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THE EVALUATION AND ASSESSMENT OF BODY IMAGE PERCEPTION AND DISTORTION IN MEN

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Abstract

Background: Perceptual body image distortion can be defined as a discrepancy between an individual's mental representation of their body and their actual body size and shape, and is associated with negative physical and psychological health outcomes. Current methods to assess perceptual body image in men tend to utilise poor imagery, lack ecological validity, focus on Body Mass Index (BMI) variation, and demonstrate little consideration of male-specific body concerns and ideals.

Aims: This thesis presents 6 research studies that aimed to: (i) develop novel visual body stimuli that overcome current limitations of existing measures, (ii) evaluate their reliability and validity in estimating perceptual body image in community-based male samples, and (iii) improve our understanding of the methodological and individual factors that influence visual male body size and weight judgements.

Methods and Results: Study 1 evaluated the accuracy of men's visual body size discriminations using figures ranging in BMI from underweight to obese. This study identified the Just Noticeable Difference (JND) of body size between pairs of figures using a method of constant stimuli, providing evidence of perceptual discriminations consistent with Weber's law. This informed the development of two male figure scales with a perceptual underpinning for the BMI differentiation between figures. Preliminary evidence for the reliability and validity of these figure scales in estimating men's current and ideal body perceptions was provided in Study 2. In Study 3, a calibrated mapping between male body shape, fat mass and muscle mass was developed using a database of 3D body scans and body composition measurements. Principal component analysis identified main components of shape variation that were visually modelled as a function of fat mass and muscle mass to develop an interactive body scale. The face validity of this scale was evaluated in Study 4 through fat and muscle ratings of the body model calibrated for points along each body composition dimension. Findings indicated that men were able to visually perceive changes in both dimensions as intended. Preliminary evidence for the reliability and validity of this interactive scale was provided in Study 5. Study 6 investigated the accuracy of categorical male body weight judgements, using 3D body scans presented at 2- and 8-viewpoints. Categorical weight perceptions and weight-loss beliefs were found to be directly related to the BMI and viewpoint of the stimuli, as well as the individual's sex and attitudinal body image.

Conclusion: Several novel visual body stimuli have been developed that present high-quality imagery, wide variation in body size and shape, precise calibration to measurements of body composition, and/or consider visual discriminations of male body weight. Preliminary evidence for the reliability, validity, and suitability of these measures among community-based male samples has been provided, with recommendations for further evaluations and potential modifications. This thesis has also given insights into individual and methodological factors that influence male body weight judgements and supports the visualisation of male body composition in perceptual body image measures.

Table of Contents

List of Tables

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

List of Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

List of Acronyms

2-AFC	2-Alternative Forced Choice
2D	Two-dimensional
3D	Three-dimensional
AFA	Anti-Fat Attitudes Questionnaire
AIC	Akaike's Information Criteria
AN	Anorexia Nervosa
ANOVA	Analysis of Variance
BAS	Body Appreciation Scale
BD	Body Dissatisfaction
BDD	Body Dysmorphic Disorder
BDI	Beck Depression Inventory
BIA	Bioelectrical Impedance Analysis
BIC	Bayesian Information Criteria
BID	Body Image Distortion
BIMTM-MB	Body Image Matric of Thinness and Muscularity – Male Bodies
BMI	Body Mass Index
BN	Bulimia Nervosa
BSQ	Body Shape Questionnaire
CGI	Computer-Generated Imagery
COVID-19	SARS-CoV-2
DEXA	Dual Energy X-Ray Absorptiometry
DL	Difference Limen
DMS	Drive for Muscularity Scale
EDE-Q	Eating Disorder Examination Questionnaire
EDE-QS	Eating Disorders Examination Questionnaire Short
FFMI	Fat Free Mass Index
HSE	Health Survey for England
ICC	Intraclass Correlation Coefficient
ISAK	International Society for the Advancement of Kinanthropometry
JND	Just Noticeable Difference
KMO	Kaiser-Meyer-Olkin
LEAS	Lincoln Ethics Application System

LL	Log-Likelihood
MB	Muscularity Behaviours
MBAS	Male Body Attitudes Scale
MBAS-R	Male Body Attitudes Scale – Revised
MBI	Muscularity-orientated Body Image
MBS	Male Body Scale
MCU	Modular Camera Unit
MD	Muscle Dysmorphia
MFBS	Male Fat Body Scale
ML	Maximum Likelihood
NHS	National Health Service
NSM-M	New Somatomorphic Matrix – Male
PCA	Principal Component Analysis
PSE	Point of Subjective Equality
REML	Restricted Maximum Likelihood
RSE	Rosenberg Self-Esteem Scale
SATAQ	Sociocultural Attitudes Towards Appearance Questionnaire
SOPREC	School of Psychology Research Ethics Committee
VBSM	Visual Body Scale for Men
VBSM-BF	Visual Body Scale for Men – Body Fat
VBSM-M	Visual Body Scale for Men – Muscularity
VDT	Video Distortion Technique
VR	Virtual Reality
WBIS-M	Modified Weight Bias Internalisation Scale
WCR	Waist-to-Chest Ratio
WHO	World Health Organisation
WHR	Waist-to-Hip Ratio

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Chapter 1: Introduction

1.1 What is Body Image?

Body image is a multi-faceted construct that encompasses people's thoughts, emotions and perceptions relating to their own body and those of others (Grogan, 1999; Muth & Cash, 1997). The study of body image originated as a neurological practice with inquiries into the relationship between brain damage and distorted body image perceptions in the early 20th century (Hingorani et al., 2011). Investigations did not move away from associations with neurology until Paul Schilder (1950) began to extend this field of research to explore the variability of body image and its applications in people's daily lives. Body image research, its methodologies and applications have since developed and evolved into diverse areas of study, including psychology, sociology and medical science. Research has progressed rapidly and now explores a range of perceptual, attitudinal, and cognitive-behavioural components of body image (Hosseini & Padhy, 2019).

Perceptual body image can be defined as an individual's mental representation or estimation of body weight, size and shape, as it applies to their own body and those of other people (Cash et al., 1991; Slade, 1994). Perceptual body image distortion (BID) is therefore characterised as a discrepancy between a person's actual and perceived body size and shape (Cash & Deagle, 1997). This cognitive misinterpretation has been associated with a variety of negative psychological and physical health outcomes, including depression, anxiety, eating disorders and excessive exercising (Kimber et al., 2015).

Attitudinal body image is characterised by people's thoughts and emotions driven by their body size and shape, which can include both positive and negative evaluations, investment and affect (Cash, 1994). Body image evaluations refer to the thoughts, beliefs and level of satisfaction or dissatisfaction that a person experiences in relation to their physical appearance (Cash, 1994). Investment refers to the importance or attentional focus that people place on their appearance in relation to their identity or sense of self (Cash, 1990; Cash & Labarge, 1996). Body image affect is defined by the emotions that occur as a result of body image evaluations in particular situations or contexts (Cash, 1994; Szymanski & Cash, 1995).

Cognitive-behavioural approaches to body image often consider how people interpret their self-schemas and estimations of body size and shape, as well as their personal investment in their appearance (Cash, 2012). This information processing can be influenced by a variety of internal and external factors, including their sociocultural environment, hormonal status and individual psychological characteristics (Cash & Smolak, 2011). These factors influence a person's body image experiences in their day-to-day life and can elicit a range of emotions and appearance-related behaviours (Grogan, 2006).

Although perceptual and attitudinal body image are thought to be global, independent dimensions (Cornelissen et al., 2019), and are often examined separately in research (Gardner & Bokenkamp, 1996; Waldman et al., 2013), they are also considered to be interconnected (Hosseini & Padhy, 2019). The characterisation of body image into these components and the ways in which they are measured in research is not uniform and is constantly changing. In addition, the number of new and revised tools and measures used to assess these two dimensions of body image is constantly expanding (Stewart & Williamson, 2004; Thompson, 2004; Thompson & Gardner, 2002). The measurement of body image is becoming increasingly complex, especially considering the interrelation between perceptual and attitudinal components, and the multidimensionality of body image as a construct (Irvine, McCarty, McKenzie, et al., 2019).

1.2 Why is Male Body Image Important?

Historically, the measurement of perceptual and attitudinal components of body image has focused primarily on the female experience, largely as a result of the associations of distorted body image and body dissatisfaction with eating disorders (Stice, 2002; Thompson & Stice, 2001). Recently, however, researchers have begun to direct more emphasis towards understanding how men perceive, think and feel about their bodies. This change in direction is likely a result of increasing empirical evidence of associations between men's body dissatisfaction and a variety of negative health outcomes and related behaviours that impact on people's wellbeing and quality of life, including depression, suicide ideation, social avoidance, and eating disorder pathology (Jankowski et al., 2018; Olivardia et al., 2004; Parent, 2013). Several detrimental health behaviours have shown to be particularly prominent in the male population, including the use of anabolic steroids and exercise dependence (Baum, 2006; Murray et al., 2016; Strother et al., 2012). Increased use of appearance-related consumer products and procedures among men has also been recorded, such as the use of tanning shops, make-up and cosmetic procedures (Frederick et al., 2007; Jankowski et al., 2014; Jankowski et al., 2018), which may reflect a rise in the pressures that men are facing to achieve unrealistic appearance ideals.

Socially-driven male appearance ideals are shifting further away from what is naturally achievable by promoting a physical appearance that is not only highly lean and muscular, but also well-groomed and youthful (Jankowski et al., 2018; Strother et al., 2012). This can lead to increased body size and shape concerns, dissatisfaction and unhealthy behaviours in men (Halliwell et al., 2007; Kimmel & Mahalik, 2004; Pope et al., 2000; Swami, 2006). Enhancing our understanding of the impact of these appearance ideals on men's wellbeing and developing more accurate measures of body image in a male context are crucial as this has implications for a variety of health outcomes, such as in the diagnosis and management of eating disorders and muscle dysmorphia (MD), and optimising the success of weight-management programs (Gardner, 2014).

1.2.1 Eating Disorders

Body image concerns and distortions are thought to play a significant role in the development and maintenance of eating disorders (Calugi et al., 2018; Stice & Whitenton, 2002; Thompson & Stice, 2001). Eating disorders and their associated clinical manifestations have been evidenced more in women than men, which has led to a common view of eating disorders as a 'female condition' (Greenberg & Schoen, 2008). However, men experience similar disturbances in their body image, maladaptive body shape and weight-control behaviours, and disordered eating behaviours to women (Mitchison & Mond, 2015; Núñez-Navarro et al., 2012). This can lead to impairments in men's psychosocial wellbeing, occupational productivity and overall health-related quality of life. A recent review reported that men account for around 10-25% of all eating disorder cases in the UK (Sweeting et al., 2015). However, there is a lack of data available on the prevalence of eating disorders in men, which may be a consequence of the gendered stereotypes associated with these disorders (Strother et al., 2012).

Societal perceptions of a masculine identity and gender-appropriate emotions and behaviours have resulted in a stigma associated with eating disorders, with some individuals believing that a man who experiences an eating disorder is "less than a man" (Thapliyal et al., 2020). This cultural expectation stems from a belief that poor mental health is a sign of weakness in men, often resulting in feelings of emasculation, alienation, shame, depression, denial, and fear (Austen & Griffiths, 2019; Quiniones & Oster, 2019; Thapliyal et al., 2020). Experiences of body shame or dissatisfaction are often stigmatised as a 'female issue', which can prevent or delay the recognition or acceptance of eating disorder symptoms in men, thus hindering disclosure and help-seeking behaviours (Griffiths et al., 2014; O'Gorman et al., 2020; Quiniones & Oster, 2019; Strother et al., 2012). There is evidence that men are less likely to pursue clinical help for disordered eating behaviours, and are less likely than women to receive an eating disorder diagnosis if they do decide to seek treatment (Thapliyal et al., 2020). It is often the case that clinicians overlook or misinterpret symptoms in men, which in turn may result in a statistical underrepresentation of the true occurrence of eating disorders in this population (Räisänen & Hunt, 2014).

A metasynthesis of nine qualitative studies exploring the influence of gender in people's experiences of eating disorders and treatment highlighted that men often have to report more extreme symptoms to be truly recognised by clinicians and to allow for the provision of treatment (Thapliyal et al., 2020). It has been argued, therefore, that more gender-inclusive treatment is necessary, as many men reported receiving eating disorder information that ignored male-specific concerns, as well as feeling isolated during treatment programs that seemed to be targeted towards women. This lack of gender-appropriate information and treatment is likely a result of insufficient large-scale population studies targeting eating disorders in men compared to women, which therefore limits the data available to clinicians and obstructs their ability to provide evidence-based treatment (Quiniones & Oster, 2019; Strother et al., 2012; Thapliyal et al., 2020). This emphasises the need for greater understanding, consideration, and assessment of male-specific issues in eating disorder diagnostic tools and interventions.

1.2.2 Muscle Dysmorphia

The growing internalisation of a society-related drive for muscularity in men has led to the development of MD, a subtype of body dysmorphic disorder (BDD). MD has been characterised as a persistent preoccupation with being lean and muscular, with a specific dissatisfaction in muscularity rather than general body shape (Leone et al., 2005; Pope Jr et al., 1997). MD is typically associated with the male population, particularly in bodybuilding or weightlifting groups, however, there are currently no reliable estimates of the prevalence of this disorder in the UK (Tod et al., 2016). Individuals with MD tend to engage in detrimental health-related behaviours, such as excessive gym attendance, disordered eating, body exposure avoidance or anxiety, anabolic steroid use, and excessive body checking (American Psychiatric Association, 2013; Hildebrandt et al., 2004; Leone et al., 2005; McCreary, 2007; Mitchison & Mond, 2015; Pope et al., 2000). MD can also cause interference in an individual's quality of life, social and occupational functioning, including social avoidance or anxiety, withdrawal from career activities, and repeated social comparisons (Hildebrandt et al., 2004; Leone et al., 2005; Mitchison & Mond, 2015). A biopsychosocial model highlights the influence of socioenvironmental factors, such as cultural ideals and mass media, emotional and psychological factors, including body dissatisfaction, poor self-esteem and negative affect, as well as physiology, including an individual's actual body size, on the development of MD (McCreary, 2007). It is crucial that perceptual body image measures consider male-specific body concerns, dissatisfaction, and ideals relating to muscularity, in order to improve our understanding of the perceptual attributes and prevalence of this disorder in the male population.

1.2.3 Obesity

There is a complex relationship between body image and obesity that can cause individuals who perceive themselves as obese to engage in either healthy or unhealthy weight management behaviours (Duncan et al., 2011; Rancourt et al., 2017; Romano et al., 2018). The influence of body size evaluations and weight-stigma on people's wellbeing and quality of life is a global concern, with extensive evidence that appearance ideals promoting leanness and muscularity have a negative impact on the social and psychological experiences of individuals with obesity (Kuchler & Variyam, 2003; Shwartz & Brownell, 2004). Obesity is characterised as having elevated or abnormal levels of body fat that present a risk for an individual's health (Björntorp, 2002). The Body Mass Index (BMI), calculated by dividing a person's weight (kg) by the square of their height (m^2), is generally used for obesity classification as a proxy for body fat percentage (World Health Organisation [WHO], 2000). Obesity is categorised as having a BMI of 30 kg/m^2 or above (see Chapter 2). This condition has become a global health concern, with approximately 27% of men in the UK categorised as obese and 41% as overweight (National Health Service [NHS] Digital, 2020). A UK report has estimated the economic cost of overweight and obesity to be £27 billion each year (McKinsey Global Institute, 2014). However, it is difficult to attain an accurate estimate due to the association of obesity with other health conditions, including type 2 diabetes (Maggio & Pi-Sunyer, 2003), cardiovascular disease (Van Gaal et al., 2006), and liver disease (Marchesini et al., 2008). This cost is also likely to have amplified in the past year, due to the increased risks of SARS-CoV-2 (COVID-19) transmission and mortality for individuals with obesity (Kassir, 2020).

Wider societal costs can be attributed to the impact of weight bias and stigmatisation on the health and wellbeing of individuals with obesity, resulting from complex socioeconomic factors such as job and academic performance, income and employment discrimination, and healthcare provision (Puhl & Brownell, 2002; Singh et al., 2019). For example, higher-weight males have reported feeling stigmatised or even ignored by health professionals, which can lead to an avoidance of medical care over time (Tomiyama et al., 2018). Experiences of weight stigma have also been linked to a variety of negative health outcomes, behaviours and psychosocial distress, such as depression, binge eating, low self-esteem and a lack of motivation to exercise (Griffiths et al., 2018; Vartanian & Porter, 2016; Wu & Berry, 2018).

There is evidence of sex-specific patterns of stigma relating to body weight, with women showing a general linear pattern and men showing a more U-shaped pattern with higher levels of weight stigma associated with obese and underweight BMIs (Griffiths et al., 2018; Himmelstein et al., 2018). Weight bias is often founded on inaccurate beliefs that people are overweight or obese as a result of poor self-discipline and a lack of willpower, and that stigmatisation or shame will help motivate individuals to lose weight (Darling & Atav, 2019; Täuber et al., 2018). This social ideology, known as the attribution framework, is based on applying negative attributions to explain unfavourable outcomes, such as an individual's physical appearance (Swami, Furnham, et al., 2008). This leads to a misunderstanding that overweight or obese people are fully responsible for their weight status and that weight loss depends solely on levels of personal control and individual behaviours. Swami and colleagues (2008) investigated the relationship between different body weights and perceived levels of laziness, loneliness and being teased. It was observed that men with a BMI between 21 and 22 kg/m^2 and a low waist-to-chest ratio (WCR) were rated lower for these traits than men with BMIs outside this range and with higher WCRs. BMI was found to be the best predictor of laziness ratings, which is consistent with attributional beliefs that overweight and obese individuals are responsible for their weight and that weight loss is a matter of self-control and discipline. In spite of these misperceptions of obesity as purely a lifestyle disease, it is now commonly understood to be a much more complex interaction between environment and biology, including genetic, metabolic, nutritional, socioeconomic and lifestyle factors (Fairburn & Brownell, 2013; Madrigal et al., 2000; Nagata et al., 2019).

1.3 Theoretical Approaches to Attitudinal Body Image

Attitudinal body image comprises individuals' affective relationship with human body size and shape, such as their feelings, beliefs, evaluations, and emotional investment relating to their bodies. Negative attitudinal body image has been widely described and is associated with a variety of psychological health concerns, including suicidal ideation and depression, eating disorder pathology, sexual inhibition and social avoidance, as well as the use of anabolic steroids (Jankowski et al., 2018). People's thoughts and feelings relating to their own and other people's bodies have also been the emphasis of a range of theoretical approaches to attitudinal body image, including evolutionary, sociocultural and cognitive-behavioural perspectives (Cash & Smolak, 2011).

1.3.1 Evolutionary Theory

Evolutionary approaches to body image have mainly been concerned with judgements of attractiveness and the relationship between body features and mate selection. This perspective argues that judgements of attractiveness are based on the evaluation of physical attributes that are universal visual cues of a partner’s fertility and health (Crossley et al., 2012). In terms of male attractiveness, characteristics that indicate masculinity and dominance may be considered more attractive and used as a signal of fitness and reproductive potential (Swami, 2006). One of these key characteristics is male upper body shape, which has been identified as a strong determinant of desirability (Swami & Tovée, 2008). More specifically, a V-shaped torso, identified by a high WCR, has been linked to higher levels of testosterone and is a strong determinant of attractiveness ratings (Swami, 2006).

According to evolutionary theory, judgements of attractiveness and mate preferences play a vital role in the general direction of human sexual selection within society (Buss, 1987). Physical characteristics that are favoured within mate selection are likely to appear more regularly in future generations, as well as provide indications to prior human reproductive patterns. An awareness of mate appearance preferences can result in increased pressures and behavioural tactics to appear attractive to potential mates (Buss, 1988). The theory of runaway selection (Fisher, 1930) suggests that these favoured physical traits are likely to become exaggerated over time, to the point they are no longer correlated with health or fitness, due to increased pressures driven by prevalent mate preferences (Barber, 1995). Individual levels of parental investment may also play a role within this sexual selection process. In this perspective, males are seen to have less direct investment in their offspring than their female counterparts, as historically they have been expected to provide resources such as food, shelter and protection (Trivers, 1972). Therefore, evolutionary theory argues that females seek male partners who demonstrate a capability to provide such resources. One study tested this assumption on a broad scale, using 37 samples within 33 countries across the globe (Buss, 1987). In general, it was found that males valued physical attractiveness and relative youth in their mates, while females preferred relatively older mates whose characteristics signalled greater capability to provide resources.

Evolutionary inclinations can be used to explain the different barriers and pressures that males and females face during mate selection and why they employ different approaches to attract mates. It has been proposed that optimal physical traits may differ depending on environmental pressures and sociocultural norms, and that this may play a role in people's body size and shape preferences (Tovée et al., 2006). Physical and behavioural indications of fertility can differ across cultures and are dependent on a range of factors, such as age-specific mortality, sociocultural norms and contraceptive practices (Buss, 1987). Although female fertility is universally age-dependent, reproductive capability in males is less so and therefore cannot be as accurately evaluated using physical cues as in females (Symons, 1995).

1.3.2 Sociocultural Theory

Sociocultural approaches to body image focus on how different individuals and groups of people are influenced by their social and cultural environments. A range of external factors and pressures can play a role in people's perceptions, beliefs, feelings and behaviours relating to their body, including societal norms, cultures and traditions, technology, socioeconomic status, and exposure to different forms of media (Swami, 2006). This area of research has largely concentrated on how sociocultural environments construct particular appearance ideals and expectations that can result in the development of disturbed eating behaviours and negative body image (Tiggemann, 2011). Appearance standards are shared through a range of sociocultural paths, such as family, friends and mass media, and can then be internalised by individuals who apply these standards to their own bodies or those around them. The degree to which people internalise appearance ideals, as well as their current mood and psychological state, influences their overall level of body satisfaction, depending on their perceptions of their body in relation to this ideal (Swami, 2006). Furthermore, body dissatisfaction and high internalisation of unrealistic appearance ideals may motivate individuals to invest in unhealthy behaviours as a means of getting closer to their appearance goal (Carraça et al., 2013; Neumark-Sztainer et al., 2006; Swami, 2006). Two sociocultural models have been commonly used to describe how sociocultural channels mediate the relationship between body image and a person's social and cultural environment, these being the Dual Pathway Model and the Tripartite Influence Model.

1.3.2.1 The Dual Pathway Model

The Dual Pathway Model (Stice & Agras, 1998) is an early theoretical framework of eating pathology that focuses on the relationship between appearance ideals, body dissatisfaction and disordered eating behaviours. It was originally proposed to understand the influence of the thin-ideal on the development of bulimic pathology in females. The model suggests that sociocultural pressures to achieve the thin-ideal and internalisation of this ideal lead to body dissatisfaction, due to the ideal being largely unrealistic and unachievable. It is proposed that these sociocultural pressures are transferred through two channels; mass media and significant others. The model also suggests that this body dissatisfaction may lead to disordered eating behaviours through unhealthy dieting and negative affect. The Dual Pathway Model has since been updated and extended to incorporate additional risk factors and pathways such as the influence of BMI, impulsivity, perfectionism and substance use (Stice & Whitenton, 2002; Stice & Shaw, 2002). This framework has provided the building blocks for more recent theoretical models, including the Tripartite Influence Model. However, it has primarily been founded on Caucasian female samples and has shown variable suitability among male groups (Mason & Lewis, 2015; Womble et al., 2001).

1.3.2.2 The Tripartite Influence Model

The Tripartite Influence Model (Thompson et al., 1999) suggests that sociocultural appearance ideals are transferred and preserved through three channels; family, peers and the media. The model proposes that this path is mediated by the internalisation of appearance ideals and appearance comparisons to others. Festinger's social comparison theory (1954) states that individuals make evaluations about themselves based on comparisons to similar others. This theory highlights two types of comparison; upward comparisons where individuals compare themselves to others who they see as 'superior' in the relevant characteristic, and downward comparisons in which individuals compare themselves to those thought of as 'inferior'.

The Tripartite Influence Model has been used to understand male body image in a variety of ethnic groups and cultures, with growing evidence of the influence of family, friends and the media on men's body image, appearance ideals and related behaviours (Dogan et al., 2018; Mellor et al., 2009; Ricciardelli et al., 2000). Although the model has predominantly been applied to body image concerns and disordered eating in females, it has also been modified and used as a framework for examining the internalisation of both lean and muscular body ideals in the male population (Girard et al., 2018; Karazsia & Crowther, 2009; Smolak et al., 2005; Stratton et al., 2015; Tylka, 2011; Tylka & Andorka, 2012). When both evolutionary and sociocultural approaches to body image are considered, it suggests that while some aspects of body image are instinctive and inherent to the human species, other aspects are influenced by one's sociocultural environment and individual experiences (Swami, 2006).

1.3.3 Cognitive-Behavioural Models

Cognitive-behavioural approaches to body image focus on the importance of understanding relationships between people's thoughts, feelings, behaviours and their unique life experiences. This perspective considers the influence of different levels of thought, from global, pervasive beliefs, known as cognitive schema, that are formed through people's prior life experiences, to more specific situation-based judgements (White, 2000). A 'body image schema' has been proposed where people's self-evaluations of their own appearance are based on context-specific schema that are established by the sum of all their previous experiences (Altabe & Thompson, 1996). This cognitive schema is then used to drive individual behaviour and influence the way in which information relating to the body is processed.

Another cognitive-behavioural approach to body image is Higgins' (1987) self-discrepancy theory that proposes three separate self-domains; the 'actual self', the 'ideal self' and the 'ought self', which can be considered from either a first or third-person perspective. In this model, the 'actual-self' is the subjective representation of particular attributes that a person believes they possess, the 'ideal-self' refers to the representation of attributes that a person aspires to and the 'ought-self' is a representation of the attributes that the person believes they should possess. The model assumes that people are motivated to match their ideal and actual self and that any divergence between these self-domains may cause discomfort, or other forms of negative psychological wellbeing, as well as behavioural consequences. This theoretical approach also suggests that there are individual differences in the particular sources that motivate people to match their ideal and actual self, that are derived from each person's previous experiences. In addition, the impact that the discrepancy between a person's actual and ideal self has on them is dependent on the personal meaning of that particular attribute. Self-discrepancy theory has since been modified to include additional self-domains, such as the 'future-self' and 'feared-self', that describe representations of the attributes that the person may eventually possess or fear they possess (Vartanian, 2012). A variety of psychometric measures have been developed in support of self-discrepancy theory, including Higgins' Selves Questionnaire (Higgins, 1987) and the Body-Image Ideals Questionnaire (Cash & Szymanski, 1995). Visual figure scales are also commonly used to assess ideal and current body perceptions, where self-discrepancies are assumed to be the difference between the two silhouettes selected as the closest representations of their ideal and current self (Williamson et al., 1993).

1.4 Perceptual Body Image

1.4.1 Visual Perceptions of Body Size and Weight

Perceptual body image is characterised as an individual's mental representation or estimation of their own body weight, size and shape, as well as those of other people (Cash et al., 1991; Slade, 1994). Research exploring self-perceptions of body size and shape has commonly assessed the accuracy of people's current body perceptions in relation to their actual body size and shape. An array of literature has demonstrated that obese and overweight individuals tend to underestimate their own body size and believe themselves to be of a healthier weight than they actually are (Brug et al., 2006; Harris et al., 2008; Kuchler & Variyam, 2003; Oldham & Robinson, 2016; Robinson, 2017; Wetmore & Mokdad, 2012). This phenomenon appears to be most extreme in people at the lower end of the overweight spectrum and particularly prominent in the male population, as there is a greater tendency for females to overestimate their body size (Kuchler & Variyam, 2003; Robinson & Kersbergen, 2017).

Visual normalisation theory proposes that misperceptions of body size and weight are becoming more common as a result of the increasing rates of obesity observed within Western society (Ambroziak et al., 2019; Burke et al., 2010; Robinson & Kirkham, 2014; Yaemsiri et al., 2011). This change in people's social environment means that they are being regularly exposed to larger body sizes, and this is resulting in a shift in body sizes that are judged as 'normal' (Robinson & Kirkham, 2014). This perceptual shift can influence judgements of people's own body size, as well as that of others, based on a norm comparison approach in which visual evaluations of body size are made in relation to these internalised norms (Robinson & Kersbergen, 2017). In support of this theory, there is evidence that presenting individuals with images of certain body sizes can influence the judgments and perceptions that are attributed to these body types (Boothroyd et al., 2016; Jucker et al., 2017; Oldham & Robinson, 2016). For example, Robinson and Kirkham (2014) examined the effect of visual exposure to obese or healthy-weight male bodies on people's judgements of what constitutes a healthy weight. It was found that when participants were shown photographs of obese males, they perceived larger body sizes as being healthier than when exposed to images of healthy-weight bodies. This relationship was mediated by alterations in what people judged as a 'normal' weight. Similarly, Robinson and Christiansen (2015) found that exposure to images of obese males led to increased judgements of attractiveness of larger body sizes among female participants, again mediated by this perceptual change. Therefore, this demonstrates that people's visual evaluations of body size and weight are flexible and can be influenced by what they are frequently exposed to.

Body size and shape misperceptions have also been addressed in research exploring visual adaptation and aftereffects, which has found that prolonged exposure to certain body stimuli can bias people's perceptions of subsequently-viewed bodies (Brooks et al., 2020). It has been argued that this visual adaptation serves to recalibrate a person's perceptual mechanisms to their specific environmental context, by altering the response properties of the neurons that are activated by the stimulus (Clifford & Rhodes, 2005). Body-size aftereffects have been evidenced in an array of research that has manipulated bodies in various dimensions, including body surface area (Hummel et al., 2012), body width (Brooks et al., 2018), and levels of adiposity and muscularity (Stephen et al., 2016). The visual adaptation paradigm has been recognised as a perceptual mechanism underlying visual normalisation theory, with both approaches acknowledging the influence of visual exposure to bodies on people's perceptions of their own body, as well as those of others (Brooks et al., 2016; Brooks et al., 2018). There is also evidence to suggest partial overlap in the neural mechanisms that encode body size relating to the self and others (Brooks et al., 2016).

In both the UK and USA, research has shown a generational change in national perceptions of body weight (Burke et al., 2010; Johnson et al., 2008). A comparison of two consecutive health surveys in the USA (1988-1994 and 1999-2004) demonstrated a significant reduction in the probability of people self-reporting as overweight between the two time periods, particularly in males aged 20 to 45 (Burke et al., 2010), which may exhibit a societal shift in weight norms. Despite systematic inclinations to underestimate body size and weight, individual differences have been found in the accuracy of body size evaluations. There is evidence that when overweight individuals are made aware of the healthcare guidelines for obesity and overweight classification, they are less prone to underestimations of body weight (Robinson & Kersbergen, 2017). It has also been suggested that certain sociodemographic groups demonstrate more accurate estimations of body weight, including females (Johnson-Taylor et al., 2008; Robinson, 2017) and individuals from higher socioeconomic backgrounds (Burke et al., 2010).

