcripts repeatedly, a number of sub themes were identified within each of the main themes. These sub themes were then further analysed to create more sub themes with a quasi-statistical approach determining the importance of themes based on how often they are referred to within interviews. An example of this thematic analysis is shown in Figure 7.4.

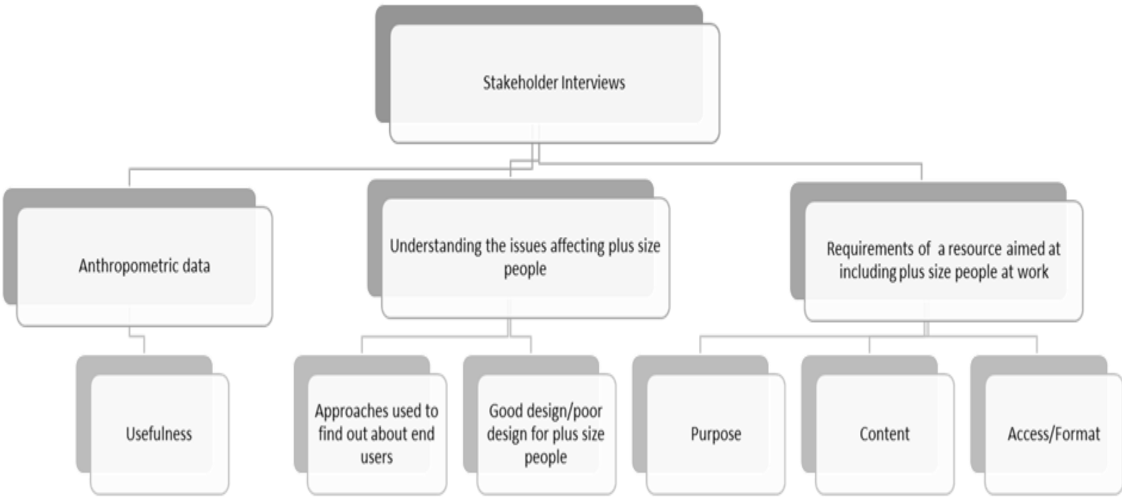


Figure 7.4 Example of major thematic analysis from stakeholder interviews (n=10)

7.7.3.1 Anthropometric data

A total of 170 references were coded under the theme of anthropometric data resulting from the thematic analysis (Figure 7.5). All participants (n=10) thought that an anthropometric data set providing a greater insight into the size and shape of the current plus size working population would be useful to them or their organisation. 36 references were made by participants as to why such data was required.

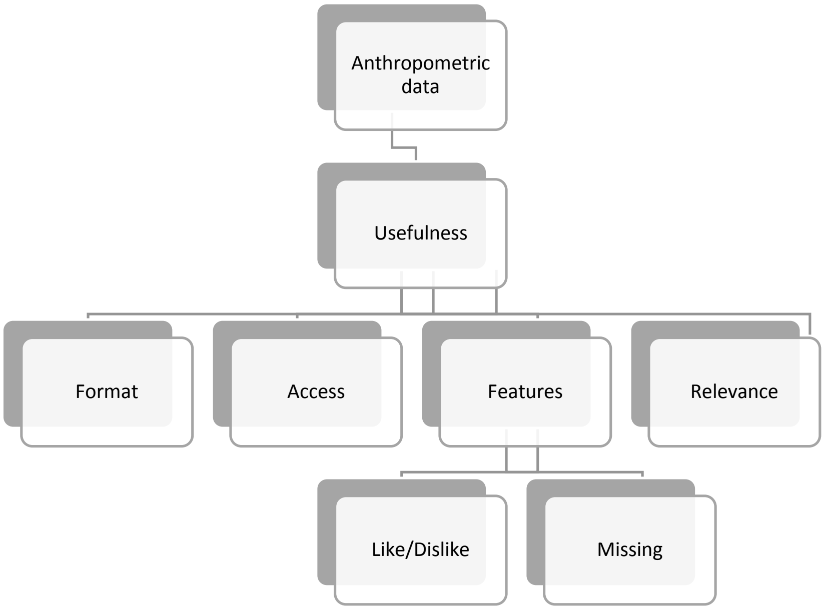


Figure 7.5 Anthropometric data thematic analysis from stakeholder interviews (n=10)

The main reasons cited was the age of current data sources (11 references) and concern about the relevance of current sources (10 references);

> *“my worry about that is that they’re getting a little dated now”* (participant 2)

> *“we either estimate where they might need additional space due to their size because the data we normally use doesn’t seem appropriate for them*” (participant 7)

The need for additional anthropometric data to support stakeholder working practices and design decisions is a view supported by Gordon et al., (2012) and Park et al., (2012) who both suggest that despite the growing prevalence of being overweight, obese and classed as plus size, the anthropometry of this population has not been studied enough to minimise the impact on design. Participants highlighted examples where despite following the most up to date anthropometric guidance;

“it was obvious it wasn’t going to fit…..it was nowhere near”
(participant 3)

Interestingly, participants identified the urgency for supplementing the current anthropometric data available for minimising not only issues now, but also for preventing even more problems in the future. This suggests that design decisions made today based on the current anthropometric data may still have impact in 2050. This is of interest as the incidence of being plus size and the actual size of the population in terms of BMI, is predicted to increase to even higher levels (HSCIC, 2013) implying that designs based on existing anthropometric data may accommodate even less of the population by 2050.

“remember… design of buildings and modes of transport such as trains and aeroplanes are essentially 20-30 years behind the data
(participant 7) *.*

24 references were made by 9 participants about where such anthropometric data might be used in their working activities (Table 7.3).

Industry/environment	Task	Number of references
Transport	Seating design	3
	Cab layout	2
Office	Workstation layout	4
	Seating design	3
	Shared spaces	2
Retail	Uniform	2
	ATM design	1
Uniformed services	PPE	2
Unspecified	Toilet design	3
	Room to move around	2

Table 7.3 Instances where anthropometric data (providing a greater insight into the size and shape of plus size people) would have been used.

Within these different tasks, the 9 participants made a further 35 references why the additional data would aid them in their working/design activities. 12 references implied that the data to include plus size people in workplace design was either missing or they had been unable to find the data they required; In addition, 9 references were made to the need to have data that was representative of the population;

> *"I think a lot of the stuff on the PPE side has been done for the military so it's mostly on the male side and I can't imagine they were plus size"* (participant 6)

Interestingly, the benefit of having guidance/regulations/published information was raised by 8 participants accounting for 12 of the remaining 14 references. 8 references related to the importance of having this information available to satisfy clients; to for example, justify the recommendation for wider seating options within the working environment. 4 references concentrated on how having some guidance/regulations/published information would have benefited the participant (Table 7.3).

> *"unless it's specifically mentioned in black and white then they may not agree"* (participant 1)

> *"it would be useful to have that sort of guidance out there, then I might be able to help them. At the moment it's not available"* (participant 4)

> *"clients assume I know – I'm the expert. The reality is, I base it on my experience and my best guess"* (participant 5)

Participants were asked about their preferred format for the presentation of this newly acquired anthropometric data (Chapter 6). Although format and access were separate in the interview schedule, all participants commented that access was more important than format.

“if I can’t access it, I can’t use it and then it doesn’t matter what form it takes” (participant 8)

“I know there is a more updated version of the anthropometric data I use, but we don’t own the licence so that’s a big barrier” (participant 4)

Views on how to access the data were however mixed, with similar number of references made to accessing the data via a hard source, web based, via an app or web based with the ability to download (Table 7.4).

When prompted, all 10 participants made suggestions for the data presentation with 33 references. The most positive responses (11) related to preferences for an interactive format;

“more interactive versions, let’s say for example, having a picture of a plus sized person and then being able to click on a measurement and see exactly what it measures would be helpful I think” (participant 7)

Seven references were made about presenting the data using visual cues, for example to identify the body part. The ability to switch between percentiles and actual measurements (mm) was also mentioned by half of participants (n=5). Although presenting the data in a table was referenced negatively by 4 participants (5 references) because of the lack of meaning of the dimensions and lack of context provided by a list of numbers, a further 2 participants responded positively to the use of tables (2 references);

“Tables are good in that you can look up the individual’s measurements and percentiles and refer back to standard etc. That’s what people are used to…” (participant 6)

Access	Number of references (n=28)	Examples
Hard source	8	*"Being of a certain age I'm less comfortable using anything demanding high level computing wise"* (participant 2) *"Good to show clients the actual data at their desk so an actual hard copy is a must"* (participant 3)
Web based	7	*"I would like to access it online"* (participant 9) *"Online – we're under pressure not to print"* (participant 7) *"So many more options online"* (participant 1)
App	7	*"Apps - I've used some recently which I loved "* (participant 10) *"So mobile"* (participant 7)
Web based with ability to download	5	*"sometimes easier to work with a physical document if you've got to review it or check off what you've done - but for reading and basic information working through the online version is fine"* (participant 3) *"sometimes we don't have access to www so we need to take it with us" (*participant 4)
Combination – no preference	1	*"I think it would be great to have various options"* (participant 7)

Table 7.4 Participants preferences on how to access the anthropometric data

The high number of suggested ideas from participants with regards to the format and access of the new anthropometric data illustrated their ability to consider ways in which to maximise the usefulness of such data. The majority of participants currently utilised anthropometric data sources that presented the data in a one dimensional tabular format. This agrees with findings by Molenbroek et al., (2000) who suggested that designers and product evaluators use one-dimensional data to verify the product-human dimension fit. However, the findings of this study indicate that this was primarily due to ease of access rather than preference for this format. Participants felt that they knew of more up to date sources but did not have access to these due to financial or licensing requirements.

One of the major findings was the preference for the anthropometric data to be presented in a visual and interactive format This was an important when considering both ‘what’ type of resource would be successful and also ‘how’ it could be implemented. All participants suggested that practical examples such as using plus size people in diagrams to identify realistic body dimensions, indicating how a certain body size and shape may be represented and including corrections for luggage and winter clothing could assist stakeholders in applying the data to their working practices maximising usefulness. The anthropometric information was considered just a starting point supporting finding by Nickpour and Dong, (2011). Interactive resources with an emphasis on context have been shown to promote understanding of issues in previous studies by White, (2010) and Pasin and Giroux, (2011). More innovative interactive design tools using anthropometric data are documented within the literature, for example HADRIAN (Marshall et al., 2010). However, no participants in this study reported using such tools despite wanting the data collected in Chapter 6 to be presented more interactively. This highlights the need for the data to be accessible in order to be deemed useful (Nickpour and Dong, 2011) and able to inform working practices.

7.7.3.2 Information to assist in the understanding of issues experienced by plus size people in the working environment

A total of 167 references were coded under the theme of information to assist in the understanding of issues experienced by plus size people in the working environment. Participants (n=10) used a range of methods to find out about their end users including observation (2 references), user trials (6 references) and simulation suits such as the 'third age' or bariatric suit (6 references).

The use of simulation equipment and materials to encourage engagement, interaction and empathic learning has been well documented by Gibb et al., (2015). These include the development of ‘Cambridge simulation gloves’ to provide an insight into how limitations in hand movement can affect product use, simulation glasses which recreate the effects of moderate visual impairments, and the ‘third age suit’ which was developed to raise awareness of the needs of older drivers (Cook et al., 2009). The use of bariatric suits in raising awareness of the issues encountered by plus size people has been less well documented with the majority of the research focused on exploring weight stigma and body image (Mills and Gill, 2016; Incollingo et al., 2016) or in manual handling of bariatric patients education primarily within healthcare (Gable et al., 2014). Of the 6 participants that made reference to the use of bariatric simulation suits, two reported it as a valuable tool to raise awareness of the issues that may be encountered by plus size people although only one participant had worn a bariatric suit;

> *“it enabled me to see the world through different eyes”* (participant 9)

Negative responses to the use of the simulation suits by 4 participants centred around ethics, concern that bariatric suits lack realism to body size and shape and also that;

> *“ wearing a bariatric suit for 30 minutes does not make understand what it is like to be plus size. It fools you into thinking you understand*

what the issues are… in fact that's even more concerning that not having a clue" (participant 7)

However, direct contact with the end user(s) was referenced most frequently (14) as it was seen as the most appropriate method for eliciting information;

"If you can talk to people – if they're willing to talk then that's always the best option" (participant 8)

"It's something that often people have got their own ideas how to solve the problems they've got, so it really is having that face to face communication, which I think is essential" (participant 10)

Interestingly, 4 references were made by 3 participants, about potential difficulties in speaking with plus size people due to embarrassment, not wanting to offend and/or draw attention to the issue. In these instances, 2 participants thought that having guidance about the issues that plus size people might experience could be combined with capability guidance to improve understanding. The lack of guidance/standards relating to plus size people at work was also highlighted by 6 participants (9 references) as an important tool to improve the understanding of issues experienced by plus size people in the working environment.

"I think there are a lot of people who don't even understand what the problems may be for a plus sized person so even putting something really simple out there, for guidance would be really useful" (participant 9)

When asked about their experiences of design to include plus size people, none of the participants were able to recall positive design examples. Conversely, 12 references were made to poor design for plus size people, including inappropriate works car rental choices, uniform that didn't fit, crowded toilet cubicles and most commonly (6 references) mismatch between the office furniture and workplace layout;

> *"It hadn't been looked at before because of the standard tick box DSE assessment had been done, but those sort of questions hadn't been asked"* (participant 9)

As well as finding out about end users and exploring good/bad designs for plus size people, a major sub theme of raising awareness was identified as key in the understanding of issues experienced by plus size people in the working environment. 46 references were made suggesting increasing awareness as an important factor to consider (Table 7.5). Participants suggested that making resources available to explain the issues affecting plus size people at work supported by guidance for stakeholders would help to raise awareness and hence understanding.

Training at undergraduate or post qualification level was also referred to as a way of improving understanding. None of the stakeholders had received any education specifically related to plus size people. This led to feelings of being unprepared or 'guessing' at the needs of plus size people in the working environment. Although there is literature exploring the benefits of training for raising plus size awareness (Blanch-Hartigan et al., 2013; Flemming, 2015) none of the participants had received any pre or post qualifying education related to plus size inclusion at work;

> *"Everyone knows what DDA means because they've had to go on some kind of a training course" (*participant 2)

All participants thought training would help to raise awareness especially in light of the;

> *"growing importance associated with the plus size demographic being on the increase"* (participant 6)

Increasing awareness	Number of references (n=46)	Examples
Resources	14	*"You need to start from basics because it's not out there"* (participant 7) *"I need something to help me understand…see the world through their eyes"* (participant 3) *"really need to be informed about what the issues are for plus size people. I'm just assuming I know what the issues are"* (participant 7)
Guidance	11	*"set of guidelines or design recommendations that we could refer to, to make sure we've addressed – even a checklist- have you considered this and that"* (participant 1) *"Clients won't want to understand plus size people unless it's in a guidance document"* (participant 6*)*
Training	11	*"It wasn't an issue when I qualified – now it's a serious issue but nobody's an expert in it to teach us" (*participant 8*)* *"Training of some sort would help me to understand". When you have training people take note"* (participant 7*)*
Research	4	*"I need to be able to evidence my work – with no guidance and no papers its difficult. Research into the area would help me understand"* (participant 2)
Other	6	*"Get plus size people to tell me about their issues. That would help me to understand* (participant1)

Table 7.5 References (n=46) made to raising awareness to help participants understanding of issues affecting plus size people at work

Preferences for format and accessing potential training was varied. These included a 10 minute video accessed online or a half day highly practical workshop. Once again the importance of interactive engagement was highlighted. Techniques for interactive learning (e.g. 'hands-on' tasks and practical tests) have been shown to be very successful in previous research (Abdulwahed and Nagy, 2009; Pasin and Giroux, 2011) and have been shown to increase ability to transfer new knowledge from short term to long term memory (Cairncross and Mannion, 2007). This supports the use of such formats in the development of an education package to raise awareness and support stakeholders in including plus people in workplace design.

7.7.3.3 Preferences for a resource aimed at including plus size people in workplace design

A total of 144 references were coded under the theme of requirements of a resource aimed at assisting stakeholders in including plus size people in workplace design. 3 main sub themes were identified;

- purpose
- content
- access and format

An example of the thematic analysis is shown in Figure 7.6.

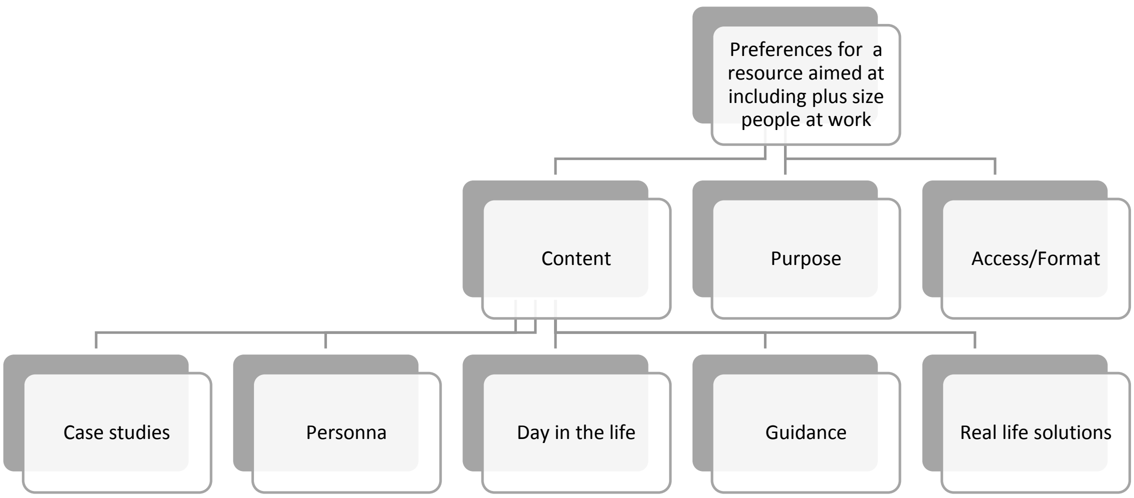


Figure 7.6 Thematic analysis from stakeholder interviews (n=10) for resource requirements

Purpose

Half of participants (n=5) thought the main purpose of the resource should be to raise awareness of the issues affecting plus size people within the working environment. The remaining half (n=5) thought the purpose of the resource should be to enable stakeholders to work with data and with guidance to meet the needs of clients and end users. 4 participants acknowledged that the resource may fulfil many other purposes such as moving the profession forward (n=1), responding to need (n=1), showing we care (n=1) and filling the gap between employers and employees (n=1).

"having something, anything to follow will help us all" (participant 7)

Content

All participants (n=10) had ideas on the content of a resource aimed at assisting stakeholders in including plus size people in workplace design with 171 references being made in total. The introduction of guidance, defined as 'advice or information aimed at resolving a problem or difficulty, especially as given by someone in authority' (HSE, 2013) was preferred by the majority of participants (n=8). The majority of participants (n=8) were keen to see some form of guidance in the content of the resource. References were also made to including basic checklists of things to consider (8 references) when designing to include for plus size people to act as either as a memory aide (3 references) or out lining some of the things that people would need to consider (7 references). The reasons cited for this was due to both raising awareness of the issues and also of having 'evidence' to show to clients to support recommendations. Suggestions included the use of a basic checklist detailing points to consider or annotated diagrams of plus size people in working environments with questions to initiate the thought processes needed for inclusion. The preference for the production of additional guidance by participants in this study was in contrast to the findings of various studies of similar stakeholders who reported that the use of such resources is currently limited and not effective (Restrepo and Christiaans, 2003; McGinley and Dong, 2009). Aurisicchio (2010) believed that this may be due to stakeholders being overloaded with information coming from multiple sources with the additional issue that seeking information from these sources is often complicated and time consuming. Perceived lack of value, accessibility (Fidel and Green, 2004) or relevance (Restrepo and Christiaans, 2003) are also documented. Participants acknowledge that there was a danger that the addition of guidance to support inclusion for plus size people at work might;

> *"be seen as yet something else the employers have to factor in"* (participant 5)

or

> *"yet more hoops to jump through"* (participant 1)

This has placed more demand for the presentation of this information in an accessible, usable and useful way.

Preference for including additional design tools such as case studies was referenced frequently (16) by participants as a way of understanding end users. 13 references were positive in that the participants were keen to see them included in the resource;

> *"case studies – real life experiences are the things that switch people on*" (participant 7)

> *"Case studies yes, absolutely. They'll be useful because sometimes you're looking at things, at a problem as part of your daily job and actually just going and looking at what other people have done can help you generally. It might not be the exact solution you're looking for, but it can help the thinking process*" (participant 4)

However, 3 references made by 2 participants, suggested caution with implementing case studies based on the risk of limiting their appropriateness;

> *"When you create a case study you create a particular scenario and if people have a problem which doesn't fit that scenario they can't see beyond the scenario"* (participant 1)

> *"you have to choose your case studies carefully so as not to make them appear too specific"* (participant 8)

Case studies, designed to share good practice and demonstrate how others address issues and challenges are frequently cited in the literature by a range of organisations such as the National Health Service (NHS) and Health and Safety Executive (HSE). However, participants in this study emphasised the desire for case studies to be short and concise (6 references) preferably just one page (2 references) to enable the transfer of knowledge and application of solutions across different work scenarios. This supports findings by Sayers et al., (2006) who concluded that the most effective awareness raising messages are typically short, simple, flexible and memorable. Participants also stated a preference for information to be positive, focusing for example on the opportunities and benefits provided by including plus size people at work (for example, better for all) rather than risks and penalties associated with continuing without modifying current practices. 9 participants also made 14 references to the importance of including photographs or other visuals in the case study;

> *"pictures/photos…I think we sometimes forget that it can be quite hard to imagine"* (participant 4)

> *"if you've got a photograph then that's brilliant. If you've got before and afters that's even better"* (participant 1)

The majority of participants (n=9) discussed the need to include 'real life solutions' as part of content of the resource (13 references). Participants wanted information to help them understand how plus size people move (4 references), the impact of winter clothing or carrying bags on the shape and size of the person (2 references); how the anthropometry may affects the task and vice versa (2 references) basically;

> *"For me, I struggle sometimes to take it to the practical level; they don't have naked passengers in rail!"* (participant 7)

> *"anything to lift that data and make it applicable to the situations I face everyday"* (participant 7)

Several participants (n=4) made 9 references about the use of 'day in the life' and blogs in the resource as a way of providing stakeholders with information. 2 participants felt that blogs were a good way of involving end users in the design process especially if plus size people were difficult to recruit into user trials.

Although personas are also documented in the literature as a tool to raise awareness of the context (Pruitt and Adlin, 2006) only 4 participants had an understanding of persona or had used them in their working/design activities (Table 7.6).

Personas are fictitious people with personalities that represent typical users (Allanwood and Beare, 2014).Used to demonstrate the difficulties a specific user group can experience using a product or in a certain environment, they may help to understand and visualize relationships between the user and their social and physical environments or products (Cooper et al., 2007). Griffin (2013) suggests that because they do involve engaging 'real' users, they may be useful in plus size design as this user group can be difficult to access. However, for those participants making references to persona, the majority were negative references due to this exact fictitious nature and the perceived danger of stereotyping the plus size individual when little is known about their characteristics;

> *"I don't want to give them too much because I don't believe we know it" (*participant 5)

Negative comments related to persona	Positive comments related to persona
"it makes the people seem like cartoon characters" (participant 7) *"I'd rather have a photo of a real person with their specific details rather than a generic model that represents nobody"* (participant 3) "*Fact please, not fiction"* (participant 10) "*Dehumanising"* (participant 7) *"Always seem to be based on worst case scenarios "* (participant 10)	*"well I think I found them really useful even just for myself to image problems a bit better"* (participant 4*)* *"a different way of thinking about the issues"* (participant 8)

Table 7.6 References related to the use of persona

Specifications such as interactivity, ease of access and use, and simplicity were high priorities and of great importance for participants in terms of the usability of the additional information required by the stakeholder in order support the inclusion of plus size people. The right level of detail was also a key usability issue mentioned by participants.

