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Anthropometric Study to Understand Body Size and Shape for Plus Size People at Work

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Abstract

Over 60% of the adult population in the United Kingdom is now overweight/obese or classed as 'plus size' and as the incidence of being plus size rises the demographics of the working population have also changed.A first stage scoping study[1] 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 exclude plus size people and a better understanding of the anthropometric requirements of plus size workers is needed. This paper will present the findings of an Anthropometric Measurement Validation Study to establish if self-measured anthropometric data (including novel measures such as knee splay) in a plus size working age population is feasible as the data collection method for a larger scale survey. A sample of 20 plus size working participants (10 male and 10 female) aged 18 years and over were recruited. Data were collected for weight and stature, and 12 anthropometric measurements recorded via self-measurement and researcher measurement for comparison. Self-measurement was completed by participants following instructions in a self-measurement guide. Data analysis using *t*-testsfoundthat the two methods of measurement (self and researcher) agreed sufficiently closely for 11 of the 14 measurements. This resulted in the self-measurement method being utilised for data collection in an ongoing larger scale anthropometric study to understand the body size and shape for plus size people at work.

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1. Introduction

Overweight and obesity is recognised as a major health problem in many countries of the world[2]. The clear majority of the adult population (61%) in the United Kingdom is now either overweight/obese [3] or classed as 'plus size'. This is higher than almost all other developed countries in the world. Even with numerous public health interventions such as 'Change4Life'[4], Food labelling systems (for example Traffic Light System) and widespread weight management guidance the incidence of being plus size continues to rise changing the demographics of the working population.

The economic consequences of an increased percentage of plus size workers are well documented and include increased absence from work and reduced productivity and being plus size also represents a major risk factor for premature job leave[5]. 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 [6]. 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[7].

Despite the increasing worldwide prevalence of overweight/obesity and the benefits of employment, there is limited literature on the anthropometric characteristics of the plus size worker. Anthropometry is the science of human body dimensions [8] with each individual havinga unique body measurements in different proportions that determine their body shape. Therefore, there is great variability in size and shapeacross the working population. 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 [9]. There are several anthropometry data sets available to support the design process includingAdultdata[8], BodySpace[9], and PeopleSize[10]. Because anthropometry data are expensive to collect, surveys have rarely been conducted for civilian populations (rather than military) which leads to the majority of anthropometric dimensions not being empirically sourced. This has implications in terms of usefulness for designers who may be trying to accommodate a specific population. In addition, the majority of values in data sets rely on ratio scaling methods to estimate many anthropometric dimensions from stature. The rapid increase in the prevalence of plus size people in the working population may not be fully accounted for in these scaling methods[11] in terms of mass and the proportion of each dimension (body shape). Further research is required to collect key anthropometric data to enhance comfort, safety, and user satisfaction within the working environment and reduce the risks of absenteeism, reduced productivity and premature job leave.

A literature review revealed a lack ofcurrent and comprehensive anthropometric data for the plus size UK working population and a need to further understand the anthropometry of the plus size working population. Incorrect adjustments for, or the omission of, anthropometric data in product or workplace design has been associated with work-related psychological discomfort[12], and increased risk of work related musculoskeletal disorders [13] and therefore more knowledge is essential to design safe, comfortable and productive working environments.

Relying on self-reported anthropometric data is an efficient 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[14] have focused primarily on stature and weight. No studies have been identified that include anthropometric measurements required for workplace design and that are specific to plus size people.

The aim of this study is to establish whether self-measurement of anthropometric data in a plus size working age population is feasible and reliable as the data collection method for a larger scale survey.This will be achievedusing a set ofanthropometric dimensions pertinent to workplace design, the development of a self-measurement instruction guide and finally the comparison of the self-measured and researcher measured anthropometric measurements.Additionally, the new anthropometric data will be discussed in the context of existing datasets currently used in workplace design.

2. Methods

2.1Self-MeasurementInstruction Guide

Following a review of the literature, stature, weight and 12additional anthropometric measurements (standing and sitting postures) were selected for inclusion in the study as being relevant to both workplace design and the plus size individual(Table 1). A unique measure of knee splay [15] was included to represent the observed sitting postures of plus size individuals [16]. A self-measurement instruction guidewas developedto enable participants to collect the self-measureddata with concise, easy to follow instructions for each measurement supported by pictures (Fig. 1).