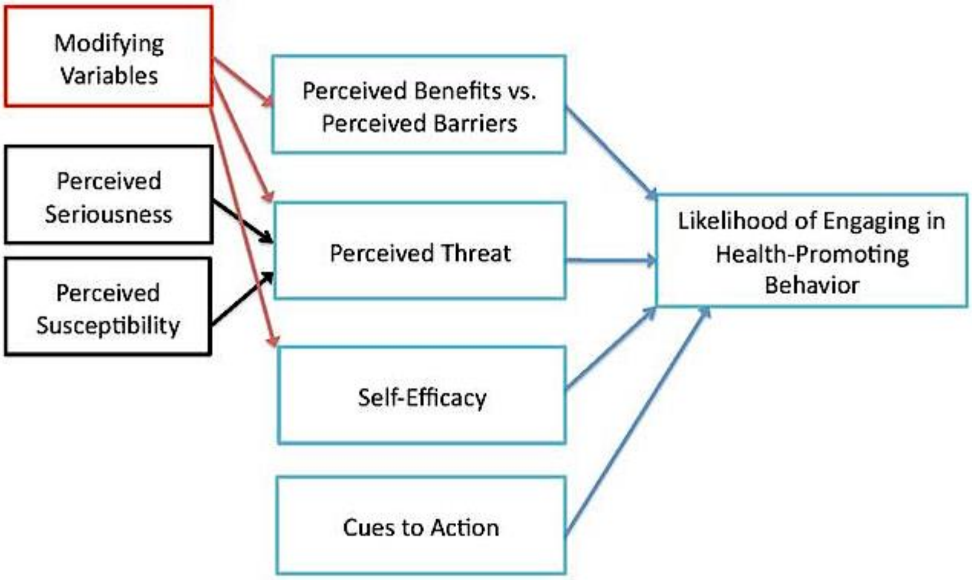
There has been a recent focus on the influence of body size and weight evaluations on obesity as a global health issue, as these perceptions can have critical implications for the effectiveness of interventions and health programs (Kuchler & Variyam, 2003). Self-perceptions of being overweight have been associated with both healthy weight-loss behaviours (Duncan et al., 2011; Rancourt et al., 2017) and poor weight-management behaviours (Romano et al., 2018). These mixed findings may be a result of individual weight-change intentions, desires for muscularity, or the internalisation of weight-related stigma (Rancourt et al., 2017).

Internalised weight stigma describes an aspect of body image in which people adopt negative attitudes related to their own weight, which may cause them to feel concerned about being rejected or negatively evaluated by others (Meadows & Calogero, 2018; Täuber et al., 2018). This social identity threat can impact on an individual's psychological wellbeing, through feelings of self-blame and shame, and their engagement in health-related behaviours (Haynes et al., 2018; Major et al., 2012). This may be why many overweight individuals underestimate their own weight, as a form of self-serving bias to protect their psychological wellbeing from the potential harmful effects of self-stigma (Jansen et al., 2006; Robinson & Hogenkamp, 2015).

The health implications of individual body weight evaluations can also be explained by the Health Belief Model (Rosenstock, 1974; Rosenstock et al., 1988), that considers two distinct areas of health and health-related behaviours; threat perception and behavioural evaluation (see Figure 1.1). Threat perception refers to a person's perceived susceptibility to and anticipated severity of a health outcome or behaviour. In this case, it concerns a person's perceptions of their own weight, or weight change, and the impact this has on their health-related quality of life. The model proposes that if an individual is unable to accurately judge their weight gain or its severity, they are unlikely to adopt the positive health-related behaviours necessary to reduce their weight (Wardle et al., 2006; Wetmore & Mokdad, 2012; Yost et al., 2010). The ability to detect weight change in others is also important in a variety of contexts, including healthcare professionals' screening of overweight or obese patients (Bramlage et al., 2004; Caccamese et al., 2002; Johnson et al., 2008; Perrin et al., 2005; Robinson & Kirkham, 2014; Yoong et al., 2014). Therefore, improving our understanding of the relationship between actual body size and perceptual body image may have a range of clinical implications, including helping to prevent or treat obesity and improve weight loss intervention outcomes (Gardner, 2014).

Figure 1.1

The Health Belief Model (Rosenstock et al., 1988)



1.4.2 Visual Biases in Weight Estimations

Perceptual body image research has investigated the role of inherent visual biases on people's estimations of body size and shape, and the influence that these have on related health outcomes and behaviours. Two natural visual biases that have been repeatedly explored within the literature are contraction bias and Weber's law.

1.4.2.1 Contraction Bias

Contraction bias assumes that body size is judged using a personal internal reference schema that is founded on an accumulated average of the bodies an individual has seen throughout their life, particularly those that they have seen more recently, known as their 'visual diet' (Poulton & Poulton, 1989; Winkler & Rhodes, 2005). Contraction bias argues that this template is used most accurately when judging bodies of a similar size to the template, with a reduction in accuracy as the body becomes increasingly dissimilar. This can result in an underestimation of larger bodies and overestimation of smaller bodies, as compared to a person's reference template.

Contraction bias has been supported by extensive empirical evidence (Cornelissen et al., 2015; Cornelissen et al., 2016), in which participants have been asked to estimate either their own body size or the size of other bodies, ranging in BMI. For example, Cornelissen and colleagues (2016) presented participants with photographs of female bodies varying in BMI and asked them to estimate the weight of the bodies, in kilograms or stones. They found that women tended to systematically overestimate the weight of bodies that were below the Health Survey for England (2008) female average of 70kg, and underestimate bodies above this average. This bias has also been used to support research findings that people who are overweight or obese tend to underestimate their own body size in relation to individuals with a lower BMI (Robinson & Kersbergen, 2017; Truesdale & Stevens, 2008; Wetmore & Mokdad, 2012).

1.4.2.2 Weber's Law

Weber's law (1834) states that the smallest difference between two stimuli that can be reliably discriminated, known as the Just Noticeable Difference (JND), is a constant proportion of the magnitude of the stimulus. The magnitude of the stimulus required to produce this JND is referred to as the Difference Limen (DL). Weber's law proposes that the size of a JND is associated with stimulus intensity and adheres to the following Weber fraction, where I represents the magnitude of the stimulus, ΔI represents the DL and K represents a constant (Gescheider, 1997):

$$\frac{\Delta I}{I} = K$$

In the case of body size perception, Weber's law argues that changes in body size become gradually more difficult to notice as BMI increases (Cornelissen et al., 2016). This means it would be more difficult to notice a single BMI unit variance between two bodies at the upper end of the BMI spectrum than at the lower end. The JND can be considered to be inversely related to the precision of body size estimation, with a small JND highlighting greater precision in these judgements. Therefore, if the JND increases linearly with BMI, the precision of body size estimates will decrease respectively, thus requiring proportionally larger differences in body size between larger bodies than smaller bodies for the differences to be reliably detected. It has been suggested that this has beneficial applications for designing figure rating scales in body size perception research (Cornelissen et al., 2018). According to this principle, the bodies in a figure scale should ideally be spaced by a standard multiple of JNDs across the range of BMI, so that there is an equal distance between bodies in perceptual space. This would allow for an equivalent perceptual ability to distinguish between bodies in the scale, which may improve the precision of participants' body size judgements and the scale's application in clinical settings.

Weber's law also has potential implications in healthcare settings, especially for weight-change efforts in people at either end of the BMI spectrum. For example, individuals with obesity may need to lose a greater amount of weight for it to be noticeable by themselves or others, as compared to people of lesser body weights (Cornelissen et al., 2016). This could have a negative impact on people's own motivation to lose weight if they are unable to visually detect positive changes to their appearance. Alternatively, patients with eating disorders who are underweight may find it easier to detect changes in their own body size than those with higher body weights. This could have implications for their psychological wellbeing and treatment outcomes, including increased body size concern, weight-loss behaviours and potential relapse in recovering patients (Cornelissen et al., 2015). Weber's law may also play a role in the detection of weight change in others, which is particularly important when considering the ability of healthcare professionals to track weight changes in their overweight or obese patients (Bramlage et al., 2004; Caccamese et al., 2002; Johnson et al., 2008; Perrin et al., 2005; Robinson & Kirkham, 2014; Yoong et al., 2014). Inaccurate weight perceptions may prevent or delay patients from being screened for weight-related health concerns or being provided with suitable support to achieve a healthy weight.

1.4.3 Perceptual Body Image Measurement

Perceptual body image is generally assessed using a range of two-dimensional (2D) methodologies that have evolved over time with advances in technology, two of the most popular being video distortion techniques and figure rating scales. Video distortion techniques (VDT) are computerised interactive methodologies that generally involve individuals manipulating images of their body to assess the accuracy of their current body size and shape estimations, body ideals and levels of body dissatisfaction (Allebeck et al., 1976; Gardner & Bokenkamp, 1996; Gardner & Brown, 2010; Smeets et al., 1999). While there is evidence of VDT being a valid and reliable measure of BID (Probst et al., 1998), this method is generally used to obtain an estimate of an individual's perceived whole-body size and shape, as it tends to only allow for alterations along the horizontal axis of the body. Therefore, VDTs are limited in their ecological validity and realism, and generally fail to consider perceptions relating to individual body parts (Cornelissen et al., 2016; Gardner, 1996). Ecological validity can be defined as the degree to which body stimuli truly represent the human body in the real-world (Talbot et al., 2020). Systematic linear changes in the general width of a body do not represent realistic body weight gain or loss, and this technique does not consider the influence of body composition or anatomical structures on shape change (Cornelissen et al., 2015; Cornelissen et al., 2017). In addition, this method of adjustment can be problematic in that the original size of the body image presented to participants can have a significant impact on participants' responses (Fuentes et al., 2013).

Another common method of assessing perceptual body size estimations and body dissatisfaction is the use of 2D figure rating scales. These scales are commonly a sequence of outline drawings of human figures, ranging from small to large for a specific dimension of variation, such as body fat percentage or BMI (Gardner & Brown, 2010; Talbot et al., 2020). They can also consist of computer-generated images or photographs of real bodies at different sizes (Moussally et al., 2017; Mutale et al., 2016; Swami et al., 2012). Figure scales are often used to gain a visual representation of people's perceived current or ideal body size and shape, as well as to identify ideal partner preferences (Williamson et al., 1993). When figures are calibrated for a measurement of body variation, such as BMI, they can also allow for an index of body dissatisfaction, based on discrepancies between current and ideal body perceptions (Talbot et al., 2020). There is evidence that these discrepancies are associated with measures of body appreciation, body dissatisfaction, drive for muscularity, and eating disorder symptomatology (Altabe & Thompson, 1992; Swami et al., 2012; Talbot, Cass, & Smith, 2019; Talbot et al., 2020).

Figure rating scales and other 2D image sets are commonly applied in research and clinical settings as they are relatively cheap, easy to administer, and can be used with a range of different populations and language abilities (Talbot, Smith, & Cass, 2019). However, these methods have some critical limitations. Figure scales are often based on hand-drawn figures or artistic impressions of photographs of bodies at different sizes and are, therefore, limited in their realism (Bateson et al., 2007; Tassinary & Hansen, 1998). Some figure drawings present disproportionate limbs, a lack of definition in certain body regions and little, if any, separation between the torso and arms in the figures, which result in a lack of ecological validity (Gardner & Brown, 2010; Thompson & Gray, 1995). In addition, they only present partial variability in shape changes between figures, and the figures are always presented in the same order within the scale (Crossley et al., 2012; Gardner et al., 1998). Presentation of body silhouettes in 2D also limits the richness of body size and shape information available to participants. For example, figures shown from a front-view, such as those presented in Stunkard et al.'s (1983) figure drawing scale (see Figure 1.2), portray information relating to the width of the bodies but give little indication of their depth.

Figure 1.2

Stunkard et al.'s (1983) Male 2D Figure Rating Scale

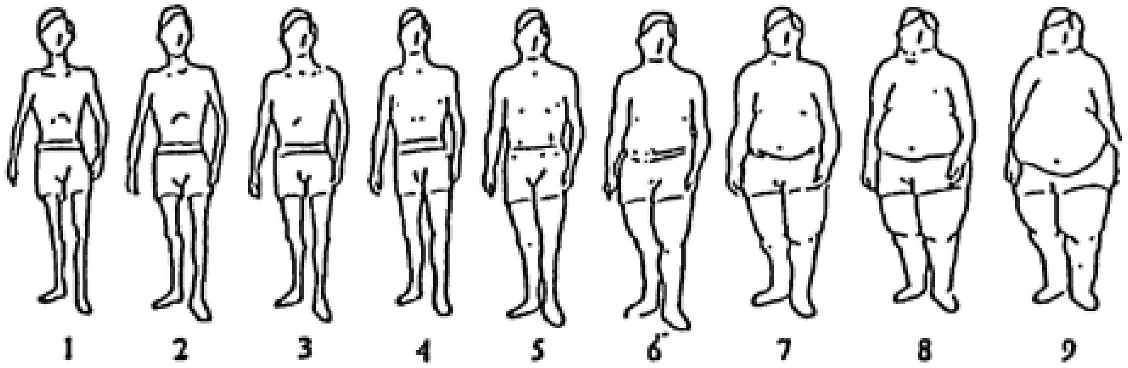


Figure scales only present a limited number of figures (normally 9 bodies or fewer) and, therefore, are unlikely to include a true representation of an individual's perceived current or ideal body (Gardner & Brown, 2010). The presentation of a limited range of figures that are simultaneously presented in ascending order also has potential implications for test-retest reliability, as participants may use the location of figures within the scale to inform their selections, rather than solely the size and shape of the figures (Talbot, Smith, & Cass, 2019). There is evidence that the way in which figures are presented, either in order or unordered, influences participant estimations of current and ideal body perceptions (Doll et al., 2004). It has been argued that figure scales are a better measure of attitudinal body image, such as body dissatisfaction, than perceptual estimations, due to these restrictions and general issues with ecological validity (Gardner & Brown, 2010).

1.4.4 Beyond BMI and 2D Methodological Approaches

There has been a lack of consistency in the methods used in research to measure men's perceptual estimations of body size and shape, which can make it difficult to interpret and compare findings across the literature (Gardner, 2014). As previously discussed, methods that have been relied upon are often overly simplistic (Stunkard et al., 1983), limited by poor imagery (Gardner et al., 1998; Ralph-Nearman & Filik, 2018), and/or do not account for male-specific body concerns and ideals (McCabe & Ricciardelli, 2004). Another critical limitation in existing 2D methods is that they often consider general body size or adiposity, indexed by BMI, as the primary dimension of variation between male bodies (Cafri & Thompson, 2004; Gardner & Brown, 2010).

1.4.4.1 Limitations of BMI

Human body shape varies along two dimensions of body composition; muscularity and adiposity, and BMI is unable to differentiate between these components (Sturman et al., 2017; Wells, Cole, et al., 2008). This is problematic for perceptual body image measures that rely on BMI, as individuals with the same BMI can have very different body compositions and consequently, different body shapes (Mullie et al., 2008; Yajnik & Yudkin, 2004). In addition, the focus of BMI solely on height and weight can often result in individuals with more developed musculature being categorised as either overweight or obese, which suggests high levels of fat mass and an increased health risk that may not be warranted (Frankenfield et al., 2001; Okorodudu et al., 2010). This issue of BMI misclassification tends to be more prominent in men than women (Burkhauser & Cawley, 2008).

BMI fails to consider inherent body weight distribution and body composition differences between men and women, as well as the physiological changes that occur as individuals age (Prentice & Jebb, 2001; Wells, 2007). Sex differences in body composition are mainly the result of hormonal activity during puberty, although they are present from the very early stages of life (Wells, 2007). Males tend to demonstrate a central fat distribution and greater visceral adipose tissue within the body, while females generally have more subcutaneous adipose tissue and peripheral distribution of fat in the lower limbs and hips (Geer & Shen, 2009). A higher level of visceral adipose tissue in males has been indicated as a risk factor for obesity-related complications including diabetes, insulin resistance and non-alcoholic fatty liver disease (Chan et al., 1994; Geer & Shen, 2009; Kim et al., 2004; Kissebah et al., 1982). The male body also tends to remain fairly constant in its shape over the lifespan, although increasing levels of fat tend to be deposited on the abdomen with age, whereas there is a greater association between body shape and age in females (Shimokata et al., 1989). This seems to hold across ethnicities and populations, although it is somewhat dependent on ethnic genetic factors and the environment in which people live (Wells, 2007). Given these differences, it has been suggested that the categorical threshold for being overweight and obese should be adjusted for different ages, as well as for men and women, to reflect similar levels of adiposity across groups (Nevill & Metsios, 2015). In consideration of the simplistic nature of BMI and its inability to distinguish between dimensions of body composition, it is important that approaches to perceptual body image measurement move away from BMI toward the presentation of both muscularity and adiposity in male bodies.

1.4.4.2 Interactive 3D Computer Software

In response to the methodological limitations of 2D measures, research has begun to consider the use of three-dimensional (3D) methods to investigate individual body perceptions. For example, interactive 3D computer programs have been developed to assess individual levels of body dissatisfaction and BID (Gardner & Brown, 2010). Interactive methodologies originally began with simplistic video distortion methods (Allebeck et al., 1976; Gardner & Bokenkamp, 1996; Smeets et al., 1999). However, more updated computer software has since been developed, with ongoing improvements in technology, that allow for visual representations of male bodies as 3D objects in space. For example, Daz Studio software, developed by Daz Productions Inc. (www.Daz3d.com), has been used in a range of body image research, including investigations into the categorical perceptions of health and physical attractiveness (Tovée et al., 2012), and the relationship between actual physical dimensions and ideal body shape perceptions in men and women (Crossley et al., 2012). This software presents realistic, high-definition, computer-generated 3D body models that can be personalised and altered in a variety of dimensions to create specific, detailed changes in body size and shape that cannot be captured using 2D measures. However, Daz Studio and similar modelling software have recently been used to create computer-generated imagery (CGI) that visually match line-drawn bodies from existing figure rating scales or represent linear changes in body shape, without precise calibration of the figures to actual measurements of body variation (Arkenau et al., 2020; Talbot, Cass, & Smith, 2019). Images generated in this way may, therefore, still have limitations in the realism of their appearance, their portrayal of accurate body size and shape information, and the ability for individuals to relate to the virtual models presented (Alexi et al., 2019).

1.4.4.3 3D Body Scanning

Body scanning technologies have become a popular and increasingly accessible method of measuring individual variation in 3D body size and shape. Whole-body scanning technologies originally emerged in the late 1990s (Treleaven & Wells, 2007), and were predominantly used in the fashion industry, to improve clothing size selection and enhance personalisation for individuals (Apeagyei, 2010). For example, the UK’s most recent national sizing survey collected data from over 11,000 individuals using a 3D body scanner to develop brand-specific size charts for clothing (Bougourd & Treleaven, 2002). 3D body scanning technologies are now additionally being applied within a range of sport (Troynikov & Ashayeri, 2011), ergonomic (Tneb et al., 2000) and healthcare contexts (Treleaven & Wells, 2007). Of particular interest is its use in characterising and modelling human body shape, as this has applications in many areas of health research, including evaluations of developmental normality, estimations of skin-surface area, the production of prosthetics, and calculations of appropriate individual treatment doses (Grazioso et al., 2018; Treleaven & Wells, 2007).

In terms of perceptual body image, 3D scanners can provide anthropometric measurements and visualisation of body size and shape that has implications for research and clinical practice (Grogan et al., 2017; Thaler et al., 2018; Treleaven & Wells, 2007). The Civilian American and European Surface Anthropometry Resource was the first project to attain a large dataset of around 6,000 3D full-body scans and anthropometric measurements in Europe and the USA (Robinette et al., 1999). This database has been used in a number of studies interested in 3D body shape variation, anthropometric data, and the assessment of perceptual body image (Azouz et al., 2006; Mölbert et al., 2017). The growing application of 3D body scanning in this field is likely a result of the many benefits of these technologies. Body scanners are becoming less costly and more accessible, they are also relatively quick and easy to use, and can therefore be applied to large numbers of people in both clinical and research settings (Haleem & Javaid, 2019; Wells, Ruto, & Treleaven, 2008).

Although 3D body scanning is a physically non-invasive measure of body size and shape, its impact on individuals' wellbeing and health-related behaviours has not been investigated thoroughly. It is important to consider how individuals may experience the body scanning process and whether this method has potential impacts on attitudinal body image, health-related motivations and behaviours. Women's experiences and reactions to whole-body scanning have been explored (Grogan et al., 2017). Although women were mostly at ease with the scanning process, they expressed having various reactions to seeing their scan, including shock, laughter and disappointment, with some participants focusing their attention on specific aspects of their bodies (Grogan et al., 2017). In regard to health-related intentions, scanning was generally seen as a useful motivator to maintain or increase levels of physical activity, particularly in women who were already active, healthy eaters. However, many women expressed concern regarding the impact of scanning on vulnerable others and believed this would depend on an individual's mind set, body image and personality. In a similar investigation of men's experiences of whole-body scanning, men recognised the use of body scans as a form of motivation to engage in exercise and a healthier diet and reported that scanning would be a useful method of tracking fitness and body shape change (Grogan et al., 2019). The majority of men criticised areas of their body after viewing their 3D scan, some of which were new concerns that they did not have before being scanned. As was found in women,

men reported concerns that other men may find the scanning process daunting or upsetting, especially if their body scan did not match personal expectations. Therefore, there are important factors to consider when using 3D body scanning within healthcare contexts, and as a tool to improve health behaviours and wellbeing. However, the potential benefits of this technology to both body image research and clinical practice are critical.

1.4.4.4 Principal Component Analysis

The application of 3D scanning technologies in body image research is relatively new, and, subsequently, the ways in which 3D data are being processed, analysed and applied within research is constantly progressing. Individual body scans are generally recorded as high-density 3D point clouds that require a level of processing before the models can be used for both research and clinical applications (Daanen & Ter Haar, 2013). This processing can be compartmentalised into three stages: initialisation, registration and model building (Hirshberg et al., 2012). Due to the nature of 3D scanning, some areas of the body are likely to be missing from the scans due to their obstruction from the cameras, including between the legs and the bottoms of feet (Allen et al., 2003). Similarly, smaller areas of the body, like fingers and ears, may not be captured exhaustively by the cameras. Therefore, the initialisation stage involves filling in missing segments and smoothing scattered fragments within the original scans. Generally, individual body scans then need to be standardised so that each model has the same number of points and that each point corresponds to the same anatomical landmark on the body (Shu et al., 2009). One way this has been achieved is by fitting each body scan to a generic template model using a set of landmarks, in order to ensure correspondence and geometric equivalency between the anatomical features, also known as registration (Hirshberg et al., 2012). Another possible method involves alignment of the body scans by translating them to the same centre of gravity and positioning them to the same X, Y, and Z-axes (Azouz et al., 2006). Once all the body scans have been standardised, the models can then be statistically analysed as single entities or in different anatomical segments to characterise and model body shape.

The third stage of 3D body scan processing involves statistical analysis or modelling of the 3D data to characterise variation in body size and shape (Hirshberg et al., 2012). Principal component analysis (PCA) has generally been used to identify the main components of shape variation across scans and represent the shape change components visually (Wells, Ruto, & Treleaven, 2008). PCA is a method of data compression using the X, Y, and Z coordinates of the vertices of each high-density body mesh. The standard method of PCA involves forming a shape vector for each individual scan, computing a mean vector and covariance matrix, and then using the absolute values of the eigenvalues from the covariance matrix to define the significance of each principal component (Shu et al., 2009). These principal components represent the main ways in which the 3D bodies vary in shape and each component can be visualised separately to gain a greater understanding of how they relate to shape change (Azouz et al., 2006). The components are ordered from the highest to lowest proportion of total shape variation that they explain across the scans. There are issues with using PCA as an approach to characterising body shape variation, in that minor disparities in body position and pose, such as arm positioning and height, can impact on the results (Allen et al., 2003). In addition, PCA requires registration of all body scans to be in correspondence with each other, which can be a lengthy and varied process depending on the level of similarity between scans (Azouz et al., 2006). However, this approach provides valuable data for characterising body shape variation, developing improved methods of processing 3D anthropometric data, and assessing a range of body image components relating to perceptions of shape and weight.

1.5 Thesis Rationale

Given the critical limitations in existing measures of male perceptual body image discussed previously, there is a necessity to develop and evaluate novel measures to assess men’s current and ideal body size and shape perceptions that overcome these limitations, and are appropriate and specific to the general male population. In particular, there is a clear need for measures that are precisely calibrated for dimensions of male body variation, use high-quality imagery, present a wide range in body size and shape, and allow for estimations of male-specific body perceptions.

1.6 Thesis Research Aims

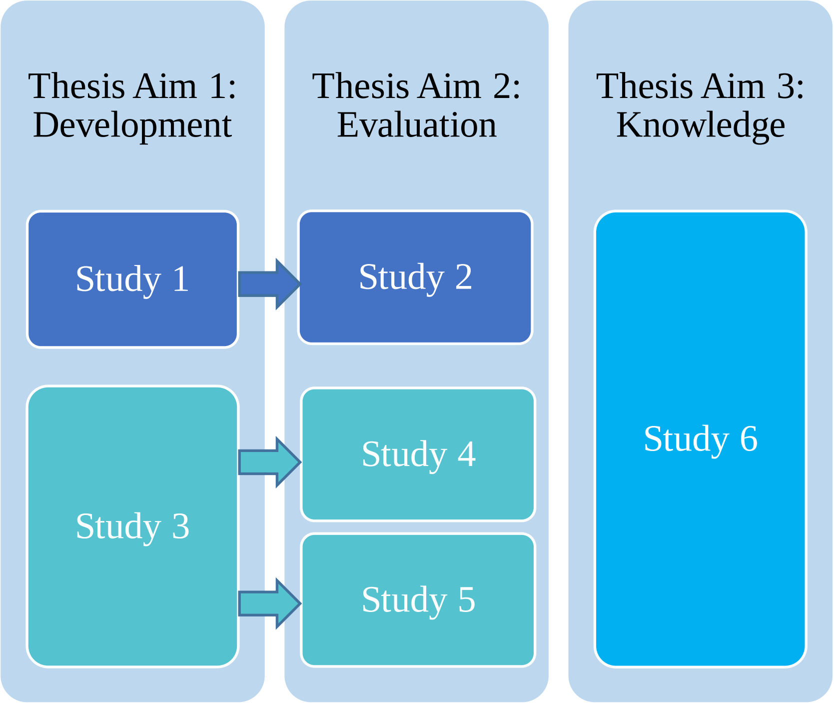
The overarching research aims of this thesis are to:

1. Develop new measures of perceptual body image that overcome many of the current limitations of existing male stimuli and scales.
2. Evaluate the reliability, validity and suitability of these new measures in estimating current and ideal body perceptions among community male samples.
3. Improve our understanding of the methodological and individual factors that influence visual male body size and weight judgements.

These main research aims are addressed in the 6 studies presented in this thesis (Figure 1.3).

Figure 1.3

Visual Mapping of Research Studies to Overarching Thesis Aims



The specific research aims of each individual study are set out below:

Study 1 (Chapter 3):

- To investigate men's ability to discriminate differences in body size between pairs of computer-generated male figures, in order to determine whether men's visual perceptions of male body size are consistent with Weber's law.
- To develop JND-based male body scales that present perceptually appropriate variation in BMI between figures, based on the accuracy of perceptual body size judgements.

Study 2 (Chapter 3):

- To pilot test the reliability and validity of the new JND-based male figure scales (developed in Study 1) in assessing estimations of perceived current and ideal body size among a general sample of adult men.

Study 3 (Chapter 4):

- To develop new 3D computer-generated male body stimuli with a calibrated mapping between fat mass, skeletal muscle mass and 3D body shape.

Study 4 (Chapter 5):

- To evaluate whether independent alterations in the fat and muscle dimensions of the new interactive male body scale (developed in Study 3) result in visually-perceptible changes in body size and shape in adult men.

Study 5 (Chapter 5):

- To pilot test the reliability and validity of the new interactive 3D male body fat and muscle scale (developed in Study 3) in assessing estimations of current and ideal body perceptions among a general sample of adult men.

Study 6 (Chapter 6):

- To evaluate the view-dependent accuracy of men's and women's categorical body weight judgements and weight-loss beliefs using stimuli derived from 3D male body scans.

Chapter 2: Methodology

This chapter describes and summarises the equipment, software and measures used in the research studies within this thesis. It includes descriptions of the Daz Studio software and 3dMD body scanner, and how they have been used in this thesis to develop research stimuli. It also summarises each of the psychometric questionnaires administered in the research studies presented. Finally, this chapter describes approaches and procedures used for the bio-impedance analysis, body girth measurements, and calculation of BMI in both real and computer-generated bodies.

2.1 Daz Studio

Daz Studio is a 3D computer modelling package, developed by Daz Productions Inc. (Utah, USA), that can be used to create, render and export 3D objects and animations. This free 3D software delivers a wide range of options for designing and manipulating 3D male and female body models, with numerous possibilities for the model's appearance, body size and shape, clothing, positioning and environment. The program provides approximately 320 body size and shape morphs from the neck down, of which 16 alter aspects of the whole body, such as 'body tone', and the remaining manipulate specific body areas, such as 'shoulder width'. Figure 2.1 provides an example of the software interface, with a 'Genesis 8' male avatar and selection of the body morphs shown.

Figure 2.1

Daz Studio Interface with Genesis 8 Male Avatar

2.1.1 Development of CGI Stimuli

Daz Studio 4.10 software was used in Study 1 (Chapter 3, Section 3.3.2.1) of this thesis to develop a set of computer-generated stimuli. Initially, a standard body was created in the 'Z-studio' environment using a 'Genesis 8 male' base model and 'Edward' character features. The following character specifications were selected, as they were perceived to make the model look most realistic: Edward eyes 02, Edward face 50%, G&M classic side part hair, skin translucency low, and freckles4 body. The intimate boxers (colour 33) were also chosen, as this attire is form-fitting and presentable, without covering important visual information relating to body size and shape, and the hands were adjusted (pose 18 – 50%) to create a relaxed grip position. The size and shape of the standard body was then adjusted using the 'Measure Metrics' tool in Daz Studio to match the model to average measurements recorded in the Health Survey for England (HSE) 2008 dataset. The HSE 2008 recorded individuals' mean hip (cm), waist (cm), height (cm), and weight (kg) measurements, as well as their age and sex. These measurements were then used to calculate their BMI and waist-to-hip ratio (WHR). An average height of 178.12 cm (N = 797) and WHR of 0.85 (N = 533) were found for Caucasian men aged 18 to 45 (*M* = 30.57 years), with a BMI within the normal weight classification. The standard model was altered to match these average height and WHR measurements. Lastly, the standard body was positioned at a three-quarter angle from the user's view, as previous research has evidenced this to be the optimal orientation for differentiating male body size and weight (Cornelissen et al., 2018; D'Amour & Harris, 2019).