Access and Format

26 references were made by all participants (n=10) under the sub theme of in what form they would like the resource to take and a further 37 references on how they would like to access it. Interestingly, all participants expressed similar preferences for form with the majority of references highlighting the need for an interactive format (17) and the use of visual cues either photographs, diagrams or scenarios (15) to;

> *"show me what we're talking about … pictures are so more powerful than words or a table with numbers in it!"* (participant 10)

Similarly to section 7.7.3.1 focussing on the anthropometric data there was no consensus on how to best provide access to support design decisions. There were mixed views from participants regarding a resource being introduced in the form of a mobile phone app. 6 participants were keen to pursue access via an app primarily because it was mobile (4 references) you always had it with you (3 references) and it had potential to be interactive (4 references). Despite these benefits of interactivity and mobility (Ventola, 2014), increased efficiency in working practices involving decision making (Mikan et al., 2013) especially those requiring best practice (Mosa et al., 2012), 2 participants stated they would never use an app because they were unfamiliar with the technology and couldn't show it to their clients (3 references). This suggests that the requirement;

> *"to have something to show the client"* (participant 2)

may not be wholly met by an app alone suggesting that additional access in another form would be required to encourage widespread engagement for range of stakeholders. Similar number of references supported access to the resource via the web (6), and hard copy only (5) with a higher number of references supporting a combination of web based with the option to download a PDF and print as required (12) reported by 4 participants. Web based access with the ability to download information and print as required was, therefore, the preferred combination.

7.8 Limitations

Participants were selected using a purposive sampling strategy; although a relatively small sample (n=10) care was taken to ensure the sample was as random as possible by inviting 33 participants from a range of stakeholder groups to undertake the interview. However, a bias may have been introduced with participants self-selecting to participate.

Although all stakeholder groups (Figure 7.2) were represented in the study population, in some groups this was only by a single participant for example estates/building control. It was therefore not possible to attribute comments to specific stakeholders as it might have revealed their identity. A larger sample size within each stakeholder group may have resulted in the ability to compare finding across different stakeholder groups. Although this was not an objective of the study, it would have been interesting to ascertain if the requirements of the resource was job role specific.

Robson (2011) suggest that there are disadvantages associated with the use of telephone interviews including lack of depth of subject analysis due to the need to be relatively short and the loss of visual and contextual cues (for example, observation of nonverbal responses). The use of the preliminary online questionnaire aimed to collect demographic data prior to the interview thereby maximising the time available for the in depth interview. The researcher also transcribed the interviews verbatim in order to pick up where possible, pauses, corrections and other figures of speech. To overcome these potential limitations, further data collection methods could have been used, for example focus groups (Phelps and Horman, 2010).

The summary list of preferences has been generated based on the findings of the stakeholder interviews. Further refinements in terms of specification and usability testing would be required prior to implantation to maximise stakeholder acceptance.

7.9 Summary list of preferences

The increasing quantity, range and diversity of information aimed at enhancing working/design practices coupled with the increasing demand for person centred and inclusive design has placed more emphasis on the outputs of this research to be presented in a useful, usable and accessible way. This makes it imperative to capture stakeholder preferences to provide optimal information and tools. Based on the findings from the stakeholder interviews a list of preferences to direct the design of a resource for supporting stakeholders in including plus size people in workplace design has been generated.

7.9.1 Purpose

The resource should;

- explain (provide the context) why there is a need to consider plus size people in workplace design.
- act to raise the awareness of issues affecting plus size people at work (based on published evidence).
- provide easy access to current anthropometric data.
- signpost to training opportunities related to plus size people at work.

7.9.2 Anthropometric data

The resource should;

- present the anthropometric data visually and interactively in the form of a plus size body image with a point and click facility for each dimension.
- enable the anthropometric data to depict the size and shape of the generated image to be dragged and dropped in various working environments to visualise fit/space.
- contain allowances for items of clothing and accessories which can be added to the generated image.

7.9.3 Additional information to support the inclusion of plus size people in workplace design

The resource should;

- portray the physical and non-physical issues affecting plus size people at work.
- include short, concise case studies to highlight examples of good design/working practices including plus size people. These should be visual, for example photographs before and after intervention.
- Persona if used, should be based on real users and include psychological and physical elements to help raise awareness of the issues experienced by plus size people within the working environment.
- act as a checklist for things to consider within the working environment, for example 'consider the influence of abdominal depth on reach envelopes' or 'is there enough room under the working surface to accommodate the preferred sitting position?' This may take the form of a range of working scenarios with clickable information bullets over certain features.
- contain 'hints and tips' for supporting inclusion for plus size people at work in terms of 'access for all'. For example, the provision of a range of chairs in shared spaces to accommodate individual preferences, range of pool cars.
- include a link to a short training video aimed at scene setting and raising the awareness of issues affecting plus size people at work. This should 'plant a seed' rather than give specific recommendations due to the limited research and knowledge base surrounding the capabilities of plus size people at work.

7.9.4 Access

The resource should;

- be accessible via a number of sources in order to meet the requirements of a range of stakeholders.

- offer the facility to download and print off information to meet the demands of different clients and stakeholders.

7.10 Conclusions

The findings support the following conclusions:

- A resource supporting stakeholders in including plus size people in workplace design would be welcomed by stakeholders from a range of backgrounds due to their perceived lack of awareness of the subject.
- A number of preferences on format, content and access were expressed by all stakeholders. Based on the stakeholders suggestions there is potential for a resource to be designed and developed specifically to meet their needs.
- The resource would need to go beyond a quantitative approach of measuring and listing anthropometric measurements and analysing the usability of designs in relationship to people's capabilities. The focus should instead be on raising and understanding the physical and non-physical issues experienced by plus size people in the working environment.
- Stakeholders feel that for a resource to be effective it must be visual, interactive and accessible; these factors would encourage engagement.

The objectives of the stakeholder interview study have been achieved. The stakeholders have indicated how they would like the data from the plus size anthropometric study (Chapter 6) presented. In addition, it has been possible to gain an understanding of any additional information required by the stakeholder to support the inclusion of plus size people in workplace design and also to explore how stakeholders would like to access this information to support design decisions. The production of a summary list of preferences for a resource aimed at supporting stakeholders in including plus size people in workplace design has achieved the final objective of this study.

8. Summary, Conclusions and Wider implications

8.1 Introduction

This research has identified and explored issues affecting plus size people in the working environment and collected anthropometric data to understand the size and shape of this population. Stakeholders were engaged to capture their views on the presentation of this data in order to support inclusion for plus size people at work: being in work has economic, social and moral benefits and has been identified as a key factor in an individual's wellbeing (Burton and Waddell, 2006). This chapter summarises the research, provides recommendations based on the findings of the research studies presented in this thesis and identifies the contribution to new knowledge within the wider literature.

8.2 Summary of findings

The research presented in this thesis has addressed the objectives identified in Chapter 1**.** The previous literature and methodologies related to the study of plus size people within the working environment were explored and critically appraised **(Objectives 1 and 2).** Measures of body composition and size were discussed and a limited range of research evidencing the physical and psychological function of plus size people at work was identified. Being plus size has been associated with functional limitations such as altered balance, restrictive movement patterns and higher postural stress although findings are based primarily on small scale laboratory based studies. Despite larger scale epidemiology research suggesting that plus size people are more likely to suffer from workplace injury, have higher rates of sickness absence and premature job leave, no studies were identified concerning size issues experienced in the working environment.

8.2.1 Scoping Study

To understand the experiences of plus size people at work and identify any issues a questionnaire based survey was conducted and reported in Chapter 4 **(Objective 3).** Problems related to fit, such as seat size and fit of uniform and PPE were highlighted by the sample size of 135. For individuals required to wear a uniform, 51% reported concerns with regards to how it fitted with 41% having similar issues with PPE. This impacted on their ability to wear the uniform/PPE resulting in safety concerns or feelings of exclusion. Seat size both within their own working area and in shared spaces was an issue for 30% of participants. Comments related to having to squeeze into the seat, preference for choosing seats with no arms and poor comfort, may help explain why seating was an aspect of the working environment that participants would most like to change. Issues related to space impacting on the ability to move around the working environment unhindered, were also identified. In particular, toilet cubicle size, was the main space issue identified with 42% of participants experiencing difficulties. Preventing these issues of fit and space within the working environment requires an understanding of the anthropometric characteristics of the population using them. The high number of physical issues identified in this study suggest that aspects of the working environment may be inadequate when consideration is given to the increasing prevalence of being plus size in the UK. This necessitates further exploration of the anthropometric characteristics of the plus size working population.

8.2.2 Anthropometric Measurement Validation Study

As a result of the fit and space related issues identified, Chapter 5 aimed to establish whether self measurement of anthropometric data in a plus size working population is a feasible and acceptable data collection method for an anthropometric study to understand the body size and shape of the plus size working population **(Objective 4).** Existing literature documents the use of self measurement primarily for stature, weight and waist circumference, suggesting it as a valid method for collecting this data. However, despite the advantages of low cost and resources, especially when populations are geographically diverse, no studies were identified that utilised self measurement as this kind of data collection tool. Following a review of the literature, 14 anthropometric measurements were selected for inclusion in the study. A unique measure of knee splay (in a non-pregnant population) was included to represent the observed sitting posture of plus size individuals. Self measurement data (completed using a guide) of these 14 anthropometric measurements relevant to workplace design were compared against researcher measured data for the same measurements. Based on a sample of 20 participants (10 male and 10 female) no significant differences were found between the self and researcher measured data for 11 out of the 14 measurements ($p \leq 0.05$). For 3 measurements; stature, weight and hip circumference, the values differed significantly, although in practical terms, the differences were relatively small and highlighted known limitations of self measurement including response bias.

8.2.3 Plus Size Anthropometry Study

The larger scale anthropometry study (Chapter 6) using self reported anthropometric data aimed to understand the body size and shape of plus size working age people in the UK **(Objective 4)** and identify issues experienced in the working environment. 47 males (mean BMI of 40.3 kg/m^2) and 54 females (mean BMI 43.5kg/m^2) completed the study (n=101) with findings suggesting that there is much variability among the body size and shape of plus size working population. Correlation analysis using Pearson product moment coefficient found that in males, hip breadth may be a useful measure for predicting largeness in the plus size population, being strongly and significantly correlated to a number of other measures. In females, abdominal depth was a useful measure for predicting largeness.

Fit and space issues were again reported by the majority of these plus size participants (n=101) as previously identified in the scoping study (Chapter 4). Seat size was the area of highest concern with 81% of participants reporting issues (for example chairs, stools, car seats). The majority of individuals who were required to wear a uniform and/or PPE again raised concerns with regards to the fit. Toilet cubicle size was identified as an issue for 73% of participants and 62% of participants felt that space within their working area limited their ability to move around unhindered. Although some issues were reported by all participants, participants with a BMI of 34.9kg/m^2 or less reported significantly less issues than those with a BMI of 35 kg/m^2 and over.

When compared to existing datasets, the results suggest that the study population is substantially larger in breadth, depth and circumference measurements. Measures of length, such as height and forward fingertip reach were not larger. Based on the popular compromise to design to include the 5th to 95th percentile of the population a proportion of the study population may be potentially excluded, when current design decisions are based on 10 out of the 14 anthropometric measurements collected. Nearly all of the participants were larger than the 95th percentile limit for thigh thickness, weight, hip and abdominal circumference, abdominal depth, and hip breadth which may impact on safety, comfort and accessibility. Knee splay, representing the observed sitting posture of plus size individuals, was also substantially larger than the current hip breadth and shoulder breadth values in existing data sets. Exclusion rates based on this novel knee splay study data were very high for both male and female participants at both the 95th percentile and 99th percentile design limits.

8.2.4 Stakeholder Interviews

Finally, semi structured telephone interviews were undertaken with stakeholders to capture their preferences for a resource communicating the findings from objective 4, with the aim of supporting inclusion for plus size people at work **(Objective 5).** The final study, (Chapter 7) concluded that a resource to support stakeholders in including plus size people in workplace design, would be welcomed. Stakeholders suggested that the purpose should be to set the context of why it is important to consider plus size people in design whilst raising awareness of the issues currently experienced by this population and providing easy access to anthropometric data to support this. Preferences were shown towards including case studies, checklists and 'hints and tips' with anthropometric data enhanced with practical 'add on's' such as clothing and equipment allowances. However, to be of benefit, it must be visual and interactive and accessible in a number of formats. Preferences for the resource are detailed in Section 7.9.

8.3 Recommendations

The findings of the 4 studies indicate that there are a number of opportunities for facilitating the inclusion of plus size people in the working environment. As a result, a number of recommendations can be made; categorised into 4 main areas:

- Recommendations related to fit – including seating and uniform/PPE
- Recommendations related to space – individual and shared spaces
- General recommendations
- Resource recommendations

In addition, the furthering understanding of the size and shape of the plus size working population could potentially impact on standards and guidance. An example of how the findings may differ from or be used to supplement specific standards or guidance is discussed in more detail in the subsequent sections.

8.3.1 Recommendations related to fit

The high number of fit related issues (Chapters 4 and 6) in combination with the anthropometric data collected in Chapter 6 has led to the following recommendations:

8.3.1.1 Seating

Office seating

A seat should provide stable bodily support over a period of time in a posture that is comfortable, physiologically satisfactory and task appropriate (Pheasant and Haslegrave, 2006) regardless of the size of the user. BS EN 1335-1:2000 Office furniture - Office work chair - Part 1: Dimensions - Determination of dimensions (British Standardisation Organisation, 2000) specifies the requirements of an office chair in order to achieve this. However, findings from this thesis further inform and supplement the information contained within the standard as shown in detail in Appendix 8.1 and summarised below:

- Office chairs that meet the specifications detailed in BS EN 1335-1:2000 will be unsuitable in terms of fit for the majority of plus size users. Therefore, an individual assessment of the individual to determine their requirements will be required.
- Office chairs should be highly adjustability to enable users with different distributions of adipose tissue to adopt positions of comfort and to facilitate function (for example, sit to stand and forward reach).
- Office chairs should be assessed for suitability in the working environment in which they will be used to check for conflicts in terms of space.

Seating in shared areas

- Within shared areas, a range of seating options should be provided to meet the preferences of a range of users. This may include seats without armrests, double seats or benches (for example, Figure 8.1) Demarcated individual seating spaces (Figure 8.2) may lead to the individual feeling as if they are taking up two seats and should be avoided.

Figure 8.1 Seating to accommodate a range of user preferences

Figure 8.2 Demarcated shared seating

- Where seats are combined with fixed table/working surface such as in a cafeteria or lecture theatre, additional moveable seating without a fixed surface should be provided to encourage use by all.

8.3.1.2 Uniform/PPE

- Due to the spread effect (Section 6.7.4) uniform and PPE needs to fit and be suitable for a range of working postures (standing, sitting and bending). This will help to maximise comfort, safety and compliance.
- Privacy should be maintained during the ordering and fitting procedure to minimise embarrassment and any feelings of exclusion. Consider a range of uniform options and enabling the individual to try on uniform/PPE away from the work environment.

8.3.2 Recommendations related to space

Similar to fit, the high number of space related issues (Chapters 4 and 6) in combination with the anthropometric data collected in Chapter 6 has led to the following recommendations:

8.3.2.1 Toilet cubicle size

The main space issue identified related to the size of toilet cubicles.

- Toilet cubicle size design recommendations (such as those contained within Approved Document M, Department for Communities and Local Government, 2015) may need to be reviewed in light of the anthropometric data collected in Chapter 6. Consideration should be given to the use of knee splay measurement data instead of hip breadth to determine seat size. Adequate clearance taking into account knee splay should be provided suitable for seated knee use.

- In the shorter term, using the term accessible toilet rather than disabled toilet may provide an alternative for the plus size individual to ingress/egress and manoeuvre within the cubicle without hindrance.
- Clearance around the toilet seat should be maintained to minimise the plus size individual coming into contact with equipment such as sanitary bins or toilet roll dispensers.

8.3.2.2 Clearance

In sitting and standing, the provision of adequate clearance in all directions (side to side, forward to backward and at foot level) is essential if the user is adopt a satisfactory posture (Mc Keown, 2011).

- Knee splay (rather than hip breadth or knee breadth) should be used to determine the side to side clearance in seated postures as this is the position of comfort and necessity adopted by plus size individuals.
- At floor level (in standing and sitting) greater clearance is required due to the wider base of support required by plus size individuals to perform functional activities such as sit to stand and dynamic balance tasks.
- Due to an increase in abdominal depth, additional space may be required behind the working surface/desk. This is to enable the plus size individual to sit/stand further away from the front of the surface accommodating the increase in abdominal depth.

8.3.2.3 Reach

- Functional reach may be reduced as a result of the individual having to sit/stand further away from the working surface due to abdominal depth. The reach envelopes should therefore be reduced to avoid discomfort, over reaching and maintain task performance. This is pertinent given evidence in the literature suggesting poorer balance (Hamilton et al., 2015) and lower tolerances for postural stress (Park et al., 2009) than normal weight individuals.

- The requirement to reach across the body (requiring adduction at the gleno humeral joint) should be minimal. Soft tissue apposition between the upper limb and abdomen and chest will limit the ability to perform this activity without excessive trunk rotation with its associated risks.

8.3.2.4 Access

- Access dimensions should cater for the largest user who may need to work in the area. Allowances should also be made for the use of any tools or equipment and well as the altered movement strategies adopted by plus size individuals including a wider gait pattern and larger turning circles.
- Adequate storage within the working environment should be provided to avoid shared spaces (such as photocopying rooms and corridors) being used for this purpose with the resulting loss of circulation space. The latter may impact on the plus size individual being able to mobilise without hindrance.

8.3.3 General recommendations

As well as the specific recommendations relating to fit and space within the working environment, a number of general recommendations can also be made:

- The majority of plus size individuals expressed concern with aspects of their working environment. Due to the significant increase in issues reported by individuals with a BMI over 35kg/m^2, specific consideration should be given to incorporating the recommendations for these individuals.
- End user involvement remains a priority in design activities. Due to the sensitive nature of collecting body measurements from plus size individuals the option of self measurement (following a measurement guide) should be offered as an alternative to estimating the size of the individual or using outdated datasets. It has been shown as a valid

tool to collect anthropometric data (for 11 measurements) in a plus size population.

- Assessment of the suitability of the working environment in terms of fit and space must go beyond the physical dimensions. It is recommended that the perception of stability and safety as well as fit and space from the plus size user's view is considered throughout the design process. For example ' does the chair look robust enough to support me?' 'Will I have enough space to fit in between the rows of seats?' This may take the form of a 'checklist' as (suggested by stakeholders in Chapter 7). An example of how these points could enhance a checklist currently in use – the DSE (Display Screen Equipment) assessment, to be inclusive for plus size individuals is shown in Appendix 8.2.

The integration of these recommendations into the design of the working environment will contribute to meeting the needs of plus size people, as summarised by one participant:

> *"I just want to go to work and do my job. Instead I spend most of my day thinking about whether I can fit in there or not and who might be watching if it's a not!"* (female, 25-44 years)

8.3.4 Resource recommendations

One way in which the recommendations (fit, space and general) could be integrated into the design of the working environment is via a resource aimed at encouraging empathy and supporting stakeholders in including the needs of plus size people within the working environment. Through interviews, Chapter 7 captured the ideas and preferences from stakeholders for the development of such a resource as follows:

- The resource should be visually engaging, interactive and accessible in a variety of formats.

- The resource should facilitate discussion and idea generation about the context of including plus size people in workplace design.
- The resource would need to go beyond a quantitative approach of measuring and listing anthropometric measurements and analysing the usability of designs in relationship to people's capabilities. The focus should instead be on raising, understanding and promoting empathy towards the physical and non-physical issues experienced by plus size people in the working environment.

Further development of this resource is discussed in Section 8.5.

8.4 Contribution to knowledge

In this thesis, different methods were successfully used to meet the objectives of the research. This has resulted in the contribution of new knowledge relating to including the needs of plus size people in workplace design.

This Scoping Study (Chapter 4) identified specific issues experienced by a sample of plus size people in the working environment and quantified which issues are of most importance/relevance. This has not previously been addressed in the literature. In addition, the analysis of additional comments made by participants has given insights into the way in which design of the physical environment may create barriers to inclusion within the working environment.

The use of self measurement in previous research has been limited primarily to the measures of stature, weight and waist circumference. The development of a self instruction guide in the Anthropometric Measurement Validation Study (Chapter 5) has enabled the extension of this method to include 14 measures applicable to workplace design. As a result, this thesis has presented an alternative methodology to traditional or 3D scanning for the collection of anthropometric measurements which has been shown to be;

- Valid - for 11 anthropometric measurements
- Acceptable to the target population
- Resource lean
- Suitable for 'hard to reach' populations.

Via the collection of measurement data including the unique measure of knee splay, from 101 plus size individuals, a data set for plus size people currently working in the UK has been compiled. Uniquely, this data set is based on actual measured data and not estimates based on secular trends or algorithms. This has enabled a better understanding of the size and shape of this population in terms of variability and predictors of largeness (hip breadth for males and abdominal depth for females). Comparison to existing datasets has provided knowledge on the how the plus size population differs to this data; which dimensions are larger and by how much. Building on the new knowledge contributed by Chapter 4 (Section 8.2.1), this study has also identified the body size level (BMI 35kg/m^2 and above) experience more issues within the working environment. This has previously not been explored in the literature.

End user participation in the design of resources is not a novel concept and is well documented as resulting in better design solutions (De Looze et al., 2000; Vink et al., 2006) and greater acceptability of the output (Gyi et al., 2013). However, this thesis (Chapter 7) provides the first insight into the preferences from stakeholders for the purpose, content, format and access of a resource specifically aimed at supporting them in including plus size people in workplace design. This in turn could facilitate a safer, healthier and more comfortable working environment for this population. The ideas generated, enthusiasm and engagement of the stakeholders strongly suggests that a resource may help raise the awareness of the issues faced by plus size individuals and supported by more up to date data, may facilitate the inclusion of plus size people in workplace design activities.

8.5 Ideas for further research

The research reported in this thesis provides new knowledge relating to plus size people at work in terms of understanding their body size and shape, issues they experience at work and how stakeholders can be supported in including plus size people in workplace design. In addition, there are further opportunities to develop the knowledge base within the field.

Chapters 4 and 6 identified the issues experienced by plus size people in the working environment. The nature of the questionnaire based surveys used resulted primarily in quantifying the issues rather than eliciting a more in depth understanding. Further exploration, in focus groups or interviews may be useful in exploring emerging issues, such as the need to consider the perceived robustness of chairs and the constant 'waying up' of the environment reported by participants. This may further help to enhance the design of new products and the resource aimed at supporting stakeholders in including plus size people in workplace design via promoting greater understanding and empathy.

Due to a small number of participants with a BMI of 34.9 kg/m^2 and under (Chapter 6) it was not possible to compare issues reported by participants with a BMI of between 30kg/m^2 to 34.9kg/m^2 to those with lower or higher BMI's. This is identified as an area of further study in order to ensure recommendations are targeted at the appropriate end users.