Table 1. Anthropometric Measurements Taken

Anthropometric Measure	
In Standing	In Sitting
Weight	Sitting Shoulder Height
Height	Abdominal Depth
Chest Circumference	Hip Breadth
Abdominal Circumference	Thigh Thickness
Hip Circumference	Buttock to Front of Knee
Shoulder Breadth (bideltoid)	Popliteal Height
Forward Fingertip Reach	Knee Splay

2.2 Sampling

20 participants, 10 males and 10 females, were recruited byself-selection. All participants were resident in the United Kingdom. The inclusion criteria for recruitment were that participants were aged 18 years of age or above, were working (or had worked in the 12 months prior to the study) either on an employed or self-employed basis, and classed themselves as ‘plus size’ or ‘larger than average’. Ethical approval for the study was gained from the Loughborough University Ethical Advisory Committee.

2.2 Data Collection

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.

An information sheet detailing the purpose of the study and their right to withdrawn at any time was sent to the participant with the Self-Measurement Instruction Guide together with a standardised 300cm fabric tape measure. Participants were requested to complete the self-measurement formby following the instructions in the guide. Once completed, the participants were requested to place the completed Self-Measurement Instruction Form into a sealed envelope.

For the researcher-measured component, stature, weight and the 12 anthropometric measurements were collected using traditional methods (including weight scales, stadiometer, modified sitting height table and anthropometer) following protocols described in Pheasant [9]. All equipment was calibrated prior to each usage and the researcher was experienced in taking anthropometric measurements.

The self-measurement component was completed before the researcher-measured component to avoid anylearning effect by the participantsand 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.