After finalising the standard male body, an animation was created in Daz Studio to develop a sequence of bodies across the BMI spectrum. This involved generating many frames and identifying key frames along the range to alter the model's adiposity and weight, using the 'emaciated', 'thin' and 'heavy' morphs in the software. Each body shape morph ranges in a scale from 0-1 and uses a slider to adjust the model's body size and shape, according to the position chosen along this continuum. A total of 310 frames were chosen for the full animation, based on methods used in previous research (Cornelissen et al., 2016), and changes in adiposity and weight were applied at specific key frames (see Table 2.1).

Table 2.1

Position of the Body Shape Morphs at Each Key Frame in the Animation

	Weight Morph			
Frame Number	Emaciated	Thin	Heavy	Fitness
0	1	1	0	0.5
80	0	1	0	0.5
150	0	0	0	0.5
310	0	0	1	0.5

The specific locations of these key frames were chosen to allow for a larger number of bodies between the third and fourth key frames than between the first and second, or second and third. This replicated methods used in previous research, in which changes in the BMI of the CGI models were found to be approximately double the size between frames at the upper end of the BMI range, than between the other key frames (Cornelissen et al., 2016). This meant that around twice the number of frames were required at the higher end of the BMI spectrum to allow for more regular increments in BMI across the range. Therefore, the key frames were selected to be frames 0, 80, 150 and 310 in the animation, where frame 150 was the original standard body. Figure 2.2 presents the computer-generated models at all four key frames to give a visual example of the changes in weight and adiposity.

Informal feedback on the visual appearance of the figures at these key frames was obtained from 5 graduate students at the School of Psychology. Each student was presented with all 4 images on a computer screen. They were then asked to comment on the appearance of each figure and provide any suggestions on how they could be modified to improve their realism. The only common suggestion among the students was that a low-to-medium level of muscularity should be portrayed in the male bodies at all sizes. Therefore, an additional ‘fitness’ morph was set to 0.5 (50%) across the full animation (see Table 2.1), to address the students’ feedback and account for the sexual dimorphism of body composition between males and females (Geer & Shen, 2009; Wells, 2007). Additional suggestions from some of the students included increasing the size of the arms of the male figure at key frame 310, and reducing the level of emaciation of the figure at key frame 0. However, each of these alterations were only proposed by one of the students, and therefore, no changes were made to these figures.

Figure 2.2

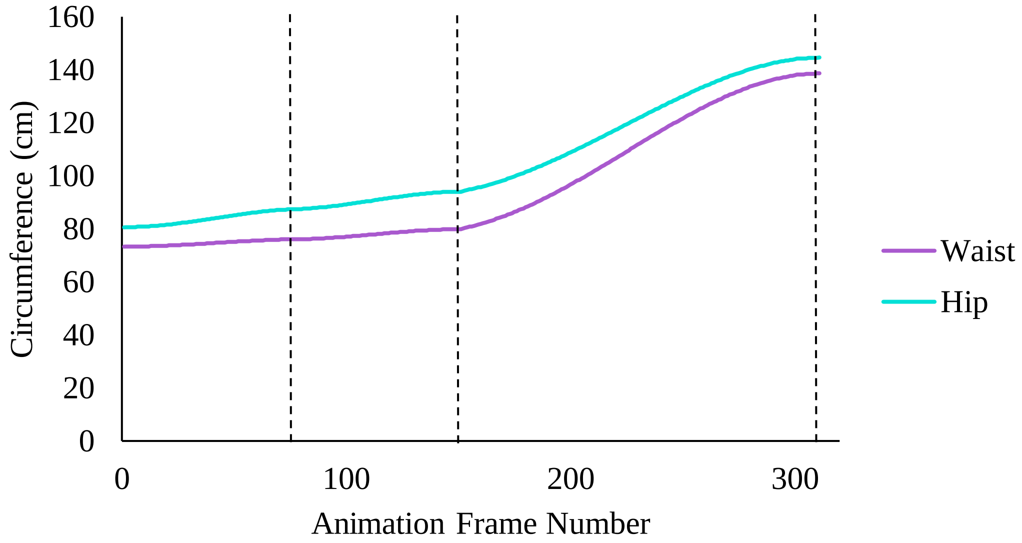
Male Figure for Each Key Frame in the 310-Frame Animation

Frame	Figure	Frame	Figure
0		80	
150		310	

Once the appearance of the models at the key frames was finalised, the BMI of the CGI model at every frame was calculated. To calculate the BMI of the models, waist and hip measurements were recorded for every 10th frame across the 310-frame sequence using the ‘Measure Metrics’ tool in Daz Studio. BMI was calculated for each model using a calibration equation described later in this chapter, with calculations based on an average age of 30.57 years and height of 178.12 cm, as determined by the HSE 2008 dataset. Linear increases in hip and waist measurements were assumed for the frames in between every 10th frame. RStudio software (https://www.rstudio.com/) was used to interpolate these measurements and record the predicted waist and hip circumferences for every frame, which were then used to estimate the BMI for each model. Figure 2.3 displays the measured and interpolated waist and hip circumferences for each frame.

Figure 2.3

Plot of Model Waist and Hip Circumferences for Each Animation Frame



Note. The vertical dotted lines indicate the locations of each key frame in the 310-frame animation.

The full sequence of 310 frames presented bodies ranging in BMI from 16.5 to 45 kg/m^2. A subset of the frames, identified as those closest in BMI to each increment of 0.25 kg/m^2 across the range, were then selected. This resulted in a total of 115 frames, with the difference in the intended BMI to its actual estimated BMI varying by ± 0.1 kg/m^2. These frames were then rendered as high-definition images in Daz Studio: 880 x 1120 pixels with a 11:14 aspect ratio. This method led to the development of a set of high-definition, realistic, male body images varying in BMI from 16.5 to 45 kg/m^2. All other features of the male bodies, including their hair, skin, skeletal proportions, posture and positioning, were standardised throughout the images, therefore maintaining a single ‘identity’ across the BMI range.

2.2 3dMD Body Scanner

A 3dMD anthropometric surface imaging system has been used in Study 3 (Chapter 4, Section 4.3.2) of this thesis to accurately capture variation in 3D male body size and shape. This full-body scanner contained nine modular camera units (MCU), with each MCU consisting of two monochromatic cameras, a speckle projector, and a colour camera. The speckle projectors displayed a standardised pattern of light onto each individual body and the monochromatic cameras captured images at a rate of 7 frames per second, allowing for 360° body geometry and texture to be recorded. Output from the 3dMD system following each body scan included a full-body polygon surface mesh with X, Y, and Z coordinates, as well as a mapped surface texture. The manufacturer's specifications for this 3dMD system report a geometry accuracy of approximately 0.5 millimetres (http://3dmd.com/dev/3dmd-systems/3d-systems/3dmdbody-system/). Figure 2.4 presents a 360° photograph of the 3dMD anthropometric surface imaging system used in this thesis.

Figure 2.4

360° Photograph of the 3dMD Anthropometric Surface Imaging System

2.2.1 Body Scanning

The 3dMD body scanner was used in Study 3 (Chapter 4, Section 4.3.2) of this thesis to obtain a database of 176 male body scans. Participants were asked to change into a pair of pale grey 'jersey trunks' provided by the researcher for body scanning. They were given the opportunity to select a garment from a range of underwear sizes (XS-XXL) and were asked to check that the garment was not too tight or loose fitting, which would alter their body shape. Participants were also specifically requested not to wear anything underneath the garment, in order to prevent any alterations in body size or shape from additional clothing. If concerns around hygiene were expressed, participants were given disposable underwear, similar to those used for spray tans, to wear underneath the scanning garment. Participants were then shown to a private changing room where dressing gowns of different sizes were provided for additional coverage and comfort prior to scanning.

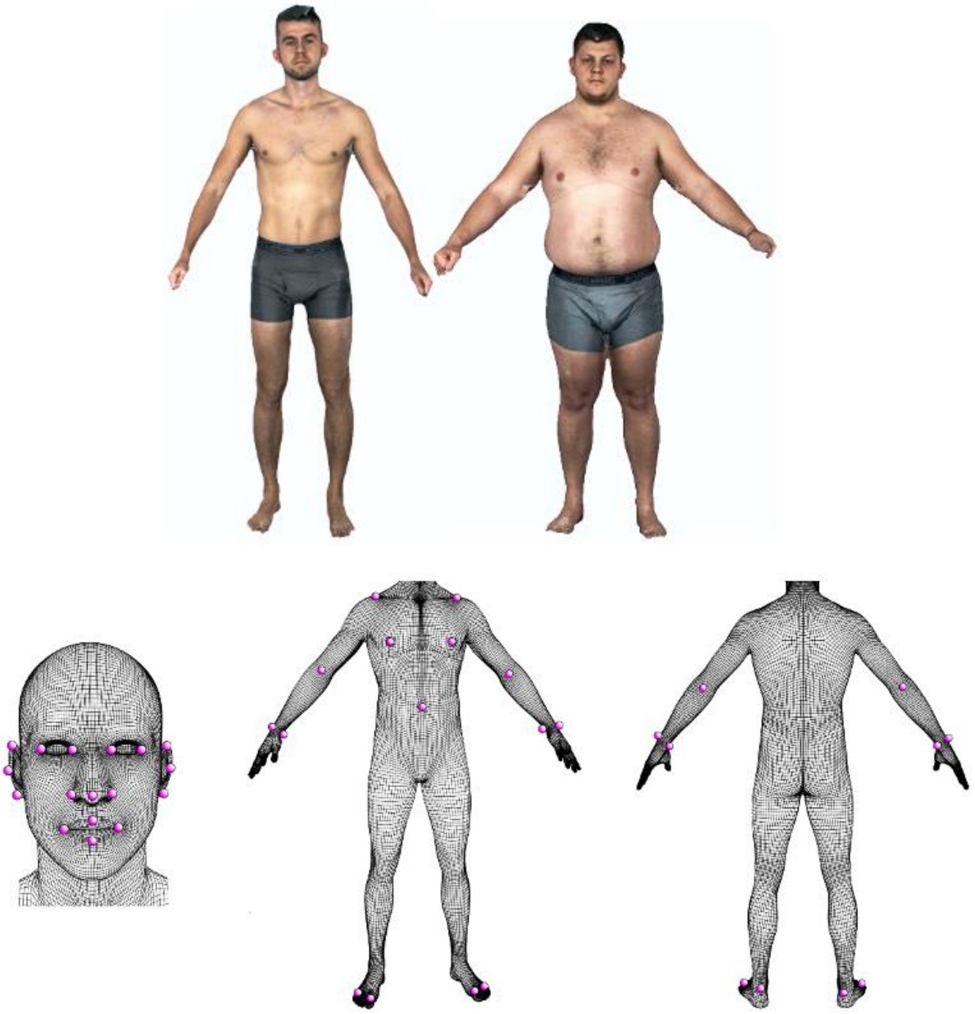
In order to obtain the body scans, participants were required to stand in the centre of the body scanner for 20 seconds, with their legs approximately shoulder-width apart and their arms raised from their sides, with fingers closed in a gripped position. Participants were asked to slowly raise and lower their arms by their sides during this timeframe. The researcher then generated a scan by selecting a frame with the participant in a suitable 'A-pose' from the short-animated video produced in the 3dMD software. This output included a 360° surface mesh with a mapped texture and X, Y, and Z coordinates. Participants were shown their scan once it formed on the master PC display, and could then move their 3D avatar around in the software to see it from all angles if they chose. Participants were also given the option to take photographs and videos of their 3D body scan on their personal phone to take home with them.

2.2.2 Scan Processing and Registration

The 3D body scans obtained using the 3dMD scanner were initially edited and processed using Wrap3 software (Wrap 3.3.17, Russian3DScanner, 2018) to remove any non-manifold topology or small irrelevant components from each scan and repair any segments lost. A template body mesh was then wrapped around each individual scan by matching 36 pre-selected landmarks on corresponding features of both models, such as the elbows and tip of the nose (see Figure 2.5). This allowed all the scans to have a standardised topology, with the same number of coordinates, whilst maintaining individual variations in body size and shape. Polygon selection was applied to exclude the individual's hands from wrapping, as this feature was not relevant to the data analysis in this thesis. This resulted in each scan being composed of 79,522 vertices in total.

Figure 2.5

Examples of Two 3D Body Scans (Top) and the Landmarked Template Body Mesh (Bottom)



2.2.3 Development of Research Stimuli

The processed 3D body scans were used as the basis of visual stimuli in a number of studies within this thesis. In Study 3 (Chapter 4, Section 4.4.3), the 3D body scans were analysed using PCA to develop a calibrated mapping between human body shape, adiposity, and muscularity. This led to the development of an interactive 3D male body scale that was then used to assess men's current and ideal body perceptions in Study 5 (Chapter 5, Section 5.7.2.1). This interactive body scale was also used to generate a set of 2D visual stimuli in Study 4 (Chapter 5, Section 5.3.2) to evaluate the face validity of the two body composition dimensions of the scale. In Study 6 (Chapter 6, Section 6.3.2.1), the processed 3D body scans were also used to develop a set of visual body stimuli presented from different viewpoints to investigate the view-dependent accuracy of men's and women's categorical male body weight perceptions. The following section will describe the development of the series of 2D visual stimuli used in Study 4 (Chapter 5, Section 5.3.2) and Study 6 (Chapter 6, Section 6.3.2.1).

2.2.3.1 Study 4 (Chapter 5)

A set of 2D stimuli were generated in Study 4 (Chapter 5, Section 5.3.2) from the interactive male body scale to evaluate whether independent alterations in the fat and muscle dimensions of the scale result in visually perceptible changes in body size and shape. To develop these 2D images, five equally spaced points along the muscle mass dimension of the scale and ten equal steps along the fat mass dimension were selected. The different number of points for each dimension were chosen based on the total range of fat mass (range = 43.5 kg) and muscle mass (range = 33.2 kg) in the scale, and a visual assessment of the relative change in body size and shape of the predicted model based on each of the dimensions. The relative ranges of fat mass and muscle mass were dependent on those found in the database of 176 body scans in Study 3 (Chapter 4, Section 4.4.2), as this was assumed to approximately map onto ranges found in the Lincoln male population. The fat mass dimension ranged from 2.5-46 kg; therefore, the ten equally distanced points were taken in steps of 4.83 kg along the range. The muscle mass dimension ranged from 28.4-61.6 kg, leading to five equally distanced points separated by 8.3 kg. Therefore, the muscle mass points were 28.4, 36.7, 45.0, 53.3 and 61.6 kg, whereas the fat mass points were 2.5, 7.3, 12.2, 17.0, 21.8, 26.7, 31.5, 36.3, 41.1 and 46.0 kg, with all points rounded to the nearest 0.1 kg. Images of the predicted male body in the scale were taken at each level of fat and muscle mass, resulting in 50 different combinations of fat and muscle mass in total. These images were achieved using an image generator built into the interactive tool in MATLAB (2018), with each body shown at three orientations; a front, side, and three-quarter view, and were displayed as 930 x 290 pixel images within an online survey.

2.2.3.2 Study 6 (Chapter 6)

The 3D male body scans were used to create the visual body stimuli in Study 6 (Chapter 6, Section 6.3.2.1), in which a selection of body scans from the underweight, normal weight, overweight and obese BMI categories were presented to investigate the view-dependent accuracy of men’s and women’s categorical male body weight perceptions. The individuals selected for the male stimuli had a mean age of 23.50 years (*SD* = 3.84) and ranged from 19 to 33 years old across the sample. They had a mean BMI of 25.23 kg/m^2 (*SD* = 5.86), varying from 16.19 to 36.02 kg/m^2. Given that height is a contributing factor to calculations of individual BMI, the height range across scans was restricted as much as possible and varied from 170 to 184 cm (*M* = 177.12, *SD* = 3.76). Previous research has shown that muscularity is likely to influence visual perceptions of body weight and health (Oldham & Robinson, 2016). Therefore, muscularity was evaluated based on the scans' associated measurements of skeletal muscle mass obtained from the database in Study 3 (Chapter 4, Section 4.4.2). Again, the range of skeletal muscle mass was constrained and varied from 29.3 to 45.6 kg (*M* = 37.43, *SD* = 5.38) across the scans.

To generate 2D stimuli from the 3D scans, a set of eight screenshots were taken of each scan positioned at every 45° angle using Autodesk Maya software (Autodesk, 2019). The heads on the scans were disguised with a 3D white cube and the texture of each individual scan was replaced with a realistic 'skin' to remove any identifiable information and standardise the skin tone across scans. Applying a standardised realistic texture was a beneficial way of ensuring that the stimuli had a realistic appearance but did not resemble any specific individual. It also meant that the skin was constant across all stimuli and did not impact on the participants' judgements. The scans were placed in an environment with a grey background and floor, to allow for shadows of the bodies to be visible across the screenshots, based on specified lighting in the virtual environment.

Participants were shown these images in two different presentation formats: 2-orientations and 8-orientations. For stimuli presented in 2-orientations, the images displayed bodies positioned in a front and side-view (see Figure 2.6), while the 8-orientations showed bodies at every 45° angle around the body (see Figure 2.7). In an online survey, the series of 8-orientations were displayed in two rows of 4-images, with the positioning of the body mirrored between the two rows. For example, the first image from the left-side of the screen on the top row presented a forward-facing body, while the corresponding image on the bottom row presented a backward-facing body. Presenting the images in two rows maximised the size of the images when displayed on a laptop or computer screen, without requiring participants to scroll up-down to view all the images simultaneously. The 2-orientation stimuli and each row of 4-images in the 8-orientation stimuli were displayed as 2800×1080 pixel images.

Figure 2.6

Example of a Normal Weight Male Stimulus Presented in 2-Orientations

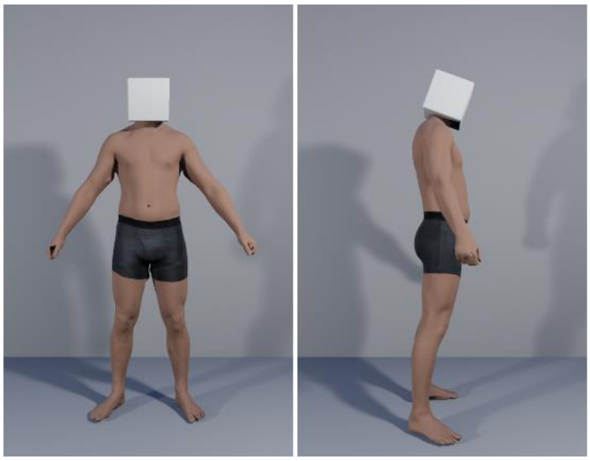
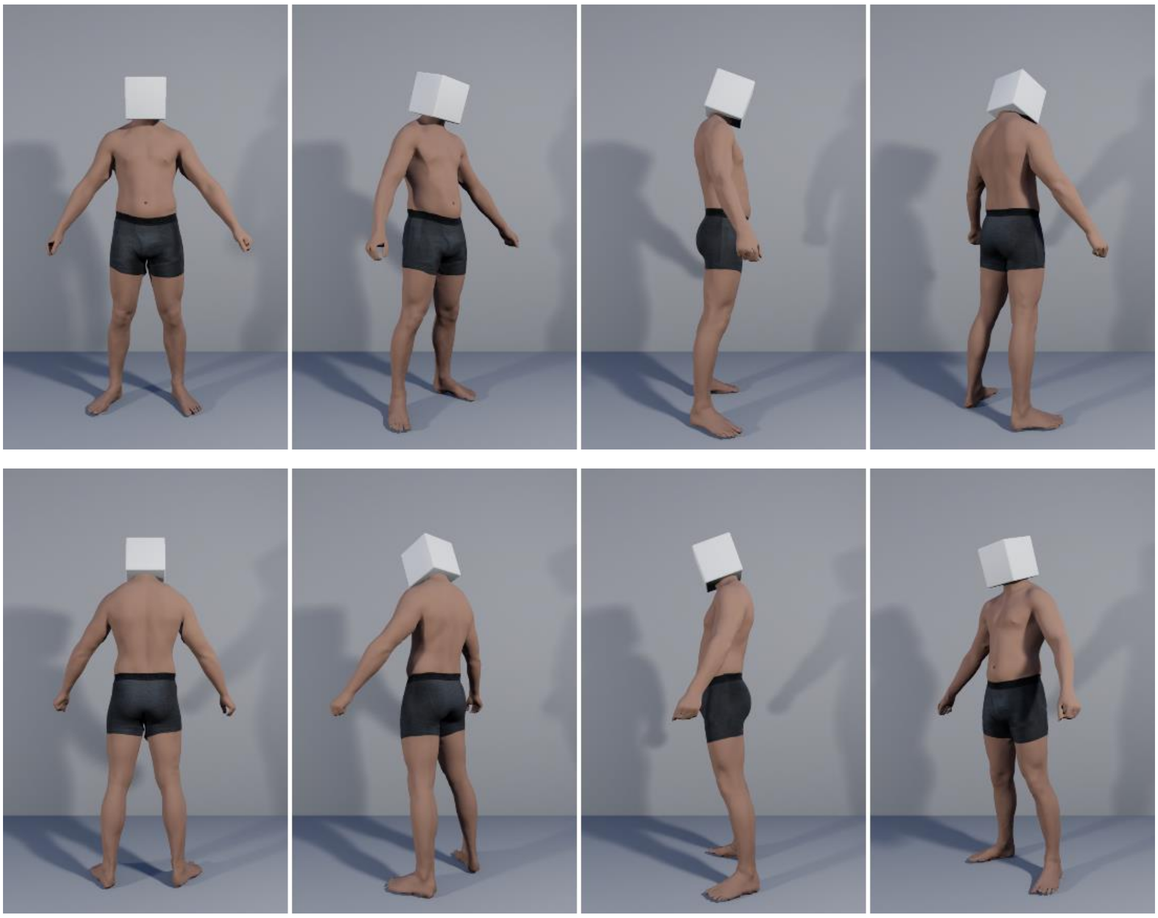


Figure 2.7

Example of a Normal Weight Male Stimulus Presented in 8-Orientations



2.3 Bio-Impedance Analysis

Bioelectrical impedance analysis (BIA) has been used in Study 3 (Chapter 4, Section 4.3.2) and Study 5 (Chapter 5, Section 5.7.3) to obtain participant body fat mass and muscle mass measurements. BIA is a commonly used method of estimating an individual's body composition that measures the resistance, or impedance, of the body to a small electric current as it travels through water (Cornish, 2006). It is an efficient, simple to use, and relatively cost-effective method that is suitable for large scale studies (Lee & Gallagher, 2008). One disadvantage of BIA is that it is not a safe technique for individuals with pacemakers, or other implanted electrical devices, given its use of an electrical current. Therefore, this was stated within the information sheets of all relevant studies described in this thesis.

Previous research has provided evidence that BIA has good agreement in measurements of total body muscle mass, fat mass and fat percentage compared to the gold standard technique of body composition estimation, dual energy X-ray absorptiometry (DEXA) (Ling et al., 2011; Sun et al., 2005; Wattanapenpaiboon et al., 1998), and skinfold calliper measurements (Kitano et al., 2001). However, there is some evidence to suggest that BIA is most accurate in individuals within a normal adiposity range, with BIA overestimating the total body fat percentage of individuals with low fat levels and underestimating the body fat percentage of obese individuals (Sun et al., 2005). The agreement between BIA and DEXA, or skinfold measurements, in estimating body fat percentage has been shown to vary depending on the particular prediction equations used in the BIA (Aandstad et al., 2014; Wattanapenpaiboon et al., 1998). BIA has also demonstrated good test-retest reliability over periods of up to a week (Aandstad et al., 2014; Jackson et al., 1988). In general, the reliability and validity of BIA as a method of body composition estimation has presented mixed findings, which is likely a consequence of different prediction equations, comparison techniques and study populations being used (Fogelholm & van Marken Lichtenbelt, 1997). The validity of participant body fat measurements from the BIA scale used in this thesis is assessed in Study 3 (Chapter 4, Section 4.4.2.2) through comparisons with estimations derived from skinfold calliper measurements in a sample of 26 adult men.

2.4 Tanita Bio-Impedance Scale

A Tanita MC-780MA Multi-Frequency Segmental Body Composition Analyser has been used in Studies 1 and 2 (Chapter 3, Sections 3.3.3 and 3.7.3), Study 3 (Chapter 4, Section 4.3.2) and Study 5 (Chapter 5, Section 5.7.3) to obtain participant body composition and weight measurements (Figure 2.8). This eight-electrode bio-impedance scale uses a small, undetectable high frequency electrical current (50kHz, 90µa) to estimate the following; weight (kg), BMI (kg/m^2), body fat (kg and %), muscle mass (kg), skeletal muscle (kg and %), bone mass (kg), fat free mass (kg), total body water (kg and %), intra-cellular and extra-cellular water (kg). Body fat, muscle mass and fat free mass are estimated for the total body and individual segments of the body, including the central trunk, right arm, right leg, left arm and left leg. These body composition estimates are calculated using prediction equations that include an individual's sex, age and height (cm), which are inputted for each participant prior to measurement.

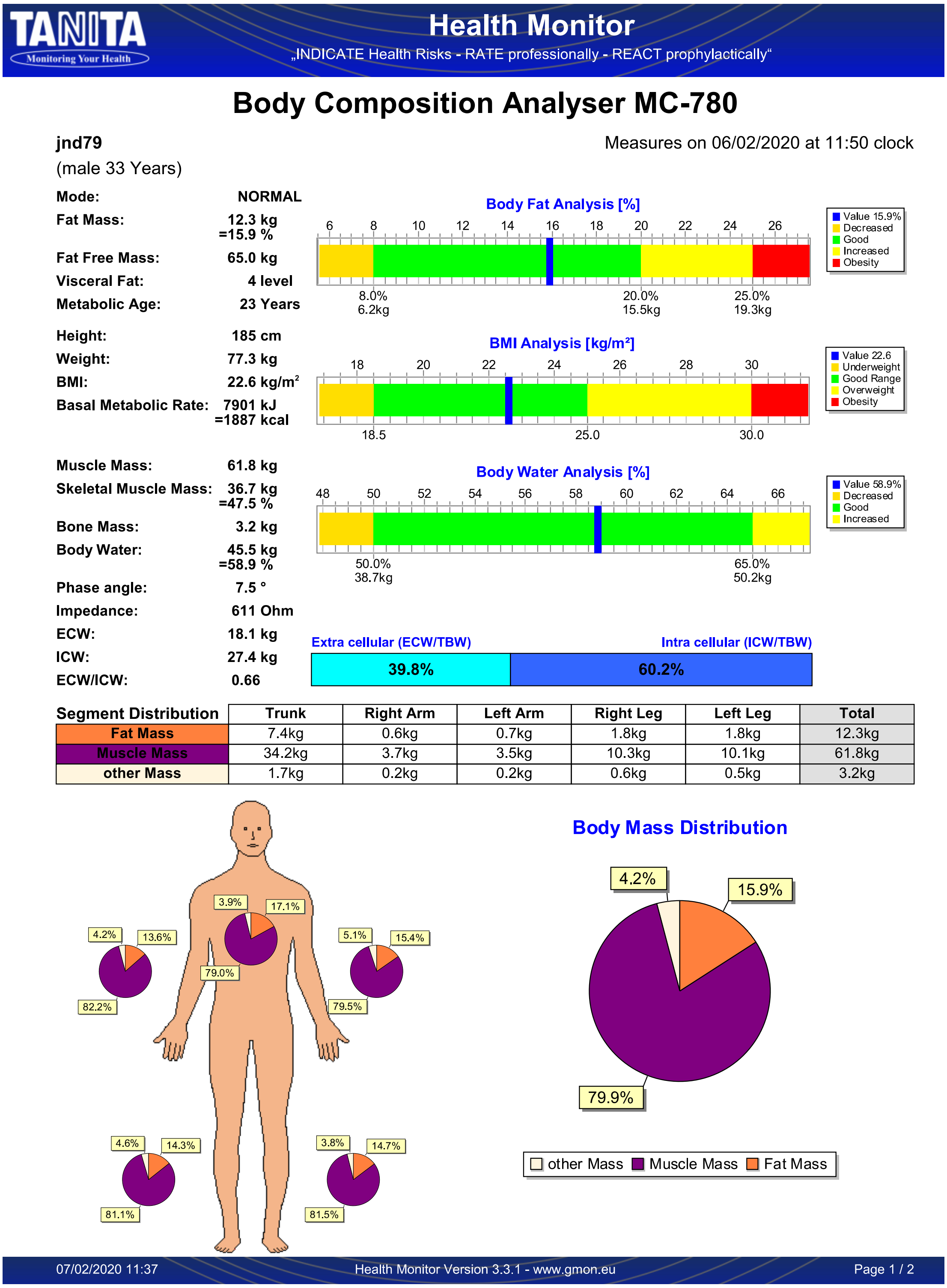
When using the bio-impedance scale in the relevant studies in this thesis, participants were asked to remove any bulky clothing, or wear the provided research garment, and stand bare foot on the electrode platform. Individual data were then inputted into the scale, including the participant's date of birth, gender, and height (cm). They were then instructed to hold the hand electrodes with their arms straight down by their sides, once their body weight (kg) had been measured. Participants were asked to ensure that their arms were not touching their sides and their inner thighs were separated, in order to obtain a more accurate measurement. The BIA results were then stored directly in the Tanita software on a computer connected to the bio-impedance scale. Participants were then provided with a printed report of their personal body composition measurements to take away with them, if desired (see Figure 2.9).

Figure 2.8

Photograph of the Tanita MC-780MA Multi-Frequency Segmental Body Composition Analyser

Figure 2.9

Example of a Tanita Body Composition Report



TANITA Monitoring Your Health

Health Monitor

„INDICATE Health Risks - RATE professionally - REACT prophylactically"

Body Composition Analyser MC-780

jnd79

(male 33 Years)

Measures on 06/02/2020 at 11:50 clock

Mode: NORMAL
Fat Mass: 12.3 kg =15.9 %
Fat Free Mass: 65.0 kg
Visceral Fat: 4 level
Metabolic Age: 23 Years

Height: 185 cm
Weight: 77.3 kg
BMI: 22.6 kg/m²
Basal Metabolic Rate: 7901 kJ =1887 kcal

Muscle Mass: 61.8 kg
Skeletal Muscle Mass: 36.7 kg =47.5 %
Bone Mass: 3.2 kg
Body Water: 45.5 kg =58.9 %

Phase angle: 7.5 °
Impedance: 611 Ohm
ECW: 18.1 kg
ICW: 27.4 kg
ECW/ICW: 0.66

Segment Distribution	Trunk	Right Arm	Left Arm	Right Leg	Left Leg	Total
Fat Mass	7.4kg	0.6kg	0.7kg	1.8kg	1.8kg	12.3kg
Muscle Mass	34.2kg	3.7kg	3.5kg	10.3kg	10.1kg	61.8kg
other Mass	1.7kg	0.2kg	0.2kg	0.6kg	0.5kg	3.2kg

07/02/2020 11:37 Health Monitor Version 3.3.1 - www.gmon.eu Page 1 / 2

Note. This figure presents an example of the BIA report derived from the Tanita scale that was provided to participants, which included estimates of fat mass, fat free mass, visceral fat, metabolic age, height, weight, BMI, basal metabolic rate, muscle mass, skeletal muscle mass, bone mass and body water.