To represent the observed sitting posture of plus size people (Sibella et al., 2003) a novel measure of knee splay (in a non pregnant population) was utilised in the measurement set (Chapters 5 and 6). Opportunities to explore the relevance of other such functional or dynamic measures in a plus size population such as comfortable reach (bearing in mind abdominal depth) or sitting elbow height (may be affected by abdominal circumference/breadth; Smith et al., 2014) to enhance the application of anthropometric data to the working environment. Due to the sampling strategy, sample size and distribution of the data (Chapter 6) this thesis has stopped short of recommending specific values, for example for side to side clearance, seat depth or toilet cubicle size. Extending the sample size may provide more confidence in the data, which would then enable the recommendation of specific values/ranges to enable inclusion in design decisions. Further research addressing the impact of these inclusive design decisions on secondary users should also be explored.

Self measurement as a data collection tool was well received by plus size participants (Chapters 5 and 6) and was found to be a feasible and acceptable method of collecting anthropometric data. The extension of the use of self reported measurement to a wider range of dimensions could enable further understanding of the size and shape of this population or indeed other potentially hard to reach and widely dispersed populations. It could also help to overcome the barriers of cost and resources which are well documented as prohibiting more frequent large scale anthropometry surveys amongst the general population (Bridger et al., 2013).

Finally, the findings from all 4 research studies (Chapter 4, 5, 6 and 7) could ultimately contribute to a resource aimed at supporting stakeholders in including plus size people in workplace design. Although the preferences from a range of stakeholders, in terms of purpose, content, access and format were collected and presented in Chapter 7, and recommendations stated in Section 8.3.4, further development is required to design and construct such a resource prior to user testing.

8.6 Discussions of findings/recommendations within the wider literature

The research presented in this thesis has focussed on including the needs of plus size people in workplace design. However, the key issues and recommendations have implications outside of the scope of the working environment such as in the transport and home/leisure industries.

8.6.1 Transport

Transportation is critical for many reasons including travel, economic activity and mobility (Tovey, 2012). Despite this importance, plus size people experience issues with modes of transport such as cars, buses and airplanes. In a small interview study (n=10) by Kösten et al., (2016) more than half of the participants reported seat sizes (n=7), seat belts (n=7) and the size of toilet cubicles (n=6) in public transport to be a problem- very similar issues to the findings reported in this thesis. These findings support Tovey (2012) who suggests that although transport designers have recognized the requirement to accommodate variations in height, they have been slower in the appreciating the changes resulting from an increase in population weight and circumference.

Automotive industry

Optimizing postural comfort, easy access to the controls (such as steering wheel, gear levers, pedals), reducing the effort to get in and out of the vehicle whilst at all times respecting the standards relating to direct and indirect visibility are some of the challenges facing both end users and designers in the automotive industry (Jeong and Park, 2016). Similar to seating within a work environment, the purpose of an automotive seat is to provide stable bodily support over a period of time. However, the emphasis on comfort is crucial due to the potentially prolonged requirement to remain seated (on longer journeys) and its association with driver fatigue; a main factor in the causes of road traffic incidents (Deros, 2015). Although comfort is difficult to define as it is a subjective impression of the sitting position (Jain and Pandey, 2008), comfort level is determined in part by the body posture adopted by the driver. Typically, as with the working environment, design practice is often to accommodate from the 5th up to the 95th percentile of the target population that is aiming to accommodate 90% of the population. Therefore, potentially plus size people will be excluded from automotive seat design. Existing guidance such as the Motor Vehicle Seat Dimensions: SAE 2732 (SAE International, 2008) suggests a seat width (at its anterior edge) of 500mm to maximise comfort – however, the findings from this thesis suggest that

580mm would be the minimum required to accommodate the mean of the study population.

Failure to accommodate the anthropometric variables of the plus size driver may also change how the driver interacts with other elements within the vehicle (Tovey, 2012) resulting in poorer access to the controls (such as steering wheel, gear levers and pedals) than normal weight individuals. For example, a plus size person may prefer to sit further away from the steering wheel due to abdominal depth. However, in order to reach the steering wheel and pedals, they are forced to sit with their abdomen pressed up against the steering wheel which is not only potentially uncomfortable but may lead to different and potentially more severe injury patterns in collisions (Jeong and Park, 2016). This is also likely to go against the recommended 250mm distance between the sternum and the centre of the steering wheel (Segui-Gomez et al., 1999). Although alternatives to the traditional reclined or upright seating positions are being developed, such as the elevated posture (Smith et al, 2015) in an attempt to improve driver comfort and access, consideration should be given to exploring these postures using plus size participants given that the majority of the population now fall into this category. Bi-dimensional manikins recommended for standard testing (such as in SAE JA26b, 2008) or 3D virtual manikins should also be representative of the plus size population to avoid high exclusion rates for circumference, breadth and depth measurements.

The implications of the findings of this thesis, go beyond automotive design for comfort and access. Safety is of paramount importance in the industry especially as being plus size is linked to poor compliance with seat belt usage due to comfort and fit (Dietrich, 2014) and increase in mortality from road traffic accidents compared to normal weight individuals. Rice and Zhu (2013) reported that drivers with a BMI under 18kg/m^2 and those with a BMI between 25 and 29.9kg/m^2 had death rates similar to normal weight individuals based on data from the Fatality Analysis Reporting System. However, among plus size individuals, the higher the BMI, the more likely a driver was to die in the collision. A BMI of 30 to 34.9kg/m^2 was linked to a 21% increase in risk of death, and between 35 and 39.9kg/m^2 to a 51% increase. Drivers with a BMI above 40kg/m^2 were 81% more likely to die than those of normal weight in similar collisions. Interestingly, these risks remained for drivers wearing seat belts and also when the airbag was deployed, suggesting that cars are well designed to protect normal weight occupants but are deficient in protecting plus size occupants. The reasons for this are unclear; it may be that closer proximity to the car structures is a consideration or that comorbities associated with plus size individuals may be a factor. However, Rice and Zhu (2013) suggest that crash-test dummies are typically normal size adults and children. They are not designed to account for the nation's changing body types. How automobile safety devices including seat belts, respond to the additional size, shape and weight of the plus size population is becoming more crucial.

Public transport

On a daily basis, Tovey (2012) suggests that plus size individuals using public transport may face uncomfortable, unsafe and discriminatory practices due primarily to the design of vehicles and transport facilities failing to recognize their requirements in terms of seat design, crashworthiness and terminal layout. Table 8.1 highlights some potential examples with regards to buses, airplanes and trains and where the research in this thesis and recommendations made may have an impact.

Factors	Mode of transport		
	Buses	**Airplane**	**Trains**
Immediate environment	Inappropriate seat size, lack of clearance in front/between seats. No armrests. Double seats often too narrow "taking up 2 seats". Seats look robust	Inappropriate seat size, lack of clearance in front/between seats. Special requests for extension seat belts. Life jacket have restricted head room and difficult to access under seat due to limited reach Restricted use of tray table. Difficult egress/ingress to seats without disturbing others	Inappropriate seat size, lack of clearance in front/between seats. Double seats often too narrow "taking up 2 seats". Seats look robust.
Wider area inside the bus/plane or train	Narrow aisles. Flimsy looking straps to hold onto. Fear of falling if having to stand. Embarrassment of touching others if bus is crowded. Generally single sided handrail onto bus. Bus may pull away before user is seated Fear of falling due to reduced balance recovery.	Narrow aisles. Small toilets – not always able to use accessibility toilets. Difficult access to overhead lockers due to limited reach	Narrow aisles on some trains. Small toilets – not always able to use accessibility toilets Embarrassment of touching others if train is crowded.
Wider area outside the bus/plane or train	Bus stops generally have high perching seats which may increase load of joint and require balance.	Long walk from terminal. Steep access steps "look flimsy". Overcrowding in lifts due to use and baggage. Body scanner is limited in width. Embarrassment if required to have pat search or remove belts/shoes.	Ticket barriers are width limited. Turnstiles still in use which may be too small for user. Limiting seating on platforms/inappropriate seating Overcrowding in lifts due to use and baggage

Table 8.1 Potential areas where plus size individuals using public transport may face uncomfortable, unsafe and discriminatory practices.

Buses

Incompatibility between the design of the interior of the bus and the anthropometric characteristics of passengers has been identified as a potential cause of injuries sustained by passengers during collisions involving buses (Palacio et al., 2009). As a result, Zunjic et al., (2012) proposed that 35 anthropometric measurements should be taken in to account when designing the interior of buses; the anthropometric data collected in this thesis will assist in ensuring the plus size population are included within emerging designs. For example, Zunjic et al., (2012) suggests maximum body breadth is important for determining the width of bus doors, width of aisle and total number of passenger that can be accommodated on the bus. Knee splay should be used instead of hip breadth to determine the minimum width of the seat and to determine the position of the handrail, which is normally on the back of the seat in front, abdominal depth in a seated position should be considered.

Fiedler (2007) suggested that one of the main issues with utilizing buses is that there is often not enough time to access the bus, select a seat and become seated prior to the bus pulling away. This may result in a fear of falling for plus size individuals (Kösten, 2016) especially as being plus size has been associated with a reduction in postural stability (Hamilton et al., 2015) even in nonmoving environments. As well as recommending that buses should not move away before passengers are seated (in existence but not enforceable) visually robust grab rails need to be placed at lower levels to accommodate a reduction in reach due to abdominal depth. This would provide increased stability even if the bus was moving. Accessible seating close to the bus access point, with seat width based on knee splay and a slightly higher seat height might enable a plus size individual to sit/stand with reduced physical effort before the bus pulls away.

Air transport

Air travel is a growing market with airlines expected to be carrying upwards of 3.6 billion passengers in 2016 (IATA, 2013). In addition, the average occupancy of an aircraft is approximately 80% greater than other forms of transport such as trains or buses. Despite the increasingly prevalence of being plus size in most developed countries, the width of the standard airline seat has decreased from an average of 457mm to 420mm (ATAG, 2015) over the past 10 years, with the average seat pitch (space between a point on one seat and the same point on the seat in front of it) now being at 780mm. This reduction has been associated with trying to increase passenger numbers without incurring additional costs (Zeng and Li, 2015). However, the mean shoulder breadth and hip breadth from this thesis was 550mm and 600mm respectively which would exclude a nearly all of the study population from the existing design of a standard airplane seat. In addition, when considering knee splay as a more functional measure of the seat width required to accommodate plus size individuals in comfort, the potential exclusion rates would be even higher. This may result in plus size people coming into contact with adjacent passengers at knee, hip and shoulder levels perceived by most participants as stressful and embarrassing (Kösten et al., 2016). Although the findings of this thesis relating to buttock to front of knee length were already accommodated within existing datasets, mean abdominal depth was 537mm. This depth would need to be accommodated by the given seat pitch which could result in plus size individuals having only approximately 240mm between their abdomen and the seatback in front. This is reduced further, when the depth of the seat back cushion and posterior displacement of the seat in front due to the load of the person is taken into account. This may help to explain why air travel was frequently mentioned as problematic by plus size people due to small seat sizes, seat belts being too short, inaccessible food trays, toilet sizes and inadequate leg room. Various design solutions have been put forward to address airplane seats to accommodate the plus size passenger such as The Santo seat (Figure 8.3) which is larger than a usual seats, and makes use of space at the back of aircraft where the fuselage narrows. Also, a bench style seating arrangement has been proposed by Airbus (Figure 8.4). However, any designs should be based on up to date anthropometric data and take into account the acceptability of the design by potential users.

Figure 8. 3 The SANTO seat by SII Deutschland.

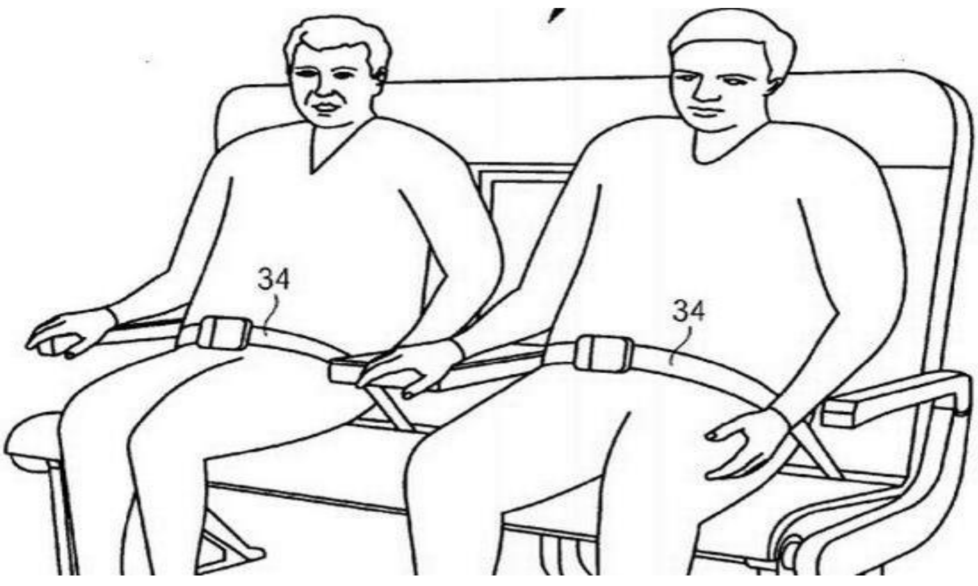


Figure 8. 4 New seating configuration proposed by airbus

Rail

The findings of this thesis are also applicable to the rail industry with 8% of the UK population travelling by train at least once a week (DfT, 2016). Rail travel differs from travel by car in that occupants do not need to engage with controls such as steering wheel, gear lever or pedals. In addition, there is no legal requirement to wear a seat belt leading to fewer parameters that may affect the comfort and safety of the user. This may be one reason, that in the interview study by Kösten et al. (2016) the internal design of trains were seen by a number of participants as an example of good public transport design - particularly in terms of their generally greater choice of seating, for example quad arrangement of seats with or without a table, single 'priority' seats or double seats without armrests; wider aisles with opportunity to stand by the doors and toilets that were larger than on airplanes. However, with the emphasis on space saving design initiatives within the industry in a bid increase seating capacity (DfT, 2016), maintaining choice and accessibility for the plus size population, via an understanding of body size and shape and issues they experience, must be at the forefront.

8.6.2 Home and Leisure

The recommendations made on the design of seating, clothing, toilet cubicle size, and space including clearance, access and reach throughout this chapter could also be applied to many other areas in the home and leisure industry with which plus size individuals interact in their daily life**.** According to Kösten et al. (2016) taking a bath, shower cubicles, public toilets, gym equipment, theme parks, going to the cinema/theatres or any activity that requires having to wear special clothing provided by the activity were all highlighted as difficult or in some cases impossible for a plus size person due to concerns over whether they would have enough space or would exceed the weight limits. Dickins et al., (2011) and Jackson et al., (2014) suggests that plus size people are more likely to feel uncomfortable in public due to the concerns over not fitting and the potential embarrassment, therefore participation is more likely to be avoided (Forhan et al., 2010). The design of the environment therefore acts as a form of stigma by reinforcing other forms of stigmatisation resulting in a tendency towards social isolation as plus size individuals choose not to draw attention to themselves (Thomas et al., 2010). This in turn may promote weight gain (Jackson et al, 2014; Kösten et al., 2016), contrary to previous studies that suggest design accommodating larger users is feeding into the rise of the incidence of being plus size (Puhl and Heuer, 2009). The importance of careful consideration of design criteria, (for example based on 5th to 95th percentile), or using traditional anthropometric dimensions (ISO: 7250 Basic Human Body Measurements for Technical Design; International Standardisation Organisation, 2015) rather than more functional measures such as knee splay, may become even more urgent if UK laws preventing discrimination against people based on their size are reformed (Hervey and Rostant, 2016). Currently, being plus size is only a *“very tenuous route"* for protection under the Equality Act 2010 (Legislation.gov.uk, 2010) because the Act is largely based on a medical model of disability. However, should direction of travel move away from this medical model towards a social model of disability such as in The EU Directive (2000/78/EC), limited participation (potentially due to the design of the environment) and attitudinal barriers as a result of not fitting and being embarrassed, would then be considered under anti-discrimination law.

The onus to include the needs of plus size people in all domains of public life is undoubtedly growing (Foresight, 2007) and this has resulted in a number of additional recommendations from the findings of this research:

- 2D or 3D virtual application and 'crash dummies' used in fit and safety testing should be representative for plus size body size and shapes to improve comfort and safety for plus size users.
- Safety critical equipment, for example airplane seatbelts should be longer to fit the increasing size of the population. They should not have to be specially requested (which may stigmatise).
- Examples of good practice, for example providing a range of seating configurations on trains, should be highlighted and implemented across other sectors.

8.7 Conclusions

This research has focussed on the experiences and characteristics of plus size individuals within the working environment. This research has shown that plus size individuals experience a number of difficulties, primarily related to fit and space, which necessitate a better understanding of their size and shape via anthropometry. Stakeholders have identified their requirements for a resource aimed at addressing these issues which has led to a summary list of preferences. As a result of the research in this thesis the following conclusions are supported;

- Plus size individuals report a range of issues at work and in the working environment. Fit of equipment, tools and furniture specifically seating, uniform and PPE has been identified as problematic. Circulation and shared spaces within the working environment has also been raised as an issue (Chapter 4). These issues are more prevalence for individuals with a BMI of 35kg/m^2 and over (Chapter 6) which is the fastest growing demographic of the population.
- Self-measurement, using a specifically developed guide is a feasible and acceptable method of collecting data for 11 anthropometric measurements relevant to workplace design; stature, weight, chest circumference, abdominal circumference, hip circumference, shoulder breadth (bi deltoid), forward fingertip reach, shoulder height (sitting), abdominal depth, hip breath, thigh depth, buttock to front of knee, knee splay and popliteal height. This may offer a more acceptable alternative to traditional anthropometric data collection methods for plus size individuals (Chapter 5).
- There is much variability in the body shape of UK plus size working population. Reasons for this variability are unknown although it is likely to lie in the fatty dimensions. This moves away for the ability to design for an average plus size 'Jack' or 'Jill' (Chapter 6).
- Plus size people are larger than the measurements in existing datasets. However, they are not larger in all dimensions. Length measurements remain similar to existing datasets but measurements

of breadth, circumference and depth have substantially increased. Exclusion rates, that is the percentage of the study population that may be excluded from design that accommodates up to the 95th or 99th percentile of existing datasets, are high for 10 out of the 14 measurements collected. These measurements once again relate to circumference, breadth and depth rather than measures of length. This suggests that anthropometric datasets often used may not be appropriate for including the plus size population (Chapter 6) and as a result this may have an impact on the standards and guidance in current use.

- Knee splay, a novel measure in a plus size population was substantially larger than measurements for hip and shoulder breadth. Given the functional relevance of this measurement in terms of meeting the requirements of the plus size population, consideration should be given to exploring using this to determine clearances within a working environment (Chapter 6).
- Identifying reasons why people cannot access or readily use products is needed to counteract exclusion. Sufficient data on the end users – in this case, plus size individuals – needs to be available in order to make informed decisions about the inclusivity of products or environments with respect to social acceptability or usability.
- A resource to support stakeholders in considering plus size people in workplace design would be welcomed. The purpose of this would be to raise awareness of the issues experienced by plus size people supported by data to understand the size and shape of this population. However, to ensure the integration and success of such a resource it must be visual and interactive and readily accessible to stakeholders (Chapter 7).
- Research to better integrate the needs of plus size individuals into everyday design such as transport and home/leisure can only contribute to improving comfort and safety for plus size people enabling participation and improving wellbeing.

9. References

Abdelmoula, A. Martin, V. Bouchant, A. Walrand, S. Lavet, C. Taillardat, M. (*2012).* Knee extension strength in obese and nonobese male adolescents*. Applied Physiology, Nutrition and Metabolism.* 37, 269-275.

Abdulwahed, M. Nagy, Z. (2009). Applying Kolb's experiential learning cycle for laboratory education. *Journal of Engineering Education*. 98 (3), 283-294.

Ahmad, N., Adam, S. I. M., Nawi, A. M., Hassan, M. R., and Ghazi, H. F. (2016). Abdominal Obesity Indicators: Waist Circumference or Waist-to-hip Ratio in Malaysian Adults Population*. International Journal of Preventive Medicine,* 7, 82-90.

*A*llanwood*,* G. Beare, *P.* (2014). *User Experience Design: Creating Design Users Really Love*. London: Bloomsbury Publishing*.*

Allison, D. Fontaine, R. Heo,M. Mentore, J. Cappelleri, J. Chandler, L. Weiden, P. Cheskin, L. (1999). The Distribution of Body Mass Index among Individuals with and Without Schizophrenia. *Journal of Clinical Psychiatry*. 60(4), 215-220.

Altshuler, L. Mintz, J. Leight, K. (2002).The Life Functioning Questionnaire (LFQ): a brief, gender-neutral scale assessing functional outcome. *Psychiatry Research*. 112, 161–182.

Amick, B. Gimeno, D. (2008). Measuring work outcomes with a focus on health-related work productivity loss. *Pain management: evidence, outcomes, and quality of life: a sourcebook.* Amsterdam: Elsevier

Andersson, G. (1999). Epidemiological features of chronic low-back pain. *Lancet*. 354(9178), 581-5.

Annis, J. (1996). Ageing effects on anthropometric dimensions important to workplace design. *International journal of Industrial Ergonomics*. 18(5-6), 381-388.

Arezes, P. Baptista, J. Barroso, M. Carneiro, P. Cordeiro, P. Costa, N. Melo, R. Miguel, A. Perestrelo, G. (2016). *Occupational Safety and Hygiene IV*. London: Taylor and Francis.

Armstrong, T. Buckle, P. Fine, L. Hagberg, M. Jonsson, B. Kilborn, A.Silverstein, B. Sjogaard, G. (1993). A conceptual model for work-related neck and upper-limb musculoskeletal disorders. *Scandinavian Journal of Work, Environment and Health.* 19(2), 73–84.

Atlantis. Baker, M. (2008). Obesity effects on depression: systematic review of epidemiological studies. I*nternational Journal of Obesity***.** 32. 881–891.

Air Transport Action Group (ATAG). (2015). Facts and Figures. Available from: http://www.atag.org/factsand-figures.html
(Accessed 1/11/16)

Aurisicchio, M. Bracewell, R. Wallace, K. (2010). Understanding how the information requests of aerospace engineering designers influence information-seeking behaviour. *Journal of Engineering Design.* 21(6), 707-730.

Beaton, D. Kennedy, C. (2005). Beyond return to work: testing a measure of at-work disability in workers with musculoskeletal pain. *Quality of Life Research*.14, 1869–1879.

Berrigan, F. Simoneau, M. Tremblay, A. Hue, O. Teasdale, N. (2006). Influence of obesity on accurate and rapid arm movement performed from a standing posture. *International Journal of Obesity*. 30, 1750–1757.

Benden, M. (2008). *Could you stand to lose: weight loss secrets for office workers*. (2nd ed). Dallas, TX: Trinity River Publishing.

Benden, M. Fink, R. Congleton, J. (2011). An in situ study of the habits of users that affect office chair design and testing. *Human Factors*. 53(1), 38-49.

Bhattacherjee, A. Chau,N. Sierra, C. Legras, B. Benamghar,L. Michaely, J. (2003). Relationship of job and some individual characteristics to occupational injuries in employed people: a community based study. *Journal of Occupational Health*, 45(6), 382-391.