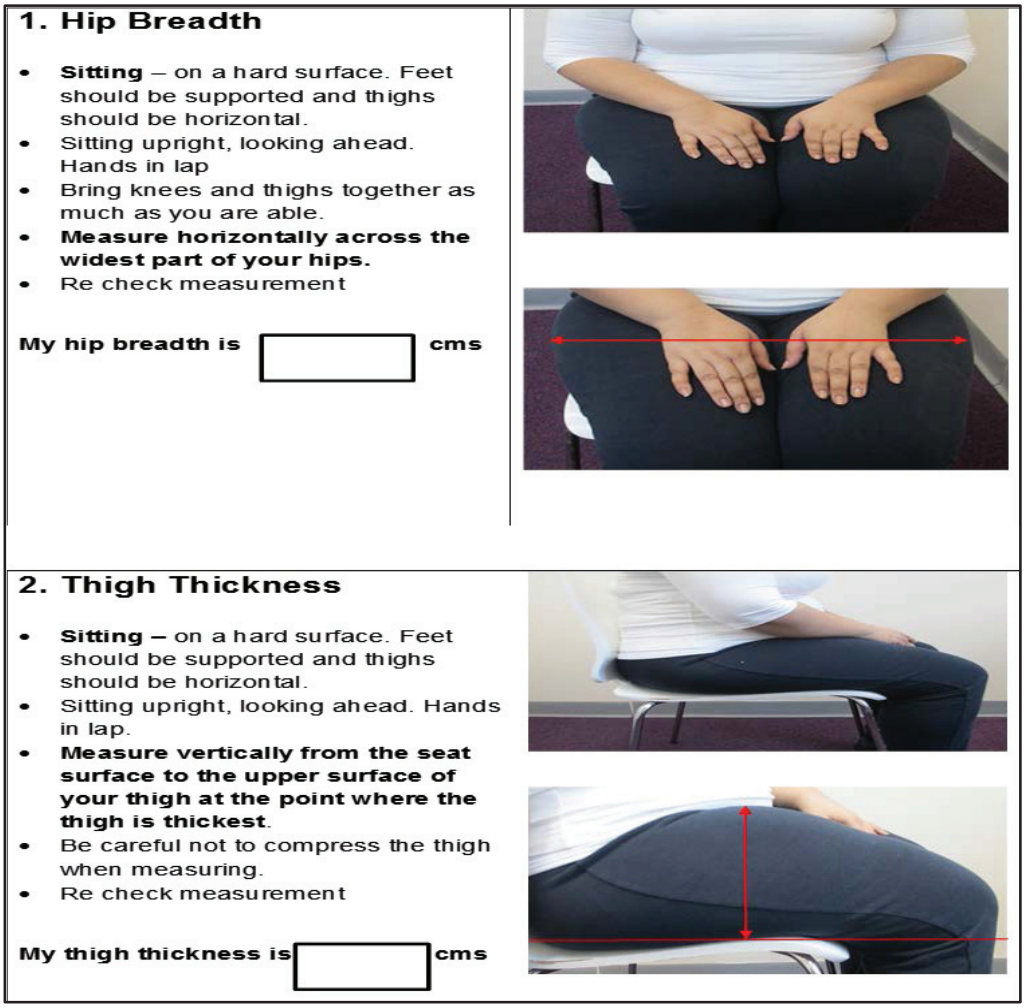

Fig. 1.Example from Self-Measurement Instruction Guide.

3. Results

3.1Sample

20 participants (10 males and 10 females) in employment completed the study. The distribution is summarized in Table 2.

Table 2. Sample group – age and gender distribution (n=20)

Age Range	Number of Participants	
	Male	Female
18-24yrs	2	3
25-44yrs	4	4
45-64yrs	2	3
65yrs and above	2	0

3.2Comparison of Self-Measured and Researcher Measured Data

The data from the Self-Measured and Researcher-Measured components were entered into SPSS software for statistical analysis. Paired comparison *t* tests were used to compare the self-measured and researcher-measured data for each anthropometric measurement. Following statistical analysis, 11 out of the 14measurements taken via self-measurement were comparable to those obtained via the researcher-measured technique (Table 3) with no significant differences between the measures ($P \leq 0.05$); however three anthropometric measurements (stature, weight and hip circumference) differed significantly (Table 4).

Table 3.Anthropometric Measurements with no significant difference between self-measurement and researcher measured techniques (n=20)

Anthropometric Measurement	Paired Differences		t	df	Sig. (2 tailed)
	95% Confidence Interval of the Difference				
	Lower	Upper			
Chest Circumference	-1.110	0.410	-0.960	19	0.349
Abdominal Circumference	-1.100	0.302	-1.192	19	0.248
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 4. Anthropometric Measurements with significant difference between self-measurement and researcher measured techniques (n=20)

Anthropometric Measurement	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
Hip Circumference	-1.281	-0.189	-2.156	19	0.044

3.3 Comparison of Anthropometric Measurement Data to Exisitng Datasets

The primary aim of this study was to establish if self-measured anthropometric data in a plus size working age population is reliable and feasible as the data collection method for a larger scale survey. However, anthropometric measurement data collected in this studywas also compared to the 95th percentile of current datasets[8,9](common practice utilised by designers and stakeholders when designing for plus size people)to gain further information on the size and shape of the current plus size working population (Table 5).

Table 5.Comparison of Study Anthropometric Measurement Data to Existing Datasets

Anthropometric Measure	Male			Female		
	Study Mean	Existing dataset 95%ile [8,9]	Difference	Study Mean	Existing dataset 95%ile [8,9]	Difference
Weight	113.6 kgs	94 kgs	+ 9.4 kgs	110.2 kgs	81 kgs	+ 29.2 kgs
Height	1760 mm	1855 mm	In range	1567 mm	1710 mm	In range
Chest Circumference	1359 mm	No male data for comparison		1235 mm	1193 mm	In range
Abdominal Circumference	1367 mm	1092 mm	+ 275 mm	1278 mm	957 mm	+ 321 mm
Hip Circumference	1298	1168 mm	+ 130mm	1278 mm	1157 mm	+121 mm
Shoulder Breadth (bideltoid)	598 mm	510 mm	+ 88 mm	530 mm	435 mm	+ 95 mm
Forward Fingertip Reach	835 mm	971 mm	In range	775 mm	867 mm	In range
Sitting Shoulder Height	618 mm	645 mm	In range	573 mm	610 mm	In range
Abdominal Depth	526 mm	344 mm	+ 182 mm	491 mm	305 mm	+ 186 mm
Hip Breadth	551 mm	405 mm	+ 146 mm	569 mm	435 mm	+ 134 mm
Thigh Thickness	303 mm	185 mm	+ 118mm	239 mm	180 mm	+ 59 mm
Buttock to Front of Knee	619 mm	645 mm	In range	618 mm	620 mm	In range
Popliteal Height	450 mm	490 mm	In range	428 mm	445 mm	In range
Knee Splay	586 mm	405 mm	+ 180mm from current hip breadth data	543 mm	435 mm	+ 108 mm from current hip breadth data