2.5 Psychometric Measures of Male Body Image

The following self-report questionnaires have been used in studies within this thesis to assess attitudinal and behavioural factors relating to body image, including; body shape concerns, eating habits, depression, self-esteem, body attitudes, drive for muscularity, internalisation of sociocultural body ideals, perceived sociocultural pressures and weight bias. The questionnaires were presented to participants on a computer screen using an online Qualtrics survey in each of the relevant studies in this thesis. A copy of each of the questionnaires is included in Appendix A.

2.5.1 Anti-Fat Attitudes Questionnaire

The Anti-Fat Attitudes Questionnaire (AFA; Crandall, 1994) has been used in Study 6 (Chapter 6, Section 6.3.2.2) to measure individual levels of internalised weight bias and anti-fat attitudes. The scale consists of 13 items that are rated on a 10-point response scale (0 = ‘very strongly disagree’, 9 = ‘very strongly agree’). It comprises 3 subscales; a Dislike subscale, measuring people’s aversion towards overweight and obese individuals, a Fear of Fat subscale, assessing personal concerns about their own current level of fat or weight, and a Willpower subscale, evaluating people’s principles concerning the controllability of body weight. The 7 items of the Dislike subscale, 3 items of the Fear of Fat subscale and 2 items of the Willpower subscales are averaged to calculate individual subscale scores, with higher scores representing greater endorsement of that aspect of anti-fat bias. A systematic review of weight bias questionnaires has supported the content validity, structural validity, convergent validity, discriminant validity, and internal consistency reliability of the AFA (Lacroix et al., 2017). Previous research has demonstrated Cronbach’s alphas above .80 for the AFA and each of its subscales in male and female samples (O’Brien et al., 2007, 2008; Pepper & Ruiz, 2007).

2.5.2 Beck Depression Inventory

The Beck Depression Inventory (BDI; Beck et al., 1961) is a 21-item self-report measure of characteristic symptoms of depression, such as guilt, sense of failure, punishment, suicidal ideation, and social withdrawal. Each item of the BDI presents four statements scored from 0 (indicating no change in the specific behaviour) to 3 (indicating increased behaviour severity) that are summed to reveal a total score for depression. Total scores range from 0 to 63 and are categorised according to the following cut-off points: ‘normal ups and downs’ (1-10), ‘mild mood disturbance’ (11-16), ‘borderline clinical depression’ (17-20), ‘moderate depression’ (21-30), ‘severe depression’ (31-40), and ‘extreme depression’ (>40). The BDI has been used in Studies 1 and 2 (Chapter 3, Sections 3.3.2.2 and 3.7.2.2), Study 5 (Chapter 5, Section 5.7.2.2), and Study 6 (Chapter 6, Section 6.3.2.2) of this thesis to characterise individual levels of depression based on these categories. The BDI has demonstrated high internal consistency for both clinical and non-clinical populations, with previous research finding Cronbach's alphas of .85, .88 and .91 (Ambrosini et al., 1991; Beck & Steer, 1984; Reynolds & Gould, 1981). It has also shown high content validity and the ability to differentiate between individuals with and without depression (Ambrosini et al., 1991; Beck et al., 1988; Richter et al., 1998).

2.5.3 Body Appreciation Scale -2

The Body Appreciation Scale (BAS; Avalos et al., 2005) was developed to assess various evidence-based characteristics of positive body image, including favourable opinions of one's body, body acceptance, respect for one's body and protection of one's body. All 13 questionnaire items are rated on a 5-point response scale (1 = 'never', 5 = 'always') and an average score is calculated, with higher scores representing a greater overall body appreciation. The BAS has revealed correlations between body appreciation and various constructs, including body esteem, optimism, self-compassion, positive affect and positive appearance evaluations (Avalos et al., 2005; Van Diest & Tylka, 2010; Swami, Stieger, et al., 2008; Wasylkiw et al., 2012). It has also demonstrated construct validity and good internal consistency, with Cronbach's alphas above .90 in previous research (Avalos et al., 2005; Swami, Stieger, et al., 2008; Tiggemann & McCourt, 2013; Wasylkiw et al., 2012).

The Body Appreciation Scale – 2 (BAS-2; Tylka & Wood-Barcalow, 2015) was later developed to overcome several limitations of the original BAS, brought to light from the literature, including the gender-specific wording of item 12 stating "I do not allow unrealistically thin images of women presented in the media to affect my attitudes toward my body", low factor loadings of specific items and the wording of items according to prior assumptions around positive body image. The BAS-2 has been administered in Study 5 (Chapter 5, Section 5.7.2.2) as a measure of general body appreciation. This modified scale consists of 10 items, 5 from the original BAS and 5 developed as additional items, with the same 5-point scoring system. A systematic review of 23 studies that evaluated properties of the BAS-2 revealed moderate to strong evidence for the internal consistency, structural validity, and test-retest reliability of the scale (Kling et al., 2019). Strong evidence was also found for the discriminant and convergent validity of the BAS-2, with significant associations between the scale and related attitudinal measures, such as self-esteem. Previous research has also demonstrated Cronbach’s alphas of .94 for women and .93 for men (Tylka & Wood-Barcalow, 2015).

2.5.4 Body Shape Questionnaire

The Body Shape Questionnaire (BSQ; Cooper et al., 1987) is a measure of body dissatisfaction and body shape preoccupations that asks individuals to report how they have felt about their appearance over the past four weeks. The original questionnaire was developed through interviews with a variety of female clinical groups, including those with Anorexia Nervosa (AN) and Bulimia Nervosa (BN). The BSQ consists of 34 items scored using a 6-point response scale (1 = ‘never’, 6 = ‘always’), with a total body dissatisfaction score calculated by summing scores across all scale items. Several shorter forms of the BSQ have since been developed, including two 16-item versions and four 8-item versions.

The second 16-item version, known as the BSQ-16b (Evans & Dolan, 1993), has been used in Studies 1 and 2 (Chapter 3, Sections 3.3.2.2 and 3.7.2.2), Study 5 (Chapter 5, Section 5.7.2.2), and Study 6 (Chapter 6, Section 6.3.2.2) to measure general concerns around body shape, and was scored in the same way as the original BSQ. It has been adapted for use with male participants in this thesis by re-wording the fourth item, “Have you noticed the shape of other women and felt that your own shape compared favourably?” from ‘women’ to ‘men’ when participants self-reported as being male. Total scores for the BSQ-16b range from 16-96, and are commonly categorised according to the following cut-off points: ‘no concern’ (<38), ‘mild concern’ (38-51), ‘moderate concern’ (52-66) and ‘marked concern’ (>66). Both the original BSQ and BSQ-16b have demonstrated good convergent validity and structural validity (Evans & Dolan, 1993; Pook et al., 2008; Rosen et al., 1996), as well as the ability to differentiate between individuals with high body concerns and those without (Probst et al., 2008). The scales have also shown good internal consistency, with Cronbach’s alphas above .70 in previous research (Kling et al., 2019).

2.5.5 Drive for Muscularity Scale

The Drive for Muscularity Scale (DMS; McCreary & Sasse, 2000) has been used in Study 5 (Chapter 5, Section 5.7.2.2) to assess people’s motivations and preoccupations with increasing their muscularity levels, as well as their engagement in relevant behaviours. The questionnaire consists of 15 items rated on a 6-point response scale (1 = ‘never’, 6 = ‘always’) and an average score is calculated across all items. The questionnaire has two distinct subscales; the Muscularity Behaviours subscale (MB) and the Muscularity-oriented Body

Image subscale (MBI), that have both demonstrated validity in male samples (Kling et al., 2019; McCreary et al., 2004). The MB subscale consists of 8 items assessing an individual's engagement in behaviours that can lead to increased muscle mass, such as the consumption of protein shakes and a high-calorie diet. The MBI subscale comprises 7 items that measure an individual's satisfaction with their body shape and desire to increase their own muscle mass. The concurrent, construct, convergent and discriminant validity of the DMS, and internal consistency of both subscales, have been supported in previous research (Chittester & Hausenblas, 2009; Kling et al., 2019; McCreary & Sasse, 2000; McCreary, 2007). Previous research has also demonstrated Cronbach's alphas of .88 for the DMS, and .90 and .86 for the MBI and MB subscales in men (Bergeron & Tylka, 2007; Lavender et al., 2012). The DMS has also shown significant negative associations with other related body image measures, including self-esteem and body appreciation (Kling et al., 2019).

2.5.6 Eating Disorder Examination Questionnaire

The Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994) is used to assess individuals' eating disorder symptoms and related behaviours over the previous 28 days, and has been adapted as a more efficient and economical alternative to the Eating Disorder Examination interview (Fairburn & Cooper, 1993). This questionnaire comprises 28 items rated on a 7-point response scale (0 = 'no days', 6 = 'every day'), that constitute four individual subscales relating to different aspects of eating disorder behaviour; Eating Concern, Weight Concern, Restraint and Shape Concern. The 5-item Eating Concern subscale measures a person's anxiety and preoccupation with food and eating, while the 5-item Weight Concern subscale assesses levels of distress and dissatisfaction with their own body weight. The 5 items in the Restraint subscale measure an individual's restrictive eating behaviours, such as dieting and food avoidance, while the 8-item Shape Concern subscale evaluates their dissatisfaction and preoccupation with their own body shape. Individual subscale scores are calculated by averaging scores across relevant items and a global score can also be calculated by averaging scores across all four subscales. All EDE-Q subscales are used in Study 1 (Chapter 3, Section 3.3.2.2) and Study 6 (Chapter 6, Section 6.3.2.2) of this thesis, while only the Shape Concern subscale, Weight Concern subscale, and global score are used in Study 2 (Chapter 3, Section 3.7.2.2) and Study 5 (Chapter 5, Section 5.7.2.2). The particular subscales selected for use in these chapters were dependent on the specific research aims and objectives of each study.

The following community norms for EDE-Q global scores and each of the subscales were found by Fairburn and Beglin (1994) among a sample of 241 women; Restraint (M = 1.25, *SD* = 1.32), Eating Concern (*M* = 0.62, *SD* = 0.86), Shape Concern (*M* = 2.15, *SD* = 1.60), Weight Concern (*M* = 1.59, *SD* = 1.37) and Global (*M* = 1.40, *SD* = 1.13). The EDE-Q has been used extensively with a range of female samples and has demonstrated high internal consistency (Aardoom et al., 2012; Peterson et al., 2007), good discriminant validity (Aardoom et al., 2012), test-retest reliability and psychometric properties in this population (Berg et al., 2012; Luce & Crowther, 1999). Generally, lower community norms have been identified in both clinical and non-clinical male samples (Carey et al., 2019; Mond et al., 2014; Smith et al., 2017). For example, the following averages were found in a study conducted by Lavender and colleagues (2010) using a sample of 404 men; Restraint (*M* = 1.04, *SD* = 1.19), Eating Concern (*M* = 0.43, *SD* = 0.77), Shape Concern (*M* = 1.59, *SD* = 1.38), Weight Concern (*M* = 1.29, *SD* = 1.27), and Global (*M* = 1.09, *SD* = 1.00). Validation of the EDE-Q in male populations has been more limited, however, there is evidence of adequate test-retest reliability and internal consistency of the scale, with one study showing Cronbach's alphas ranging from .73 to .89 in men (Rose et al., 2013). There is also evidence to support the convergent validity of the EDE-Q (Penelo et al., 2013), and significant associations between the subscales and measures of depression and self-esteem in men (Grilo et al., 2015).

2.5.7 Male Body Attitudes Scale

The Male Body Attitudes Scale (MBAS; Tylka et al., 2005) has been used in Studies 1 and 2 (Chapter 3, Sections 3.3.2.2 and 3.7.2.2) as a measure of men's attitudes, dissatisfaction and preoccupation with their own muscularity, body fat and height, all of which have been identified as central factors of body satisfaction in men (Ridgeway & Tylka, 2005). This gender-specific questionnaire consists of 24 items that are scored using a 6-point response scale (1 = 'never', 6 = 'always'), with reverse scoring of items 4, 17, 18 and 19. All items can be averaged to obtain an estimation of overall body attitude, with higher average scores demonstrating greater body dissatisfaction. The MBAS also evaluates attitudes relating to specific body dimensions using three subscales; the 8-item low body fat subscale, the 2-item height subscale, and the 10-item muscularity subscale. The low body fat subscale assesses attitudes and perceptions relating to an individual's adiposity, while the muscularity subscale measures satisfaction with their muscularity in different regions of the body, such as the shoulders, chest, back and arms. The height subscale assesses an individual's attitude toward their height and whether they have aspirations to be taller. There is evidence to support the construct validity of the MBAS subscales, through significant associations with men's drive for muscularity and body measurements (Bergeron & Tylka, 2007; Tylka et al., 2005). The

MBAS has also demonstrated test-retest reliability and strong internal consistency. For example, Cronbach's alphas of .94 for the low body fat subscale, .90 for the muscularity subscale, and .85 for the height subscale were found in a sample of 368 adult men (Bergeron & Tylka, 2007).

2.5.8 Modified Weight Bias Internalisation Scale

The Modified Weight Bias Internalisation Scale (WBIS-M; Pearl & Puhl, 2014) has been used in Study 6 (Chapter 6, Section 6.3.2.2) to assess the acceptance and internalisation of weight stigma and stereotypes in people of diverse body weights. This scale consists of 11 items that are rated on a 7-point response scale (1 = 'strongly disagree', 7 = 'strongly agree') and an average score is calculated across the items, with higher scores indicating greater internalisation of weight stigma. The WBIS-M was modified from the original Weight Bias Internalisation Scale, developed by Durso and Latner (2008), to make it accessible for use in men and women of all body weights. A systematic review of weight bias measures has provided evidence to support the content validity, convergent validity and discriminant validity of the WBIS-M (Lacroix et al., 2017; Pearl & Puhl, 2014). This scale has also demonstrated excellent internal consistency reliability, with Cronbach's alphas of .94 and .93 found in samples of men and women (O'Brien et al., 2016; Pearl & Puhl, 2014).

2.5.9 Rosenberg Self-Esteem Scale

The Rosenberg Self-Esteem Scale (RSE; Rosenberg, 1965) is a 10-item self-report measure of global self-esteem that assesses general feelings towards the self, without focusing on any specific aspects of the individual. The items are scored on a 4-point response scale (1= 'strongly agree', 4 = 'strongly disagree') with reverse scoring on items 1, 2, 4, 6 and 7 to reveal a total self-esteem score, with higher scores indicating higher levels of global self-esteem. RSE scores are generally categorised into 'low self-esteem' (<15), 'normal self-esteem' (15-25) and 'high self-esteem' (25-30). This scale has been used in Studies 1 and 2 (Chapter 3, Sections 3.3.2.2 and 3.7.2.2), Study 5 (Chapter 5, Section 5.7.2.2), and Study 6 (Chapter 6, Section 6.3.2.2) to characterise levels of self-esteem based on these cut-off points. The RSE has demonstrated good internal consistency, with Cronbach's alphas ranging from .72 to .90 in previous studies (Gray-Little et al., 1997; Robins et al., 2001), as well as concurrent and predictive validity for various adult groups (Hagborg, 1993; Robins et al., 2001; Schmitt & Allik, 2005). The RSE has also demonstrated construct validity through significant associations with individual personality traits and domain-specific attitudes toward the self (Robins et al., 2001).

2.5.10 Sociocultural Attitudes Towards Appearance Questionnaire

The Sociocultural Attitudes Towards Appearance Questionnaire-4 (SATAQ-4; Schaefer et al., 2015) measures sociocultural influences and pressures consistent with the Tripartite Influence Model (Thompson et al., 1999) on standards of appearance, in relation to eating disturbances and body image. Specifically, it evaluates the internalisation of the thin-ideal and the athletic-ideal, as well as pressures from family, peers and media to achieve these ideals. This questionnaire consists of 22 items that are rated on a 5-point response scale (1 = ‘definitely disagree’, 5 = ‘definitely agree’). The SATAQ-4 consists of the following 5 subscales; internalisation – thin/low body fat, internalisation – muscularity/athletic, family pressures, peer pressures and media pressures. The 5-item internalisation – thin/low body fat subscale assesses an individual’s desire to achieve a thin and lean body. The internalisation – muscular/athletic subscale consists of 5 items that measure an individual’s desire to achieve a highly muscular and athletic body. The family, peer and media pressure subscales each comprise 4 items that assess perceived pressures from each of these external factors to attain sociocultural appearance ideals. The two internalisation subscales have been used in Studies 1 and 2 (Chapter 3, Sections 3.3.2.2 and 3.7.2.2), Study 5 (Chapter 5, Section 5.7.2.2), and Study 6 (Chapter 6, Section 6.3.2.2) to assess individual’s motivations, preoccupations and internalisation of the thin and athletic appearance ideals. The SATAQ-4 has demonstrated convergent validity and good internal consistency in previous research, with Cronbach’s alphas above .75 found in men, women and adolescent boys (Rodgers et al., 2016; Yamamiya et al., 2019). There is also evidence to support the construct validity of the scale, through significant associations with body shape and weight concerns, self-esteem and disordered eating in men (Rodgers et al., 2016; Schaefer et al., 2015).

2.6 Body Girth Measurements

In Studies 1 and 2 (Chapter 3, Sections 3.3.3 and 3.7.3), Study 3 (Chapter 4, Section 4.3.2) and Study 5 (Chapter 5, Section 5.7.3), participants’ body girth measurements were taken using a soft tape measure to record waist, chest, hip and relaxed right bicep circumferences to the nearest millimetre. Participants were given the opportunity to take the measurements themselves, in order to improve comfort and respect any religious or cultural issues. In such cases, participants were given clear instructions by the researcher on how to conduct each measurement accurately. In all relevant studies, waist measurements were taken at the top of the individual’s navel, while chest measurements were taken around the widest part of their chest, usually across the nipples. Low hip measurements were taken around the widest part of an individual's buttocks, and the right bicep measurement was taken half-way between the individual’s elbow and top of the shoulder, with the arm kept relaxed by their side. The waist, chest and hip measurements were then used to calculate participants’ WHR and WCR, using the following formulae:

$$WHR = \frac{Waist\ circumference\ (cm)}{Hip\ circumference\ (cm)}$$

$$WCR = \frac{Waist\ circumference\ (cm)}{Chest\ circumference\ (cm)}$$

2.7 Body Mass Index

BMI, previously known as the Quetelet Index (Jelliffe & Jelliffe, 1979), is widely used as a measure of nutritional status and as an indicator of disease risks associated with extreme body weight (Wells, 2007). It is calculated by dividing a person’s weight (kg) by the square of their height (m^2) and is categorised into classifications of underweight, normal weight, overweight and obese, as shown in Table 2.2 for individuals of European, Hispanic and Black descent (WHO, 2000). The classifications of overweight and obese are based on observational research in the USA and Europe investigating the association of morbidity and mortality with BMI (Deurenberg, 2001). These cut-off points have been found to underestimate health risks associated with obesity in Asian and South Asian populations, therefore, slightly different classifications for overweight and obese are used for these groups (WHO Expert Consultation, 2004). Benefits of BMI are that it is a quick, simple, inexpensive and non-invasive measure that has been found to correlate with body fat percentage and act as an invaluable predictor of future morbidity and mortality (Daniels, 2009; Deurenberg, 2001; Must & Strauss, 1999). High BMI has also been linked with a range of negative health outcomes, including cardiovascular diseases, type II diabetes and kidney disease (Daousi et al., 2006; Hsu et al., 2006; Wells, 2007).

Table 2.2

BMI Classification According to WHO Guidelines

Classification	BMI (kg/m^2)
Underweight	< 18.5
Normal Weight	18.5 – 24.9
Overweight	25.0 – 29.9
Obese (Class I)	30.0 – 34.9
Obese (Class II)	35.0-39.9
Obese (Class III)	≥ 40.0

In this thesis, BMI has been calculated for participants based on either self-reported measurements (Study 6) or those taken by the researcher in-person (Studies 1, 2, 3, and 5), as well as for computer-generated avatars using measurements recorded in Daz Studio (Study 1). BMI measurements for the participants and visual stimuli were then categorised from underweight to obese, according to the WHO BMI categories shown in Table 2.2.

2.7.1 Calculation of Participant BMI

In Studies 1 and 2 (Chapter 3, Sections 3.3.3 and 3.7.3), Study 3 (Chapter 4, Section 4.3.2) and Study 5 (Chapter 5, Section 5.7.3), participant's height and weight were measured in-person by the researcher using a stadiometer and the Tanita MC-780MA Multi-frequency Segmental Body Composition Analyser. For the height measurements, participants were asked to remove their shoes, stand straight facing away from the stadiometer, and keep their head looking directly forward. Participant height was then recorded to the nearest half centimetre and inputted into the Tanita scale. For the weight measurements, participants were asked to remove their shoes and any bulky clothing before stepping on to the scale. BMI was then calculated by the Tanita scale from these measurements using the following formula:

$$BMI = \frac{Weight\ (kg)}{Height\ (m)^2}$$

In Study 6 (Chapter 6, Section 6.4.1), a self-reported estimate of BMI was calculated for each participant using measurements of height and weight obtained as part of the EDE-Q (Fairburn & Beglin, 1994) that was administered in an online survey. Participants reported their own height and weight either using the metric or imperial system, depending on their personal preference. In cases where measurements were self-reported using the imperial system, the measurements were converted to the metric system (i.e. kilograms and metres) for calculation of BMI using the formula above.

2.7.2 Calculation of CGI Stimuli BMI

In Study 1 (Chapter 3, Section 3.3.2.1), a series of CGI male body models were developed to evaluate men's ability to discriminate differences in BMI between pairs of bodies, as well as to estimate current and ideal body size perceptions. These models were calibrated for BMI using the following calibration equation that has been previously applied to both male and female computer-generated avatars (Cornelissen et al., 2015, 2017; Groves et al., 2019).

$$\begin{aligned} BMI = 6.8195 + (0.21302 \times hip) + (0.22509 \times waist) - (0.13991 \times height) \\ + (0.06781 \times age) - (0.00101 \times age^2) \end{aligned}$$

This calibration equation was developed using a series of anthropometric measurements and demographics taken from approximately 5,000 Caucasian men in the Health Survey for England (HSE) 2008 dataset. This process involved conducting multiple regressions of BMI on age, height, waist and hip data from the HSE dataset and creating calibration curves using the hip, waist and height measurements. In order to calibrate the body models used in Study 1 (Chapter 3, Section 3.3.2.1), anthropometric measurements of the CGI models were extracted using digital measuring tapes within the 'Measure Metrics' function in Daz Studio 4.10 (see Figure 2.10). The BMI of each computer-generated model was then calculated using the calibration equation above.

Figure 2.10

Example of the Measure Metrics Function in Daz Studio 4.10

Distance Units : SI (km | m | cm)
Angle Units : Degrees

V	Node	Measurement
	12. Low Hip Circumference	94.07 cm
	11. Waist Circumference	79.90 cm
	01. Height	1 m 78.09 cm

2.7.2.1 *Methodological Justification*

Other approaches have been used in previous research to estimate the BMI of computer-generated body models. For example, Crossley and colleagues (2012) used a method in which models were calibrated for BMI using an estimated weight based on measurements taken in Daz Studio. Firstly, the volume of male and female 3D CGI models was estimated in the software by scaling the models to the actual measured heights of participants or the average height of a man or woman in the UK. The weights of the models were then estimated by multiplying their volume by the density of either an average young adult male or female derived from previous literature (Krzywicki & Chinn, 1967; Pollock et al., 1975). Based on these weights and heights, BMI was then calculated using the standard BMI formula. This approach was not applied in this thesis as its focus on the total volume of the model does not account for variation in density in different regions of the body. Instead, the calibration equation selected for use in this thesis was derived from an extensive dataset of hip, waist and height measurements that capture realistic variation in men's body shape in relation to BMI.

2.8 Chapter Conclusion

Described within this chapter are a selection of computer software, technical equipment and methodological approaches that have been used to develop visual stimuli for the studies presented in this thesis. Also, a wide range of psychometric questionnaires that have been administered to assess components of attitudinal body image in these studies, including; body shape concerns, eating habits, depression, self-esteem, body attitudes, drive for muscularity, internalisation of sociocultural body ideals, perceived sociocultural pressures, and weight bias. A variety of procedures have also been used to obtain measurements of body girth, body composition, and BMI in both real and CGI male bodies. Combining these common and novel methodological approaches will provide new insights into men’s current and ideal body size and shape perceptions, how best to present visual male body stimuli, and how innovative methods and technologies can be applied to overcome existing limitations in perceptual body image measurement.

Chapter 3: Visual Perceptions of Male Body Size and Weight Using CGI Stimuli

3.1 Introduction

Weber's law (1834) states that the smallest difference between two stimuli that can be reliably discriminated, known as the JND, is a constant proportion of the magnitude of the stimuli. In a way, the JND can be considered as an inverse measure of precision, with smaller JNDs indicating greater precision in judgements of stimulus magnitude. In body image research, the JND can be characterised as the smallest difference in body size, indexed by BMI, between pairs of bodies that can be reliably detected (Cornelissen et al., 2018). The magnitude of body size distortion required to produce this JND is referred to as the DL. The Point of Subjective Equality (PSE) can be defined as the stimulus magnitude at which there is an equal chance for an individual to judge a body as smaller or larger than a reference body, therefore, it is the point at which two bodies appear the same (Cornelissen et al., 2015). Following Weber's law, it would be expected that a plot of the association between the JND and stimulus BMI would present a positive linear slope with a constant Weber fraction across the stimuli range, where the fraction is calculated as the JND divided by the BMI of the stimulus. This positive linear relationship indicates that larger differences in BMI between bodies would be required as the BMI of the stimulus increases for a difference to be visually perceptible.

Weber's law has implications for the development of figure scales for assessing perceptual body image. It has been suggested that the ideal figure scale would present stimuli with the smallest possible JND in relation to stimuli BMI and would have a constant Weber fraction across the range of figures (Cornelissen et al., 2018). Designing perceptually-driven figure scales in this way may allow for greater specificity and sensitivity of participants' body size judgements, thus improving the psychometric applications of these scales and their accuracy in measuring body size estimations. This approach has previously been used in scales for assessing other sensory perceptions, such as the dol scale for the perception of pain that was developed based on people's ability to differentiate between different pain intensities (Hardy et al., 1947).

Historically, JND estimations have been achieved using several different psychophysical methods, including the method of constant stimuli (McBride & Booth, 1986; Simpson, 1988) and the method of limits (Herrick, 1969; McBurney et al., 1967). It is important to consider that estimations of the JND may depend on the particular approach and methodology used to attain them. One approach to estimate the JND of a stimulus is a variation of the method of limits known as the staircase-method, or up-down method (Cornsweet, 1962).

This method is characterised by the implementation of four predetermined conditions, these being; the chosen position to start the stimuli series, the chosen position to end the stimuli series, the magnitude of the difference between each stimulus, and if/when the magnitude should be altered. This method involves presenting participants with a sequence of stimuli that gradually increase or decrease in their intensity or value in small steps. The direction of this change in the stimulus depends on participants' responses, with a reverse in direction occurring when the participant alters their response. An advantage of this method is its time-efficiency, in that it normally requires presentation of relatively fewer trials than other methods as stimuli are concentrated around the threshold (Cornsweet, 1962; Gescheider, 1997). However, participants are likely to gain an awareness of the order in which stimuli are being presented during the task, and therefore there is a potential for anchoring effects and manipulation of the results. Similarly, designing the perceptual task is likely to require a compromise between a reduced number of trials for efficiency and a greater number of trials for more reliable results (Cornsweet, 1962).

Another method commonly used to achieve an estimate of the JND of a stimulus is the method of constant stimuli. This method has been used in perceptual body image research to assess visual judgements of body size, both of one's own body and of others. For example, Gardner and colleagues (1989) adhered to the method of constant stimuli to measure judgements of own body size among obese and normal-weight individuals. Single images of the participant's body were shown at 11 levels of body size distortion, from a reduction in size of 20% to an increase of 20%, and participants were asked to report whether any distortion was present. Participants could respond with 'too wide' or 'normal' in some trials, and 'too thin' or 'normal' in other trials, with 50 trials for each level of distortion, in order to determine their JND and the PSE. In this study, the PSE was the proportion of body size distortion equivalent to an individual's perceived current body size, and was calculated as the level of distortion at which participants correctly detected body size distortion at a rate of 50%. The upper and lower difference thresholds were the distortion levels correctly detected at a rate of 75% and 25% respectively, and the JND was measured by halving the difference between these two thresholds. The researchers found a PSE of -0.62%, demonstrating a very slight underestimation of own body size, and an average JND of 7.27% with no significant differences between males and females, as well as between obese and normal-weight participants. Although the large number of experimental trials used in the method of constant stimuli can be unnecessary and inefficient, with the potential for possible participant fatigue effects, this thorough approach is advantageous to the reliability and accuracy of results (Gardner, 2012; Gardner et al., 1989; Leek, 2001).

In a recent study conducted by Talbot, Smith and Cass (2019), the method of constant stimuli was applied to assess visual judgements of body fat and muscularity in male bodies. In this study, participants were shown images of bodies and asked to make dichotomous categorical judgements as being either ‘skinny’ or ‘fat’, and ‘muscular’ or ‘scrawny’. The images represented 16 different levels of adiposity and muscularity, and each was presented to participants 30 times. These images were adapted from the New Somatomorphic Matrix-Male (Talbot, Smith, Cass, & Griffiths, 2019) and the Visual Body Scale for Men (Talbot, Cass & Smith, 2019). Participant responses were used to calculate the PSE and JND for both muscularity and body fat judgements. In this case, the PSE represented the stimulus level at which judgements shifted from one category to the other at a response rate of 50%. The PSE was not found to be significantly associated with participant body attitudes or eating behaviours. However, the JND for muscularity was found to be positively associated with weight concern, therefore showing men with higher weight concerns were less precise in the categorisations of muscularity.

Cornelissen and colleagues (2016) conducted several experiments using the method of constant stimuli to investigate whether visual biases, specifically Weber’s law and contraction bias, related to visual perceptions of body weight in others. One experiment involved participants judging differences in body size between pairs of images of various body weights, in order to determine whether judgements would become more difficult and less accurate as body weight increased, as is consistent with Weber’s law. The method of constant stimuli was used to identify the JND of BMI at eight distinct BMI ranges, covering points both within and between BMI categories. Twenty-four participants were shown pairs of CGI bodies and asked to decide which was larger in body size using a 2-alternative forced choice (2-AFC) task. Participants were presented with eight blocks of images, with each block representing one of the following BMI ranges; 14.5-18.5, 16.5-20.5, 20-24, 23-27, 24.5-30.5, 27-33, 32-38, 37-43 kg/m^2. In each block, the difference in BMI between the pairs of bodies varied between 0 to 2.5 kg/m^2, in steps of 0.25 kg/m^2. Each image pairing was shown to participants 20 times within the relevant block, and the stimuli within each block, and order of the blocks, were randomised for each participant. The JND for each block was calculated as the smallest difference in BMI between bodies that could be correctly discriminated at a rate of 75%. Cornelissen et al.’s (2016) findings highlighted that people’s ability to visually detect differences in body size became increasingly poor as the BMI of the stimuli increased. Similarly, it was found that the

Weber fraction was relatively constant across the BMI spectrum. However, this study only explored female participants' visual discriminations of female CGI stimuli. There is a need to conduct a similar investigation of male participant's visual discriminations of male stimuli, to identify whether the same Weber's law-consistent behaviours are demonstrated.