Blanch-Hartigan, D. Ruben, M. (2013). Training clinicians to accurately perceive their patients: Current state and future directions. *Patient education and counseling*. 92(3), 328-336.

Błaszczyk, J. Cieślinska-Świder, J. Plewa, M. Zahorska, B. Markiewicz, A. (2009). Effects of excessive body weight on postural control. *Journal of Biomechanics*. 42(9), 1295-1300.

Boboko, N. (2002). Work ability, age and its perception. *Experimental Ageing Research*. 28, 59-71.

Bolton-Smith, C., Woodward, Tunstall-Pedoe, Morrison. (2000). Accuracy of the estimated prevalence of obesity from self reported height and weight in an adult Scottish population. *Journal of Epidemiology and Community Health,* 54(2), 143-150.

Borg, G. (1990). Psychophysical scaling with applications in physical work and the perception of exertion. *Scandinavian Journal of Work, Environment and Health.* 16, 55-58.

Bradtmiller, B. Gordon, C. Kouchi, M. Jurgens, H. Lee, Y. (2004). Traditional anthropometry. In Pheasant, S. Haslegrave, C. (2006). *Bodyspace: anthropometry, ergonomics and the design of work.* 3rd edition. Florida: Taylor and Francis.

Brewis, A. (2014). Stigma and the perpetuation of obesity. *Social Science and Medicine*. 118, 152-158.

Bridger, R. Bennett, A. (2011). Age and BMI interact to determine work ability in seafarers. *Occupational Medicine*. 61, 157-162.

Bridger, R. Basher, K. Bennett, A. (2013). Sustaining person environment fit with a changing workforce. *Ergonomics.* 56(3), 565-577.

British Standards Institute (2000). BS EN 1335-1:2000. Office furniture - Office work chair - Part 1: Dimensions -Determination of dimensions. London: BSI

Brooke-Wavell, K. Jones, P. West, G. (2004). Reliability and repeatability of 3-D body scanner (LASS) measurements compared to anthropometry. Annals of Human Biology. 21(6), 571-7.

Burton, W. Chen, C. Conti, D. Pransky, G. Edington, D. (2004). Caregiving for ill dependents and its association with employee health risks and productivity. *Journal of Occupational and Environmental Medicine*. 46. 1048–56.

Burton, K. Waddell, G. (2006). '*Is work good for your health?* TSO: London. Available from https://www.gov.uk/government/publications/is-work-good-for-your- health-and-well-being.
(Accessed 20/6/16)

Caballero, B. (2007). The global epidemic of obesity: an overview. *Epidemiology Review.* 29, 1-5.

Caberlon, C. Padoin, A. Mottin, C. (2013). Importance of musculoskeletal pain in work activities in obese individuals. *Obesity Surgery*. 23(12), 2092-2095.

Cairncross, S. Mannion, M. (2007). Interactive multimedia and learning: realizing the benefits. *Innovations in Education and Teaching International*. 38, 156-164.

Capodaglio, P. Castelnuovo, G. Brunani, A. Vismara, L. Villa, V. Capodaglio, E.(2010). Functional Limitations and Occupational Issues in Obesity: a review. *International Journal of Occupational Safety and Ergonomics.* 16(4), 507-523*.*

Cash, T. Hicks, K. (1990). Being fat versus thinking fat: Relationships with body image, eating behaviors, and well-being. *Cognitive Therapy Research*. 14, 327-334.

Caterson, I. Leibman, S. Smith, G. Sambrook, P. Fransen, M. March, L. (2009). Influence of BMI on Health-related Quality of Life: Comparison Between an Obese Adult Cohort and Age-matched Population Norms. *Obesity*. 17, 2114–2118.

Cavdar, K. (2014). Determination of the Some Anthropometric Data of Turkish Men Population. *Gazi University Journal of Science.* 27(2). 801-807.

Cavuoto,L. Nussbaum, M. (2013). Differences in functional performance of the shoulder musculature with obesity and ageing. *International Journal of Industrial Ergonomics.* 43, 393-399*.*

Cavuoto,L. Nussbaum, M. (2013). Obesity related differences in muscular capacity during sustained isometric exertions. *Applied Ergonomics*. 44, 254-260.

Chang, Y., Guo, X., Chen, Y., Guo, L., Li, Z., Yu, S. Sun, Y. (2015). A body shape index and body roundness index: two new body indices to identify diabetes mellitus among rural populations in northeast China. *BMC Public Health.* 15, 794-801.

Clarkson, P. Coleman,R. (2013.) History of inclusive design in the UK. *Applied Ergonomics.* 1-13

Commission for Architecture and the Built Environment (CABE). (2010). *Inclusive Design.* Available from http://www.cabe.org.uk/publications/the-principles-of- inclusive-design.
(Accessed 19/7/2016)

Connell, L. Ulrich, P. Brannon, E. Alexander, M. and Presley, A. (2006). Body shape assessment scale: Instrument development for analysing female figures. *Clothing and Textiles Research Journal*. *24*(2), 80-95

Cook, S. Richardson, J. Gibb, A. Bust, P. Leaviss, J. (2009). Raising Awareness of the Occupational Health of Older Construction Workers, cib W099 International Conference, Melbourne, Australia, 37.

Cooper A. Reimnan, R. Cronon, D. (2007). *About Face 3. The Essentials of Interaction Design.* Indianapolis: Wiley Publishing.

Creswell, J. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed). California: Sage Publications.

Crowe, S. Cresswell, A. Robertson, A. Huby, G. Avery, A. Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*. 11, 100-112.

Dekkers, J. Van Wier, M. Hendriksen, I. Twisk, J. Van Mechelen, W. (2008). Accuracy of self-reported body weight, height and waist circumference in a Dutch overweight working population. *BMC Medical Research Methodology, 8*, 69-80.

De Looze, M. Van Greuningen, K. Rebel, J. Kingma, I. Kuijer, P. (2000). Force direction and physical load in dynamic pushing and pulling. *Ergonomics.* 43. 377–390.

Delliman, N., Haslegrave, M. Chaffin, D. (2004). *Working postures and movements*. Florida: CRC Press.

DelPrete. L. Caldwell, M. English, C. Banspach, S. Lefebvre C. (1992). Self-reported and measured weights and heights of participants in community-based weight loss programs. *Journal of American Dietetic Association*. 92(12), 1483-1496.

Department of Health (2009).Change4Life. Available from
http://www.nhs.uk/change4life/Pages/change-for-life.aspx
(Accessed 22/6/16)

Department of Health (2009). The National Child Measurement Programme Guidance for PCTs: 2009/10 school year. London: Health. Available from
http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/dH_086724
(Accessed 18/7/16)

Department of Health (2011) Healthy Lives, Healthy People: A call to action on obesity in England. Available from
https://www.gov.uk/government/publications/healthy-lives-healthy-people-a-call-to-action-on-obesity-in-england
(Accessed 22/6/16)

Department for Communities and Local Government (2015). Approved document M: Access to and use of Buildings: part 1 and 2. Available from
https://www.gov.uk/government/publications/access-to-and-use-of-buildings-approved-document-m
(Accessed 20/5/16)

Department for Transport (2016). Rail passenger factsheet. Available from
https://www.gov.uk/government/statistics/rail-factsheets-2016
(Accessed 15/12/16)

Department for Work and Pensions (2015). ‘Improving health and work and changing lives. Available from
https://www.gov.uk/government/publications/2010-to-2015-government-policy-employment
(Accessed 26/11/16)

Deros, B. Daruis, D. Nor, M. (2015). Incorporating Malaysian's Population Anthropometry Data in the Design of an Ergonomic Driver's Seat *Procedia - Social and Behavioural Sciences.* 195, 2753-2760.

Després, J. (2012). Body Fat Distribution and Risk of Cardiovascular Disease An Update. *Obesity*. 126, 10-19.

Dickins, M. Thomas, S. King, B. Lewis, S. Holland, K. (2011). The Role of the Fatosphere in Fat Adults' Responses to Obesity Stigma: A Model of Empowerment Without a Focus on Weight Loss. *Qualitative Health Research*. 21(12), 1679-1691.

Dietrich, J. (2014). *Obesity and seatbelt use: a fatal relationship. The American Journal of Emergency Medicine*. 32(7), 756 – 760.

Dreyfus, S. Dreyfus, H. (1980). *"A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition"* (PDF). Washington, DC: Storming Media.
(Accessed 20/9/16)

Eskelinen, L. Kohvakka, A. Merisalo, T. (1991). Relationship between the self assessment and clinical assessment of health status and work ability. *Scandinavian Journal of Work, Environment and Health*.17, Suppl 1, 40-47.

European Union. EU. (2000).Employment Equality Framework Directive. Council directive establishing a general framework for equal treatment in employment and occupation 2000/78/EC

Feathers, d. D'Souza, C. Paquest, V. (2015) Anthropometry for Ergonomic Design. In: Wilson, J. and Sharples, S. *Evaluation of Human Work*. 4th ed London: Taylor and Francis. 725 – 749.

Fereday, J. (2008). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*. 5(1).18-30.

Feuerstein, M. Nicholas, R. Huang, G. Haufler, A. Pransky, G. Robertson, M. (2005). Workstyle: development of a measure of response to work in those with upper extremity pain. *Journal of Occupational Rehabilitation*. 15, 87–104.

Feuerstein, M. Nicholas, R. (2006). Development of a short form of the Workstyle measure. *Occupational Medicine*. 56, 94–99.

Fidel, R. Green, M. (2004). The many faces of accessibility: engineers' perceptions of information sources. *Information Processing and Management* 40(3). 563-581.

Fielder, M. (2007). Older people and public transport: Challenges and chances of an ageing society. Koln: Germany: European Metropolitan Transport Authorities.

Finkelstein, E. Trogdon, J. Brown, D. Allaire, B. Dellea, P. Kamal-Bahl, S. (2008). The Lifetime Medical Cost Burden of Overweight and Obesity: Implications for Obesity Prevention. *Obesity*. 16, 1843–1848.

Fischer, F. Borges, F. Rotenberg, L. (2006). Work ability of health care shift workers. *Chronobiological International Journal*. 23, 1165-79.

Fjeldstad, C. Fjeldstad, A. Acree, L. Nickel, K. Gardner K. (2008). The influence of obesity on falls and quality of life. *Dynamic Medical Journal.* 7, 4-9.

Fleming, J. (2015). Training to raise staff awareness about safeguarding children. *Nursing Children and Young People.* 27(3), 22 -27.

Forhan, M. Risdon, C. Solomon, P. (2013). Contributors to patient engagement in primary health care: perceptions of patients with obesity. *Primary Health Care Research and Development.* 14,367-372.

Frontera, W. Hughes, V. Lutz, K. Evans, W. (1991). A cross-sectional study of Muscle strength and mass in 45- to 78-yr-old men and women. *Journal of Applied Physiology.* 71, 644–650.

Furniture Industry Research Association (FIRA). (2016). Furniture Design Toolkit (PDF).

Gable, B. Gardner, A. Celik, D. Bhalla, M. Ahmed, R. (2014). Improving Bariatric Patient Transport and Care with Simulation. *Western Journal of Emergency Medicine*. 15(2), 199–204.

Garg, A. Kapellusch, J. (2009). Applications of biomechanics for prevention of work related musculoskeletal disorders. *Ergonomics.* 52(1), 36-59.

Gibb, A. Cook, S. Nyateka, N. Bust, P. Jones, W. Finneran, A. (2015). Wearable simulations for ill-health conditions in construction. *Proceedings of the Institution of Civil Engineers*. 168(6), 51-56.

Gignac, M. Badley, E. Lacaille, D. Cott, C. Adam, P. Anis, A. (2004). Managing arthritis and employment: making arthritis-related work changes as a means of adaptation. *Arthritis and Rheumatism.* 51, 909–916.

Gignac, M. Cao, X. Tang, K. Beaton, D. (2011). An examination of arthritis related work place activity limitations and intermittent disability over four-and-a-half years and its relationship to job modifications and outcomes. *Arthritis Care Research* .63, 953–962.

Gilleard, W. Smith, T. (2007). Effect of obesity on posture and hip joint moments during a standing task, and trunk forward flexion motion. *International Journal of Obesity.* 31(2), 267–271.

Goedhard, W. Rijpstra, T. Puttiger, P. (1998). Age, absenteeism and physical fitness in relation to work ability. *Studies in Health Technology and Informatics*. 48, 254-257.

Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report*. 8(4), 597-607

Goodman-Deane, J. Ward, J. Hoskings, I. Clarkson, J. (2014). A comparison of methods currently used in inclusive design. *Applied Ergonomics*. 45, 886-894.

Gorber, S .Tremblay, M. Moher, D. Gorber, B. (2007). A Comparison of Direct vs. Self-report Measures for Assessing Height, Weight and Body Mass Index: A Systematic Review. *Obesity Reviews*. 8, 307–326.

Gordon, C. Bradtmiller, B. (2012). Anthropometric change: implications for office ergonomics. *Work*. 41(1), 4606-4611.

Gov UK. (2010). Definition of disability under the Equality Act 2010: OGL. Leeds. Available from https://www.gov.uk/definition-ofdisability-under-equality-act-2010.
(Accessed 1/12/16).

Griffin, H. O'Connor H. Rooney, K. Steinbeck, K. (2013). Effectiveness of strategies for recruiting overweight and obese Generation Y women to a clinical weight management trial. *Asia Pacific Journal of Clinical Nutrition.* 2, 235 -240.

Gupta, D. Zakaria, N. (2014). *Anthropometry, apparel sizing and design*. Oxford: Woodhead publishing Ltd.

Gyi, D. Sang, K. Haslam, C. (2013). Participatory ergonomics: co-developing interventions to reduce the risk of musculoskeletal symptoms in business drivers. *Ergonomics*. 56(1), 45-58.

Hamilton, M. Strawderman, L. Hale, B. Babski-Reeves, K. (2015). Effects of BMI and task parameters on postural sway during simulated small parts assembly. *Ergonomics*, 58(3), 504-512.

Han, E. Norton, E. Stearns, S. (2009). Weight and wages: fat versus lean paychecks. *Health Economics*.18(5), 535-548.

Han, H. Nam, Y. Choi, K. (2010). Comparative analysis of 3D body scan measurements and manual measurements of size Korea adult females. *International Journal of Industrial Ergonomics.* 40, 530-540.

Health and Social Care Information Centre. (2005). Health Survey for England.
Available from http://healthsurvey.hscic.gov.uk/support-guidance/public-health/health-survey-for-england/adult’s-obesity-and-bmi.aspx.
(Accessed 1/7/16).

Hervey, T. Rostant, P. (2016). ‘All About that Bass’? Is Non-Ideal-Weight Discrimination Unlawful in the UK? *The Modern Law Review*. 79(2), 248-282.

Hoffman, A. Montgomery, R. Aubry, W. Tunis, S. (2010). How Best To Engage Patients, Doctors and Other Stakeholders In Designing Comparative Effectiveness Studies. *Health Affairs.* 29(10), 1834-1841.

Holmberg, S. Thelin, A. Thelin, N. (2005). Knee osteoarthritis and body mass index: a population-based case-control study. *Scandinavian Journal of Rheumatology*. 34, 59–64.

Howell, D. (2007). *Statistical Methods for Psychology*. California: Thomson Wadsworth.

HSCIC, Health and Social Care Information Centre. (2013) Health Survey for England – 2013. Chapter 10, Adult anthropometric measures. Available from: http://www.hscic.gov.uk/catalogue/PUB16076/HSE2013-Ch10-Adult-anthmeas.pdf
(Accessed 7/11/16).

HSE (1999). *Personal Protective Equipment at Work*. Guidance on Regulations. HMSO: London

HSE (1992). *Management of Health and Safety at Work Regulations*. Guidance on Regulations. HMSO: London

HSE (1998). *Provision and Use of Work Equipment Regulations*. Guidance on Regulations. HMSO: London

HSE (2014). Heat Stress in the workplace: A brief guide. Available from http://www.hse.gov.uk/pubns/indg451.htm
(Accessed 12/7/15)

HSE (2015). Health and safety statistics. Slips, trips and falls. Available from http://www.hse.gov.uk/statistics.
(Accessed 21/7/16)

Hue, O. Simoneau, M. Marcotte, J. Berrigan, F. Doré, J. Marceau, P. (2007). Body weight is a strong predictor of postural stability. *Gait and Posture.* 26(1), 32-38.

Hulens, M. Vansant, G. Lysens, R. Claessens, A. Muls, E. (2001). Exercise capacity in lean versus obese women. *Scandinavian Journal of Medicine and Science in Sports.* 11(5), 305-309.

Hulens, M. Vansant, G. Lysens, R. Claessens, A. Muls, E. (2001). Study of differences in peripheral muscle strength of lean versus obese women: an allometric approach. *International Journal of Obesity*. 25, 676-681.

International Air Transport Association (IATA). (2013). Airlines to welcome 3.6 billion passengers in 2016
Available from: http://www.iata.org/pressroom/pr/pages/2012-12-0601.aspx
(Accessed 8/12/16)

Ilmarien, J. (2005). *Towards a Longer Work Life*. FIOH Helsinki. Available from www.stm.fi/c/document_library/get_file?folderId=39503.
(Accessed 8/6/16)

Incollingo, R. Heldreth, C. Tomiyama, A. (2016). Putting on weight stigma: A randomized study of the effects of wearing a fat suit on eating, well-being, and cortisol. *Obesity*. 24(9), 1892-1898.

ISO:15535 (2012). General requirements for establishing anthropometric databases'. International Standardisation Organisation

ISO:7250 (2015) 'Basic Human Body Measurements for Technical Design'. International Standardisation Organisation

Jackson, S. Beeken, R. Wardle, J. (2014). Perceived Weight Discrimination and Changes in Weight, Waist Circumference, and Weight Status. *Obesity* 22(12), 2485-2488.

Jain, R. Pandey, R., (2009). A Study on the Role of Body Posture on Static Seating Comfort. SAE Technical Paper. 26-0080. Available from http://papers.sae.org/2009-26-0080/
(Accessed 2/12/16)

James, P. (2004). Obesity: The worldwide epidemic. *Obesity*. 22(4), 276–280.

Jeong. Y. Park, W. (2016). Differences between obese and non-obese drivers in preferred vehicle interior components setting and driving posture, *Ergonomics*. 10, 1080- 1088.

Johnson, K. Mervis, C. (2000). Effects of varying levels of expertise on the basic level of categorization. *Journal of Experimental Psychology*. 126(3). 248-277

Jusot, F .Khlat, M. Rochereau,T. Serme, C. (2008). Job loss from poor health, smoking and obesity: a national prospective survey in France. *Journal of Epidemiology and Community Health*. 62(4), 332-337.

Kaleta, D. Makowiec-Dabrowska, T. Jegier, A. Lifestyle index and work ability. *International Journal of Occupational Medicine and Environmental Health.* 19(3), 170-177.

Kaplan-Leiserson, E. (2000). Casual dress/Back-to-business attire. *Training and Development. 54* (11), 38-39.

Karhu, O. Kansi, P. Kuorinka,I. (1977). Correcting working postures in industry: a practical method for analysis. *Applied Ergonomics*. 8, 199-201.

Kee, D. Karwowski, W. (2002). Analytically derived three-dimensional reach volumes based on multijoint movements. *Human Factors*. 44, 530–544.

Keys, A. Karvonen, N. Kimura, N. Taylor, H. (1973). Indices of relative weight and obesity. *Journal of Chronic Diseases*. 25, 329–343.

King, N. Horrocks, C. (2010). *Interviews in Qualitative Research*. London: SAGE Publications.

Kirk, D. McClelland, I. Suri, J. (2015). Involving People in Design Research. In J. Wilson and S. Sharples (eds) *Evaluation of Human Work*, 4th ed. London: Taylor and Francis.

Klarenbach, S. Padwal, R. Chuck, A. Jacobs, P. (2006). Population-Based Analysis of Obesity and Workforce Participation. *Obesity*. 14, 920–927.

Kortt**,** M. Baldry, J. (2002).The association between musculoskeletal disorders and obesity. Australian Health Reviews. 25(6), 207-214.

Kosten, L. Gyi, D. Masson, A. (2016) Plus size and inclusivity in design. *Proceedings of Ergonomics and Human Factors Conference*. Daventry, UK. 19-21 April.

Kouchi, M. Mochimaru, M. (2011). Errors in landmarking and the evaluation of the accuracy between traditional and 3D anthropometry. *Applied Ergonomics*. 42, 518-527.

Kouvonen, A. Vahtera, J. Oksanen, T. Pentti, J. Väänänen, A. Heponiemi, T. (2013). Chronic workplace stress and insufficient physical activity: a cohort study *Occupational and Environmental Medicine*. 70, 3-8.

Kunak, D. (1990). Backing into the system: from marketing concept to human factors in product design. *Ergonomics*. 33(5), 535-540.

Laitinen, J. Nayha, S. Kujala, V. (2005). Body mass index and weight change from adolescence into adulthood, waist-to-hip ratio and perceived work ability among young adults. *Internal Journal of Obesity.* 29(6), 697-702.

Larsson, U. Mattsson, E. (2001). Functional limitations linked to high body mass index, age and current pain in obese women. *International Journal of Obesity Related Metabolic Disorders*. 25, 893–899.

Larsason, U. (2004). Influence of weight loss on pain, perceived disability and observed functional limitations in obese women. *International Journal of Obesity.* 28, 269–277.

Lee, J., Istook, C., Nam, Y. (2007). Comparison of body shape between USA and Korean women: (Hourglass, Bottom Hourglass, Top Hourglass, Spoon, Triangle, Inverted Triangle, Rectangle). *International Journal of Clothing Science and Technology*, *19*(5), 374-391.

Levangie,P. Norkin, C. (2001). *Joint Structure and Function*. 3rd Edition. Philadelphia: Davis Company.

Linberg, P. Vingard, E. Josephson,M. (2006). Retaining the ability to work-associated factors at work. *European Journal of Public Health*. 16, 470-475.

Lobstein T, Jackson Leach R. (2007). International comparisons of obesity trends, determinants and responses. Evidence review. Foresight Tackling Obesities, Future Choices. Available from: http://www.foresight.gov.uk. (Accessed 13/4/16)

Low. J. Griffith,G. Alston, C. (1996). Australian farm workers injuries: incidence, diversity and personal risk factors. *Australian Journal of Rural Health*. 4, 179-189.

Luppino**,** F. de Wit, L. Bouvy, P. Stijnen, T. Cuijpers, P. Penninx, B. Zitman, F. (2010). Overweight, obesity and depression: a systematic review. *Psychiatry*. 67(3), 220-9.

Maffiuletti,N. Jubeau,M. Munzinger, U. Bizzini, M. Agnosti, F. (2007). Differences in quadriceps muscle strength and fatigue between lean and obese subjects. *European Journal of Applied. Physiology*. 101, 51-59.

Maranto, C. (2000). Weight discrimination: a multidisciplinary analysis. *Employee Responsibilities and Rights Journal*. 12(1), 19-24.

Marshall, R. Case, K. Porter, M. Summerskill, S. Gyi, D. Davis, P. Sims, R. (2010). HADRIAN: a virtual approach to design for all. *Journal of Engineering Design.* 21 (2-3), 253-273.

Martinez, M. Latorre, R. (2006). Health and work ability among office workers. *Saude Publica.* 40(5), 851-858.

Masson, A. Hignett, S. Gyi, D. (2014). Exploring and describing workplace Issues for plus size people. Proceedings of the 3rd International Conference on Ergonomics Modelling, Usability & Special Populations / 5th International Conference on Applied Human Factors and Ergonomics. Krakow, Poland. 21- 25 July

McGraw,B. McClenaghan, B. Williams, H. Dickerson, J. Ward, D. (2000) Gait and postural stability in obese and nonobese prepubertal boys. *Archives of Physical Medicine and Rehabilitation*. 81, 484-489.