For both male and female participants, anthropometric measures of height, chest circumference, forward fingertip reach, sitting shoulder height, buttock to front of knee and popliteal height all fell within the current 5thpercentile to 95thpercentile range of existing datasets [8,9]. There were 7 measures which exceeded the 95thpercentile range of existing datasets with abdominal depth, abdominal circumference and hip breadth demonstrating the largest differences. There were no comparison data for knee splay as this is a new measure to beused in a non-pregnant population - the implications of this measure will be addressed further in the discussion.

4. Discussion and Conclusions

4.1 Comparison of Self-Measured and Researcher Measured Data

No significant differences were found between the anthropometric measurements from the two methods of measurement (self and researcher) for 11 of the 14 measurements. The anthropometric measurements with a significant difference were weight, stature and hip circumference and this has been reported in other literature[17]where weight was under reported and height was over reportedfor self-measurement by both male and female participants. Previous studies[18]have suggested that this pattern of misreporting may be due to prolonged time between self-measurement and researcher-measurement, equipment differences, differences in clothing worn or differences in time of day of measurements. These factors were standardized as far as possible during this study but the possibility that participants either estimated their weight and height rather than taking actual measurements or reduced their weight and increased their height consciously cannot be excluded. Hip circumference was also under reportedfor self-measurement compared to researcher measurement although to a lesser degree than weight which may be due to difficulties in identifying the level of maximum protrusion for measurement (due to the lack of anatomical landmarks for guidance) or again due to conscious under reporting. It is interesting that weight, height and hip circumference might be measures that are 'known' to the participant (for example through clothing sizes). However, although the differencesforthese 3 measurements are statistically significant, practically 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 for 11 ofthe 14 anthropometric measurements confirms that self-measurement (utilizing the self-measurement guide) is both reliable andfeasible as the data collection method for a larger scale anthropometric study to further understand the body size and shape for plus size people at work.

4.2 Comparison of Anthropometric Measurement Data to Exisitng Datasets

A common compromise in design is to accommodate the 5th to 95th percentile of the population. One of the knowledge gaps when designing to include plus size people is the lack of an up to date and comprehensive anthropometric database of the plus size working population based on empirical measurements rather than estimates. Although, the sample size in this study was small (n=20) and this is a limitation, this study has identified that for 6 of the 14 anthropometric measurements values were accommodated by the current datasets. However, 7 of the 14 anthropometric measurements included in this study exceeded the current 95thpercentile values [8,9]. These measures are particularly relevant when designing for clearance. For example, abdominal depth (clearance between seat back and obstructions), thigh thickness (clearance required between seat and underside of table or other obstacles) and turning circles (necessary for unimpeded movement within the working environment). This suggests that the majority of participants in this study could have been excluded from current workplace design. The measure of knee splay is defined as the distance between the outer borders of the knees whilst seated in the preferred posture[15] – thishas not previously been applied to a non-pregnant population and there are no comparable data. It was included in this study as the standard anthropometric measurements of knee breadth and hip breadth, for seat width and clearance (chairs, toilet seats, shared seating, car seats),aremeasured taken with knees together, a posture infrequently adopted by plus size individuals due an increased abdominal circumference and depth. When compared to existing hip breadth data, 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.

The larger scale anthropometric study aims to further identify key anthropometric variables that explain the body shape and variability among plus size people and the potential for including knee splay as an essential addition to datasets to support the design of safe, comfortable and productive working environments.

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