Cornelissen et al. (2018) used a 2-AFC task to investigate the JND for BMIs at three different body orientations; front, three-quarter and side-view. Participants were shown computer-generated body stimulus pairs on a screen and asked to decide which of the bodies was larger. The images were presented in blocks that represented each of the four BMI categories, with reference BMIs of 15, 20, 27 and 36 kg/m^2, at one orientation. Participants' responses adhered closely to Weber's law, with a constant Weber fraction and linear increase in JND, when bodies were shown in side and three-quarter views. The mean JNDs for the side and three-quarter views were not statistically different. It may be the case that the presentation of computer-generated bodies in the front view obscured certain visual cues of body size. For example, the front-to-back abdomen width of the bodies presented in this study increased at a faster rate than the lateral abdomen width, and therefore they may have provided a more prominent visual cue of BMI differences in the side and three-quarter views.

This thesis chapter presents two studies. Study 1 (Section 3.2) aims to investigate the accuracy of men's visual discriminations of body size in male CGI bodies. The study design and stimuli development are based on previous research exploring women's visual biases in perceptions of body weight in female bodies (Cornelissen et al., 2016). The JND of BMI is identified for male bodies of different sizes and these results are then used to inform the development of new figure scales. This is particularly important as JND values across the BMI spectrum may not be the same for male and female bodies, which has implications for how sex-specific figure scales should be developed. It also provides a perceptually-driven underpinning for the BMI spacing between bodies in the scales, rather than the arbitrary or linear spacing that is commonly present in existing measures. This approach to designing figure scales may allow for more accurate, specific and sensitive estimations of male body size in research and clinical health contexts. Study 2 (Section 3.6) aims to assess estimations of perceived current and ideal body size using these new JND-based scales in a general male sample. It also investigates the reliability and validity of these scales, in order to evaluate their suitability for use in research and clinical settings.

3.2 Study 1: Aims and Objectives

The present study aimed to: (i) investigate men’s ability to discriminate differences in body size between pairs of computer-generated male figures, in order to determine whether men’s visual perceptions of male body size are consistent with Weber’s law, (ii) develop male body scales that present perceptually appropriate variation in BMI between figures, based on the accuracy of these perceptual judgements.

The main objectives of this study were:

1. To use the method of constant stimuli to identify the JND of body size, defined as the smallest possible difference in BMI between pairs of bodies for which individuals can accurately detect the larger body 75% of the time
2. To test for Weber’s law behaviour by comparing the JNDs across participants, as a function of stimuli BMI
3. To develop perceptually-driven, computer-generated male figure scales in which the BMI spacing between bodies is determined by the JND values across the BMI range.

3.3 Study 1: Methods

Study 1 was granted ethical approval by the University of Lincoln’s School of Psychology Research Ethics Committee (SOPREC) on the 6th November 2018 (PSY181949).

3.3.1 Participants

In order to determine an appropriate sample size for this study, a power analysis was conducted using the repeated measures, within-factors analysis of variance (ANOVA) option in G*Power 3.1.9.6 (Faul et al., 2009), based on previous data collected in females (Cornelissen et al., 2016). This analysis projected that a sample of 8 participants was adequate to quantify a statistically significant association between stimulus BMI and JND, based on a power of .90, alpha level of .01 and a partial eta-squared of .40, as provided by the authors. The power calculation was driven by women’s responses when viewing female CGI bodies, therefore a conservative position was taken towards participant recruitment for this study, aiming for at least two-to-three times the calculated sample size. This approach was applied given a lack of information about how male participants would perform in the task and to account for a likelihood of participant dropout between sessions 1 and 2 in the study. A total of 32 participants were recruited from University of Lincoln staff, students and members of the general public. Participants were recruited through the University of Lincoln’s staff news webpage, the School of Psychology’s research participation system (SONA), social media invitations, posters and word-of-mouth.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 to 45 years
2. Participants who self-identify as male (cis-gender/as assigned at birth)

Participant exclusion criteria for this study were as follows:

1. Participants with a current or previous diagnosis of an eating or body image disorder

3.3.2 Materials

3.3.2.1 CGI Stimuli

A set of 310 realistic, high-definition male body models, ranging in BMI from 16.5 to 45 kg/m^2, were developed for this study using Daz Studio 4.10 software. These computer-generated 3D bodies present graded changes in BMI of 0.25 kg/m^2 whilst maintaining a single ‘identity’ in a standardised body posture. A variety of physical features were selected to create this ‘identity’, including hair style and colour, clothing, eye colour, and the appearance of the skin. The positioning of the male bodies, the environment in which they were displayed, and the lighting within this environment were also kept constant. A detailed description of how this series of male bodies was developed can be found in Chapter 2 (Section 2.1.1).

3.3.2.2 Psychometric Measures

A number of self-report questionnaires were used to investigate individual levels of depression, self-esteem, body shape dissatisfaction and preoccupations, and attitudes towards eating. These questionnaires are described in more detail within the general methods section of this thesis (Chapter 2, Section 2.5). The measures were administered in order to characterise the study sample but were not included in the JND analysis, as this was beyond the scope of the research aims and participants were not asked to relate the visual stimuli presented to their individual attitudes, beliefs or their own body size and shape.

Body Dissatisfaction. The MBAS (Tylka et al., 2005) was used to measure individuals’ body attitudes, dissatisfaction and preoccupations. The low body fat and muscularity subscales were selected to investigate body image in relation to these dimensions of body composition separately. The male version of the BSQ -16b (Evans & Dolan, 1993) was administered to measure general body shape preoccupations and concerns experienced over the previous four weeks, while the EDE-Q (Fairburn & Beglin, 1994) was used to measure the potential presence of eating disorder symptoms and behaviours relating to eating concerns, weight concerns, shape concerns and restraint.

Internalisation of Appearance Ideals. The two internalisation subscales of the SATAQ-4 (Schaefer et al., 2015) were used to assess individual preoccupations and motivations towards the thin-ideal and the athletic-ideal.

Depression and Self-Esteem. The BDI (Beck et al., 1961) was administered to identify depression symptoms and attitudes, while the RSE (Rosenberg, 1965) was used to assess individual self-esteem levels.

3.3.3 Study Procedures

Participants who expressed interest in taking part were provided with either an electronic or hard-copy information sheet (Appendix B.1) that included the aims of the study, what participation would involve, whether there were any benefits or potential risks, the researchers' contact details and relevant resources for additional support. Participants were invited to attend a single laboratory-based session that would take approximately 60 to 90 minutes in total. At the start of the session, participants provided written consent (Appendix B.2) and were then asked to complete a computer task involving a 2-AFC paradigm. Participants were shown pairs of the CGI stimuli side-by-side on a screen and asked to select which body they perceived to be larger in body size, by pressing the corresponding left or right arrow key on the keyboard. The image pairs were displayed on the screen for 250 milliseconds and then a blank screen was shown until the participant made their response. The images were presented in seven stimuli blocks, representing narrow ranges along the BMI spectrum, these being; 16.5–20.5, 20–24, 23–27, 24.5–30.5, 27–33, 32–38, 37–43 (see Table 3.1). These BMI ranges were selected to gain responses both within and across the distinct BMI categories of underweight, normal weight, overweight and obese.

The image in the middle of each block range was selected as the standard body for comparison with all other images in that block. This standard body represented either a BMI category boundary or a central BMI within a category (see Table 3.1). This standard body was presented during each trial and compared with every other image in steps of 0.25 kg/m^2 within the block, as well as with itself. For example, in block 1 the standard body had a BMI of 18.50 and was compared to images with a BMI of 16.5, 16.75, 17, 17.25, 17.5, 17.75, 18, 18.25, 18.5, 18.75, 19, 19.25, 19.5, 19.75, 20, 20.25 and 20.5. Therefore, the difference in BMI between the standard body and comparison body shown in each trial varied from 0 to ± 2 kg/m^2 in this block and from 0 to ± 3 kg/m^2 across all blocks. Each pair of images within every block was also presented 10 times to the participant. After each block, participants were given the opportunity to take a break to avoid fatigue effects and could return to the task using a key press at any time. The order in which the blocks were presented was randomised, as well as the order in which the image pairs were shown within each block. Furthermore, the presentation of the standard body within each trial was randomly allocated to either the left or right-hand side of the computer screen, in order to neutralise the effects of spatial location when determining the JND (Gescheider, 1997).

Once the 2-AFC task was complete, participants were then asked to provide demographic information, including their age and ethnicity, and complete the self-report questionnaires presented to participants on a computer screen using an online Qualtrics link. The order in which these psychometric measures were presented was randomised within the survey. Lastly, anthropometric measurements were obtained using a Tanita MC-780MA bio-impedance scale, stadiometer and tape measure, including participant BMI and waist, chest, hip and bicep circumferences in centimetres, as described in Chapter 2 (Sections 2.4, 2.6 and 2.7.1). At the end of the session, participants were presented with a debrief sheet (Appendix B.3) detailing the aim of the study, their right to withdraw, their personal identification number, relevant resources for support and researchers' contact details.

Table 3.1

BMI Range, Category and Standard Body BMI for Each Stimuli Block

Block	BMI (kg/m^2)			BMI Category	Standard Body Category
	Min.	Max.	Standard Body		
1	16.5	20.5	18.5	Underweight-Normal	Boundary
2	20.0	24.0	22.0	Normal	Within
3	23.0	27.0	25.0	Normal-Overweight	Boundary
4	24.5	30.5	27.5	Normal-Overweight	Within
5	27.0	33.0	30.0	Overweight-Obese I	Boundary
6	32.0	38.0	35.0	Obese II	Boundary
7	37.0	43.0	40.0	Obese III	Boundary

3.3.4 Data Analysis

All demographic, anthropometric and psychometric data was analysed using IBM SPSS Statistics (Version 26.0) software, whereas data analysis to determine the JND of BMI in the male stimuli was carried out using RStudio software (https://rstudio.cloud/). The JNDs of BMI were calculated using a classical psychophysical method in which a psychometric function was constructed from the proportion of correct participant responses for each difference in BMI between figures across the full range of CGI stimuli (Gescheider, 1997). A linear least squares regression model was used to determine the line-of-best-fit for the psychometric function and allowed for the calculation of the PSE and DL for the standard body in each stimuli block. A linear mixed-effects model was then run to predict the DL from the BMI of the standard body in each stimuli block of the 2-AFC task. Finally, the model coefficient and intercept were used in a linear function to determine the BMI spacing between figures for two male body scales, based on the calculated JND multiplied by a factor of two and three separately. This psychophysical approach is described in full detail in the results section of this study.

3.4 Study 1: Results

3.4.1 Participant Characteristics

A total of 32 adult males, aged 18 to 45 years (*M* = 23.58, *SD* = 5.38), were recruited for this study. The sample had a mean BMI of 25.69 kg/m^2 (*SD* = 4.89), ranging from 17.72 to 37.35 kg/m^2. The participants self-reported a range of ethnicities, including ‘White’/‘White British’/‘Caucasian’ (n = 25), ‘Indian’ (n = 2), ‘Mixed’ (n = 2), ‘Chinese’ (n = 1) and ‘Other’ (n = 1). Table 3.2 presents the range, means and standard deviations for the participant anthropometric measurements in the sample.

Table 3.2

Participant Anthropometric Measurements

Measurement	Total sample (N = 32)			
	Mean	SD	Min.	Max.
Chest (cm)	99.73	9.43	81.50	117.00
Waist (cm)	92.14	13.17	71.00	118.00
Hip (cm)	103.52	9.15	84.00	121.00
Bicep (cm)	31.25	3.31	23.00	36.00
BMI (kg/m^2)	25.69	4.89	17.72	37.35

Table 3.3 presents the means, standard deviations and Cronbach's alphas for the psychometric measures of body attitudes and shape concerns, depression, self-esteem, eating behaviours, and internalisation of body ideals in the sample. The Cronbach's alphas demonstrated adequate to excellent internal consistency ($\alpha > .70$) for all psychometric scales and subscales except for the Eating Concern subscale of the EDE-Q, which showed poor internal consistency in this particular sample ($\alpha = .55$).

Table 3.3

Means, Standard Deviations and Cronbach's Alphas for Psychometric Measures

Measures	Total sample (N = 32)		
	Mean	SD	α
BDI	8.47	6.71	.85
RSE	19.53	6.55	.92
SATAQ-4: Athletic	3.17	1.03	.87
SATAQ-4: Thin	2.79	0.96	.84
MBAS: Muscularity	3.04	1.01	.88
MBAS: Low body fat	3.14	1.20	.88
BSQ-16b	37.47	13.64	.91
EDE-Q: Restraint	1.68	1.50	.78
EDE-Q: Eating Concern	0.57	0.70	.55
EDE-Q: Shape Concern	2.17	1.47	.80
EDE-Q: Weight Concern	1.33	1.24	.77

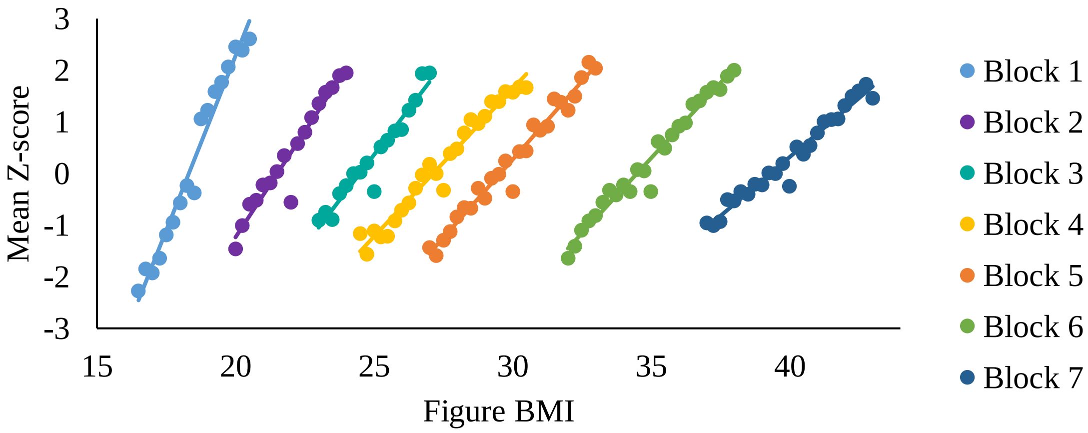
3.4.2 JND Calculation

In order to calculate the average DL for the BMI of each standard body presented in the 2-AFC task, a classical psychophysical method was used in which a psychometric function was constructed from the proportion of correct participant responses at each stimulus intensity (Gescheider, 1997). Firstly, the difference in BMI between the two bodies in each trial of every block was calculated, with one of the bodies in each trial being the standard body. This allowed for the accuracy of participant's responses for each BMI difference within each stimuli block to be coded as either a 'hit' or 'miss', depending on which body was selected as larger. This was then converted into a proportion of correct responses, calculated as the total number of 'hits' for each BMI difference divided by the total number of trials. The psychometric function of the proportion of correct responses for each participant and stimuli block was then converted from a sigmoid curve to a linear function by transforming the proportions into Z-scores, using a normal distribution table. Average Z-scores for every BMI difference within each stimuli block were calculated for the total sample (Figure 3.1).

A linear least squares regression model was then run for each participant and the BMI of the standard body in each block to predict the Z-scores of the proportion of correct responses. Participant data were excluded from further analysis at this point if their r^2 value for the fitted model was less than .25, with the intention of removing noise from the analysis without limiting the dataset too much. This method of least squares determined a line-of-best-fit for the psychometric function by minimising the squared deviations of values from the straight line.

Figure 3.1

Mean Z-Score Across Participants for the Proportion of Correct Responses in Each Stimuli Block



Next, the upper difference threshold (DL_u) at the 0.75 point on the psychometric function and the lower difference threshold (DL_l) at the 0.25 point on the function were calculated, these being Z-scores of -0.675 and 0.675 respectively. The following formulae were used to determine these thresholds, where b refers to the y-intercept of the straight line and a is equal to the slope of the line:

$$DL_l = \frac{-0.675 - b}{a}$$

$$DL_u = \frac{0.675 - b}{a}$$

This method also led to a calculation of the PSE; the point at which the proportion of ‘hits’ and ‘misses’ were equal. The PSE is the 0.5 point on the psychometric function, or the value for a Z-score of 0, and was calculated according to the following formula:

$$SE = \frac{0 - b}{a}$$

The difference between the DL_u and the PSE produced the upper difference threshold, while the difference between the PSE and the DL_l yielded the lower difference threshold. The upper and lower difference thresholds were then averaged to give the DL for each standard body BMI and these were averaged across participants for each stimuli block, as shown below:

$$DL = \frac{(DL_u - PSE) + (PSE - DL_l)}{2}$$

A linear mixed-effects model was then run using restricted maximum likelihood (REML) estimation to predict the DL from the BMI of the standard body in each stimuli block. Comparisons of Akaike’s Information Criteria (AIC), Bayesian Information Criteria (BIC) and Log-Likelihood (LL) were used to select the most appropriate model for the data. Firstly, the simplest possible mixed model was computed, where each participant has their own random intercept, to account for within-participant variance only (AIC: 469.00, BIC: 478.94, LL: -231.50). Next, a mixed model with both a fixed effect of standard body BMI and a random effect of subjects was run (AIC: 430.46, BIC: 443.71, LL: -211.23), which demonstrated a better model fit. A likelihood ratio test was then used to determine whether there was a statistically significant difference in model fit between the two mixed models. A significant difference was found ($X^2(1) = 40.55$, $p < .001$), and therefore the mixed model with fixed and random effects was selected. Table 3.4 presents a summary of the mixed-effects model, including the model coefficient and intercept.

Table 3.4

Summary of Linear Mixed Model with Fixed and Random Effects

	b	SE *b*	95% CI	*t*	*F*	*p*
(Intercept)	-0.082	0.194	-0.461, 0.297	-0.424	-	.672
Standard Body BMI	0.046	0.006	0.034, 0.058	7.528	56.672	.000

A comparison between the predicted DLs for each standard body BMI from the mixed model and the DLs from the raw data showed similar results, except for a peak in the average DL for the raw data in block 4 (Figures 3.2 and 3.3). However, both data sets presented relatively linear functions. The model-predicted DLs generally had smaller standard deviations than the raw DLs across the stimuli blocks and a constant Weber fraction across the stimuli range, therefore it was applied to inform the development of new male figure scales.

Table 3.5

Mean Raw and Model-Predicted DL Values and Weber Fraction for Each Stimuli Block

Block	Standard Body	Model-predicted DL			Raw DL		
		Mean	SD	Weber Fraction	Mean	SD	Weber Fraction
1	18.5	0.75	0.40	0.04	0.57	0.27	0.03
2	22.0	0.87	0.38	0.04	0.94	0.57	0.04
3	25.0	1.02	0.40	0.04	1.05	0.52	0.04
4	27.5	1.11	0.39	0.04	1.40	1.10	0.05
5	30.0	1.25	0.41	0.04	1.20	0.62	0.04
6	35.0	1.51	0.41	0.04	1.42	0.85	0.04
7	40.0	1.65	0.36	0.04	1.62	0.92	0.04

Figure 3.2

Mean Raw DL Values at Each Standard Body BMI

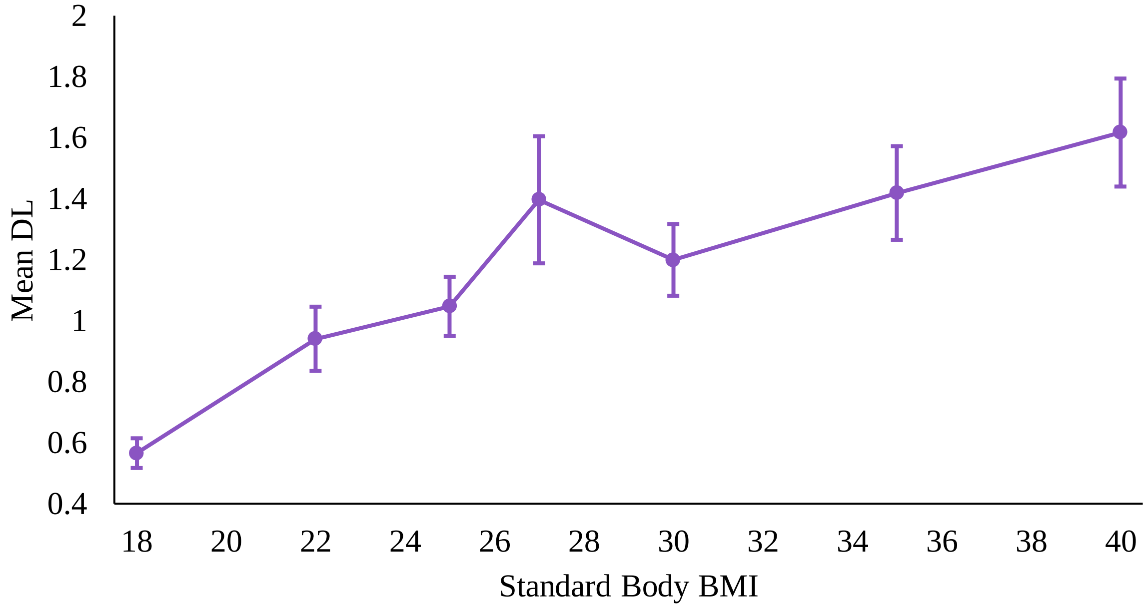
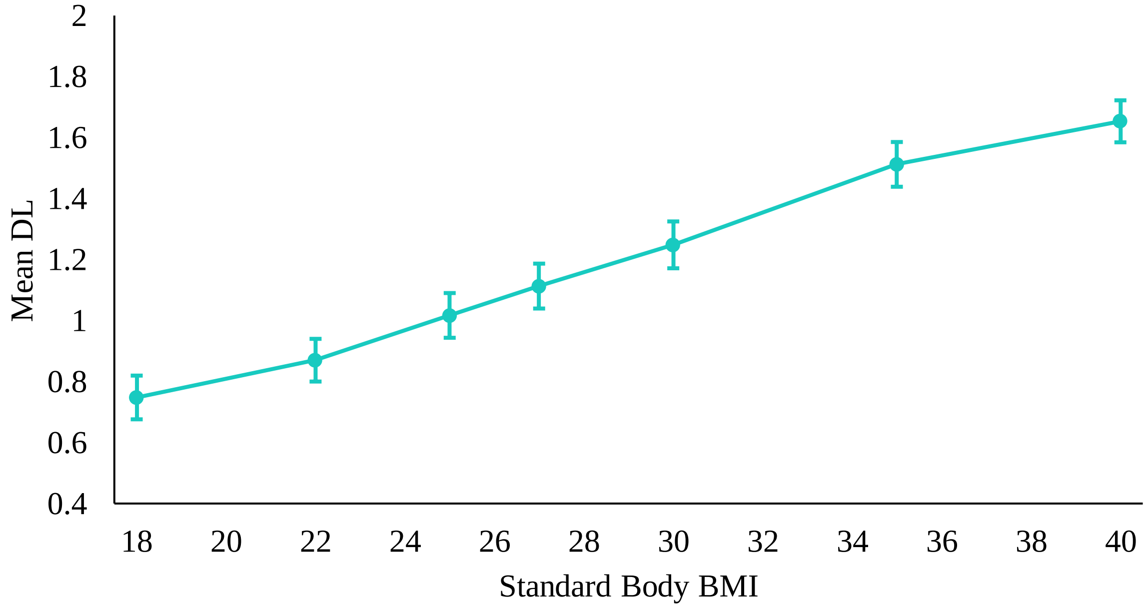


Figure 3.3

Mean Model-Predicted DL Values at Each Standard Body BMI



3.4.3 Development of Figure Scales

To develop perceptually-driven male figure scales, a linear function was used to determine appropriate BMI spacing between adjacent bodies, based on the model-predicted DL values across the BMI spectrum. Firstly, the JND value for the lowest BMI body presented to participants (16.5 kg/m^2) was calculated using the following function:

$$Y = a(X) + b$$

In this equation, Y corresponds to the JND at a chosen BMI value (X), a represents the model coefficient and b is the intercept. Given a model coefficient of 0.046 and an intercept of -0.082, the JND for a BMI of 16.5 kg/m^2 was calculated as 0.67 kg/m^2. This JND value was then added to the initial BMI of 16.5 kg/m^2 to determine the BMI of the subsequent body in the scale. This process was repeated across the BMI range, resulting in a series of 24 bodies representing a range in BMI from 16.5 to 43 kg/m^2.

The same linear function was then used to determine BMI spacing between figures based on the JND values multiplied by either a factor of 2 or 3, in order to develop two figure scales with different numbers of bodies. This involved calculating the BMI value 2 and 3 JNDs above the absolute threshold at various points along the BMI spectrum, which was then used to determine the BMI spacing of bodies for two separate figure scales. Table 3.6 presents the calculation and BMI spacing of the bodies for a figure scale based on the relevant JND's multiplied by 2, while Table 3.7 shows the same information using the JND's multiplied by 3. For both scales, the BMI of the individual bodies was rounded to the nearest 0.25 kg/m^2, in order to select the appropriate figure from the range of high-definition, realistic male body images generated in Daz Studio. These calculations resulted in the development of two male figure scales; the first based on the JND's multiplied by 2 consisted of a series of 13 bodies ranging in BMI from 16.5 to 43.75 kg/m^2, and the second using the JND's multiplied by 3 comprised 9 bodies varying from 16.5 to 43 kg/m^2. The 13-body scale consisted of 2 underweight bodies, 4 normal weight bodies, 2 overweight bodies and 5 obese bodies. Alternatively, the 9-body scale comprised 1 underweight body, 3 normal weight bodies, 2 overweight bodies and 3 obese bodies.

Table 3.6

Calculation of Body Scale BMIs Using JND Multiplied by 2

BMI	JND	JND multiplied by 2	BMI + (JND multiplied by 2)	BMI to closest 0.25	BMI Category
16.50	0.67	1.35	17.85	16.50	Underweight
17.85	0.73	1.47	19.32	17.75	Underweight
19.32	0.80	1.60	20.92	19.25	Normal
20.92	0.88	1.75	22.67	21.00	Normal
22.67	0.96	1.91	24.58	22.75	Normal
24.58	1.04	2.09	26.67	24.50	Normal
26.67	1.14	2.28	28.94	26.75	Overweight
28.94	1.24	2.49	31.43	29.00	Overweight
31.43	1.36	2.71	34.14	31.50	Obese I
34.14	1.48	2.96	37.10	34.25	Obese I
37.10	1.62	3.23	40.34	37.00	Obese II
40.34	1.76	3.53	43.86	40.25	Obese III
43.86	1.93	3.85	47.71	43.75	Obese III

Table 3.7

Calculation of Body Scale BMIs Using JND Multiplied by 3

BMI	JND	JND multiplied by 3	BMI + (JND multiplied by 3)	BMI to closest 0.25	BMI Category
16.50	0.67	2.02	18.52	16.50	Underweight
18.52	0.77	2.30	20.82	18.50	Normal
20.82	0.87	2.61	23.43	20.75	Normal
23.43	0.99	2.97	26.40	23.50	Normal
26.40	1.13	3.38	29.78	26.50	Overweight
29.78	1.28	3.84	33.62	29.75	Overweight
33.62	1.46	4.37	37.99	33.50	Obese I
37.99	1.66	4.97	42.96	38.00	Obese II
42.96	1.88	5.65	48.61	43.00	Obese III

3.5 Study 1: Discussion

3.5.1 Summary and Interpretation of Main Findings

Study 1 aimed to develop new computer-generated male figure scales in which the BMI separation between bodies was based on the JND of body size across a wide stimuli BMI range. This study used a series of photorealistic, high-definition computer-generated images in a computerised 2-AFC task to determine the JND of BMI across a range of stimuli BMIs from 16.5 to 43 kg/m^2 for a general population sample of 32 adult men. Psychometric measures of body dissatisfaction, depression, self-esteem and ideal internalisation were administered in order to characterise the attitudinal body image of the sample. The mean scores for the EDE-Q subscales were similar to those found in Fairburn and Beglin's (1994) community sample of 241 female participants and slightly higher than those found in a sample of 404 undergraduate men (Lavender et al., 2010). Mean scores for both the BDI and RSE indicated levels of depression and self-esteem that were within a normal range for non-clinical samples (Beck et al., 1961; Rosenberg, 1965), although two participants reported depression levels within the 'moderate depression' category. The mean score for the BSQ-16b was just below the cut-off for 'mild concern with shape' (Evans & Dolan, 1993), and therefore suggested a general lack of shape concern, although the standard deviation for these scores indicated some variation across participants.

As expected, responses from the 2-AFC task in this study revealed that the JND of BMI increased linearly with the BMI of the stimuli presented. In other words, participants' ability to detect the difference in body size between two bodies became progressively less accurate as the BMI of the bodies increased, as is consistent with Weber's law. In comparison to the findings from Cornelissen et al.'s (2016) research, the model-predicted DLs for the male stimuli were smaller across the stimuli BMI range than those found with the female stimuli. For example, the mean DL for a standard body with a BMI of 18.5 kg/m^2 was 0.75 kg/m^2 for the male figures and around 1.1 kg/m^2 for the female figures. At the other end of the spectrum, the mean DL for a standard body with a BMI of 40 kg/m^2 was 1.65 kg/m^2 for the male figures and approximately 2.3 kg/m^2 for the female figures. The methods used in these two studies were identical, except that one fewer stimuli block was used in the 2-AFC task in Study 1, as the male stimuli did not extend to a BMI of 14.5 kg/m^2. The findings from the linear mixed-effects model were then used to inform the development of two separate male figure scales with perceptually appropriate increments in BMI between the figures, based on the JNDs of BMI multiplied by either a factor of two or three. These figure scales achieve the ideal of presenting stimuli that are based on the JND in relation to stimuli BMI and a constant Weber fraction of 0.04 kg/m^2 across the range of figures (Cornelissen et al., 2018).