McGinley, C. Dong, H. (2009). 'Accessing user information for use in design', In Stephanidis, C. (Ed). *Universal Access in HCI*, Part 1, HCII2009, LNCC 5614. Heidelberg:Berlin, 116-125.

McKeown, C. (2011). *Ergonomics in action*. 3rd edition. England: Lavenham Press.

Menegoni, F. Manuela, G. Tacchini, E. Vismara, L. Cavigioli, M. Capodaglio, P. (2012) Gender-specific Effect of Obesity on Balance. *Obesity.* 17(10), 1951-1960.

Meng, H. O'Connor, D. Chan Lee, B. Layne, C. Gorniak, S. (2016). Effects of adiposity on postural control and cognition. *Gait and Posture*. 43, 31-37.

Mickan, S. Atherton, H. Roberts, N. Heneghan, C. Tilson, J. (2014). Use of handheld computers in clinical practice: a systematic review. *BMC Medical Informatics and Decision Making.* 14, 14-56.

Mills, C. Gill, S. (2016). Challenging Perceptions on Body Image Using a Bariatric Weighted Suit with Female University Dancers. *Journal of Obesity and Bariatrics*. 3, 1-11.

Mokdad, A, Earl, S. Ford, B Bowman, W. (2003).Prevalence of Obesity, Diabetes, and Obesity-Related Health Risk Factors. *The Journal of the American Medical Association*. 289, 76-89.

Molenbroek, J. De Bruin, R. (2000). Enhancing the Use of Anthropometric Data.Available at: *io.tudelft.nl/...de...Anthropometry/.../molenbroek/.../ enhancing_anthropometry.pd*
(Accessed 15/11/16)

Molenbroek, J. De Bruin, R. (2011). Anthropometrical Aspects of a Friendly Rest Room. In: Molenbroek, J. (Eds). *A Friendly Restroom: Developing Toilets of the Future for Disabled and Elderly People.* Amsterdam: ISO Press. 228-240.

Monteiro, M. Ilmarinen, J. Corraa Filho, H. (2006). Work ability of workers in different age groups in a public health institution in Brazil. *International Journal of Occupational Safety and Ergonomics*. 12(4), 417-427.

Morgan, D. (2007). Paradigms Lost and Pragmatism Regained: Methodological Implications of Combining Qualitative and Quantitative Methods. *Journal of Mixed Methods Research*. 1, 48-56.

Mosa, A. Yoo, I. Sheets, L. (2012). A Systematic Review of Healthcare Applications for Smartphones. *BMC Medical Informatics and Decision Making*, 12, 12-67.

Myers, A. Baker, S. Li, G. (1999). Back injury in municipal workers: a case controlled study. *American Journal of Public Health*. 89, 1036-1041.

National Institute for Clinical Excellence (2006). Obesity: Guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children. Available from http://www.nice.org.uk/guidance/CG43.
(Accessed 21/7/16)

National Institute for Clinical Excellence (2014). Weight management: lifestyle services for overweight or obese adults. Available from https://www.nice.org.uk/guidance/ph53
(Accessed 26/11/16)

Nickpour F. and Dong, H. (2008). Anthropometrics without numbers. An investigation of designers use and preference of people data, Include2009, Royal College of Art, April 8-10, London. Available at: http://www.hhc.rca.ac.uk/2084/all/1/proceedings.aspx.
(Accessed 14/11/16)

Nichols, D. Glenn, T. Hutchinson, K. (1995) Changes in the Mean Centre of Balance During Balance Testing in Young Adults. *Physical Therapy*. 75, 699-706.

Nicolle, C. Hewer, S. Leddon, C. Kingsland, C. (2005). Coming of age – an Inclusive design resource comes to fruition. Proceedings of International Conference on inclusive design. London, 5-8 April.

NIHR (2009). Exploring Impact: Public involvement in NHS, public health and social care research. Available at www.invo.org.uk
(Accessed 1/6/16)

O'Neill, D. Sweetman, O. (2013). The consequences of measurement error when estimating the impact of obesity on income. *IZA Journal of Labor Economics*. 2, 3-9.

Oha, K. Animagi, L. Passuke, M. (2014). Individual work related risk factors for musculoskeletal pain. *BMC Musculoskeletal Disorders*. 15,181-189.

Ohnari, K. Uozumi, T. Tsuji, S. (2007). Occupation and carpal tunnel syndrome. *Brain Nerve*. 59, 1247-1252.

Olds, T. Honey, F. (2005). The use of 3D whole body scanners in anthropometry. *Kinanthropometry.* London: Routledge.

Olds, T. Daniell, N. Petkov, J. Steward, A. (2013). Somatotyping using 3D anthropometry: a cluster analysis. *Journal of Sports Sciences*. 31(9), 936–944.

Open Ergonomics. (2008). PeopleSize 2008. Available from www.openerg.com*.*
(Accessed 15/10/16)

Osterhaus, J. Purcaru, O. Richard, L. (2009). Discriminant validity, responsiveness and reliability of the rheumatoid arthritis-specific Work Productivity Survey (WPS-RA). *Arthritis Research and Therapy.* 11, 73-81.

Mace, R. (1997). The 7 principles of Universal Design. [online]. North Carolina State University. Available from: http://universaldesign.ie/What-is-Universal-Design/The-7-Principles/.
(Accessed 10/11/16)

Palacio. A. Tamburro, G. O'Neill, D. Simms, C. *(2009).* Non-collision injuries in urban buses-Strategies for prevention*. Accident; analysis and prevention* 41(1), 1-9.

Pallant, J. (2007*). SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS (5th ed). NSW:* Allen and Unwin.

Pallant, J. (2016*). SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS (6th ed).* NSW: Allen and Unwin.

Park, W. Singh, D. Levy, M. Jung, E. (2009). Obesity effect on perceived postural exertion during static posture maintenance tasks. *Ergonomics*, 52(9), 1169-1182

Park, W. Ramachandran, J. Weisman, P. Jung, E. (2010). Obesity effect on male active joint range of motion. *Ergonomics*. 53(1), 102 -108.

Park, W. Park, S. (2013).Body shape analyses of large persons in South Korea. *Ergonomics*. 46(4), 692-706.

Pasin, F. Giroux, H. (2011). The impact of a simulation game on operations management education. *Computers and Education*, 57(1), 1240-1254.

Paul, J. Van Dijk, F. Frings-Dresen, M. (1994). Work load and musculoskeletal complaints during pregnancy. *Scandinavian Journal of Work, Environment and Health*. 20(3), 153-159.

Peebles, L. Norris, B. (1998). *Adultdata: The handbook of adult anthropometric and strength measurements- Data for design safety*. Department of Trade and Industry, UK.

Petty, N. Moore, A. (2004) *Principles of Neuromusculoskeletal Treatment and Management. Edinburgh:* Churchill Livingstone.

Pheasant, S. (2003). *Bodyspace – Anthropometry, Ergonomics and the Design of Work.* 2nd edition. London: Taylor and Francis.

Pheasant, S. Haslegrave, C. (2006). *Bodyspace: anthropometry, ergonomics and the design of work.* 3rd edition. Florida: Taylor and Francis.

Phelps, A. Horman, M. (2010). Ethnographic Theory-Building Research in Construction. *Journal of Construction Engineering and Management*. 136(1), 58-65.

Pischon,T. Boeing, H. Hoffman, M. Bergmann, M. Schulze, M. Overvad, K. (2008). General and abdominal adiposity and risk of death in Europe. *New England Journal of Medicine*. 359, 2105-2120.

Pluye, P. Robert, E. Cargo, M. Bartlett, G. O'Cathain, A. Griffiths, F. Boardman, F. Gagnon M. and Rousseau, M. (2011). Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. Available from http://mixedmethodsappraisaltoolpublic.pbworks.com.
(Accessed 12/4/16)

Pohjonen, T. (2001). Perceived work ability of home care workers in relation to individual and work related factors in different age groups. *Occupational Medicine.* 51, 209-217.

Pollack, K. Cheskin, L. (2007). Obesity and workplace traumatic injury: does science support the link? *Injury Prevention*. 13(5), 297–302.

Proper, K. Lando, L. Koppes, J. (2012). The prevalence of chronic psychological Complaints and emotional exhaustion among overweight and obese workers. *International Archives of Occupational and Environmental Health.* 85, 537-545.

Pruitt, J. Adlin, T. (2006). *The Persona Lifecycle: keeping people in mind trough product design*. San Francisco: Elsevier.

Puhl, R. Brownwell, K. (2006). Confronting and coping with weight stigma: an investigation of overweight and obese adults. *Obesity*. 14, 1082-1815.

Puhl, R. Moss, C. Schwartz, M. Brownwell, K. (2008). Weight stigmatisation and bias reduction. *Health Education Research*. 23, 347-358.

Puhl, R. M. and Heuer, C. A. (2009). The Stigma of Obesity: A Review and Update. *Obesity*. 17, 941–964.

Punakallio, A. Lusa, S. Luukkonen, R. (2004). Functional, postural and perceived balance for predicting the work ability of firefighters. *International Archieves of Occupational and Environmental Health.* 77(7), 482-490.

Rastrollo, M. Sabaté, J. Jaceldo-Siegl, K. and Fraser, G. (2011). Validation of self-reported anthropometrics in the Adventist Health Study 2. *BMC Public Health*. 11, 213-225.

Restrepo, J. Christiaans, H. (2003). Problem Structuring and Information Access in Design, *Journal of Design Research*. 4(2). 145-153.

Rice, T. Zhu, M. (2013), Driver obesity and the risk of fatal injury during traffic collisions. *Emergency Medicine Journal*. 21(1), 9-12.

Robson, C. (2011). *Real World Research*. 3rd Edition. West Sussex: John Wiley and Sons.

Roehling, M Roehling, P. Pichler, S. (2007). The relationship between body weight and perceived weight related employment discrimination: the role of sex and race. *Journal of Vocational Behaviour.* 71, 300-318.

Society Of Automotive Engineers (SAE). (2008). SAE J 2732. Motor Vehicle Seat Dimensions Available from: http://standards.sae.org/j2732_200806/ (Accessed 10/12/16)

Society Of Automotive Engineers (SAE). (2008). SAE J826: Devices For Use In Defining And Measuring Vehicle Seating Accommodation. SAE

Sale, J. Lohfeld, L. Brazil, K. (2002). Revisiting the quantitative-qualitative debate: Implications for mixed methods. *Quality and Quantity*. 36(1), 43-53.

Saliminen, S. Oksanen, T. Vahtera, J. Sallinne, M. Harma, M. Salo, P. Virtanen, M. Kivimaki, M. (2010). Sleep disturbance as a predictor of occupational injuries among public sector workers. *Journal of Sleep Research*. 19, 207-213.

Saunders, M.N. Saunders, M. Lewis, P. and Thornhill, A. (2012). *Research methods for business students*. India: Pearson Education.

Sayers, R. (2006). *Principles of awareness-raising: Information literacy, a case study.* Bangkok: UNESCO.

Schulte,P. Wagner, G. Ostry, A. (2007). Work, Obesity, and Occupational Safety and Health. *American Journal of Public Health*. 97(3), 428-436.

Segui-Gomez, M. Levy, J. Roman, H. Thompson, K. M. McCabe, K., Graham, J. (1999). Driver distance from the steering wheel: perception and objective measurement. *American Journal of Public Health*, 89(7), 1109–1111.

Serpil, A. Weekes, A. (2006). Measurements for pregnant drivers' comfort and safety. *International journal of vehicle design* 42(1), 101-118.

Sharples, S. and Cobb,S. (2015) Methods for observing and collecting particpants response. In: Wilson, J. and Sharples, S. *Evaluation of Human Work*. 4th ed London: Taylor and Francis. 83 – 118.

Shields, M. Gorber, S. Tremblay, M. (2008). Estimates of obesity based on self-report versus direct measures. *Health Reports.* 19(2), 61-76.

Shrestha, N. Pedisic, Z. Neil-Sztramko, S. (2016). *Current Obesity Reports.* 5, 344-360

Sibella, F. Galli, M, Tacchini, E. (2003). Biomechanical analysis of sit to stand movement in normal and obese subjects. *Clinical Biomechanics*. 18(8), 745-750.

Sims, R. Marshall, R. Gyi, D. Summerskill, S. Case, K. (2012). Collection of anthropometry from older and physically impaired persons: Traditional methods versus TC 3-D body scanner. *International Journal of Industrial Ergonomics.* 42, 65 -72.

Singh, B. Brown, T. Callaghan, J. Yack, J. (2013). Abdomen thigh contact during forward reaching tasks in obese individuals. *Journal of Applied Biomechanics*. 29, 517-524.

Sjogren-Ronka, T. Ojanen, M. Leskinen, E. (2002).Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective wellbeing among office workers. *Scandinavian Journal of Work and Environmental Health.* 28(3), 184-190.

Smith, E. Bailey, P. Crawford, J. Samaras, K. Baune, B. Campbell, L. (2014). Adiposity estimated using dual energy x-ray absorptiometry and body mass index and its association with cognition in elderly adults. *Journal of the American Geriatric Society.* 62, 2311–2318.

Spencer, E., Appleby, P., Davey, G. Key, T. (2002). 'Validity of self-reported height and weight in 4808 EPIC–Oxford participants', *Public Health Nutrition*, 5(4), 561–565.

Spyropoulous, P. Pisciotta, J. Pavlous, K. Cairns, M. Simon, S. (1991). Biomechanical gait analysis in in obese men. *Archives of Physical Medicine and Rehabilitation*. 72, 1065-1070.

Stattin, M. (2005). Retirement on grounds of ill health. *Occupational and Environmental Medicine.* 62, 135-140.

Stommel, M., Schoenborn, C. (2009). Accuracy and usefulness of BMI measures based on self-reported weight and height: findings from the NHANES & NHIS 2001-2006. *BMC Public Health*. 9, 421-427.

Tabachnick, B. Fidell, L. (2007). *Using multivariate statistics*. Boston: Pearson Allyn and Bacon.

Thoma, M. Hediger, M. Sundaram, R. Stanford, J. Peterson, C. Croughan, M. Louis, G. (2012). Comparing Apples and Pears: Women's Perceptions of Their Body Size and Shape. *Journal of Women's Health*, 21(10), 1074–1081.

Tian, S. Zhang, X. Xu, Y. Dong, H. (2016). Feasibility of body roundness index for identifying a clustering of cardiometabolic abnormalities compared to BMI, waist circumference and other anthropometric indices: the China Health and Nutrition Survey, 2008 to 2009. *Medicine (Baltimore).* 95 (34).

Tilley, A. and Dreyfuss, H. (2002). *The measure of man: human factors in design*. New York: Wiley.

Tinetti, M. Baker, D. King, M. Gottschalk, M. Murphy, T. Acampora, D. Bradley, P. Allore, H. (2008). Effect of dissemination in reducing injuries from fall. *New England Journal of Medicine*. 359(3), 252–261.

Tokmakidis, S., Christodoulos, A., Douda, H. (2012). Self-reported anthropometry: body mass index and body composition. In: Preedy VR, editor. *Handbook of anthropometry*. New York City: Springer. 167–183.

Tovey, M. (2012). *Design for Transport*. Farnham, UK: Gower Publishing.

Tuomi, K. Ilmarinen, I. JAhoka, A. (1998). *Workability Index*. 2nd edition. Helsinki: FIOH.

Tuomi, K. Huuhtanen, P. Nykyri, E. (2001). Promotion of work ability, the quality of work and retirement. *Occupational Medicine*. 51(5), 318-324.

Twells, L. Bridger, T. Knight, J. Alaghehbandan, R. Barrett, B. (2012). Obesity Predicts Primary Health Care Visits: A Cohort Study. *Population Health Management.* 15(1), 29-36.

Van de Berg, T. Elders, L. de Zwart. B. Burdorf, A. (2008). The effects of work-related and individual factors on the Work Ability Index: a systematic review. *Occupational and Environmental Medicine*. 66(4), 211-220.

Van Roijen, L. (2007). Short Form - Health and Labour Questionnaire. Institute for Medical Technology Assessment, Erasmus MC, University Medical Centre Rotterdam.

Ventola, C. (2014). Medical Applications for 3D Printing: Current and Projected Uses. *Pharmacy and Therapeutics*. 39(10), 704–711.

Verbrugge, L. Jette, A. (1994). The disablement process in the elderly spine: a database compared to young people. *Social Science and Medicine*. 38, 1–14.

Viester, L. Verhagen, E. Proper, K. Dongen, J. Bongers, P. van der Beek, A. (2013). VIP in construction: systematic development and evaluation of a multifaceted health programme aiming to improve physical activity levels and dietary patterns among construction workers. *BMC Public Health.* 12, 89-97.

Vink, P. Koningsveld, E. Molenbroek, J. (2006). Positive outcomes of participatory ergonomics in terms of higher comfort and productivity. *Applied Ergonomics.* 37, 537–546.

Virtanen, M. Ferrie, J. Singh-Manoux, A. Shipley, M. Stansfeld, S. Marmot, M. Vahtera, K. Kivimäki, M. (2011). Long working hours and symptoms of depression and anxiety. *Psychological Medicine*. 2, 1–10.

Virzi, R. (1992). Refining the test phase of usability evaluation: How many subjects is enough? *Human Factors*. 34,457-486.

Vismara, L. Menegoni, F. Zaino, F. Galli, M. Stefano, N. Capododaglio, P. (2010). Effect of obesity and low back pain on spinal mobility: a cross sectional study in women. *Journal of Neurological Engineering and Rehabilitation*. 7, 3-15.

Visscher, T. Seidell, C. (2001). The Public Health Impact of Obesity. *Annual. Reviews in* Public *Health.* 22, 355–375.

Wadden, T. Sarwer, D. Fabricatore, A. Jones, L. Stack, R. Williams, N. (2007). Psychosocial and Behavioural Status of Patients Undergoing Bariatric Surgery: What to Expect Before and After Surgery. *Medical Clinics of North America.* 91(3), 451-469.

Walliman, N. (2006). *Social research methods*. 1st ed. London: Sage

Wang,Y. Rimm,E. Stampfer,M. Willett, W. Hu,F. (2005). Comparison of abdominal adiposity and overall obesity predicting Type 2 diabetes among men. *American Journal of Clinical Nutrition.* 81, 555-563.

Wang, J. Sereika, S. Styn, M. Burke, L. (2013), Factors associated with health-related quality of life among overweight or obese adults. *Journal of Clinical Nursing.* 22, 2172–2182.

Ward, S. (2011). Anthropometric data and Australian populations – do they fit? Ergonomics Australia – HFESA 2011 Conference Edition. 11:15.

Wearing, S. Hennig,E. Byrne, N. Steele, J. Hills, A. (2006). The biomechanics of restricted movement in adult obesity. *Obesity Reviews,* 7, 13-24.

Weekes, A. (2010). Testing to Investigate the Use of Lap Belt Positioners During Pregnancy. In *ASME 10th Biennial Conference on Engineering Systems Design and Analysis*.321-328. American Society of Mechanical Engineers.

White, C. (2010). A socio-cultural approach to learning in the practice setting. *Nurse Education Today*, 30(8), 794-797.

World Health Organisation (2016).Overweight and obesity fact sheet no 311. Available from http://www.who.int/mediacentre/factsheets/fs311/en/ (Accessed 20/12/16)

World Health Organisation (2015).Waist circumference and waist–hip ratio. Report of a WHO expert consultation. Available from http://www.who.int/nutrition/publications/obesity/WHO_report_waistcircumference_and_waisthip_ratio/en/ (Accessed 21/9/16)

Zaccagni, L. Barbieri, D. Gualdi-Russo, E. (2014). Body composition and physical activity in Italian university students. *Journal of Translational Medicine.*12, 120-131.

Zech, A. Hübscher, M. Vogt, L. Banzer, W. Hänsel, F. Pfeifer, K. (2010). Balance training for neuromuscular control and performance enhancement: A systematic review. *Journal of Athletic Training.* 45(4), 392-403.

Zeng, X. Li, Y. (2015). Research on Passenger Seat Choice Behavior in Airline Revenue Management. 3rd International Conference on Management, Education, Information and Control.

Zhang, X. (2005). A normative database of thumb circumduction in vivo: centre of rotation and range of motion. *Human Factors*. 47(3), 550–561.

Zunjic A. Sremcevic V. Sijacki Zeravcic V. Sijacki A. (2012). Research of injuries of passengers in city buses as a consequence of non-collision effects. *Work*. 41, 4943-4950.

Zwane, P. Sithole, M. Hunter, L. (2010). A preliminary comparative analysis of 3D body scanner, manually taken girth body measurements and size chart measurements. *International Journal of Consumer Studies*. 34, 265–271.

Appendices

Appendix 2.1 Examples of Database Search Strategy and Terms

Database	Date	No. hits Retrieved	No. articles discarded due to duplication	No. articles discarded due to date / language	No. articles discarded due to irrelevant title	No. articles discarded after reading abstract	No. articles reviewed	No. cited articles reviewed
Ergonomics Abstracts	10/7/16	267	0	20	139	45	63	31
Web of Knowledge	24/8/16	356	118	4	149	41	44	13
Scopus	12/6/16	318	230	2	52	6	28	7
Google scholar	13/9/16	453	211	12	116	89	25	4

Topics	Search Terms	Databases
	Obese* OR “plus size*” OR “plus-size*” OR Overweight OR “Body Mass Index” OR “Waist Hip ratio” OR Adiposity AND:	
Measurement	Anthropometry OR Anthropometrics OR Measure* OR Outcome	Web of Knowledge (Web of Science with conference proceeding and Medline)
Body Shape	“Body shape” OR “Body Size” OR Somatotype* OR “Waist Hip ratio” OR Adiposity	
Workplace Design	“Work* design” OR Ergonomic* OR “Task Analysis” OR “Task Design” OR Workspace	
Temperature	Temperature* OR “Heat Stress”	
Ergonomics	Ergonomic* OR “Human Factor*”	
Posture	Posture OR Position OR “Base of Support”	
Stigma	Stigma* OR “Weight bias” OR Attitude*	
Ergonomics	Ergonomic*	
Work	Work OR Occupation*	
Workability	Workability	

Appendix 2.2 Example of the systematic approach to the critical appraisal of the literature

Author and Title	Main Aim	Approach	Sample	Findings	Comments	MMAT Score
Vismara et al (2010) Effect of Obesity and low back pain on spinal mobility	To objectively assess the posture and function of spine during standing, flexion and side flexion in obese subjects with or without LBP.	Cross sectional study Quantitative	13 obese subjects without LBP 13 obese subjects with LBP 11 normal weight subjects without LBP Females Working age	Obesity characterised by reduced ROM of spine with postural adaptation of increased pelvic tilt. Obesity with LBP associated with decreased LSP and Tsp flexion.	Volunteer subjects – non randomised sampling. Normal weight group small – no normal weight group with LBP BMI used to classify – only mean 38.9 kg/m^2 Only spinal ROM assessed – non-functional measure. Only females Not longitudinal in design.	*
Proper et al (2012) The prevalence of chronic psychological complaints and emotional exhaustion among overweight and obese workers	Determine the prevalence of chronic psychological complaints amongst overweight and obese workers.	Quantitative descriptive	N = 43,928 Dutch employees from NWCS 15-64 years of age Males and females	15.7% of obese workers reported emotional exhaustion and 3.7% reported chronic psychological complaints. Significantly higher than non-obese workers.	Dutch sample Based on 2008-9 data. Reliance on self-reported measures. Obese - classified greater than 30 BMI. Didn’t adequately adjust for co variants e.g. age, job role, education.	**

Singh et al (2013) Abdominal thigh contact during forward reaching tasks in obese individuals	To investigate the contact forces and associated moments exerted by the abdomen on the thigh suring forward reaching tasks in obese individuals.	Quantitative descriptive	10 obese individuals – 5 males and 5 females Aged 40-70 years BMI greater than 30 kg/m^2 Convenience sample	Abdomen found to exert considerable force on thigh (up to 10%) during reaching tasks reducing mvt at hip but not dependent on BMI.	Small sample size only 10 subjects Mean age 58.1 yrs – previous research has shown that age affects jt ROM No control group Convenience sampling 1 height of chair – not suitable for all	*
Author and Title	**Main Aim**	**Design**	**Sample**	**Findings**	**Comments**	**MMAT Score**
Gilleard et al (2007) Effect of obesity on posture and hip joint moments during a standing task and trunk forward flexion motion	To identify the effect of obesity on trunk forward flexion motion in sitting and standing.	Cross sectional comparison of obese and normal weight groups	10 obese subjects (BMI $38.9kg/m^2$) and 10 age and height matched normal weight subjects (BMI $21.7kg/m^2$) Females	Forward flexion motion of TSP and TSP/LSP junction was reduced in obese group. Obese subjects showed a more flexed posture.	Matches subject design Explicit methodology – repeated measures Only females Based on BMI Small sample size Foot positioning in seated forward flexion was standardised therefore not allowing for preferred positioning to be adopted.	***

Appendix 4.1 Plus size plus size people at work questionnaire

Plus Size People at Work

Including Plus Size People in Workplace Design

DO YOU DESCRIBE YOURSELF AS 'PLUS SIZE' OR 'LARGER THAN AVERAGE' ?
DO YOU HAVE DIFFICULTY FINDING CLOTHES THAT FIT YOU COMFORTABLY ON THE HIGH STREET?
DO YOU HAVE TO SQUEEZE INTO AN AEROPLANE SEAT OR THROUGH TURNSTILES?
DO YOU WORK - EITHER ON AN EMPLOYED OR SELF EMPLOYED BASIS?