3.5.2 Strengths and Limitations

Little research has been conducted to investigate the JND of body size in the male population, and therefore this study provides novel findings that have been used to develop perceptually-driven male body scales with potential applications for body image research and clinical practice. The 9-figure and 13-figure scales have been established based on actual JND values and therefore provide perceptually appropriate spacing between bodies, rather than arbitrary spacing that is often applied to existing figure scales. In addition, the scales are time-efficient, easy to administer and present different numbers of figures that make them more applicable to different contexts. Previous literature has presented mixed arguments for the ideal number of bodies to be included in a figure scale. For example, some have suggested that 7 ± 2 figures are optimal for a scale (Ambrosi-Randić et al., 2005), while others have argued for larger scales with small increments between figures (Gardner et al., 1998). A critical review of existing male figure rating scales has identified an average of 9.81 figures across unidimensional scales (Talbot et al., 2020). Therefore, two scales with different numbers of figures were developed with the intention of comparing their reliability and validity, as well as meeting the necessities of both research and clinical settings. In terms of the study procedure, the use of the method of constant stimuli for the 2-AFC task was thorough in its approach, by presenting each pair of figures 10 times and gaining responses for a large range of BMIs from underweight to morbidly obese. Finally, randomisation was used throughout the task, both in terms of the stimuli pairs and block order, to minimise potential anchoring effects from the order in which the stimuli were presented to participants.

There are some limitations in the stimuli and procedures used in this study and, consequently, to the development of the male figure scales. Firstly, the 2-AFC task was lengthy in its design with each participant responding to 1,580 trials in total, which may have resulted in potential fatigue effects, although participants were given the opportunity to take breaks between each stimuli block in the task. This is a recognised problem of the method of constant stimuli but is necessary to gain a comprehensive picture of an individual's visual sensitivity in relation to body size (Gardner, 2012; Gardner et al., 1989; Leek, 2001). Also, the male body stimuli presented to participants did not extend across the full range of BMI and were particularly restrictive at the lower end of the spectrum. In Cornelissen et al.'s study (2016), the female stimuli extended to a BMI of 14.5 kg/m^2 at the lower end, while the male bodies in this study began at a BMI of 16.5 kg/m^2. This difference in BMI range was due to innate constraints within the Daz Studio software, with the male 'Genesis 8' model not attaining a BMI of 14.5 kg/m^2 without altering the shape of the model using additional morphs in the software. The adiposity and weight morphs were kept the same for the male bodies as were previously used for the females, in order to replicate the original study (Cornelissen et al., 2016).

The stimuli chosen for the 2-AFC task were based on BMI measurements for each figure in the original sequence of 310 bodies. The closest image to each intended BMI, in steps of 0.25 kg/m^2, was selected for the task and these images varied in their discrepancy by ± 0.10 kg/m^2 from the intended BMI across the animation. However, it is unlikely that a difference in BMI of 0.10 kg/m^2 could be reliably visually detected, given that the smallest mean DL identified in this study was 0.75 kg/m^2 for the model-predicted data and 0.57 kg/m^2 for the raw data. Similarly, the bodies chosen for the 9-figure and 13-figure scales were based on BMI values rounded to the nearest 0.25 kg/m^2. Therefore, the BMIs of the bodies selected for the figure scales were not precisely equivalent to the BMIs identified from multiples of the JND values. The two figure scales also represent slightly different ranges in BMI, with the 13-figure scale presenting an additional 0.75 kg/m^2 at the upper end of the range. However, again, this difference is unlikely to be visually distinguishable, given that both the mean raw and model-predicted DLs for the obese figures were above 1.20 kg/m^2.

Finally, men’s body image concerns and ideals tend to represent changes in both muscularity and adiposity (Barlett, et al., 2008; Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; Gardner & Brown, 2010; McCabe & Ricciardelli, 2004). However, the new figure scales developed in this study do not present variation in muscularity across the figures, and therefore can only assess men’s ideal and current perceptions relating to BMI. This is a common limitation of figure scales and there is evidence to suggest that the muscularity level across bodies presented in male figure scales influences the accuracy of average BMI self-estimations (Gardner & Brown, 2010; Groves et al., 2019).

3.5.3 Implications and Future Work

This study provided evidence that Weber’s law applies to men’s body size judgements of male bodies, suggesting that perceptual factors make it more difficult for men to detect weight change in higher weight bodies than lower weight male bodies. This has potential implications for individual weight-change efforts, as men who are overweight or obese may need to lose a larger amount of weight for it to be visually detectable by others, compared to men with a lower BMI (Cornelissen et al., 2016). This may be demotivating to individuals who are trying to lose weight with the aim of improving their appearance, given that this is one of the main reasons that people at the upper end of the BMI spectrum want to reduce their weight (Dixon et al., 2002; Hankey et al., 2002). Therefore, this perceptual bias, in addition to sociocultural beliefs and weight stigma associated with certain body sizes, is likely to play a role in men's weight-change motivations and behaviours, and should be considered within interventions for related health outcomes.

As with Cornelissen et al.'s (2016) research, this study examined same-sex judgements of body size only. Future studies could investigate the accuracy of women's visual judgements of male bodies to explore potential differences in their ability to discriminate body size. This would inform the development of similar perceptually-driven scales for measuring women's weight perceptions of men's bodies that could be used to evaluate opposite-sex appearance ideals and weight-related judgements of health, as has been assessed using existing figure scales (Furnham et al., 2006; Greenleaf et al., 2004; Henss, 1995). There is evidence to suggest comparable judgements of male and female bodies among men and women, as well as similar sociocultural preferences for the ideal male and female body (Crossley et al., 2012; Swami & Tovée, 2005), therefore it could be hypothesised that opposite-sex judgements of body size would show a similar pattern.

Previous research has explored the JND of men's dichotomous categorical muscularity judgements from 'scrawny' to 'muscular' (Talbot, Smith, & Cass, 2019), but not men's ability to visually detect differences in muscularity between bodies across a wide stimuli range. Therefore, it would be valuable to conduct a similar method of constant stimuli to estimate the JND of muscularity, for the development of perceptually-spaced figure scales that vary along this dimension. These scales could be used to assess men's perceptual and attitudinal body image relating to muscularity, and may provide more specific and sensitive estimates than those derived from existing linear figure scales (Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019). Finally, future studies could also apply eye-tracking techniques to identify areas of male bodies that men use as visual cues when comparing body size between pairs of figures. Previous research has used eye movement analysis to identify several visual cues to BMI relating to attractiveness and body size judgements of female bodies (Cornelissen, Hancock, et al., 2009; George et al., 2011; Irvine, McCarty, Pollet, et al., 2019; Tovée & Cornelissen, 2001). Similar research using these JND-based male figure scales could provide explanations for differences in the accuracy of participants' body size discriminations and their ability to order the figure scales by BMI (Talbot, Smith, & Cass, 2019). It would also be interesting to investigate men’s visual attention and the use of visual cues when comparing body size between pairs of male bodies in a more realistic setting. Future research could present the computer-generated figures in virtual reality and explore potential differences in the JND of body size and/or the reliability and validity of these figure scales when bodies are presented as life-sized, 3D objects, rather than in a 2D format from a three-quarter viewpoint.

3.6 Study 2: Aims and Objectives

Study 2 aimed to pilot test the reliability and validity of the new JND-based male figure scales in assessing estimations of perceived current and ideal body size among a general sample of adult men. Estimations using the 9-figure and 13-figure scales were compared to those using an interactive computer-based version of the figure scale, with a larger number of figures and smaller systematic increments in BMI between bodies.

The main objectives for this study were:

1. To assess and compare men’s estimations of their perceived current and ideal body size using the 9-figure scale, 13-figure scale, and computerised interactive body scale
2. To estimate and compare indices of body dissatisfaction and body image distortion using each body scale
3. To evaluate the face validity, convergent validity and concurrent validity of all three versions of the male figure scale
4. To evaluate the test-retest reliability of all three versions of the male figure scale.

3.7 Study 2: Methods

A favourable ethical opinion was granted for this study by the University of Lincoln’s Ethics Application System (LEAS) on the 16th October 2019 (PSY181949).

3.7.1 Participants

Thirty-four adult men were recruited for this pilot study using posters, social media invitations, the University of Lincoln online staff news page, the SONA system and word-of-mouth. Students who signed up for this study through SONA were rewarded with 3 credit points towards their degree requirements for participating in the first session, and 1 credit point for taking part in the second session.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 to 45 years
2. Participants who self-identify as male (cis-gender/as assigned at birth)

Participant exclusion criteria for this study were as follows:

1. Participants with a current or previous diagnosis of an eating or body image disorder

3.7.2 Materials

3.7.2.1 Stimuli Creation

The 9-figure and 13-figure male body scales developed in Study 1 (Section 3.4.3) were printed as 8 x 6-inch high-quality photographs and laminated to be used as cards in this study (Figures 3.4 and 3.5). The images were labelled using a sequence of numbers at the back of each photograph to identify the version of the body scale to which it belonged, as well as its position within the body scale when ordered by BMI. This identification sequence was designed to appear as a set of randomly chosen numbers to ensure that participants could not identify the location of each individual image within the body scales.

A computer-based interactive version of the body scale was also presented to participants in MATLAB using the Psychophysics Toolbox extension (Brainard, 1997; Pelli, 1997). This interactive tool allowed participants to scroll through bodies, representing the same range of BMI, using the left and right arrow keys on a keyboard. A total of 110 images from the original 310-frame sequence were included in this version, with the figures representing a BMI range of 16.5 to 43.75 kg/m^2, in steps of 0.25 kg/m^2. The use of the arrow keys was counterbalanced so that half the participants used the right arrow key to view a body at a higher BMI and half used the left arrow key to do the same.

Figure 3.4

The 9-Figure Male Body Scale

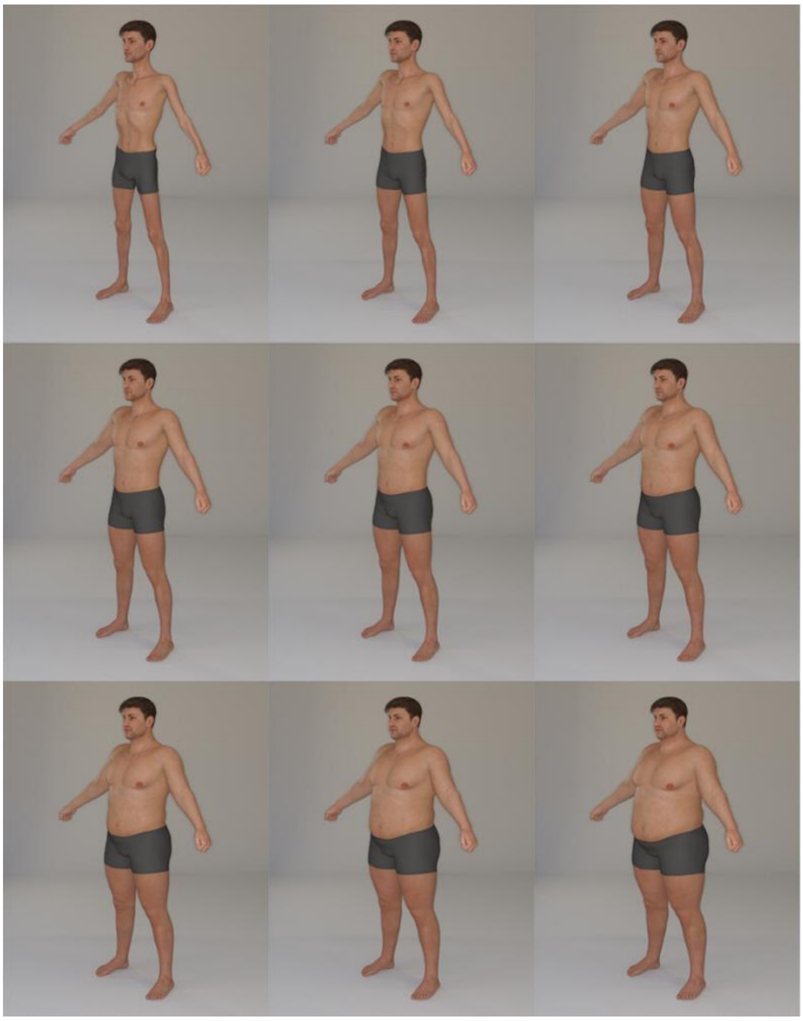
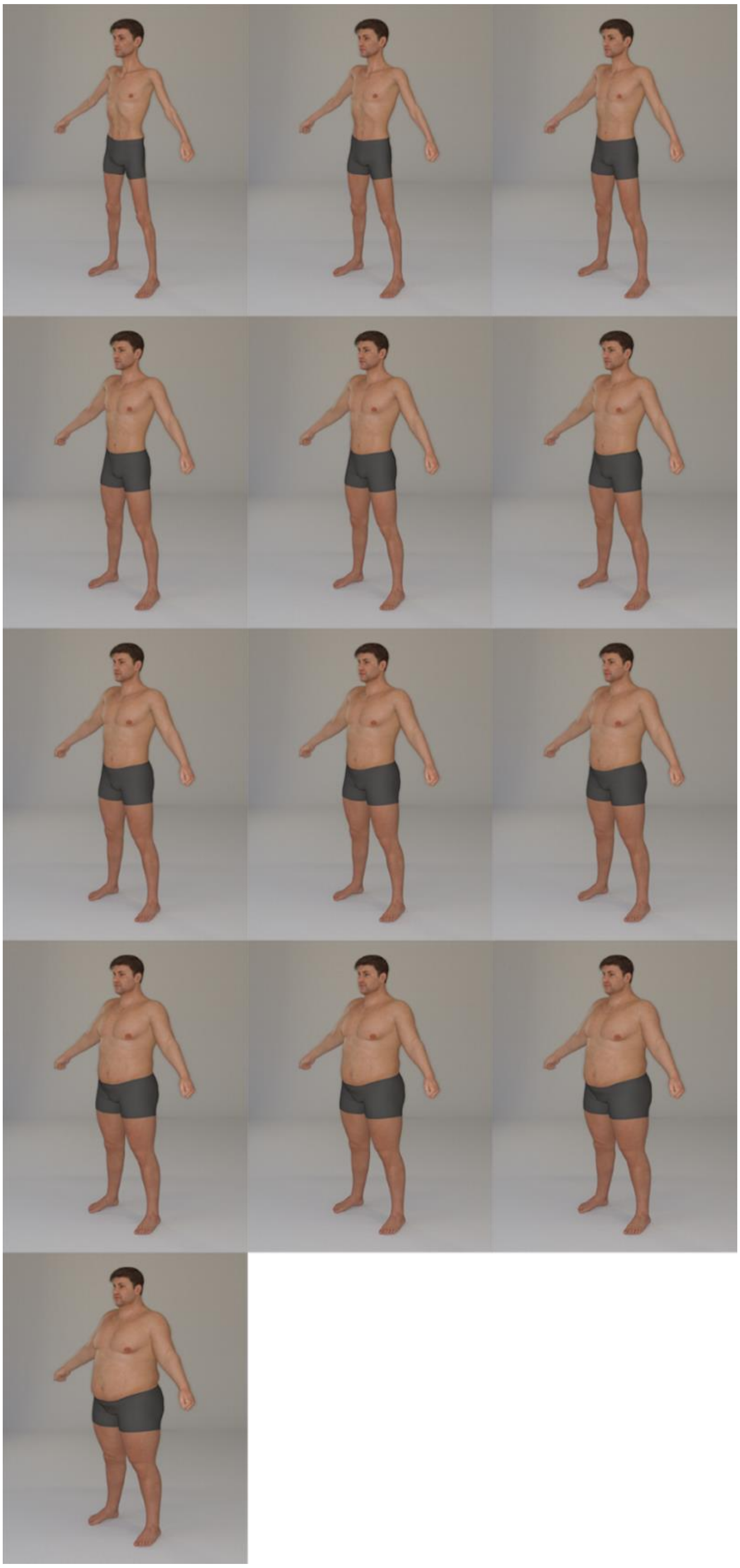


Figure 3.5

The 13-Figure Male Body Scale



3.7.2.2 Psychometric Measures

A variety of self-report questionnaires were used to assess psychological factors relating to perceptual body image, including body shape concerns, body dissatisfaction, the internalisation of thin- and athletic-ideals, levels of depression and self-esteem. These are described in more detail within the general methods section of this thesis (Chapter 2, Section 2.5).

Body Dissatisfaction. The MBAS (Tylka et al., 2005) was administered to measure men's general body dissatisfaction, as well as preoccupation with their body fat and muscularity. The low body fat and muscularity subscales demonstrated a Cronbach's alpha of .82 and .87 respectively. The shape and weight concern subscales of the EDE-Q (Fairburn & Beglin, 1994) were used to assess eating disorder-related attitudes and behaviours, as well as dissatisfaction and distress relating to their own body shape and weight. The Cronbach's alpha for EDE-Q global scores, as well as for the shape concern subscale and weight concern subscale were as follows: .85, .76, .73. The BSQ-16b (Evans & Dolan, 1993) was also used as a measure of general body dissatisfaction and body shape preoccupations, with a Cronbach's alpha of .84 in this study.

Internalisation of Appearance Ideals. The SATAQ-4 (Schaefer et al., 2015) was used to measure individual internalisation of the thin and athletic appearance ideals. The internalisation – thin subscale had a Cronbach's alpha of .68 and the internalisation – athletic subscale had a Cronbach's alpha of .79 in this study.

Depression and Self-Esteem. The BDI (Beck et al., 1961) was administered as a measure of symptoms of depression and the RSE (Rosenberg, 1965) was used to assess levels of self-esteem. The Cronbach's alpha was .87 for the BDI and .93 for the RSE in this sample.

3.7.3 Study Procedures

This study consisted of two laboratory-based sessions to evaluate the reliability and validity of the new male figure scales. Participants who expressed interest in the study were provided with either an electronic or hard-copy information sheet (Appendix B.4) detailing the aims of the research, study procedure, possible benefits and risks, confidentiality, relevant support resources and researcher contact information. They were informed that the first session would take approximately 35 minutes and that they would be invited back two-to-three days later for a second session that would take around 15 minutes.

At the start of the first session, participants provided written consent (Appendix B.5) and personal demographic information, including their age, sex (cis/as assigned at birth), ethnicity, and whether or not they had a current or previous diagnosis of an eating disorder. Participants were then asked to complete a series of perceptual body image tasks, using the card and computer-based versions of the male figure scale. For both the 9-figure and 13-figure scales, participants were asked to order the images by figure BMI. The cards were given to the participants in a random order and they were instructed to place the cards on a desk in ascending order from the smallest to largest body size. The order of the figures was then recorded by the researcher using the identification numbers at the back of each card. Next, participants were asked to select the body that most closely represented both their ideal and current body size, using each of the 9-figure and 13-figure scales individually. Using the interactive computer-based scale, participants were also asked to select the body that mostly closely represented their current and ideal body size using the keyboard. The computer task required participants to make their figure selections twice, alternating between the current and ideal tasks, and this was counterbalanced so that half the participants started with the current body task and the other half began with the ideal body task. Additionally, the BMI of the figure that was initially presented to participants during each trial was randomised, in order to minimise any potential anchoring effects. The order in which participants were presented with the three versions of the scale (9-figure card scale, 13-figure card scale and the interactive scale) was also randomised, as well as the order in which participants conducted the perceptual body size tasks to control for potential order effects.

Following the perceptual tasks, participants were asked to complete a range of psychological questionnaires measuring levels of depression, self-esteem, body dissatisfaction, body shape preoccupations and attitudes towards eating. These questionnaires were presented to participants on a computer screen using an online Qualtrics survey, and the order in which they were presented was randomised. Finally, anthropometric measurements were taken using a Tanita MC-780MA bio-impedance scale, stadiometer and tape measure, including waist (cm), hip (cm), chest (cm) and right bicep (cm) circumferences, and BMI (Chapter 2, Sections 2.4 and 2.6).

In the second session, two-to-three days later, participants were asked to complete the same perceptual body image tasks as in the first session, using all three body scales. The procedure for these tasks was identical in both sessions, with randomisation of the order of the tasks and scale versions used. At the end of the second session, participants were provided with a written debrief form (Appendix B.6) reiterating the aims of the study, confidentiality, data withdrawal procedures, relevant resources and their personal identification code.

3.7.4 Data Analysis

All data analysis for this pilot study was conducted using IBM SPSS Statistics software (Version 26.0). Descriptive statistics were computed for participant demographics, anthropometrics and psychometric scores, as well as the perceived current and ideal BMI estimations for the sample. An index of body dissatisfaction (BD) was then calculated for each participant, by subtracting their perceived current BMI estimation from their ideal BMI estimation in each session. An index of body image distortion (BID) was also derived from subtracting the participant's actual BMI from their perceived current BMI in each session. These indices were calculated separately for responses using all three versions of the figure scale. Participants' actual BMI measurements from session 1 were used to attain the estimates of BID in session 2, given that these measurements were only taken in the first session and were unlikely to have changed in the two-to-three day interval between sessions.

Spearman rank correlations were used to assess the relationships between the psychometric measures, as well as between participants' actual BMI and their attitudinal body image. ANOVAs with repeated measures were then carried out to determine whether there were any statistically significant differences in mean estimations of perceived current body size and ideal body size, as well as for BD and BID, between the three scales. The frequency and proportion of correct responses made by participants when ordering the card scales by body size were used to assess visual discriminations of BMI between the figures in each scale. The concurrent and convergent validity of each version of the scale were assessed through a series of correlations between participants' body estimations, actual BMI, BD, BID and psychometric scores. Finally, the internal reliability of each scale was determined by Pearson and intraclass correlations for estimations of perceived current body size, ideal body size, BD and BID between sessions 1 and 2. The intraclass correlations used a two-way mixed-effects model based on average ratings and absolute agreement to assess test-retest reliability. All intraclass correlation coefficients were compared to a recommended .80 standard for test-retest reliability (Carmines, 1990), while all Pearson correlation coefficients were compared to an adequate result of .70 (Terwee et al., 2007; Nunnally, 1970).

3.8 Study 2: Results

3.8.1 Participant Characteristics

A total of 34 adult men aged 18 to 45 (*M* = 24.21, *SD* = 4.86) were recruited for this study, with 30 participants in the sample completing the follow-up session two-to-three days later. The sample was predominantly of Caucasian ethnicity (80%) and ranged in BMI from 17.86 to 34.99 kg/m^2 (*M* = 25.10, *SD* = 4.05). Table 3.8 presents the range, means and standard deviations for the anthropometric measurements across the total sample.

Table 3.8

Participant Anthropometric Measurements

Measurement	Total sample (N = 34)			
	Mean	SD	Min.	Max.
Chest (cm)	97.50	10.81	80.00	122.00
Waist (cm)	87.09	11.71	70.00	115.00
Hip (cm)	102.68	9.62	87.40	128.00
Bicep (cm)	31.13	4.02	22.00	39.50
BMI (kg/m^2)	25.10	4.05	17.86	34.99

3.8.1.1 Psychological Factors

Means and standard deviations of the psychometric scores for all participants in the sample are shown in Table 3.9. Spearman's rank correlations were conducted to assess relationships between the psychometric measures of body dissatisfaction, appearance ideal internalisation, depression and self-esteem (Table 3.10). As would be expected, a statistically significant negative correlation was found between measures of depression and self-esteem ($p < .001$). Both self-esteem and depression significantly correlated with measures of body dissatisfaction, including BSQ-16b, the MBAS muscularity subscale and both EDE-Q subscales ($p < .050$). The SATAQ-4 internalisation – thin subscale was found to significantly relate to body shape concerns, measured by the BSQ-16b ($p = .004$) and EDE-Q shape concern subscale ($p = .014$), and preoccupations with low body fat, assessed by the MBAS low body fat subscale ($p < .001$). Alternatively, the SATAQ-4 internalisation – athletic subscale did not significantly correlate with the other psychometric measures ($p > .050$). Similarly, the MBAS low body fat subscale showed significant relations with the BSQ-16b ($p < .001$), EDE-Q global scores ($p = .002$) and EDE-Q shape concern subscale ($p < .001$), whereas the MBAS muscularity subscale only correlated with the BSQ-16b (*p* < .015). Finally, the BSQ-16b, EDE-Q global scores and both EDE-Q subscales were all significantly positively correlated with each other (*p* < .001). Correlations were also used to assess the relationship between participants' actual BMI and their psychometric scores. No significant correlations were found between participants' actual BMI and any of the psychometric measures in this sample (*p* > .050).

Table 3.9

Means, Standard Deviations and Range of Psychometric Measures

Measures	Total sample (N = 34)			
	Mean	SD	Min.	Max.
BDI	8.44	7.30	0.00	28.00
SATAQ-4: Athletic	3.56	0.86	1.80	5.00
SATAQ-4: Thin	2.53	0.80	1.00	4.60
MBAS: Muscularity	2.85	0.84	1.64	5.14
MBAS: Low body fat	2.72	0.76	1.67	4.50
RSE	21.00	6.51	8.00	30.00
BSQ-16b	31.50	10.35	16.00	59.00
EDE-Q: Shape concern	1.58	1.13	0.00	3.88
EDE-Q: Weight concern	1.43	1.26	0.00	4.80
EDE-Q: Global	1.22	0.81	0.00	2.98

Table 3.10

Spearman's Correlations Between Psychometric Measures

	Measures								
	1	2	3	4	5	6	7	8	9
1. BDI	1.00								
2. SATAQ-4: Athletic	-.12	1.00							
3. SATAQ-4: Thin	-.11	.80	1.00						
4. MBAS: Muscularity	.42*	.15	.15	1.00					
5. MBAS: Low body fat	.17	.24	.60**	.12	1.00				
6. RSE	-.70**	.10	-.07	-.56**	-.17	1.00			
7. BSQ-16b	.43*	.18	.48**	.41*	.71**	-.51**	1.00		
8. EDE-Q: Shape concern	.43*	.08	.42*	.32	.63**	-.49**	.74**	1.00	
9. EDE-Q: Weight concern	.46**	.01	.21	.22	.30	-.46**	.53**	.77**	1.00
10. EDE-Q: Global	.31	.15	.28	.04	.52**	-.30	.58**	.77**	.78**

* $p < .05$, ** $p < .01$

3.8.2 Comparison of Figure Scales

3.8.2.1 Current and Ideal Body Estimations

Table 3.11 presents the means and standard deviations for participants' perceived current and ideal BMI estimations using all three versions of the figure scale in session 1 and session 2. Spearman's correlations were used to evaluate associations of participants' perceived current and ideal body size between the different scales. Significant positive correlations were found between all versions of the scale for the perceived current body size estimations in sessions 1 and 2 (Table 3.12). Furthermore, significant positive correlations were also found between all scale versions for the ideal body size estimations in both sessions (Table 3.13).

ANOVAs with repeated measures were carried out to determine whether there were any statistically significant differences in mean perceived current and ideal body size estimations between the three figure scales. In session 1, Mauchly's tests revealed that the perceived current estimations ($X^2(2) = 3.82$, $p = .148$) and ideal estimations ($X^2(2) = 0.06$, $p = .972$) did not indicate any violation of sphericity. The mean estimations for perceived current body size were not statistically significantly different between the three scale versions ($F(2, 66) = 2.55$, $p = .086$). For ideal body size estimations, mean estimations were again not significantly different between each version of the scale ($F(2, 66) = 2.84$, $p = .066$).

In session 2, Mauchly's tests showed that the perceived current ($X^2(2) = 0.68$, $p = .712$) and ideal estimations ($X^2(2) = 4.38$, $p = .112$) did not indicate any violation of sphericity. ANOVAs with repeated measures demonstrated that there were no statistically significant differences in the mean perceived current estimations between the different versions of the scale ($F(2, 58) = 1.19$, $p = .311$). Similarly, no statistically significant differences were found for ideal body size estimations between the different versions of the scale ($F(2, 58) = 0.69$, $p = .505$).

Table 3.11

Means and Standard Deviations for Perceived Current & Ideal BMI Estimations

Scale	Session 1 (n = 34)		Session 2 (n = 30)	
	Current	Ideal	Current	Ideal
Interactive tool	23.89 (5.15)	22.59 (2.35)	23.24 (4.15)	22.40 (3.46)
9-figure scale	24.80 (4.60)	22.82 (1.97)	23.71 (4.11)	22.88 (1.60)
13-figure scale	24.34 (5.11)	23.10 (2.33)	23.46 (4.39)	22.94 (2.37)

Table 3.12

Correlations for Perceived Current Body Size Estimations Between Scales

Scale	Session 1 (n = 34) / Session 2 (n =30)		
	Interactive tool	9-figure scale	13-figure scale
Interactive tool	1.00 / 1.00		
9-figure scale	.95** / .94**	1.00 / 1.00	
13-figure scale	.95** / .93**	.93** / .93**	1.00 / 1.00

** *p* < .01

Table 3.13

Correlations for Ideal Body Size Estimations Between Scales

Scale	Session 1 (n = 34) / Session 2 (n =30)		
	Interactive tool	9-figure scale	13-figure scale
Interactive tool	1.00 / 1.00		
9-figure scale	.66** / .62**	1.00 / 1.00	
13-figure scale	.63** / .80**	.58** / .49**	1.00 / 1.00

** *p* < .01

3.8.2.2 Body Image Distortion and Dissatisfaction Estimations

Body image distortion (BID) was calculated as the discrepancy between a participant's actual BMI and their perceived body size using each scale in sessions 1 and 2, where negative scores indicate a perceived current body with a smaller BMI than the participant's actual BMI. Body dissatisfaction (BD) was indexed by the discrepancy between a participant's ideal and current body size estimations using each scale in sessions 1 and 2, where negative scores indicate an ideal body with a smaller BMI than their perceived current body. Table 3.14 presents the means and standard deviations for the estimations of BID and BD in sessions 1 and 2.

Spearman's correlations were used to evaluate associations of estimations of BID and BD between the different scales in each session. Significant positive correlations were found between all versions of the scale for the BID estimations in session 1 and 2 (Table 3.15). Similarly, significant positive correlations were also found between all scale versions for BD estimations in both sessions (Table 3.16). A series of ANOVAs with repeated measures were again used to examine whether there were any significant differences between all three versions of the figure scale for estimations of BD and BID in session 1 and 2. Mauchly's tests revealed that the estimations of BD did not indicate any violation of sphericity in session 1 ($X^2(2) = 3.93$, $p = .140$) and session 2 ($X^2(2) = 3.70$, $p = .158$). The mean BD estimations in the sample were not statistically significantly different between the three scale versions in both session 1 ($F(2, 66) = 0.61$, $p = .549$) and session 2 ($F(2, 58) = 0.31$, $p = .737$). Mauchly's tests showed that the estimations of BID also did not indicate any violation of sphericity in session 1 ($X^2(2) = 3.76$, $p = .150$) and session 2 ($X^2(2) = 0.68$, $p = .712$). The mean BD estimations in the sample were again not significantly different between the three scale versions in sessions 1 ($F(2, 66) = 2.31$, $p = .111$) and 2 ($F(2, 58) = 1.19$, $p = .308$).