If yes, please complete this short questionnaire exploring the experiences of 'PLUS SIZE PEOPLE AT WORK' . It should take about 5 minutes to complete and asks questions about you and your place of work and the FURNITURE, TOOLS, CLOTHING and EQUIPMENT you use at work.

Please read each question carefully before answering. There are no right or wrong answers, so please respond freely and honestly. By completing and returning the questionnaire you are giving consent for your information to be included as anonymous data in this survey. The results will be analysed and may be reported in academic journals and conferences but will not be produced in any way that could reveal your identity.

The findings of this questionnaire will be used with the aim of improving workplace design for plus size people.

For further information or questions about the survey please contact :
Annabel Masson (PhD Researcher)
Loughborough Design School
Loughborough University
Leics LE11 3TU

Email: A.Masson@lboro.ac.uk
Tel: 01509 226921

*** 1. I agree to take part in this survey**

◯ Yes

◯ No

Plus Size People at Work

About your main job

2. Do you work mainly from home?

- ◯ Yes
- ◯ No

3. What is your job title?

4. How many people work within your company/organisation?

- ◯ 1
- ◯ 2-9
- ◯ 10-49
- ◯ 50-99
- ◯ 100-249
- ◯ 250-499
- ◯ 500-2499
- ◯ 2500 or more

5. Equipment, tools and furniture.
Do the following CURRENTLY cause you any problems?

	Yes	No	Not Applicable
Seat sizes (e.g.chairs, stools, car)	◯	◯	◯
Height of desk ot table (e.g. legroom)	◯	◯	◯
Space in working area (e.g can you move around without hindrance)	◯	◯	◯
Fit of any uniform provided (e.g.aprons, overalls, footwear)	◯	◯	◯
Fit of any personal protective equipment provided (e.g.hard hat, high visibility jacket, gloves)	◯	◯	◯

Plus Size People at Work

About the environment in which you work

6. Shared spaces such as corridors, stairways and lifts.
Do the following CURRENTLY cause you any problems?

	Yes	No	Not Applicable
Seat sizes (e.g.chairs,toilets, benches)	◯	◯	◯
Width of stairways	◯	◯	◯
Width of corridors	◯	◯	◯
Size of lifts	◯	◯	◯
Size of toilet cubicle	◯	◯	◯
Circulation spaces (e.g. in cafe or meeting room)	◯	◯	◯
Other	◯	◯	◯

Other (please specify)

7. Temperature in your main work area.

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Srongly disagree
I am often too hot in warm weather	◯	◯	◯	◯	◯
I am often too hot in cold weather	◯	◯	◯	◯	◯
I am often too cold in warm weather	◯	◯	◯	◯	◯
I am often too cold in cold weather	◯	◯	◯	◯	◯

Plus Size People at Work

8. To what extent do you agree or disagree with the following statements. At my work plus size people are viewed positively by:

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Not applicable
Work colleagues	○	○	○	○	○	○
Line managers	○	○	○	○	○	○
Senior management	○	○	○	○	○	○
Customers	○	○	○	○	○	○
Suppliers/external organisations	○	○	○	○	○	○

9. How do you rate your current work ability with respect to the:

	Very good	Rather good	Moderate	Rather poor	Very poor
Physical demands of your job	○	○	○	○	○
Mental demands of your job	○	○	○	○	○

10. To what extent do you agree or disagree to the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
My work area is suitable for me	○	○	○	○	○
My size / shape prevents me from doing my job the way I want to	○	○	○	○	○
I have altered my work area to suit my size / shape	○	○	○	○	○
I tire easily because of my size / shape	○	○	○	○	○
I am viewed as less productive than my colleagues	○	○	○	○	○
I am viewed as taking more sick leave than my colleagues	○	○	○	○	○
My body size/shape affects/has affected my chances of promotion	○	○	○	○	○

Plus Size People at Work

11. What are the top 3 aspects of your work that you would like to change? Please indicate by ticking up to 3 boxes. If you do not want to change anything, please leave blank.

- ☐ Seating (chairs, stools or car seats)
- ☐ Height of desks or tables
- ☐ Fit of uniform provided
- ☐ Fit of personal protective equipment provided
- ☐ Temperature at work
- ☐ Width of staircases or corridors
- ☐ Size of toilet cubicles
- ☐ Circulation space (e.g. in cafes, meeting rooms)
- ☐ Attitudes of colleagues / managers to plus size people
- ☐ Amount of physical work involved in my job
- ☐ Other (please specify)

12. Do you have any other comments, questions or concerns relating to being a plus size person at work?

Plus Size People at Work

About you

13. What is your age?

- ◯ 18 to 24
- ◯ 25 to 44
- ◯ 45 to 64
- ◯ 65 or older

14. In what country do you currently live?

15. Please enter your height (metres and centimetres OR feet and inches)

	Metres	Centimetres	Feet	Inches
Height				

16. Are you male or female?

- ◯ Male
- ◯ Female

Clothes size - female

17. Generally, what size clothes do you wear?

○ XS ○ S ○ M ○ L ○ XL ○ XXL ○ XXXL

Other (please specify)

18. Please enter your current clothes size (UK).

	Top Half	Bottom half
UK clothes size		

Plus Size People at Work

Clothes size - male

19. Generally, what size clothes do you wear?

◯ XS ◯ S ◯ M ◯ L ◯ XL ◯ 2XL ◯ 3XL ◯ 4XL ◯ 5XL ◯ 6XL

Other (please specify)

20. Please enter your current clothes size (UK).

	Collar Size	Chest Size	Waist Size
UK clothes size			

Plus Size People at Work

Further Information

21. Would you be willing to take part in future research about plus size people at work?

- ◯ Yes
- ◯ No
- ◯ Unsure

If YES please provide contact email and/or telephone number

Thank you for taking the time to complete this survey. Your help is very much appreciated.

Appendix 5.1 Possible Anthropometric Measurements

Measurement	Definition	Posture	Equipment
Weight	Measured to nearest 0.5kgs. Person wears indoor clothes and no shoes	Standing	Weighing scales
Stature	Measured vertically from floor to top of the head. The person stands erect, looking ahead, the arms hanging loosely by the side.	Standing	Stadiometer
Sitting Height	Measured vertically from seat surface to top of the head, compressing the hair. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Seated	Anthropometer
Back of head height	Measured vertically from seat surface to occiput. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Seated	Anthropometer
Mid shoulder Height	Measured vertically from seat surface to midway point between acromion and neck. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Seated	Anthropometer
Shoulder Height	Measured vertically from seat surface to acromion. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Seated	Anthropometer
Shoulder breadth	Measured horizontally between acromions. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Standing and Seated	Anthropometer
Whole Body Breadth	Measured horizontally across the whole breath of the body. The person stands or sits erect with arms hanging loosely by sides. Measured from behind the person.	Standing and Seated	Anthropometer
Chest Circumference	The maximum circumference, measured horizontally around the chest at the level of the bustpoints. The person stands or sits, looking forward, with shoulders relaxed and breathing quietly. The person stands or sits, looking forward, with shoulders relaxed and breathing quietly.	Standing and Seated	Tape measure
Chest Height	Measured vertically from seat surface to height of the bustpoint. The person sits erect.	Seated	Anthropometer
Chest Depth	Measured horizontally from rear vertical plane to the bust point. The measure is taken at the end of	Seated	Anthropometer

	quietly breathing out without compression of the breast.		
Waist Height	Measured vertically from the seat surface to the point of maximum circumference of the abdomen. The person sits erect, hands in lap, the feet are supported at a level which ensures the thighs are horizontal.	Seated	Anthropometer
Abdominal circumference	Measured horizontally at the level of the waist or level of maximum protrusion. The person stands or sits erect with arms held slightly away from the sides of the body.	Seated and standing	Tape measure
Hip Circumference	Measured horizontally around the hips at point of maximum protrusion. The person stands or sits erect with arms held slightly away from the sides of the body	Seated and standing	Tape measure
Hip Breadth	Measured horizontally across the widest part of the hips. The person sits erect with the legs and feet supported.	Seated and standing	Tape measure
Thigh Depth	Measured vertically from the seat surface to the upper, uncompressed surface of the thigh where the thigh depth is greatest. The seat is adjusted so that the person can sit with the lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer
Buttock to front of knee	Measured horizontally from the most posterior part of the buttock to the front of knee. The seat is adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer
Buttock to back of knee (Popliteal)	Measured horizontally from the most posterior part of the buttock to the underside of knee. The seat is adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer
Knee splay	Measured horizontally between the outer borders of the knees. Person sits erect with legs in comfortable normal seated position and knees at 90 degrees.	Seated	Anthropometer
Knee to knee breadth	Measured horizontally between the outer borders of the knees. Person sits erect with legs to together and knees at 90 degrees.	Seated	Anthropometer
Top of knee height	Measured vertically from top of knees to floor. The seat is adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer
Back of Knee Height	Measured vertically from floor to the popliteal tendon. The seat is	Seated	Anthropometer

	adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.		
Ankle Circumference	Measured around the ankle at the level of the inner thigh bone. The person stands or sits with weight evenly distributed	Seated and standing	Tape measure
Foot length	Measured horizontally from the tip of the longest toe to the back of the heel. The person stands or sits with weight evenly distributed.	Seated and standing	Anthropometer
Foot breadth	Measured horizontally across the widest part of the foot, perpendicular to the length of the foot.	Seated and standing	Anthropometer
Forward Fingertip Reach	Measured horizontally from the wall to the tip of the middle finger. The person sits erect with the arm and hand stretched horizontally in front of them	Seated	Anthropometer
Forward Grip Reach	Measured horizontally from the wall to the centre of a rod gripped in the hand. The person sits erect with the arm and hand stretched horizontally in front of them	Seated	Anthropometer
Shoulder (Acromium) to Underside of the Elbow	Measured vertically from the bony tip of the shoulder (acromium) to the underside of the elbow. The person sits with the upper arm vertical and the elbow flexed to 90 degrees.	Seated	Anthropometer
Back Of the Elbow to Tip of Middle finger	Measured from the back of the elbow to the tip of the middle finger. The person sits with the upper arm vertical and the elbow flexed to 90 degrees. The hand is held in alignment with the forearm	Seated	Anthropometer
Back of the elbow to Grip	Measured from the back of the elbow to the centre of a rod gripped in the hand. The person sits with the upper arm vertical and the elbow flexed to 90 degrees. The hand is held in alignment with the forearm.	Seated	Anthropometer
Hand Length	Measured from wrist crease directly below the thenar muscle bulk at the base of the thumb to the tip of the middle finger. The hand and fingers should be held straight and flat, palm uppermost.	Seated	Vernier calliper
Hand Breadth Across Knuckles	Measured across the palm of the hand at the junction between the palm and fingers including the thumb. The hand and fingers should be held flat, palm uppermost.	Seated	Vernier calliper
Seat Height	Measured vertically from the floor to the seat surface. The seat should be adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.	Seated	Adjustable seat with anthropometer.

Appendix 5.2 Proposed Anthropometric Measurements

Measurement	Definition	Posture	Equipment	Application
Weight	Measured to nearest 0.5kgs. Person wears indoor clothes and no shoes	Standing	Weighing scales	Comparing participants. General population measure. Use in combination with stature for determining BMI
Stature	Measured vertically from floor to top of the head. The person stands erect, looking ahead, the arms hanging loosely by the side.	Standing	Stadiometer	Comparing populations. Vertical clearance. Use in combination with weight for determining BMI
Shoulder breadth (bideltoid)	Maximum horizontal breadth across the shoulders. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.	Standing	Anthropometer	Clearance at shoulder level
Chest Circumference	The maximum circumference, measured horizontally around the chest at the level of the bustpoints. The person stands or sits, looking forward, with shoulders relaxed and breathing quietly.	Standing	Tape measure	Turning circles
Abdominal Depth	Measured horizontally from rear vertical plane to the maximum protrusion on the front of the relaxed	Sitting	Anthropometer	Clearance between seat back and obstructions

	abdomen. Person sits erect with arms hanging relaxed by the side.			
Abdominal circumference	Measured horizontally at the level of the waist or level of maximum protrusion. The person stands or sits erect with arms held slightly away from the sides of the body.	Standing	Tape measure	Turning circles
Hip Circumference	Measured horizontally around the hips at point of maximum protrusion. The person stands or sits erect with arms held slightly away from the sides of the body	Standing	Tape measure	Clearance
Hip Breadth	Measured horizontally across the widest part of the hips. The person sits erect with the legs and feet supported.	Seated	Tape measure	Clearance at seat level. Seat width requirements
Thigh Thickness (depth)	Measured vertically from the seat surface to the upper, uncompressed surface of the thigh where the thigh depth is greatest. The seat is adjusted so that the person can sit with the lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer	Clearance required between seat and underside of table or other obstacles
Sitting Shoulder Height	Measured vertically from seat surface to	Seated	Anthropometer	Approximate centre of rotation for

	acromion. The person sits erect, looking ahead, hands in lap. The feet are supported at a level that ensures thighs are horizontal.			upper limb
Knee splay	Measured horizontally between the outer borders of the knees. Person sits erect with legs in comfortable normal seated position and knees at 90 degrees.	Seated	Anthropometer	Clearance especially toilet cubicle
Popliteal Height	Measured vertically from floor to the popliteal tendon The seat is adjusted so that the person can sit with lower legs vertical, thighs horizontal and feet flat.	Seated	Anthropometer	Clearance required underneath tables
Forward Fingertip Reach	Measured horizontally from the wall to the tip of the middle finger.The person sits erect with the arm and hand stretched horizontally in front of them	Standing	Anthropometer	Functional reach

Appendix 5.3 Self Measurement Guide

APPENDIX 5.3

Self Measurement Guide

You will need:

- 20 minutes of your time
- A tape measure (included)
- Help from a friend when measuring (if possible)

About measuring:

- When measuring, hold the tape measure flat against your body: it should be held snug enough so not to droop, but never tight enough as to feel restrictive.
- Wear close fitting indoor clothes (similar to what you would wear for work). Please do not wear bulky/ padded clothes or jackets or coats.
- Please do not wear shoes.
- Please empty your pockets before starting the measurements.
- All measurements should be taken to the nearest centimetre (cm).
- There are no are no right or wrong results so please record what you measure.

How to submit this information

- Ensure all questions and 14 measurements are complete.
- Please return this completed form to Annabel Masson when she visits you to repeat the measurements **OR**
- Give Annabel Masson a call on 07720718289 and submit your measurements over the phone **OR**
- Follow the link ***https://www.surveymonkey.com/r/selfmeasurement*** and complete and submit via Survey Monkey

Contact me

If you require any further information, please contact Annabel Masson

- Phone: 01509 226921 or 07720718289 and leave a message **OR**
- Email: A.Masson@lboro.ac.uk

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

About you

Please answer the all following questions about yourself.

1. Are you: male ☐ female ☐

2. What is your date of birth? ☐ ☐ ☐
DD MM YY

3. What is your ethnic group?

White	☐	Black or Black British	☐
Mixed	☐	Chinese	☐
Asian or Asian British	☐	Other ethnic group	☐

4. Which is your dominant hand? Right ☐ Left ☐

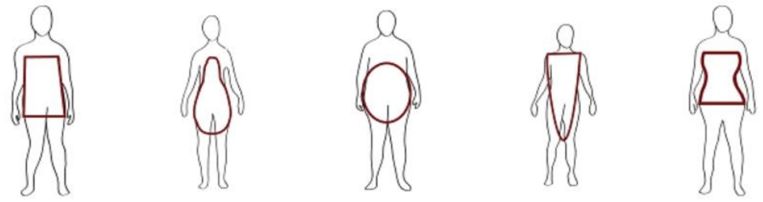
5. What is your weight (without shoes):

☐ Kgs **OR** ☐ stones ☐ pounds (lbs)
(e.g. 92.6 kgs) (e.g. 14 st) (8lbs)

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

6. How would you describe your body shape? (Think about the relative proportion of your chest, waist and hips). Please tick one box only.



Straight	Pear	Apple	Cone	Hourglass
☐	☐	☐	☐	☐

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

Your work

Please answer the all following questions about your job and place of work.

7. What is your job title?

8. Do you work mainly from home? Yes ☐ No ☐

9. Do the following CURRENTLY cause you any problems at work?

	Yes	No	Not applicable
Seat sizes (e.g.chairs, stools, car)	☐	☐	☐
Height of desk or table (e.g. legroom)	☐	☐	☐
Space in your working area (e.g. can you move around without hindrance	☐	☐	☐
Fit of any uniform provided (e.g. apron, overalls, footwear)	☐	☐	☐
Fit of any personal protective equipment provided (e.g. hard hat, high vis jacket)	☐	☐	☐
Size of toilet cubicle	☐	☐	☐
Shared circulation spaces (e.g. in cafe or meeting room)	☐	☐	☐
Width of stairways or corridors	☐	☐	☐

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

Please take the following 6 measurements in standing:

1. Height

- **Standing** – back against a door or wall. Look forward, shoulders relaxed, arms by your side
- **Please do not wear shoes.**
- **Measure vertically from the floor to the top of your head.**
- Ensure the tape measure is in a straight line
- Re check measurement

My height is ☐ **cms**

2. Full Chest

- **Standing** – look forward, shoulders relaxed, arms by your side
- **Measure around the chest and body at its fullest part** (typically at nipple level, under the armpits and over the shoulder blades).
- Hold the tape measure against your body tight enough so that it does not slip down, but not tight enough that it restricts breathing.
- Make sure the tape measure is at the same level all the way round the chest
- Take a normal breath and measure
- Do not puff out your chest
- Re check measurement

My full chest is ☐ **cms**

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

3. Stomach

- **Standing** – look forward, shoulders relaxed, arms by your side
- **Measure around the widest part of your abdomen (this normally coincides with your belly button)**
- Hold the tape measure against your body tight enough so that it does not slip down, but not tight enough that it restricts breathing.
- Make sure the tape measure is at the same level all the way round the abdomen
- Take a normal breath and measure
- Do not hold your stomach in
- Re check measurement

My stomach is ☐ **cms**

4. Hips

- **Standing** – look forward, shoulders relaxed, arms by your side
- **Measure around the widest part of your hips**
- Hold the tape measure against your body tight enough so that it does not slip down.
- Make sure your pockets are empty.
- Make sure the tape measure is at the same level all the way round the hips
- Re check measurement

My hips are ☐ **cms**

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

5. Shoulder Width

- **Standing** – look forward, shoulders relaxed, arms by your side
- From behind, **measure across the widest part of your shoulders**
- Hold the tape measure against your body tight enough so that it does not slip down.
- Re check measurement

My shoulders are [ ] **cms**

6. Forward Reach

- **Standing** – back against a wall or door, looking forward.
- Right arm and hand stretched horizontally in front of you.
- Shoulder blade should stay in contact with the wall or door.
- **Measure from the wall or door to the tip of your longest finger**.
- Ensure the tape measure is in a straight line
- Re check measurement

My forward reach is [ ] **cms**

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

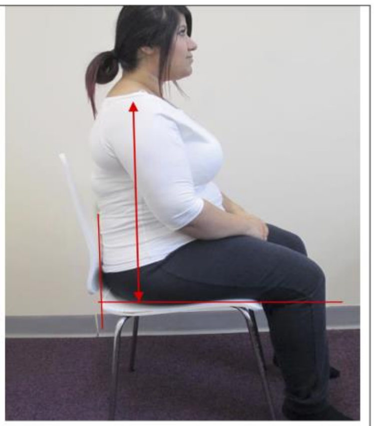
Please take the following 8 measurements in sitting:

1. Sitting Shoulder Height

- **Sitting –** on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap.
- **Measure vertically from the hard seat surface up to the bony tip on the outside of your right shoulder**.
- Ensure the tape measure is in a straight line
- Re check measurement

My sitting shoulder height is

[ ] **cms**



2. Stomach Depth

- **Sitting –** on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap.
- **Find the point where your stomach protrudes the most at the front.**
- **Measure from this point horizontally backwards in a straight line to point where your body protrudes the most at the back.**
- Ensure the tape measure is in a straight line
- Do not hold your stomach in
- Re check measurement

My stomach depth is [ ] **cms**

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

3. Hip Breadth

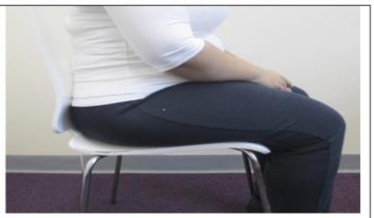
- **Sitting** – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap
- Bring knees and thighs together as much as you are able.
- **Measure horizontally across the widest part of your hips.**
- Re check measurement

My hip breadth is [ ] **cms**

4. Thigh Thickness

- **Sitting –** on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap.
- **Measure vertically from the seat surface to the upper surface of your thigh at the point where the thigh is thickest**.
- Be careful not to compress the thigh when measuring.
- Re check measurement

My thigh thickness is [ ] **cms**



LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

5. Buttock to Front of Knee

- **Sitting –** on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap.
- **Measure horizontally from the most posterior part of your buttocks to the front of your knee in a straight line**.
- Re check measurement

My buttock to front of knee

measurement is ☐ **cms**

6. Knee Height

- **Sitting** – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap
- Bring knees and thighs together as much as you are able.
- **Measure vertically from the floor to the top of the knee.**
- Ensure tape measure is in a straight and horizontal line.
- Re check measurement

My knee height is ☐ **cms**

7. Between Knee Width

- **Sitting** – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap
- Knees and thighs comfortably splayed.
- **Measure horizontally from the outer border of one knee to the other.**
- Ensure tape measure is in a straight and horizontal line.
- Re check measurement

My between knee width is

[ ] **cms**

8. Back of Knee Height

- **Sitting** – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap
- Bring knees and thighs together as much as you are able.
- **Measure vertically upwards from the floor to the tendon that you can feel on the outer edge of the crease at the back of your knee.**
- Ensure tape measure is in a straight and horizontal line.
- Re check measurement

My back of knee height is

[ ]

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

cms	

What did you wear whilst being measured? (Important)
(for example jogging bottom and t-shirt or suit trousers and shirt)

Date of measurement?