Table 3.14

Means and Standard Deviations for BD and BID Estimations in Each Session

Scale	Session 1 (n = 34)		Session 2 (n = 30)	
	BD	BID	BD	BID
Interactive tool	-1.30 (3.31)	-1.26 (4.73)	-0.84 (3.24)	-1.42 (4.50)
9-figure scale	-1.43 (4.21)	-0.59 (4.74)	-0.83 (3.89)	-0.95 (4.44)
13-figure scale	-1.07 (4.01)	-0.81 (5.06)	-0.52 (3.03)	-1.20 (4.55)

Table 3.15

Correlations for BID Estimations Between Scales

Scale	Session 1 (n = 34) / Session 2 (n =30)		
	Interactive tool	9-figure scale	13-figure scale
Interactive tool	1.00 / 1.00		
9-figure scale	.90**/ .89**	1.00 / 1.00	
13-figure scale	.91**/ .93**	.88**/ .92**	1.00 / 1.00

** $p < .01$

Table 3.16

Correlations for BD Estimations Between Scales

Scale	Session 1 (n = 34) / Session 2 (n =30)		
	Interactive tool	9-figure scale	13-figure scale
Interactive tool	1.00 / 1.00		
9-figure scale	.91**/ .78**	1.00 / 1.00	
13-figure scale	.93**/ .58**	.91**/ .87**	1.00 / 1.00

** $p < .01$

3.8.3 Face Validity

The accuracy of participant responses when ordering each of the card scales was used to assess visual discriminations of BMI between figures in the scales. Table 3.17 presents the mean, range and standard deviation for the frequency and proportion (%) of correct responses when ordering each of the card scales in body size from smallest to largest. A total of 20 participants correctly ordered all of the figures in the 13-figure scale in both session 1 (58.82%) and session 2 (66.67%). A total of 31 participants correctly ordered the 9-figure scale in session 1 (91.18%) and 28 participants in session 2 (93.33%). The 9-figure scale averaged 8.85 (98.3%) correctly ordered figures across the two sessions, while the 13-figure scale showed a slightly lower proportional average of 11.84 (91.08%) correct responses for the sample across the two sessions. Tables 3.18 and 3.19 show the total number of incorrect responses made across the sample for each figure within the card scales in sessions 1 and 2. For the 9-figure scale, it is clear that the majority of errors were made near the middle of the BMI range, with the highest frequency of errors for the figures with BMIs of 23.5 and 26.5 kg/m^2 (Figures 3.6 and 3.7). Alternatively, errors in ordering the 13-figure scale showed a bimodal distribution with the highest frequency of errors in the normal weight BMI range, especially for figures with BMIs of 22.75 and 24.5 kg/m^2, and the obese BMI range, for figures with BMIs of 34.25, 37 and 40.25 kg/m^2 (Figures 3.8 and 3.9).

Table 3.17

Frequency and Proportion of Correctly Ordered Figures for the Card Scales in Each Session

Scale	Session 1 (n = 34)				Session 2 (n = 30)			
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD
9-figure scale								
Frequency	7.00	9.00	8.83	0.57	7.00	9.00	8.87	0.51
Proportion	77.78	100.00	98.10	6.31	77.78	100.00	98.52	5.64
13-figure scale								
Frequency	5.00	13.00	11.68	2.10	3.00	13.00	12.00	2.03
Proportion	38.46	100.00	89.82	16.15	23.08	100.00	92.31	15.65

Table 3.18

Total Number of Incorrect Responses for Each Figure of the 9-Figure Scale in Each Session

Figure number	Figure BMI	Incorrect responses		
		Session 1	Session 2	Total
1	16.50	0	0	0
2	18.50	0	0	0
3	20.75	1	0	1
4	23.50	2	2	4
5	26.50	1	2	3
6	29.75	1	0	1
7	33.50	1	0	1
8	38.00	0	0	0
9	43.00	0	0	0

Figure 3.6

Total Error Frequency for Each Figure of the 9-Figure Scale per Session

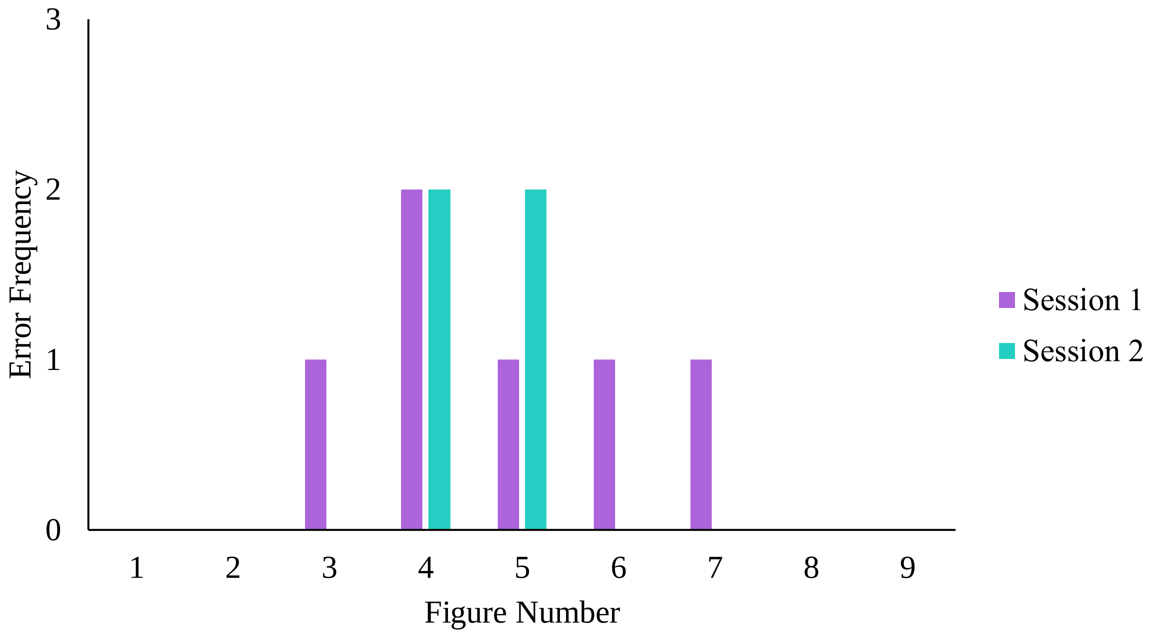
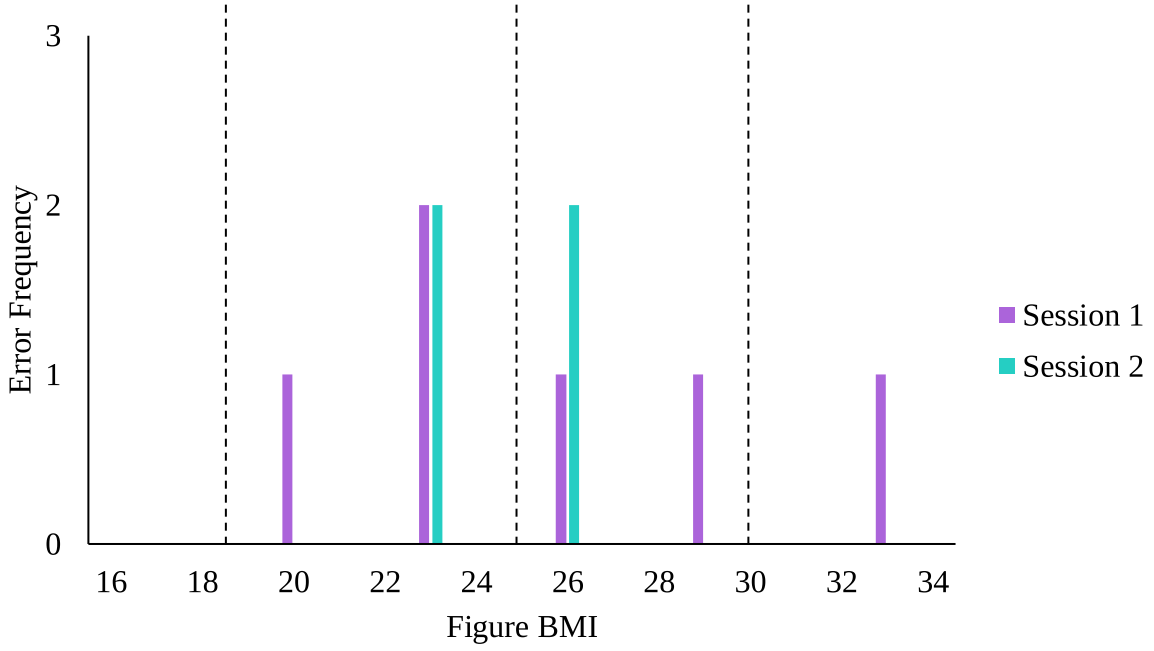


Figure 3.7

Total Error Frequency According to Figure BMI for the 9-Figure Scale per Session



Note. The dotted lines identify the BMI boundaries between the underweight, normal weight, overweight and obese categories.

Table 3.19

Total Number of Incorrect Responses for Each Figure of the 13-Figure Scale in Each Session

Figure number	Figure BMI	Incorrect responses		
		Session 1	Session 2	Total
1	16.5	1	0	1
2	17.5	1	0	1
3	19.25	0	2	2
4	21.00	4	2	6
5	22.75	5	3	8
6	24.50	4	4	8
7	26.75	3	3	6
8	29.00	3	2	5
9	31.50	3	3	6
10	34.25	4	5	9
11	37.00	6	3	9
12	40.25	7	2	8
13	43.75	4	1	5

Figure 3.8

Total Error Frequency for Each Figure of the 13-Figure Scale per Session

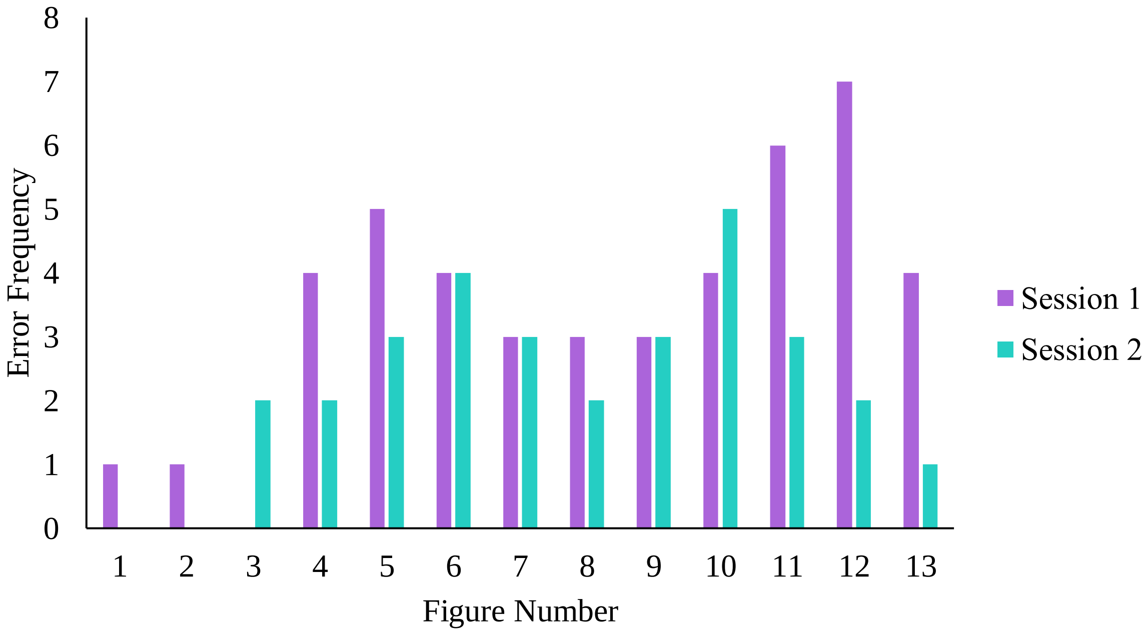
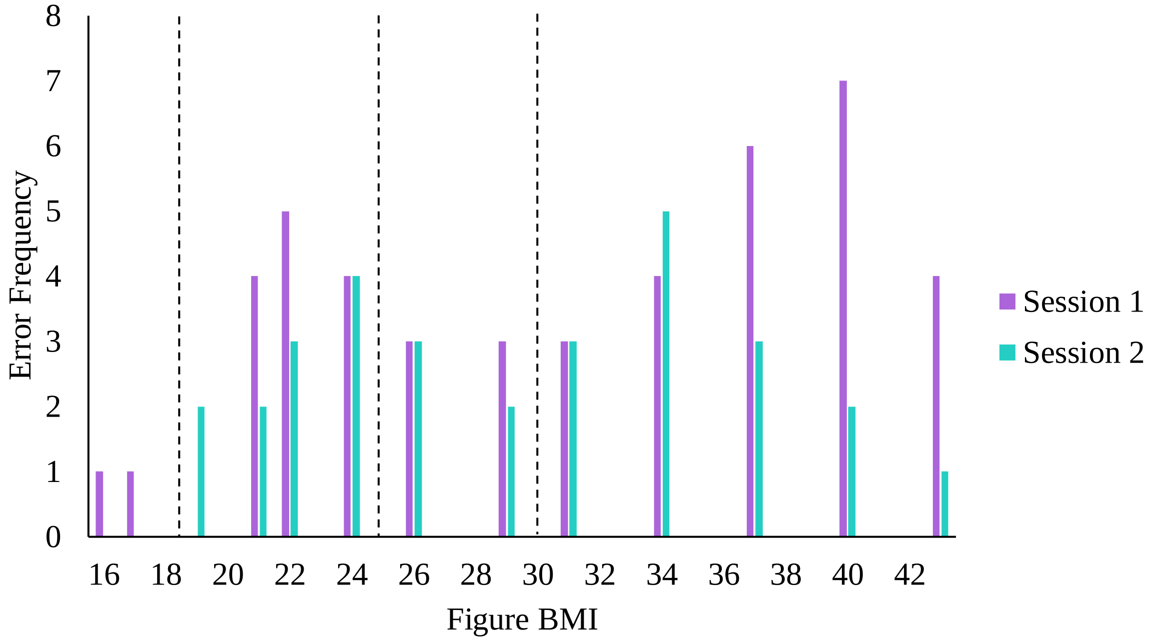


Figure 3.9

Total Error Frequency According to Figure BMI for the 13-Figure Scale per Session



Note. The dotted lines identify the BMI boundaries between the underweight, normal weight, overweight and obese categories.

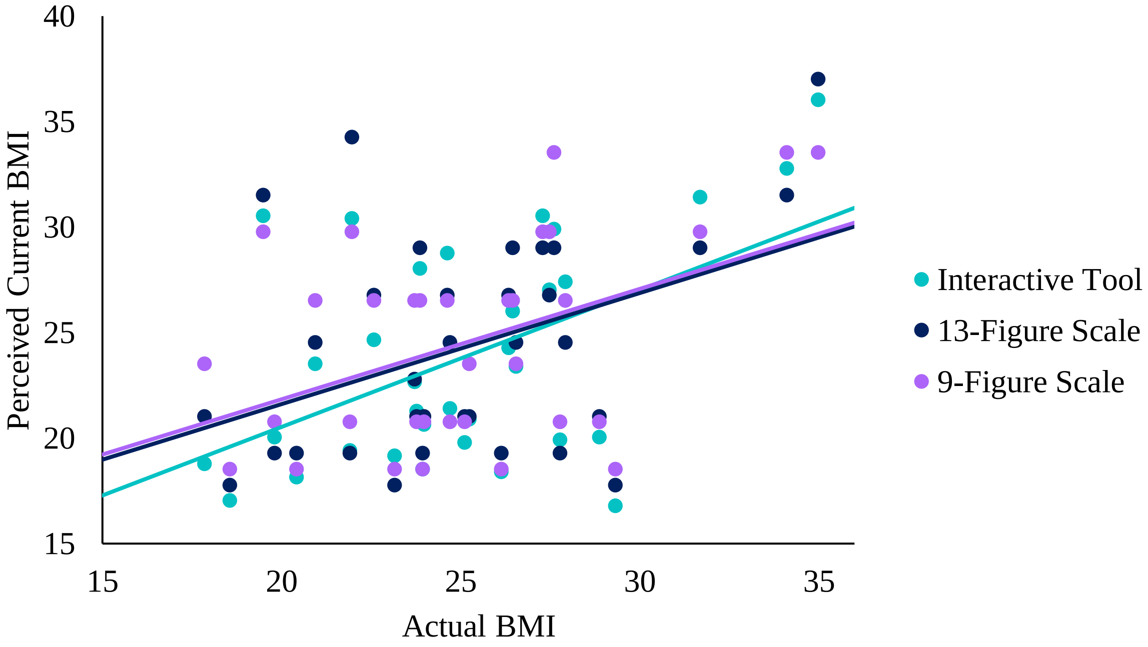
3.8.4 Convergent Validity

Correlational analysis was used to assess the relationship between participant's actual BMI and their perceived current BMI estimation for each scale in sessions 1 and 2. In session 1, there was a significant positive correlation between participants' actual BMI and perceived current BMI using the interactive tool (r_s = .37, p = .033). However, nonsignificant relationships between actual and perceived BMI were found when using the 13-figure scale (r_s = .31, p = .082) and 9-figure scale (r_s = .33, p = .064). To check whether these nonsignificant associations were due to a lack of statistical power, post-hoc power analyses were performed in G*Power 3.1.9.6 (Faul et al., 2009) using the effect sizes from this pilot study. The effect sizes of .31 for the 13-figure scale and .33 for the 9-figure scale were considered to be medium using Cohen's (1988) criteria. Based on a power of .80 and an alpha level of .05, the projected sample size needed to obtain statistical power in future trials with an effect size of .31 was approximately 63 men using the 13-figure scale. Based on a power of .80 and an alpha level of .05, the projected sample size needed with an effect size of .33 was approximately 55 men using the 9-figure scale.

In session 2, nonsignificant correlations were found between actual BMI and perceived current BMI using the interactive tool (r_s = .20, p = .278), 13-figure scale (r_s = .24, p = .194) and 9-figure scale (r_s = .24, p = .204). Statistical power analyses were again performed for sample size estimation based on the effect sizes from session 2 of this pilot study. The effect sizes of .20 for the interactive scale and .24 for the 13-figure and 9-figure scales were considered to be small using Cohen's (1988) criteria. Based on a power of .80 and an alpha level of .05, the projected sample size needed in future trials to reach statistical significance with an effect size of .20 was approximately 253 men using the interactive scale. Based on a power of .80 and an alpha level of .05, the projected sample size needed to reach statistical significance with an effect size of .24 was approximately 106 men using the 13-figure and 9-figure scales.

Figure 3.10

Scatter Plot of Relationship Between Actual BMI and Perceived Current BMI in Session 1



3.8.5 Concurrent Validity

To evaluate the concurrent validity of each scale, Spearman's correlations were used to assess the relationship between participants' perceptual body estimations using the scales and their attitudinal body image.

3.8.5.1 Current and Ideal Body Estimations

In session 1, perceived current body estimations using the interactive tool and 9-figure scale were significantly positively correlated with EDE-Q global scores ($p < .05$) and the MBAS low body fat subscale ($p < .001$), and negatively correlated with the MBAS muscularity subscale ($p < .001$). Current estimations using the 13-figure scale were also significantly correlated with the MBAS muscularity subscale ($r_s = -.39$, $p = .024$) and low body fat subscale ($r_s = .43$, $p = .011$). Participants' ideal body estimations using the interactive tool were significantly correlated with the MBAS muscularity subscale ($r_s = -.45$, $p = .008$). However, no significant associations were found between ideal estimations using either of the JND-based scales with participant's psychometric scores ($p > .05$).

In session 2, perceived current body estimations using the interactive tool and 9-figure scale were significantly correlated with both the MBAS subscales ($p < .050$), while estimations using the 13-figure scale were significantly correlated with the MBAS muscularity subscale only ($r_s = -.45$, $p = .013$). Again, a significant correlation was found between participant ideal body estimations using the interactive tool and the MBAS muscularity subscale ($r_s = -.37$, $p = .045$). No significant correlations were revealed between ideal estimations and psychometric scores using the 9-figure or 13-figure scales ($p > .05$).

3.8.5.2 Body Image Distortion and Body Dissatisfaction Estimations

In session 1, BD estimations using the interactive tool were significantly negatively correlated with the MBAS low body fat subscale ($r_s = -.59$, $p < .001$), the EDE-Q shape concern subscale ($r_s = -.37$, $p = .030$) and EDE-Q global scores ($r_s = -.46$, $p = .007$). They were also positively correlated with the MBAS muscularity subscale ($r_s = .46$, $p = .038$). Similarly, BD estimations using the 13-figure scale were also significantly correlated with the EDEQ shape concern subscale ($r_s = -.34$, $p = .050$), EDE-Q global scores ($r_s = -.39$, $p = .025$), MBAS muscularity subscale ($r_s = .41$, $p = .017$) and the MBAS low body fat subscale ($r_s = -.53$, $p = .001$). BD estimations using the 9-figure scale showed a significant correlation with the EDE-Q global scores only ($r_s = -.38$, $p = .028$).

In session 2, BD estimations using the interactive tool did not significantly correlate with any of the psychometric measures ($p > .05$). However, BD estimations using the 13-figure scale significantly correlated with the MBAS muscularity subscale ($r_s = .36$, $p = .048$) and low body fat subscale ($r_s = -.45$, $p = .013$), while those attained using the 9-figure scale were significantly associated with the MBAS low body fat subscale ($r_s = -.50$, $p = .005$). In addition, participant BID estimations using all three scales were significantly positively correlated with the MBAS low body fat subscale ($p < .05$) in sessions 1 and 2.

3.8.6 Test-Retest Reliability

3.8.6.1 Current and Ideal Body Estimations

Spearman's correlations were conducted to assess the internal consistency of all three versions of the scale for the perceived current and ideal body estimations between sessions 1 and 2. For the interactive tool, excellent reliability was found for the current body estimations ($r_s = .94$, $p < .001$), and adequate reliability for the ideal body estimations ($r_s = .75$, $p < .001$). For the smaller 9-figure scale, excellent reliability was again found for the current body estimations ($r_s = .95$, $p < .001$), while the ideal body estimations demonstrated adequate reliability ($r_s = .74$, $p < .001$). Lastly, the larger 13-figure scale revealed excellent reliability for the current body estimations ($r_s = .93$, $p < .001$), however the reliability for the ideal body estimations was poor ($r_s = .49$, $p = .005$).

Intraclass correlation coefficients (ICC) were also used to evaluate associations of the body estimations between the initial session and the follow-up two-to-three days later. Table 3.20 presents the ICC and confidence intervals for perceived current and ideal body size estimations between sessions 1 and 2. The ICC's for current body estimations were excellent for all versions of the scale (> .90), while the ICC's for the ideal body estimations were adequate for the 9-figure scale but poor for the other measures (< .80). All intraclass correlations were statistically significant ($p < .01$).

3.8.6.2 Body Image Distortion and Dissatisfaction Estimations

Spearman's correlations were also conducted to assess the test-retest reliability of all three versions of the scale for estimations of BID and BD between sessions 1 and 2. In terms of BD, the interactive tool demonstrated adequate reliability ($r_s = .74$, $p < .001$), and both the 13-figure scale ($r_s = .88$, $p < .001$) and 9-figure scale ($r_s = .87$, $p < .001$) presented good reliability. BID estimations showed good to excellent internal consistency for the interactive tool ($r_s = .89$, $p < .001$), 13-figure scale ($r_s = .87$, $p < .001$) and the smaller 9-figure scale ($r_s = .93$, $p < .001$).

ICC's were also used to assess associations between all three scales for estimations of BD and BID in the sample. Again, Table 3.20 presents the ICC and confidence intervals for BID and BD estimations between sessions 1 and 2. The ICC's for estimations of BID were excellent for all versions of the scale (> .90), while the ICC's for BD were excellent for the two JND-based scales (> .90) and adequate for the interactive tool (> .80). All intraclass correlations were statistically significant (*p* < .01).

Table 3.20

Intraclass Correlations and Confidence Intervals for Current, Ideal, BD and BID Estimations

Scale	Current		Ideal		BD		BID	
	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI
Interactive tool	.96	.92 - .98	.74	.45 - .88	.83	.64 - .92	.96	.92 - .98
9-figure scale	.96	.92 - .98	.83	.64 - .92	.92	.82 - .96	.96	.91 - .98
13-figure scale	.95	.90 - .98	.72	.41 - .87	.90	.80 - .96	.97	.93 - .99

3.9 Study 2: Discussion

3.9.1 Summary and Interpretation of Main Findings

Study 2 aimed to assess estimations of perceived current and ideal body size, as well as body dissatisfaction and body image distortion, among a general sample of 34 adult men using the JND-based figure scales developed in Study 1 (Section 3.4.3). A range of psychometric measures were administered to characterise the attitudinal body image of this sample. Comparing the mean scores for the SATAQ-4 and MBAS muscularity-focused subscales to the body fat-focused subscales demonstrated generally higher internalisation and preoccupation with achieving a muscular body ideal than a lean body ideal. The mean total score for the BSQ-16b was within the ‘no concern’ category, according to commonly used cut-off points (Evans & Dolan, 1993), demonstrating little body dissatisfaction across the sample. However, two participants presented BSQ-16b scores categorised as exhibiting ‘moderate concerns’. The mean EDE-Q shape and weight concern subscale scores and global score in this sample were similar to those found in a community sample of 404 men (Lavender et al., 2010). The mean BDI score was within the range expected among people experiencing ‘normal ups-and-downs’, although two participants reported depression levels in the ‘moderate depression’ category (Beck et al., 1961). Similarly, the mean RSE score in the sample was within the ‘normal self-esteem’ range (Rosenberg, 1965), although again two individuals’ scores were considered to show low self-esteem. The participant exclusion criteria for this study did not include specified levels of depression, self-esteem or body concerns based on the self-reported measures, so the participants with clinically meaningful psychometric scores were kept in the sample for data analysis.

In this study, the 9-figure and 13-figure scales developed in Study 1 (Section 3.4.3) were compared to an interactive computer-based figure scale that presented 110 bodies ranging in BMI from 16.5 to 43.75 kg/m^2, in steps of 0.25 kg/m^2. Significant associations were found between all three versions of the scale for participants' perceived current and ideal body size responses, as well as for estimates of BD and BID, with no significant differences in mean estimations between the scales in either session. This suggests that the figure scales were equivalent in estimating men's perceived current and ideal body size, as well as in assessing levels of BD and BID. Convergent validity was evidenced for the interactive scale through a significant association between participants' actual BMI and their current BMI estimates in session 1. The relationship between actual and perceived BMI was nonsignificant when using each of the JND-based scales in sessions 1 and 2, which could be a result of the sample size in this study, as suggested by power calculations based on these pilot data. In addition, of the four participants who did not attend their second sessions, two individuals had the highest measurements of BMI in the sample (34.99 kg/m^2 and 34.11 kg/m^2), which is likely to have influenced the strength of these correlations. This highlights a need for further research with a larger sample size to evaluate the convergent validity of the scales.

Concurrent validity was evidenced through the correspondence of BD estimations from each of the scales with psychometric measures of body shape concern and body dissatisfaction, specifically with the EDE-Q shape concern subscale, EDE-Q global scores and the two MBAS subscales. Significant correlations between the psychometric measures and BD estimations indicated that men with greater general body shape dissatisfaction and concern, as well as preoccupation with their own adiposity, demonstrated larger discrepancies between their perceived current and ideal body size using the scales. Men who reported less concern and preoccupation with their own muscularity also generally selected an ideal body size that was much smaller than their perceived current body size. This indirect measure of BD has shown significant associations with self-reported psychometric measures of body dissatisfaction in many existing figure scales (Altabe & Thompson, 1992; Swami et al., 2012; Tiggemann, 1996). However, estimations of BD from each of the scales in this study showed nonsignificant associations with participant BSQ-16b, RSE, BDI and SATAQ-4 scores, which again may be a result of the restricted sample size in this study.

There was also correspondence of the psychometric measures of body shape concern and dissatisfaction with participants' current and ideal body perceptions. Men with higher general body shape concerns and specific preoccupations with their adiposity selected larger perceived current bodies, while those with higher preoccupations with their own muscularity selected current bodies with a smaller BMI. Given that BMI is often used as an index for adiposity (Gardner & Brown, 2010), it was expected that men who were more concerned about their own body size or adiposity perceived themselves as having a larger BMI body. A significant relationship was also found between participants' preoccupations with their own muscularity and their ideal body size. Men who were more concerned with their own muscularity selected ideal bodies with a smaller BMI when using the interactive tool, which could be attributed to an established sociocultural appearance ideal for male bodies that is highly lean and muscular (Brierley et al., 2016; Tiggemann et al., 2007). Although, participants' ideal body size perceptions were not significantly associated with the SATAQ-4 subscales, measuring the internalisation of the athletic and thin appearance ideals, in either session of this study.

When ordering the figure scales by BMI as a manipulation check, participants correctly ordered a greater proportion of bodies in the 9-figure scale (98.30%) than the 13-figure scale (91.08%), as would be expected due to the larger BMI separations between bodies in the 9-figure scale. However, the proportion of correct responses was high for both scales. Interestingly, different patterns of error were evidenced for the two scales, with errors in ordering the 9-figure scale showing a unimodal distribution and errors for the 13-figure scale presenting a bimodal distribution across the BMI range. Errors were found predominantly in the normal weight and obese BMI categories across the two scales. The errors in ordering obese bodies in the 13-figure scale are representative of Weber's law-consistent behaviours and suggest that the JND of BMI multiplied by at least 3 may be required when designing figure scales, to ensure that differences between the larger bodies are visually detectable. Errors in ordering the normal weight bodies across both scales may be a result of less prominent visual cues of body size change in these figures. For example, differences in the protrusion of bony landmarks can be seen in the underweight figures, particularly in the emaciation around the ribs, while variation in the adiposity of larger bodies can be seen around the abdomen, especially in relation to the amount of overhang in the stomach. There is evidence that torso width and landmarks inside the body outline are strong cues for BMI (Cornelissen, Hancock, et al., 2009; Tovée & Cornelissen, 2001). Therefore, it could be argued that ordering performance for the normal weight bodies was hindered by a lack of salient visual cues to BMI in the figures.

Finally, there was evidence to support the test-retest reliability of these scales in assessing current body size, ideal body size, BD and BID estimations over a period of two-to-three days. Excellent internal reliability for perceived current BMI estimations was found for all three scales between sessions 1 and 2. Whereas, ideal BMI estimations showed adequate reliability for the 9-figure scale and interactive tool, and poor reliability for the 13-figure scale between the two sessions. Adequate to excellent test-retest reliability was also found between both sessions for BD and BID estimations using both the JND-based scales and the interactive tool.

3.9.2 Strengths and Limitations

This study separately assessed the face validity, convergent validity, concurrent validity and test-retest reliability of all three figure scales over two sessions, based on participants' current and ideal body perceptions, attitudinal body image and measured BMI. The JND-based figure scales used to assess men's current and ideal body perceptions consisted of high-definition CGI figures that varied in size while maintaining a consistent 'identity' in a standardised body position. These CGI stimuli are more realistic and provide more detailed body size and shape information than many existing figure scales consisting of hand-drawn male bodies of different sizes (Cafri & Thompson, 2004; Gardner et al., 2009; Stunkard et al., 1983; Thompson & Gray, 1995). In addition, each figure in the JND-based scales was associated with a specific BMI measurement, allowing for comparisons between the participant's actual BMI and their perceived current or ideal BMI. Many existing scales are unable to estimate BID from the discrepancy between an individual's actual and perceived BMI (Gardner & Brown, 2010; Talbot, Cass, & Smith, 2019), and therefore the capacity of these new scales to determine the occurrence and magnitude of BID allows for additional research opportunities and applications in clinical settings. This is particularly important as BID and BD are considered as separate constructs with little association between them, and thus should be measured independently (Gardner et al., 1998).