Do you have any comments on self-measurement?

Thank you for completing this self-measurement form. Please check that you have answered all the questions. Your help is very much appreciated.

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

Appendix 5.4 Including Plus Size People in Workplace Design

Participant Information Sheet

Researcher: Annabel Masson A.Masson@lboro.ac.uk 01509 226921
Supervisors: Dr Sue Hignett S.M.Hignett@lboro.ac.uk 01509 223003
Dr Diane Gyi D.E.Gyi@lboro.ac.uk 01509 223043

What is the purpose of this study?

Designing a workplace (for example chairs, desks, equipment, uniforms, protective clothing) relies upon the use of accurate and up to date body measurement data to ensure that a broad range of users will be accommodated comfortably and safely. Currently, there is a lack of useful measurement data which is specific to plus size people, and relevant to the design of the working environment. This study aims to find out if self-measured body measurements is an accurate way of collecting this data compared to measurements taken by the researcher.

Who is doing this research and why?
The research will be carried out by myself, Annabel Masson as part of my PhD at Loughborough Design School, Loughborough University.

Once I take part, can I change my mind?
Yes. After you have read this information sheet and asked any questions you may have, I will ask you to sign a consent form.

If you wish to withdraw from the study at any time either before or after you have signed the consent form, all you have to do is say so.

You can withdraw at any time, for any reason and you will not be required to explain your reasons for withdrawing.

What will I be asked to do?
The study is made up of two parts:

1. Self-measurement – you will be required to complete the self-measurement form that will be sent to you in the post, via email or on survey monkey

(whichever you prefer). It asks you questions about yourself and your job and then you will be required to complete thirteen measurements following the instructions on the sheet.

2. Researcher measured - after you have completed the self-measurement part of the study the researcher, Annabel Masson will arrange to come and repeat the measurements at a time and place convenient to you.

How long will it take?
Each part of the study will take approximately 20 minutes to complete.

Is there anything I need to do before the sessions?
No, there is nothing you need to do before these sessions. However, please try and wear the same clothes for each part of the study.

What personal information will be required from me?
Your name will be required purely for the contact sheet and will only been seen by the researcher, Annabel Masson. Personal details such as age and job title are included in the self-measurement form but this data will recorded anonymously in the write up of this research and will not be linked in any way to your name.

Are there any risks from participating?
There are no risks from participating in this study.

Will my taking part in this study be kept confidential?
When data is collected and throughout this research, your information will be kept anonymous. Your name will not be included and you will be identified by a number. The data will be kept in a safe and secure place at Loughborough University.

What will happen to the results of this study?
The results of this study will be used for my PhD thesis and/or for publication.

I have some more questions who should I contact?
For more information, please feel free to contact myself or my supervisors on the contact details provided.

What if I am not happy with how the research was conducted?
Loughborough University has a policy to deal with 'Research Misconduct and Whistle Blowing which is available online at: *http://lboro.ac.uk/admin/committee/ethical/Whistleblowing(2)htm.*

Thank you

Appendix 5.5 Including Plus Size People in Workplace Design

Informed Consent Form

(To be completed after participant has read participant information sheet)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethics Approval (Human Participants) Sub Committee.

I have read and understood the participant information sheet and consent form.

I have had the opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in this study.

I understand that I have the right to withdraw from this study at any time for any reason and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and stored securely.

I agree agree/do not agree (please delete as appropriate) to have my photograph taken during the study. I understand that this will not include photographing of my face to ensure anonymity.

I agree to participate in this study.

Your name: --

Your signature: --

Researcher signature: --

Date: --

Thank you

LOUGHBOROUGH
DESIGN
SCHOOL

Appendix 5.6 Understanding Body Size and Shape in Workplace Design

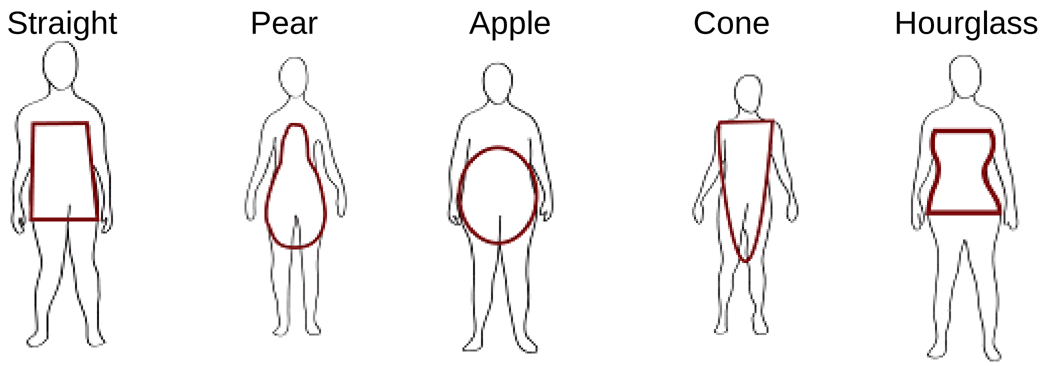
Measurements – Researcher Measured

Participant DOB:

Date of Measurement: **Time:**

Right handed **Left handed**

Body Shape



Height (cms)	
Weight (kgs)	
Full Chest	
Stomach	
Hips	
Shoulder Width	
Forward Reach	
Sitting Shoulder Height	
Stomach Depth	
Hip Breadth	
Thigh Thickness	
Buttock to Front of Knee	
Popliteal Height	
Between Knee Width	

Consent Form Collected Yes No

Self Measurement Form Collected Yes No

Appendix 6.1

Plus Size People at Work

DO YOU DESCRIBE YOURSELF AS 'PLUS SIZE' OR 'LARGER THAN AVERAGE' ?
DO YOU HAVE DIFFICULTY FINDING CLOTHES THAT FIT YOU COMFORTABLY ON THE HIGH STREET?
DO YOU HAVE TO SQUEEZE INTO AN AEROPLANE SEAT OR THROUGH TURNSTILES?
DO YOU WORK - EITHER ON AN EMPLOYED OR SELF EMPLOYED BASIS?

If yes, please complete this Self-Measurement Questionnaire which asks questions about you and your work and then requires you to take 13 body measurements following a set of instructions.

Designing a workplace (for example chairs, workstations, uniforms, protective clothing) relies upon the use of accurate and up to date body measurement data to ensure that the user population will be accommodated by the design. Currently, there is a lack of data based on actual measurements rather than estimates that is both relevant to the design of the working environment and specific to plus size people.

This PhD study aims to collect actual body measurements of the plus size working population.

Please read each question carefully before answering. There are no right or wrong answers, so please respond freely and honestly. By completing and returning the questionnaire you are giving consent for your information to be included as anonymous data in this study. The results will be analysed and may be reported in academic journals and conferences but will not be produced in any way that could reveal your identity.

The findings of this study will be used with the aim of improving workplace design for plus size people.

For further information or questions about the study please contact :
Annabel Masson (PhD Researcher)
Loughborough Design School
Loughborough University
Leics LE11 3TU

Email: A.Masson@lboro.ac.uk
Tel: 01509 226921

Plus Size People at Work

Consent

***1. By providing data I confirm that:**
- I have had an opportunity to ask questions about my participation.
- I understand that I am under no obligation to take part in this study.
- I understand that I have the right to withdraw from this study at any time for any reason and that I will not be required to explain my reasons for withdrawing.
- I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and stored securely.

◯ Yes

◯ No

Plus Size People at Work

***2. I confirm that I am:**

	Yes	No
18 years of age or over	◯	◯
Plus size or 'larger than average'	◯	◯
Working (or have worked in past 12 months)	◯	◯

Plus Size People at Work

Self Measurement Guide

You will need:
- 20 minutes of your time
- A tape measure (that uses cms)
- Help from a friend when measuring (if possible)

About measuring:
- When measuring, hold the tape measure flat against your body: it should be held snug enough so not to droop, but never tight enough to feel restrictive.
- Wear close fitting indoor clothes (similar to what you would wear for work). Please do not wear bulky/ padded clothes, jackets or coats. Please remove your shoes.
- Please empty your pockets before starting the measurements.
- All measurements should be taken to the nearest centimetre (cm).
- There are no right or wrong results so please record what you measure.

IF YOU REQUIRE A TAPE MEASURE TO BE SENT TO YOU PRIOR TO COMPLETING THE MEASUREMENTS, PLEASE EMAIL: A.Masson@lboro.ac.uk AND ONE WILL BE POSTED OUT TO YOU.

Plus Size People at Work

About You

***3. Are you:**

◯ Male

◯ Female

***4. How old are you?**

◯ 18-24 years

◯ 25-44 years

◯ 45-64 years

◯ 65 years or above

5. What is your ethnic group?

◯ Asian or Asian British

◯ Black or Black British

◯ Chinese

◯ Mixed

◯ White

◯ Other ethnic group

***6. In what country do you currently live?**

Plus Size People at Work

***7. Which is your dominant hand?**

- ◯ Right
- ◯ Left

***8. What is your weight (without shoes)?**
e.g. 92.6 kgs or 14st, 8lbs

Plus Size People at Work

10. What is your job title?

***11. Do you work mainly from home?**

- ◯ Yes
- ◯ No

Plus Size People at Work

12. Do the following CURRENTLY cause you any problems at work?

	Yes	No	Not applicable
Seat sizes (e.g. chairs, stools, car)	☐	☐	☐
Height of desk or table (e.g. leg room)	☐	☐	☐
Space in your working area (e.g. can you move around without hindrance)	☐	☐	☐
Fit of any uniform provided (e.g. aprons, overalls, footwear)	☐	☐	☐
Size of toilet cubicle	☐	☐	☐
Shared circulation spaces (e.g. in café or meeting room)	☐	☐	☐
Width of stairways or corridors	☐	☐	☐

Plus Size People at Work

Please take the following 6 measurements when standing

***13. Height**

- **Standing – back against a door or wall. Look forward, shoulders relaxed, arms by your side**
- **Please do not wear shoes.**
- **Measure vertically from the floor to the top of your head.**
- **Ensure the tape measure is in a straight line**
- **Re check measurement**

My height is (cms)

***14. Full Chest**

- Standing – look forward, shoulders relaxed, arms by your side
- Measure around the chest and body at its fullest part (typically at nipple level, under the armpits and over the shoulder blades).
- Hold the tape measure against your body tight enough so that it does not slip down, but not tight enough
that it restricts breathing.
- Make sure the tape measure is at the same level round your chest
- Take a normal breath and measure
- Do not puff out your chest
- Re check measurement

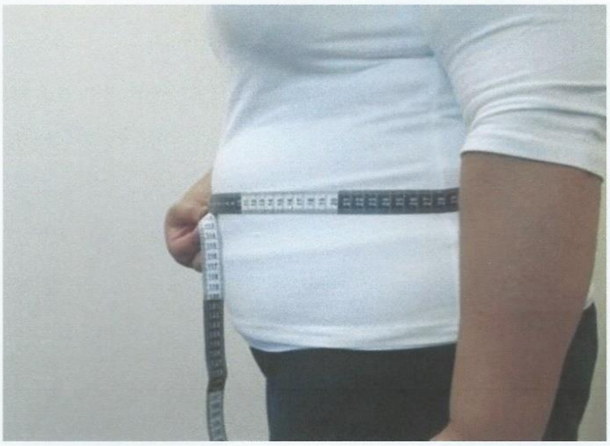
My full chest is (cms)

Plus Size People at Work

*15. Stomach

• Standing – look forward, shoulders relaxed, arms by your side
• Measure around the widest part of your abdomen (this normally coincides with your belly button)
• Hold the tape measure against your body tight enough so that it does not slip down, but not tight enough that it restricts breathing.
• Make sure the tape measure is at the same level all the way round the abdomen
• Take a normal breath and measure
• Do not hold your stomach in
• Re check measurement

My stomach is (cms)



Plus Size People at Work

***16. Hips**

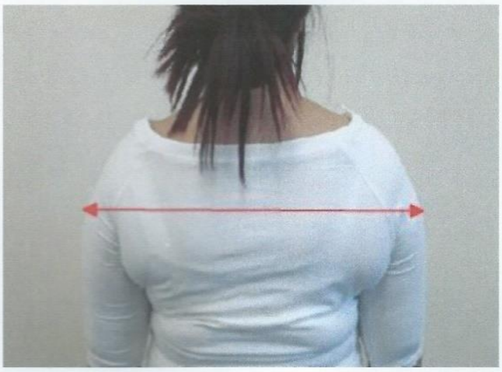
- **Standing – look forward, shoulders relaxed, arms by your side**
- **Measure around the widest part of your hips**
- **Hold the tape measure against your body tight enough so that it does not slip down.**
- **Make sure your pockets are empty.**
- **Make sure the tape measure is at the same level all the way round the hips**
- **Re check measurement**

My hips are (cms)

***17. Shoulder Width**

- **Standing – look forward, shoulders relaxed, arms by your side**
- **From behind, measure across the widest part of your shoulders**
- **Hold the tape measure against your body tight enough so that it does not slip down.**
- **Re check measurement**

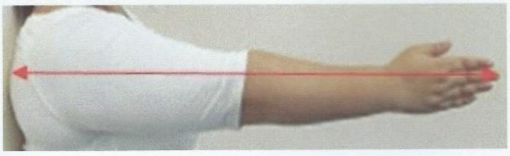
My shoulders are (cms)



***18. Forward Reach**

- **Standing – back against a wall or door, looking forward.**
- **Right arm and hand stretched horizontally in front of you.**
- **Shoulder blade should stay in contact with the wall or door.**
- **Measure from the wall or door to the tip of your longest finger.**
- **Ensure the tape measure is in a straight line**
- **Re check measurement**

My forward reach is (cms)



Plus Size People at Work

Please take the following 7 measurements when sitting

***19. Sitting Shoulder Height**

- **Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.**
- **Sitting upright, looking ahead. Hands in lap.**
- **Measure vertically from the hard seat surface up to the bony tip on the outside of your right shoulder.**
- **Ensure the tape measure is in a straight line**
- **Re check measurement**

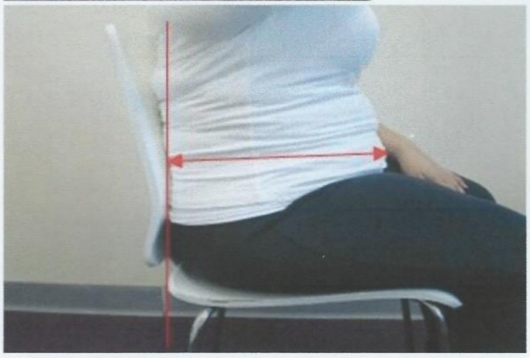
My sitting shoulder height is (cms)

Plus Size People at Work

***20. Stomach Depth**

- **Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.**
- **Sitting upright, looking ahead. Hands in lap.**
- **Find the point where your stomach protrudes the most at the front.**
- **Measure from this point horizontally backwards in a straight line to point where your body protrudes the most at the back.**
- **Ensure the tape measure is in a straight line**
- **Do not hold your stomach in**
- **Re check measurement**

My stomach depth is (cms)

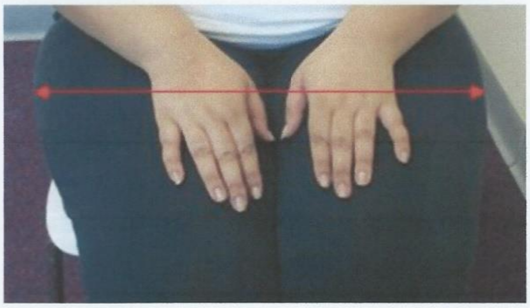


Plus Size People at Work

***21. Hip Breadth**

- **Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.**
- **Sitting upright, looking ahead. Hands in lap**
- **Bring knees and thighs together as much as you are able.**
- **Measure horizontally across the widest part of your hips.**
- **Re check measurement**

My hip breadth is (cms)



✱22. Thigh Thickness

- Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap.
- Measure vertically from the seat surface to the upper surface of your thigh at the point where the thigh is thickest.
- Be careful not to compress the thigh when measuring.
- Re check measurement

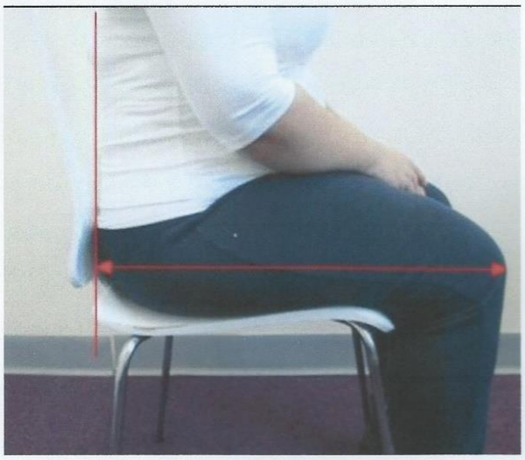
My thigh thickness is (cms)

Plus Size People at Work

***23. Buttock to Front of Knee**

• Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.
• Sitting upright, looking ahead. Hands in lap.
• Measure horizontally from the most posterior part of your buttocks to the front of your knee in a straight line.
• Re check measurement

My buttock to front of knee measurement is (cms)



***24. Back of Knee Height**

- Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.
- Sitting upright, looking ahead. Hands in lap
- Bring knees and thighs together as much as you are able.
- Measure vertically upwards from the floor to the tendon that you can feel on the outer edge of the crease at the back of your knee.
- Ensure tape measure is in a straight and horizontal line.
- Re check measurement

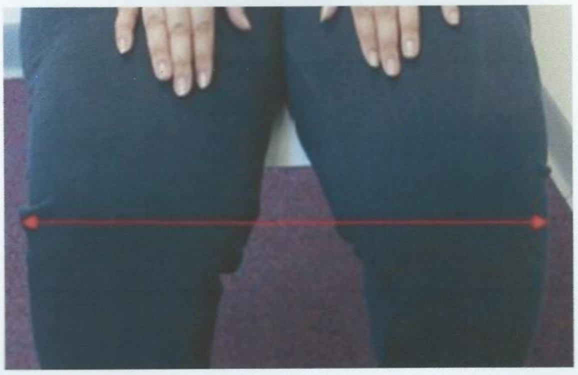
My back of knee height is (cms)

Plus Size People at Work

***25. Between Knee Width**

- **Sitting – on a hard surface. Feet should be supported and thighs should be horizontal.**
- **Sitting upright, looking ahead. Hands in lap**
- **Knees and thighs comfortably splayed.**
- **Measure horizontally from the outer border of one knee to the other.**
- **Ensure tape measure is in a straight and horizontal line.**
- **Re check measurement**

My between knee width is (cms)



Plus Size People at Work

***26. What did you wear whilst being measured? (Important)**
(for example jogging bottom and t-shirt, suit trousers and shirt)

27. Do you have any other comments, questions or concerns relating to being a plus size person at work?

28. Would you be willing to take part in future research about plus size people at work?

- ◯ Yes
- ◯ No
- ◯ Unsure

If YES please provide contact email and/or telephone number

Thank you for completing this self-measurement form.

Please check that you have answered all the questions.

Your help is very much appreciated.

Appendix 6. 2 Strength of correlation between male anthropometric measurements (S= small, M=medium)

Anthropometric Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Weight	-	S	**0.61**	**0.62**	**0.61**	S	S	M	M	**0.64**	**0.58**	M	S	**0.59**
2. Stature	S	-	M	S	S	S	M	M	M	M	S	S	S	M
3. Chest circumference	**0.61**	M	-	**0.61**	**0.72**	S	M	M	M	**0.54**	M	M	S	**0.63**
4. Abdominal circumference	**0.62**	S	**0.61**	-	**0.67**	S	S	S	M	M	M	S	S	**0.61**
5. Hip circumference	**0.61**	S	**0.72**	**0367**	-	S	S	M	M	**0.53**	**0.52**	M	S	**0.59**
6. Shoulder breadth	S	S	S	S	S	-	M	M	M	M	M	M	S	M
7. Forward fingertip reach	S	M	M	S	S	M	-	**0.58**	S	M	M	**0.59**	S	M
8. Sitting shoulder height	M	M	M	S	M	M	**0.58**	-	M	**0.62**	**0.59**	**0.61**	S	M
9. Abdominal depth	M	M	M	M	M	M	S	M	-	**0.77**	M	M	S	**0.66**
10. Hip breadth	**0.64**	M	**0.54**	M	**0.53**	M	M	**0.62**	**0.77**	-	**0.60**	**0.75**	S	**0.77**
11. Thigh thickness	**0.58**	S	M	M	**0.52**	M	M	**0.59**	M	**0.60**	-	**0.56**	S	M
12. Buttock to front of knee length	M	S	M	S	M	M	**0.59**	**0.69**	M	**0.75**	**0.56**	-	S	M
13. Popliteal height	S	S	S	S	S	S	S	S	S	S	S	S	-	**0.54**
14. Knee splay	**0.59**	M	**0.63**	**0.61**	**0.59**	M	M	M	**0.66**	**0.77**	M	M	**0.54**	-

Appendix 6. 3 Strength of correlation between female anthropometric measurements (S= small, M=medium)

Anthropometric Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Weight	-	M	0.69	0.61	0.67	M	S	M	0.77	0.59	M	0.55	S	0.59
2. Stature	M	-	M	M	M *	M	M	M	M	M	M	M	M	0.57
3. Chest circumference	0.69	M	-	0.68	0.75	M	S	S	0.61	0.58	0.55	0.50	S	0.62
4. Abdominal circumference	0.61 **	M	0.68	-	0.66	S	S	M	0.58	M	M	M	S	0.57
5. Hip circumference	0.67	M	0.75	0.66	-	S	S	M	0.61	M	M	M	S	0.53
6. Shoulder breadth	M	M	M	S	S	-	M	M	M	0.70	M	0.66	S	M
7. Forward fingertip reach	S	M	S	S	S	M	-	M	M	S	S	S	S	S
8. Sitting shoulder height	M	M	S	M	M *	M	M	-	M	M	S	M	S	M
9. Abdominal depth	0.77	M	0.61	0.58	0.61	M	M	M	-	0.58	M	0.51	S	0.71
10. Hip breadth	0.59	M	0.58	M	M	0.70	S	M	0.58	-	M	0.60	S	0.58
11. Thigh thickness	M	M	0.55	M	M	M	S	S	M	M	-	S	S	M
12. Buttock to front of knee length	0.55	M	0.50	M	M	0.66	S	M	0.51	0.60	S	-	S	M
13. Popliteal height	S	M	S	S	S	S	S	S	S	S	S	S	-	S
14. Knee splay	0.59	0.57	0.62	0.57	0.53	M	S	M	0.71	0.58	M	M	S	-

Appendix 6.4 Male exclusion data (n=47)

Dimension	Existing Database (Pheasant 2006) Peebles and Norris 1998)						Study Results						Exclusion Rate	
	1st %ile	5th %ile	50th %ile	95th %ile	99th %ile	SD	1st %ile	5th %ile	50th %ile	95th %ile	99th %ile	SD	95th %ile	99th %ile
Weight (kg)	47	55	75	94	102	12	93	97	117	177	188	27	97%	87%
Abdominal Circumference (mm)	831	877	1050	1092	1137	66	1110	1113	1370	1651	1672	130	95%	93%
Hip Circumference (mm)	875	925	1120	1168	1219	74	1018	1021	1305	1605	1668	160	98%	71%
Shoulder Breadth (Bi deltoid) (mm)	400	420	465	510	523	28	419	420	585	756	803	100	64%	54%
Abdominal Depth (mm)	195	220	270	325	345	32	331	341	540	750	779	110	96%	95%
Hip Breadth (mm)	293	310	360	405	428	29	391	450	575	853	878	110	99%	97%
Thigh Thickness (mm)	125	135	160	185	196	15	246	260	315	450	459	60	100%	100%
Buttock to Front of Knee Length (mm)	522	540	595	645	667	31	571	584	640	863	879	70	23%	18%
Knee Splay (mm) (Hip breadth) (Shoulder breadth)	*293 400*	*310 420*	*360 465*	*405 510*	*428 523*	*29 28*	*463*	*483*	*580*	*710*	*767*	*70*	*100% 82%*	*100% 79%*

Appendix 6.5 Female exclusion data (n=54)

Dimension	Existing Database (Pheasant 2006) (Peebles and Norris 1998)						Study Results						Exclusion Rate	
	1st %ile	5th %ile	50th %ile	95th %ile	99th %ile	SD	1st %ile	5th %ile	50th %ile	95th %ile	99th %ile	SD	95th %ile	99th %ile
Weight (kg)	37	44	63	81	89	11	89	99	105	115	170	23	100%	99%
Chest Circumference (mm)	746	822	1007	1193	1267	112	1000	1090	1270	1642	1701	150	79%	59%
Abdominal Circumference (mm)	675	724	911	957	1005	71	970	1142	1261	1600	1619	140	100%	98%
Hip Circumference (mm)	867	917	1110	1157	1207	73	1061	1150	1330	1695	1999	160	92%	78%
Shoulder Breadth (Bi deltoid) (mm)	332	355	395	435	458	27	351	420	520	733	799	90	92%	80%
Abdominal Depth (mm)	185	205	255	305	325	30	361	368	480	800	879	110	100%	100%
Hip Breadth (mm)	282	310	370	435	458	38	460	496	580	838	959	110	100%	100%
Thigh Thickness (mm)	139	125	155	180	195	17	192	200	300	442	449	70	100%	98%
Buttock to Front of Knee Length (mm)	500	520	570	620	640	30	492	528	625	810	848	70	47%	21%
Knee Splay (mm) ***(Hip breadth)*** ***(Shoulder Breadth)***	*282* *332*	*310* *355*	*370* *395*	*435* *435*	*458* *458*	*38* *27*	*455*	*478*	*550*	*790*	*813*	*90*	*100%* *100%*	*99%* *99%*

Appendix 7.1 Preliminary questionnaire - Stakeholder Interviews

Stakeholder Interviews - Including Plus Size People in Workplace Design

Introduction

Please fill in this short questionnaire prior to the telephone/face to face interview.
I have collected anthropometric data from 100 plus size people (BMI above 25) and I am now keen to get your views on how you would like this data to be presented and what information you would like included in a toolkit aimed at including plus size people in workplace design.

Please read each question carefully before answering. There are no right or wrong answers, so please respond freely and honestly. By completing this questionnaire you are giving consent for your comments to be included as anonymous data in this study. The results will be analysed and may be reported in academic journals and conferences but will not be produced in any way that could reveal your identity.

The findings of this study will be used as part of a resource to support the inclusion of plus size people in workplace design.
For further information or questions about the study please contact :
Annabel Masson (PhD Researcher)
Loughborough Design School
Loughborough University
Leics LE11 3TU

Email: A.Masson@lboro.ac.uk

* 1. I consent to take part in this interview

○ Yes

○ No

Stakeholder Interviews - Including Plus Size People in Workplace Design

About You

2. Please give your first name.

* 3. What is your job title?

* 4. How would you describe your level of experience in your field?

- Novice (little or no previous experience)
- Advanced Beginner (some experience, starts trying tasks independently and with context but may have difficulty troubleshooting)
- Competent (develops conceptual models, troubleshoots independently, seeks out expert advice as required)
- Proficient (can anticipate events and sees situations holistically. Will self-correct based on previous performance.Learns from the experience of others)
- Expert (relies mainly on intuition and contextual knowledge. Analytic approaches only used in novel situations or when problems occur)

Other (please specify)

Stakeholder Interviews - Including Plus Size People in Workplace Design

Anthropometric /Inclusive Design Resources

* 5. Do you utilise anthropometric (body measurements) data in your working/design activities?

- ◯ Yes
- ◯ No

* 6. Which of the following resources do you use in your working/design activities?

	Often	Occasionally	Rarely	Never
Tables (e.g Bodyspace - Pheasant, AdultData - DTI)	◯	◯	◯	◯
Web Based Databases (e.g. Peoplesize, DINED)	◯	◯	◯	◯
CAD Packages (e.g Sammie, JACK, ErgoLink)	◯	◯	◯	◯
Inclusive Design Websites (e.g. Inclusivedesigntoolkit.com)	◯	◯	◯	◯
Simulation tools (e.g. Cambridge simulation glasses or gloves)	◯	◯	◯	◯
Other	◯	◯	◯	◯

Other (please specify)

7. Do you have general comments to make on these resources?

Thank you for taking the time to complete this questionnaire. Your responses will be explored during the interview stage. Your help is very much appreciated.

Appendix 7.2 Stakeholder Interviews

Interview Schedule

- Thank you for agreeing to participate in this telephone interview.
- This interview aims to understand your experiences of using anthropometry and/ or inclusivity toolkits in your working practices and builds upon the answers that you gave in the questionnaire.
- As described in the information sheet, I have collected 14 anthropometric measurements from the plus size working population.
- This has resulted in a data set for more than 100 plus size individuals
- Now I would like to get your views on how you would like this data presented as part
  of a resource aimed at including plus size people in workplace design.
- Will take about 20-30 minutes to complete

Before we start ….

Consent

- Should have received information sheet and consent form via email – have you any questions from sheet? Or do you need anything explaining further?
- As we go through the interview, please let me know if you don't understand any of the questions.
- No right or wrong answers – so please respond freely and honestly
- Don't need to answer any questions you don't want to
- Stop at any point without giving a reason
- Interview will be recorded but data will be kept securely and deleted after analysis
- Your answers and any quotes you make will remain anonymous and will not be reproduced in any way that would reveal your identity.
- Do you have any questions regarding the interview or how the data will be used?
- Do you give your consent to be recorded?
- Do you give your consent to participate in the telephone interview?

Interview will cover 3 main areas which are; anthropometric data, issues experienced by plus size people within the working environment and toolkit content

Anthropometric Data

I have collected a data set of 14 anthropometric measurements from over 100 plus size individuals. This will provide a greater insight into the size and shape of the current plus size working population. But… I would like to know from you

If you think such data might be useful to you or your organisation?

- **If yes, example of how you might use this data**
    - *Current/recent projects*
    - *Instances when you have referred to anthropometric sources*
    - *Been unable to find data you required*
    - *Asked to design to include plus size*
    - *Uniform/clothing/PPE or workstation layout*

- **If no – why not?**
- **I could present the data in table format like Pheasant, or web based like People Size but keen to get your views on how you would like this data presented to be of most use for you?**
    - *Format? – table, wheel, interactive chart/diagram*
    - *Access – web, hard source, pocket guide*
    - *Mentioned in questionnaire, that you use ……… most often*
    - *What features do you like? and why?*
    - *What features don't you like? and why?*
    - *Can you identify any features are lacking from the anthropometric data sources and/or inclusivity resources that you currently use? " i could really do with that", "I wonder why…"*

Plus size people who completed an earlier scoping study, identified several areas within the working environment that cause them real problems/concern/challenges. These were issues surrounding

- **Fit – eg. Seating – personal and shared, toilet seats, Uniform, PPE**
- **Space – workspace layout, room to move around unhindered, toilet cubicles**
- **Organisational issues - how plus size people were perceived within the working environment**

What information would be useful to include within a toolkit that would help with understanding the issues affecting plus size people within the working environment?
Primarily….

- **To encourage empathy/diversity**
    - *Lack of literature on subject matter therefore understandable……*
    - *Approaches you use to understand your end users?*
    - *Can you tell me an examples of when you have designed for specific end users*
    - *How do you find out about end users?*
    - *Positive examples of good design for plus size people*
    - *Not so good examples/negative examples of designing for plus size people*

- *What would need to be different to include plus size people in the examples you have given*

An output from this PhD will be the production of resource aimed at assisting stakeholders (designers, ergonomists) in including plus size people in workplace design. Do you have any ideas/thoughts on how what you and your company would like included in such a resource?

- Case studies, personas, bariatric suits/props, blogs/day in the life?
  - *Do you find case studies useful? If so why? And when?*
  - *What details would you like included in case studies?*
  - *What are you experiences of using persona? Useful detail? Missing detail?*
  - *What information would you like included in persona?*
  - *How would you like persona presented?*
  - *What are you experiences of using props/simulation tools e.g. Dexterity gloves,?*
  - *Are there any props/simulation tools that may help you/your company experience issues reported by plus size people?*
  - *Would you need to use these tools yourself or would online images/videos etc…be useful?*
  - *Do you find blogs/day in the life useful? If so why? And when?*
  - *What details would you like included in blogs/day in the life ?*
- Format and access?
  - *As previously mentioned in the section regarding anthropometric data…*
  - *I am keen to get your views on how you would like the resource presented to be of most use for you?*
  - *Format?*
  - *Access – web, hard source, pocket guide*
  - *Mentioned in questionnaire, that you use ……… most often*
  - *What features do you like? and why?*
  - *What features don't you like? and why?*
- Training/education
  - *Have you/your company received any training/education specific to including plus size people at work?*
  - *Do you think there is a need? If so why? If not why?*
  - *What would you like included?*
  - *Could this resource help you/your organisation?*
  - *Useful experiences of training to include end users?*
  - *How do you like to access training?*

Do you know of any good examples/resources that would be helpful for this research that we have not already discussed?

Thank you for all your comments. Is there anything else you would like to add before we end the interview?

That concludes the interview.
Thank you for your time – your help is very much appreciated.
If you would like a follow up call /to be advised of the findings please let me know.

Appendix 7.3 Including Plus Size People in Workplace Design

Stakeholder Interviews (telephone or face to face)

Participant Information Sheet

Researcher:	Annabel Masson	A.Masson@lboro.ac.uk	01509 226921
Supervisors:	Prof Sue Hignett	S.M.Hignett@lboro.ac.uk	01509 223003
	Dr Diane Gyi	D.E.Gyi@lboro.ac.uk	01509 223043

What is the purpose of this study?

Designing a workplace (for example chairs, desks, equipment, uniforms, protective clothing) relies upon the use of accurate and up to date body measurement data to ensure that a broad range of users will be accommodated comfortably and safely. Currently, there is a lack of useful measurement data which is specific to plus size people, and relevant to the design of the working environment. A previous stage of this PhD has collected 14 anthropometric measurements from 100 plus size working people. This interview (telephone or face to face) aims to collect your views on how you would like this anthropometric data presented and explore what information you would like included in a resource/toolkit aimed at including plus size people in workplace design

Why I have been chosen to take part in this study?
You have been approached to take part in this study because you are aged 18 years and over and have some experience of utilising anthropometric data and/or design resources/toolkits, or may be interested in including plus size people in workplace design.

Who is doing this research and why?
The research will be carried out by myself, Annabel Masson as part of my PhD at Loughborough Design School, Loughborough University.

Once I take part, can I change my mind?
Yes. After you have read this information sheet and asked any questions you may have, I will ask you to verbally give your consent. This will be recorded. If you wish to withdraw from the study at any time either before or after you have given consent, all you have to do is say so. You can withdraw at any time, for any reason and you will not be required to explain your reasons for withdrawing.

LOUGHBOROUGH DESIGN SCHOOL

Loughborough University

What will I be asked to do?
The study consists of two parts:
Part 1 - A short online questionnaire prior to
Part 2 – An interview either telephone based or face to face.
If after reading this participant information sheet you consent to take part in this study, the researcher will contact you to arrange a convenient date and time to conduct the interview (either over the telephone or face to face).
Prior to the interview you will be sent a link to a short online questionnaire which should be completed and submitted prior to the interview.
The researcher will then conduct the interview on your chosen date/time. The researcher will ask your consent to participate in the interview and your consent for the interview to be voice recorded.

How long will it take?
The questionnaire should take no longer than 5 minutes to complete.
The interview will take between 20-30 minutes to complete.

Is there anything I need to do before the sessions?
No, there is nothing you need to do before these sessions.

What personal information will be required from me?
Your name will be required purely for ease of contact and will only been seen by the researcher, Annabel Masson. Personal details such as job title job are included in questionnaire, but this data will recorded anonymously in the write up of this research and will not be linked in any way to your name.

Are there any risks from participating?
There are no risks from participating in this study.

Will my taking part in this study be kept confidential?
When data is collected and throughout this research, your information will be kept anonymous. Your name will not be included and you will be identified by a number. The data will be kept in a safe and secure place at Loughborough University.

What will happen to the results of this study?
The results of this study will be used for my PhD thesis and/or for publication.

I have some more questions who should I contact?
For more information, please feel free to contact myself or my supervisors on the contact details provided.

What if I am not happy with how the research was conducted?
Loughborough University has a policy to deal with ‘Research Misconduct and Whistle Blowing which is available online at: *http://lboro.ac.uk/admin/committee/ethical/Whistleblowing(2)htm.*

Thank you

Appendix 8.1 Potential impact of thesis findings on BS EN 1335-1:2000

Dimension	Recommendations BS EN 1335-1:2000	Factors to consider	Recommendations from this Thesis
Seat			
Seat height -adjustable -adjustable range	 400-510mm 120 mm	Stature Thigh thickness Working surface height	Thigh thickness + 167mm from existing datasets. **Seat height may need adjust to lower levels** to accommodate increased thigh thickness under standard height working surface and meet preferences for lower working height (Paul et al., 1995).
Seat depth adjustable -adjustable range	 400-420mm 50mm	Abdominal depth Buttock to front of knee length	Mean abdominal depth + 256mm from existing datasets but length measure of buttock to front of knee is similar to existing datasets. Therefore, adjustability of backrest is paramount to maximise accommodation of abdominal depth and adipose tissue around buttocks without increasing depth of seat surface. **Plus size individuals may benefit from a seat with an adjustable back rest to maximise available seat depth.**
Depth of seat surface	380mm	Abdominal depth Buttock to front of knee length Altered biomechanics of plus size sit to stand (Visimara et al., 2010)	Length measure of buttock to front of knee is similar to existing datasets. Due to adipose tissue within popliteal regions, plus size vulnerable to increase pressure if depth is too long. Depth of seat surface is appropriate for the study population. **Consideration should be given to rounder seat edges to avoid pressure on popliteal region**.
Seat width	400mm	Hip breadth Knee splay	Mean hip breadth is +198mm compared to existing standards. Knee splay + 91mm and 195mm greater than existing datasets (based on shoulder breadth and hip breadth) **To ensure knees and thighs are supported in a position of comfort seat width should be increased. A wider seat anteriorly may support the thighs in a position of comfort.**
Inclination of seat surface	-2^{o} to -7^{o}	Abdominal depth and Circumference. Thigh thickness.	Plus size associated with an increase in anterior pelvic tilt (Visimara et al., 2010) due to abdominal pannus. Negative seat inclination of seat surface may result in thighs exerting upward pressure on abdomen and resulting in increased abdominal circumference/breadth in sitting requiring a greater width between armrests to accommodate abdomen. Sit to stand also more difficult from negative tilt. **Comfort and function may be facilitated by a greater range of seat inclination in positive direction.**

Cushioning	N/A	Increased weight leads to increased compression on seat surface.	**Cushioning should be appropriate to the weight of the individual and the requirements/duration of the task. Material used should avoid user slipping forward.**
Back rest			
Height of supporting point 'S' above seat surface - adjustable - adjustable range	 170mm-220mm 50mm	Stature Sitting shoulder height	Stature and sitting shoulder height is similar to existing datasets. However, adipose tissue around buttocks may be compressed in upwards direction during sitting which leads to altered positon of lordosis. Although reduced lumbar curvature associated with being plus size (Park et al., 2009) it will be further away from backrest due to size of buttocks. **Supporting point S will need to be increased in an anterior – posterior direction to enable engagement with the backrest**. In addition, the **adjustable range should be greater to meet the variation in adipose distribution**.
Height of the back pad - adjustable in height - non adjustable in height	 200mm 260mm	Stature Sitting shoulder height	These dimensions are related to length which were accommodated within existing guidelines/guidance.
Height of the upper edge of the back rest above the seat surface	360mm	Stature Sitting shoulder height	These dimensions are related to length which were accommodated within existing guidelines/guidance
Back rest width	360mm	Hip breadth Shoulder breadth	Mean shoulder breadth measurement 570mm. Curvature of backrest my further reduce the width available for support/comfort. Breadth to seat level may also be necessary to support increased abdominal breadth. **Back rest width may need to be increased to support the broader trunk/shouders of the plus size individual. Support is required from shoulders to seat.**
Horizontal radius of the backrest	400mm		Further reduces available width of back rest. Combined with the
Back rest inclination - adjustable range	 15º		Should be positioned for comfort and to meet task demands. Posterior inclination may reduce 'spread effect' associated with sitting increasing comfort. However, may lead to slipping forward on seat and/or difficulty in sit to stand. Posterior inclination will also reduce functional reach.

Arm rests			
Length of armrests	200mm		**Longer armrests may give additional postural support and assist in sit to stand**. Additionally, longer armrests may enable individuals with large abdominal depth to engage with armrests (Smith et al., 2014) in a position of comfort.
Width of armrests	40mm	Potential for wider forearms Chest circumference Waist circumference Hip breadth 'Spread effect'	**Wider armrests may give additional postural support and assist in sit to stand**. Additionally, wider armrests may enable individuals with large abdominal breadth/hip width to engage with armrests (Smith et al., 2014).
Height of armrest above seat	200-250mm	Chest circumference Abdominal depth Shoulder breadth Waist circumference 'Spread effect'	Abducted position of the shoulder due to increased chest circumference and soft tissue opposition between arms and trunk results in need for higher (and wider) armrests (Smith et al., 2014). This is in contrast to Pheasant and Haslegrave (2006) who suggests a lower armrest to facilitate a relaxed arm position. **Seating with adjustable armrests are preferable to accommodate a position of comfort** for the plus size individual.
Clear width between armrests	460-510mm	Chest circumference Waist circumference Hip breadth Knee splay 'Spread effect'	Mean hip breadth measurement 600mm. Breadth of the abdomen in seated would also need to be accommodated between the armrests. **Width between armrests should take into account hip breadth and breadth of the abdomen in a seating position.**
Underframe			
Stability	195mm	Weight	**Chair should be suitable to support higher weight limits and tested to ensure safety.** **Chair should be perceived as stable by plus size user.**

Appendix 8.2 Including Plus Size People in Workplace Design – Checklist

This checklist can be used as an aid to including plus size people in workplace design. The checklist is not an exhaustive list of items to be addressed and will not necessarily be comprehensive for all work situations but instead should be used to raise awareness of points to consider.

Individual working area **Chair**	**Yes**	**No**	**Action required / Comments**

Is the chair suitable for the task?
 	
• Is it adjustable:
  ○ Backrest height/tilt?
    ○ Seat height?
• Can the user reach the adjustability lever (s) from sitting?			

Is the depth of the seat appropriate? • Assess in preferred seating position • Look at buttocks in relation to back of chair • Can the user engage with the back rest?			
Is the seat wide enough to support thighs? • Assess in preferred sitting position			
Is the back rest high and wide enough to support from buttocks to shoulders? • If not consider use of chair with less curvature			

Is there enough space between the armrests to accommodate thigh and abdominal breadth?			
Are the armrests wide and long enough to be usable for support and/or assist with sit to stand?			
Is the weight limit of the chair appropriate? • Gas lift chairs not recommended above 100kg (HSE, 2011)			
Appearance of the chair • If bariatric chair it should comparable in terms of style, shape and fabric to encourage use • Does the chair look robust and stable? This will encourage confidence in use			
Is the diameter of the base appropriate? • Users feet need to be able to move backwards to help in sit to stand without hindrance from the base			
Does the chair fit into the direct working environment? • Is there space for the chair • Is there space for ingress and egress and the chair			
Working area	**Yes**	**No**	**Action required / Comments**
Is the height of the working surface			

appropriate? • Preference may be for a lower working height to assist with reach			
Is it possible reach all necessary tools/equipment comfortably? • Avoid over reaching • Avoid over balancing • Consider influence of abdominal depth on reach			
Shape of the working surface • Could a different shape help with reach? • Consider wider curves rather than deeper narrower curves • Corner configurations may increase problems with reach			
Is there enough space underneath the working surface to allow for position of comfort to be adopted? • Measure at knee height • Thighs should not be touching underside of surface • Remember seat may need to be higher to assist with sit to stand and reduce 'spread effect'			
Is there adequate space at floor level to enable wider foot positioning? • needed for balance and sit to • stand			
Is there enough space and clearance around the immediate task area, such as behind the chair to enable access without			

hindrance? • consider fixed structures as well as other office equipment			
Is there enough room to allow frequent changes of posture and movement away from desk? (HSE, 2011) • should be clear access • consider altered movement strategies unique to the user			
Are employers/employees aware not to clutter spaces to enable easy mobility?			
Is storage accessible in terms of limited functional reach and greater demands for clearance? • Additional demands if storage is low or high • Consider greater space for access			
Shared spaces **Toilet**	**Yes**	**No**	**Action required / Comments**
Is there enough space to get in and out of the toilet cubicle? • don't forget the person may be holding bags or carrying equipment)			
Is there enough space to turn around in the toilet cubicle when the door is closed? • consider items on the floor or on the wall			

Meeting rooms/reception areas/cafeterias	Yes	No	Action required / Comments
Is there a selection of shared seating? • With/without armrests • Bench/double seats • High/low seating • Avoid demarcated seating			
Are there alternative options if fixed seating is offered?			
Does the seating appear robust/stable? • Avoid materials that look flimsy or that they might break			
Is there enough clearance between tables and/or fixed structures? • Could the user get up leave the meeting room without having to squeeze past others/objects? • User may be carrying trays/objects			
Stairs • Are there alternative to stairs if physical demands are too great • Is there adequate passing space/points on the stairs			
Uniform/PPE	**Yes**	**No**	**N/A**
Are uniform provided in plus sizes? • Without the need to ask for a			

larger size • Fit should enable unrestricted movement			
Is there privacy in the ordering/fitting process?			
Equipment	**Yes**	**No**	**N/A**
Is all equipment (eg..ladders, company car) required suitable for the user in terms of; • Weight limits • Size • Comfort • Safety • If no, are alternatives freely offered?			
Work related activities	**Yes**	**No**	**N/A**
Is the inclusiveness for plus size people considered when planning an activity? • Business related travel? • Some team building activities may have a weight limit			