The perceptual tasks used in this study were time-efficient, simple to administer and unambiguous, which may be particularly beneficial to clinical assessments where health professionals have limited time with patients (Talbot, Smith, Cass, & Griffiths, 2019). Randomisation was also used throughout the study procedure, including the order of the perceptual tasks, the order of figures presented in each card-based scale, and the order in which the different scales were used in each task, with the aim of minimising anchoring effects in both sessions. There is evidence to suggest that when figures are presented in ascending order from left to right, participants may demonstrate a bias towards the lower BMI bodies on the left (Nicholls et al., 2006; Gardner & Brown, 2010). Presenting the JND-based scale figures in a random order minimised the risk of this bias in participant responses.

Despite having a perceptual basis for the BMI differentiation between bodies, these two JND-based scales still hold some of the common limitations of existing figure scales. For example, the scales provided visual representations of the whole body, but did not consider variation in body size in relation to individual male body parts. Therefore, they cannot be used in clinical or research settings to assess an individual's appearance dissatisfaction or preoccupation with specific areas of their body. The scales also only presented variation in body size from a three-quarter viewpoint, which somewhat limits the richness of body size and shape information available to users, although this has been identified as an optimal viewpoint for identifying the JND of BMI in CGI stimuli (Cornelissen et al., 2018). Similar male figure scales with bodies presented from other viewpoints could be developed using the same method as in Study 1 (Section 3.4.3). Interactive programmes, such as Daz Studio, can be a better method for presenting body size and shape change in different regions of the body and allow the body to be viewed from many orientations. However, these methods are generally more costly and less time-efficient than figure scales. Furthermore, shape change between the CGI figures in the scales is unlikely to be fully representative of shape change in relation to BMI in real male bodies. These artificial changes in body size and shape were determined by the particular adiposity and weight sliders selected in Daz Studio, and therefore this restricted the ecological validity of these scales. This is one of the key limitations that comes with using CGI models, rather than visual representations of real male bodies such as 3D body scans or photographs.

There are clear differences in the presentation form and user experience between the two JND-based figure scales and the interactive, computerised version. The card scales provided participants with the opportunity to visualise the full range of bodies at one time, which allowed them to directly compare the size of the figures for their perceived current and ideal body size estimations. Alternatively, the interactive computer-based scale required participants to scroll through the images one-by-one but presented many more figures with smaller differences in BMI between them. Therefore, participant responses using the interactive scale were likely closer to their true current or ideal body size perceptions than with the card scales. However, significant associations were revealed between participants' actual BMI and perceived current estimations for all three scales, and no significant differences in mean current and ideal body size estimations were found between any of the scales in either session.

The sample size for this study was smaller than in similar studies assessing the reliability and validity of male figure scales (Arkenau et al., 2020; Pope, Gruber, et al., 2000;

Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019). However, this was considered a pilot study that aimed to conduct an initial evaluation of the reliability and validity of the figure scales. In addition, data collection was terminated by the closing of university facilities and social distancing rules enforced as a result of the COVID-19 pandemic.

3.9.3 Implications and Future Work

Developing and validating perceptually-driven male figure scales has applications for both body image research and clinical practice. Besides providing a measure of men's perceptual body image that may allow for more accurate, specific and sensitive estimations of one's own and others' body sizes, these scales can be used to assess and monitor body dissatisfaction and body image distortion in men with a range of body image-related disorders (Cornelissen et al., 2016). They could also be used in research and clinical contexts to evaluate socially-driven perceptions of male bodies, including judgments of health, attractiveness and body weight norms. Before these new JND-based figure scales are used with clinical populations, further research is needed to compare these scales with existing measures in larger, varied male samples to further evaluate the reliability and validity evidenced in this study and assess their incremental validity compared to other scales. The pilot data from Study 2 provides evidence for the convergent, concurrent and face validity of the JND-based scales, as well as test-retest reliability over a period of two-to-three days. However, post-hoc power calculations suggest that a larger sample is required to have adequate power to conclusively evaluate the validity of the new scales and to identify whether any modifications are required to improve their properties.

Additional studies could seek to develop complementary versions of the scales that are more representative of individuals from other ethnic backgrounds, who may not identify with the Caucasian male figures presented (Gardner & Brown, 2010; Ralph-Nearman & Filik, 2018; Talbot, Smith, Cass, & Griffiths, 2019). The standard body used to develop the sequence of figures in Study 1 was based on average measurements from Caucasian males using data from the HSE (2008). Therefore, different standard bodies would need to be developed using measurements representative of other ethnic groups to develop these additional scales (Holmqvist & Frisén, 2010; Ruff, 2002). Similar body scales using 3D male body scans, rather than CGI stimuli, could also be developed to overcome some of the inherent issues with ecological validity that come with using computer-generated male bodies.

3.10 Chapter Conclusion

In Study 1, a method of constant stimuli was applied to determine the JND of BMI using computer-generated male figures across a BMI range from 16.5 to 43 kg/m^2. Results highlighted that men's ability to detect the difference in body size between pairs of figures became progressively less accurate as the BMI of the figures increased, as has been found previously in same-sex visual judgements among women (Cornelissen et al., 2016). These findings informed the development of high-definition, computer-generated male figure scales in which the BMI separation between figures was based on the predicted JND of body size with a constant Weber fraction across the BMI range. Preliminary evidence for the reliability and validity of these new figure scales was then provided in Study 2, based on estimations of men's perceived current and ideal body size using each of the scales across two sessions. The figure scales were found to be equivalent in assessing men's perceived current and ideal body size, as well as in estimating levels of BD and BID. There was a lack of convergent validity as evidenced by nonsignificant associations between participants' actual BMI and their current BMI estimates, however, concurrent validity was supported by the correspondence of current, ideal and BD estimations from each of the scales with psychometric measures of body shape concern and body dissatisfaction. Overall, this approach to figure scale development provided a perceptual underpinning for the BMI differentiation between figures and has overcome some of the main limitations of existing figure scales used to assess current and ideal body perceptions in men, by presenting realistic, high-definition figures calibrated for a wide range in BMI. Future work is needed to further evaluate the reliability, validity and psychometric properties of the new JND-based scales with a larger general sample of men, in order to validate these scales for use in research and clinical practice.

Chapter 4: Development of a 3D Body Scan Database to Assess Perceptual Body Image

4.1 Introduction

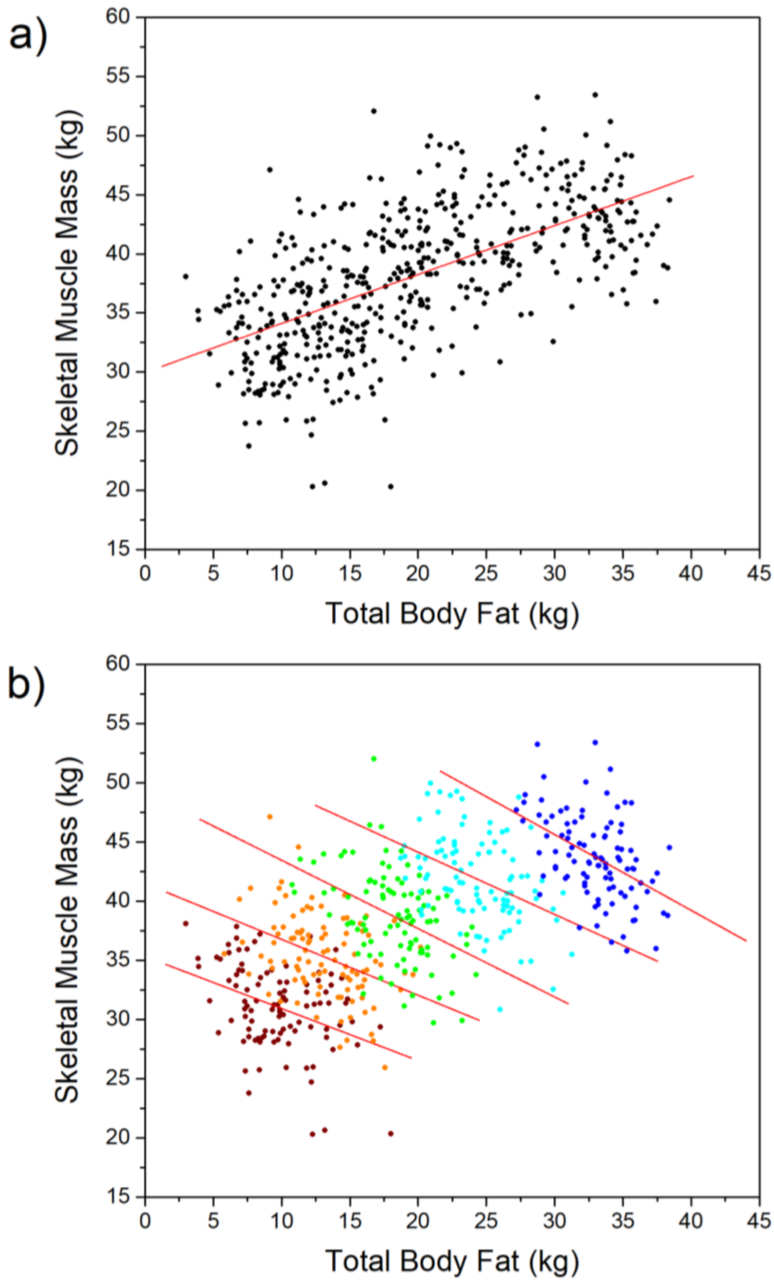
Existing perceptual body image measures are critically limited in their ability to accurately capture variation in body size and shape. Historically, measures have focused on BMI as the primary dimension of variation across bodies, however, this approach is often based on a false assumption that BMI is an accurate index of adiposity (Gardner & Brown, 2010). This misperception is likely due to the frequent use of BMI as an accurate risk indicator for a variety of weight-related health issues and diseases, including cardiovascular diseases, type II diabetes and kidney disease, as well as its common usage in determining public health policies (Daousi et al., 2006; Hsu et al., 2006; Wells et al., 2007). However, male body shape varies along two dimensions of body composition; adiposity and muscularity, and BMI is strongly correlated with both dimensions (Sturman et al., 2017; Wells, Ruto, & Treleaven, 2008). Men's body image and sociocultural ideals are also considered to reflect these two dimensions, with evidence of a split between men who are motivated to increase their muscularity and those striving for leanness (Barlett et al., 2008; Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; Gardner & Brown, 2010; McCabe & Ricciardelli, 2004). Therefore, it is important to develop perceptual body image measures that consider male body shape variation beyond BMI, in order to overcome the inherent issue of BMI-based methodology in distinguishing between fat mass and muscle mass, and to consider shape variation along both components.

The relationships between BMI, fat mass and muscle mass represent an example of Simpson's Paradox. Simpson's Paradox occurs when an association between two variables is reversed for population data that is grouped by a third variable, compared to when the data is considered together (Simpson, 1951). For example, Figure 4.1 demonstrates a positive association between muscle mass and fat mass in a large sample of 500 adult men, and the opposite relationship when the sample is grouped into narrow BMI ranges (Groves et al., 2019). Therefore, individuals with the same BMI can have very different body compositions and consequently, different body shapes (Mullie et al., 2008; Yajnik & Yudkin, 2004). This has implications for the use of BMI in health and clinical contexts as, although fat mass and muscle mass are both associated with body size, they have opposite relationships with a person's health. For example, the health risks attributed to extreme body weight are related to adiposity, rather than muscularity (Lee et al., 2008; Sturman et al., 2017). However, individuals with high levels of muscle mass are often misclassified by BMI as being overweight or obese, which implies poor health status or high levels of fat mass that may not be justified (Frankenfield et al., 2001; Okorodudu et al., 2010). Therefore, it is crucial to consider an individual's body composition in relation to levels of adiposity and muscularity, rather than solely their general body size or weight.

In research contexts, existing figure scales introduce errors in individuals' estimations of their body size and shape perceptions when selecting from a series of bodies varying in BMI. For example, men with the same BMI but different body compositions may have very different perceptions of their own BMI, with evidence suggesting differences of approximately 5 to 7 kg/m^2 (Groves et al., 2019). In addition, there is evidence to suggest independent neural mechanisms for adiposity and muscularity, where individuals can have separate perceptions relating to each dimension of body composition (Brooks et al., 2019; Sturman et al., 2017). Therefore, existing BMI-based measures are unable to accurately capture these separate body size and shape estimations in relation to levels of fat and muscle mass.

Figure 4.1

Scatter Plot of the Relationship Between Muscle Mass and Fat Mass



Note. The top scatter plot in this figure presents the relationship between fat mass and skeletal muscle mass in a sample of 500 men. The bottom scatter plot presents the same data partitioned into 5 equal sub-samples of 100 men, based on the following BMI ranges: 15-19 (wine), 19-23 (orange), 23-27 (green), 27-31 (cyan), and 31-35 (blue). The straight lines represent the ordinary least squares regression of muscle mass on fat mass for the total sample (top) and the sub-samples (bottom). The covariance values for these relationships were taken from previous literature (Groves et al., 2019).

In order to overcome this limitation, a number of figure scales presenting systematic changes in both muscularity and adiposity have been developed to estimate men's body size and shape perceptions. For example, Ralph-Nearman and Filik (2018) developed two separate scales to assess male body dissatisfaction relating to a drive for thinness and a drive for muscularity; the Male Body Scale (MBS) and the Male Fat Body Scale (MFBS). Each scale consists of artist drawings of 9 male figures representing a systematic 10% width increase from emaciated to obese in the MBS and from emaciated to very muscular in the MFBS. The figures at the extremes were based on photographs of obese, anorexic and weightlifting men, and the remaining figures were designed to visually model photographs of real men as they increased in size. This approach is limited in its ecological validity, as differences in the size of the figures were based solely on linear changes in body width that do not simulate realistic alterations in body weight or consider the influence of body composition on shape change. Similarly, the figures are limited in their realism and lack detailed body size and shape information.

Talbot, Cass and Smith (2019) have also constructed separate linear body scales, known as the Visual Body Scale for Men – Muscularity (VBSM-M) and Visual Body Scale for Men – Body Fat (VBSM-BF). The VBSM-BF consists of 10 computer-generated figures increasing in body fat percentage from 4% to 40% and the VBSM-M is comprised of 10 figures increasing in Fat Free Mass Index (FFMI) from 16.5 to 30 kg/m^2. FFMI is based on measurements of height, weight and body fat, and is generally used as a proxy for muscle mass, with FFMIs above 25 kg/m^2 considered difficult to achieve without the use of anabolic steroids (Kouri et al., 1995; Pope Jr et al., 2000). To associate a body fat percentage and FFMI to each figure, a set of 50 figures were initially generated to match those in the Modified Somatomorphic Matrix (Cafri & Thompson, 2004). These figures were then piloted to select the 20 bodies that most closely corresponded to this scale. The degree of correspondence between figures was assessed visually and, therefore, the figures for the VMSM-M and VBSM-BF were not selected using a quantifiable approach. In addition, the figures are presented in front-view only, which limits the scope of body size and shape information available to users. However, attributing an FFMI and body fat percentage to the figures allows for comparisons with participants' actual body composition and evaluations of over or under-estimations in clinical settings.

A limitation of the figure scales mentioned is that they separately consider variation in muscularity and adiposity, and this representation is artificial as it is not how we see bodies in real life (Arkenau et al., 2020). This creates a problem with ecological validity and hinders the ability to gain a true representation of people's actual body size and shape perceptions. To address this issue, figure scales that consider both muscularity and adiposity simultaneously have been developed. The Somatomorphic Matrix (Pope Jr et al., 2000) is a computerised measure that consists of 100 figures in a 10 x 10 matrix with systematic increases in the level of fat mass (x-axis) and muscle mass (y-axis). The figures represent 10 levels of adiposity, ranging from 4% to 40% body fat, and 10 levels of FFMI ranging from 16.5 to 30 kg/m^2. These figures were calibrated using an artist's impressions of photographs of men with known FFMIs and body fat percentages, calculated using skinfold measurements (Gruber et al., 1999). The drawings were reviewed and revised by kinanthropists to ensure that each figure reliably represented a particular FFMI and body fat percentage. However, this process was not reported in detail and it can be assumed that this was not carried out using a quantifiable method of calibration.

Participants were asked to select the figure that best represented their perceived current and ideal body, as well as the body of an average man of their age and the body most desired by the opposite sex. A figure in the middle of the range (FFMI of 22.5 kg/m^2 and 20% body fat) was presented on a computer and participants were able to scroll through the set of figures to independently vary the level of adiposity and muscularity. A modified version of the Somatomorphic Matrix (Cafri & Thompson, 2004) has also been developed with a total of 34 figures, rather than 100. Both versions present hand-drawn figures that lack realism, present limited information on body shape and muscularity, and were calibrated for body fat percentage and FFMI using an artist's imitation of photographs. In addition, these figures are not symmetrical in their shape, which may play a role in participant's responses, particularly as asymmetry has been found to influence attractiveness ratings (Tovée et al., 2000). The New Somatomorphic Matrix-Male (NSM-M; Talbot, Smith, Cass, & Griffiths, 2019) has since been developed to overcome some of the issues with asymmetry and ecological validity in both the original and modified measures. However, again there is no precisely calibrated mapping between the shapes of the figures presented and their level of muscularity and adiposity.

Most recently, Arkenau and colleagues (2020) have developed the Body Image Matrix of Thinness and Muscularity – Male Bodies (BIMTM-MB) comprised 64 male figures in an 8 x 8 matrix that systematically increase in adiposity (x-axis) and muscularity (y-axis). The figures were created in Daz Studio using the 'Michael' character using body size and shape morphs in the software that alter muscularity and adiposity. The figures at the extreme ends for each dimension were developed first and used as reference points to develop figures around the matrix frame. The remaining figures were then developed using a stepwise approach of progressively increasing muscularity in the vertical axis and adiposity in the horizontal axis. This process involved consultancy from a team of experts and alterations were made according to their consensus. The figures were presented from the neck down, in a standard pose with grey underwear. The BIMTM-MB was used to assess participants' perceived actual (how they look), felt (how they feel they look) and ideal (how they would like to look) body size and shape. The scale was also able to distinguish between men who weight-train and those who do not, with men who weight-train demonstrating ideal body preferences with lower adiposity and higher muscularity than non-weight-training men. However, this figure scale does not attribute measurements of body size, shape or composition to the figures. Therefore, it is not possible to make comparisons between participant responses and their actual body size and shape, or levels of muscularity and adiposity.

Clearly, as with the traditional BMI-based measures of perceptual body image, there are also critical limitations in existing measures that consider adiposity and muscularity. These issues include a lack of realism, restrictions in the number, range and viewpoint of figures presented, and separate considerations of the two dimensions of body composition. Therefore, there is a need to develop and validate new measures that represent variation in 3D body shape as a function of fat mass and muscle mass independently, in order to minimise error and improve the accuracy of estimating men's body size and shape perceptions. 3D body scanning technologies have become a popular, more easily accessible way of attaining anthropometric measurements and full-body surface models. However, they are currently unable to directly distinguish between different components of human body composition, such as adiposity and muscularity, or model 3D body shape based on a large database of body scans. Therefore, this study will use a combination of 3D body scans and BIA to develop a calibrated mapping between 3D body shape, fat mass and muscle mass. PCA will then be used to identify the main components of shape variation across scans and represent the shape change components visually, resulting in the creation of appropriately calibrated 3D male body stimuli.

4.2 Study 3: Aims and Objectives

Study 3 aimed to develop new 3D computer-generated male body stimuli with a calibrated mapping between fat mass, skeletal muscle mass and 3D body shape, by statistically modelling shape change as a function of fat mass and skeletal muscle mass independently.

The main objectives for this study were:

1. To develop a database of 3D body scans and body composition measurements from a large non-clinical male sample
2. To evaluate associations between measurements of BMI, fat mass and skeletal muscle mass in the sample, and in separate BMI subgroups, using correlation and regression analysis
3. To characterise the main components of shape variation among the 3D male body scans using PCA
4. To visually model changes in 3D body shape as a function of fat mass and muscle mass independently, resulting in calibrated 3D computer-generated stimuli

4.3 Study 3: Methods

Study 3 was granted ethical approval by SOPREC on the 12th December 2017 (PSY1718350).

4.3.1 Participants

Adult men were recruited for this study from staff and students at the University of Lincoln and the general population in and around Lincoln. Opportunity sampling methods were used including posters, flyers, social media invitations, the SONA system, the University of Lincoln staff news webpage and word-of-mouth. Recruitment commenced with inviting men of all body sizes and shapes to take part, and later focused on recruiting those with a BMI of under 18.5 kg/m^2 or over 30 kg/m^2 to ensure adequate representation of males in the underweight and obese categories. A £50 Amazon voucher draw was advertised in recruitment materials as an incentive for participation in this study.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 years or above
2. Participants who self-identify as male (cis-gender/as assigned at birth)

Participant exclusion criteria for this study were as follows:

1. Participants with a pacemaker or electrical implant
2. Participants with photosensitive epilepsy or those prone to migraines

4.3.2 Study Procedures

Participants who expressed interest in this study were sent an email with an electronic information sheet (Appendix B.7) detailing the purpose and aims of the research project, participants' right to withdraw from the study, and details regarding anonymization and storage of participant data. The information sheet also included photographs of the scanning garments to be worn and instructions on how to prepare for the session. Instructions included avoiding vigorous exercise and the consumption of alcohol for 12 hours before the session, and not drinking or eating for 3 hours prior to the session to improve the accuracy of measurements. At the start of each session, participants provided written informed consent (Appendix B.8) and completed a photograph permission form (Appendix B.9) that allowed participants to decide whether or not they consented to their photographic identity being used in future research and illustrative contexts. This form had separate consent tick boxes for laboratory studies, web-based studies, illustrative purposes and whether the head and/or body segments of their 3D scan could be used.

Following written consent, demographic information was collected for each individual, including sex, age and ethnicity. High resolution, colour 3D full-body scans of each participant were then obtained using a 24 single-lens reflex camera 3dMD anthropometric surface imaging system, as described in Chapter 2. Following the scan, measurements of body composition were taken using a Tanita MC-780MA Multi-frequency Segmental Body Composition Analyser (Chapter 2, Section 2.4). This scale was used to estimate body fat, skeletal muscle mass, fat-free mass, bone mass, water content, and BMI. Anthropometric measurements, including waist (cm), hips (cm), chest (cm) and right bicep (cm) circumferences, were also acquired using a tape measure (Chapter 2, Section 2.6), and were used to calculate the participant's WHR and WCR.

For a subset of participants, additional skinfold calliper measurements were taken by an International Society for the Advancement of Kinanthropometry (ISAK) level 2 practitioner. Calliper measurements were taken at eight different skinfold locations, including the bicep, tricep, subscapular, iliac crest, abdominal, supraspinale, front thigh and medial calf. A standard ISAK procedure (Stewart et al., 2011) was followed that involved taking two measurements at each skinfold location and calculating an average measurement for each site. In cases where the measurements differed by more than 5%, an additional measurement was taken at the same location to calculate a median value. At the end of the session, participants were presented with a debrief sheet (Appendix B.10) detailing the aim of the study, their right to withdraw, their personal identification number, relevant resources for support and researchers' contact details.

4.3.3 Data Analysis

Descriptive statistics were computed for the participant demographics, anthropometric measurements and body composition data for the sample, as well as for distinct BMI categories, using IBM SPSS Statistics software (Version 26.0). Pearson's correlations and linear regressions were conducted to assess the relationship between measurements of fat mass, skeletal muscle mass and BMI in the sample. Analysis of variance was carried out to determine whether there were any significant differences in the two dimensions of body composition between BMI groups. In order to test the reliability and validity of the fat mass and percentage estimates from the bio-impedance scale, Pearson's correlations were used to investigate the relationship between these fat estimates and those calculated from the skinfold calliper measurements.

Following a process of scan initialisation and registration, as described in Chapter 2 (Section 2.2.2), a PCA was conducted in MATLAB (2018) using the 3D coordinates of each body scan to characterise the variation in male body size and shape across the scans. The analysis was conducted by Dr Robin Kramer, a member of the PhD supervision team, and was adapted from his previous PCA approach with human faces (Burton et al., 2016; Kramer et al., 2017; Kramer et al., 2018). In order to prepare the scans for the PCA, coordinates associated with the head, hands and feet of each scan were removed, and the scans were aligned using a Procrustes analysis. Only translation and orthogonal rotation were utilised in this analysis, in order to preserve the aspects of shape change relating to scaling. A linear regression model was then used to predict body shape from actual fat mass and skeletal muscle mass measurements, using the coefficient of these variables for each individual principal component. The procedure for this analysis will be discussed step-by-step within the results section of this chapter.

4.4 Study 3: Results

A total of 247 adult men were recruited as part of a larger project by a research team from the School of Psychology at the University of Lincoln. This sample varied in age from 18 to 74 years (*M* = 33.46, *SD* = 13.57), ranged in BMI from 16.19 to 38.75 kg/m^2 (*M* = 25.30, *SD* = 3.76), and included a variety of ethnicities, with the majority (70.37%) of participants self-reporting as White/Caucasian. For the purpose of this study, only White/Caucasian men aged 18 to 45 years were selected from the wider participant sample, with the intention of controlling for possible effects of age and ethnicity on male body shape and weight distribution.

4.4.1 Participant Characteristics

The final sample consisted of 176 adult men aged 18 to 45 years (*M* = 28.84, *SD* = 7.99), who self-reported as being of either White or Caucasian ethnicity, and represented a range in BMI from 16.19 to 38.74 kg/m^2, with individuals in the underweight (n = 5), normal weight (n = 85), overweight (n = 66) and obese (n = 20) categories. Table 4.1 presents the range, means and standard deviations for participant anthropometric measurements in the sample. A comparison of the BMI distribution in this sample with Health Survey for England (HSE; 2015) statistics shows the sample to be relatively illustrative of the male population in England (Figure 4.2). However, there was a clear overrepresentation of the normal weight category and an underrepresentation of the obese category in the sample. It must be noted that these HSE statistics were based on a nationally representative sample of males aged 16 years and over, and included a range of ethnic groups.

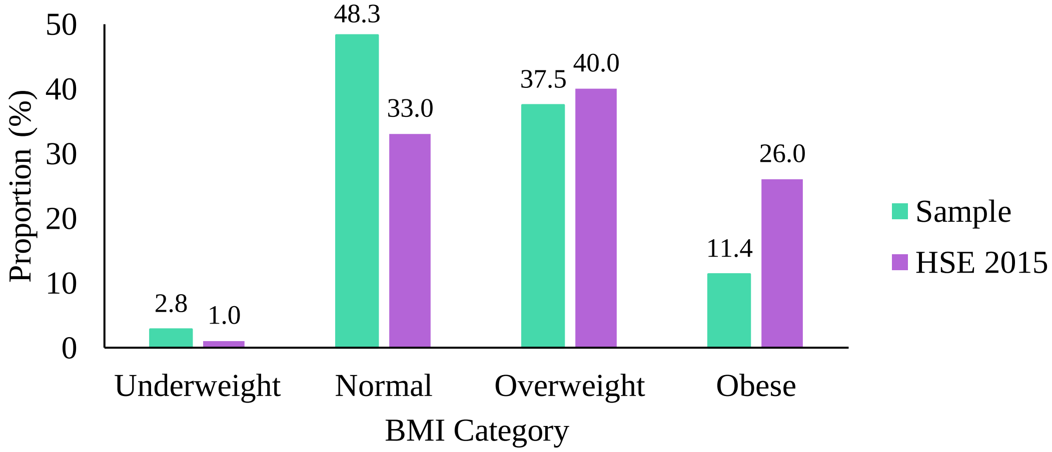
Table 4.1

Anthropometric Measurements for the Total Sample

Measurement	Minimum	Maximum	Mean	SD
Height (cm)	165.00	198.50	179.41	6.80
Weight (kg)	53.50	147.30	81.80	14.37
BMI (kg/m^2)	16.19	38.74	25.35	3.79
WHR	0.75	1.17	0.87	0.06
WCR	0.77	1.10	0.89	0.06

Figure 4.2

Comparison of Sample BMI Distribution to Health Survey for England (2015) Statistics



4.4.2 Body Composition

Table 4.2 presents the range, means and standard deviations for participant body composition measurements in the sample. Pearson's correlations were conducted to evaluate associations between measurements of BMI, fat mass and skeletal muscle mass. Significant positive correlations were revealed between BMI and fat mass ($r = .92$, $p < .01$), BMI and skeletal muscle mass ($r = .65$, $p < .01$), and fat mass and skeletal muscle mass ($r = .48$, $p < .01$). Figure 4.3 shows the relationship between the measurements of fat mass and skeletal muscle mass in the sample. Similarly, Pearson's correlations were also used to assess the relationship between measurements of BMI, body fat percentage and skeletal muscle percentage. A significant positive correlation was found between BMI and body fat percentage ($r = .85$, $p < .01$), while significant negative correlations were revealed for BMI and skeletal muscle percentage ($r = -.62$, $p < .01$), and body fat percentage and skeletal muscle percentage ($r = -.91$, $p < .01$). Figure 4.4 presents the relationship between the fat mass and skeletal muscle mass percentages in the sample. This negative association between the fat mass and skeletal muscle mass percentages is a result of these being proportions of an individual's total body mass.

Separate simple linear regression models were carried out to individually predict BMI based on the fat mass and skeletal muscle mass measurements. A significant regression equation was found for fat mass ($F(1, 174) = 903.27$, $p < .01$), $R^2 = .838$. Therefore, measurements of fat mass accounted for 83.8% of the total variance in BMI. A significant regression equation was also found for skeletal muscle mass ($F(1, 174) = 124.93$, $p < .01$), $R^2 = .439$. Therefore, measurements of skeletal muscle mass accounted for 43.9% of the total variance in BMI.

Table 4.2

Body Composition Measurements for the Total Sample

Measurement	Minimum	Maximum	Mean	SD
Fat mass (kg)	2.50	46.00	14.53	7.39
Body fat (%)	4.50	34.60	16.98	6.06
Skeletal muscle mass (kg)	28.40	61.60	39.53	5.58
Skeletal muscle (%)	33.90	59.90	48.74	4.80
Fat-free mass (kg)	50.00	101.30	67.27	8.56
Bone mass (kg)	2.50	6.00	3.36	0.46
Body water (kg)	37.40	74.30	48.47	6.16

Figure 4.3

Scatter Plot of Positive Relationship Between Fat Mass and Skeletal Muscle Mass in Sample

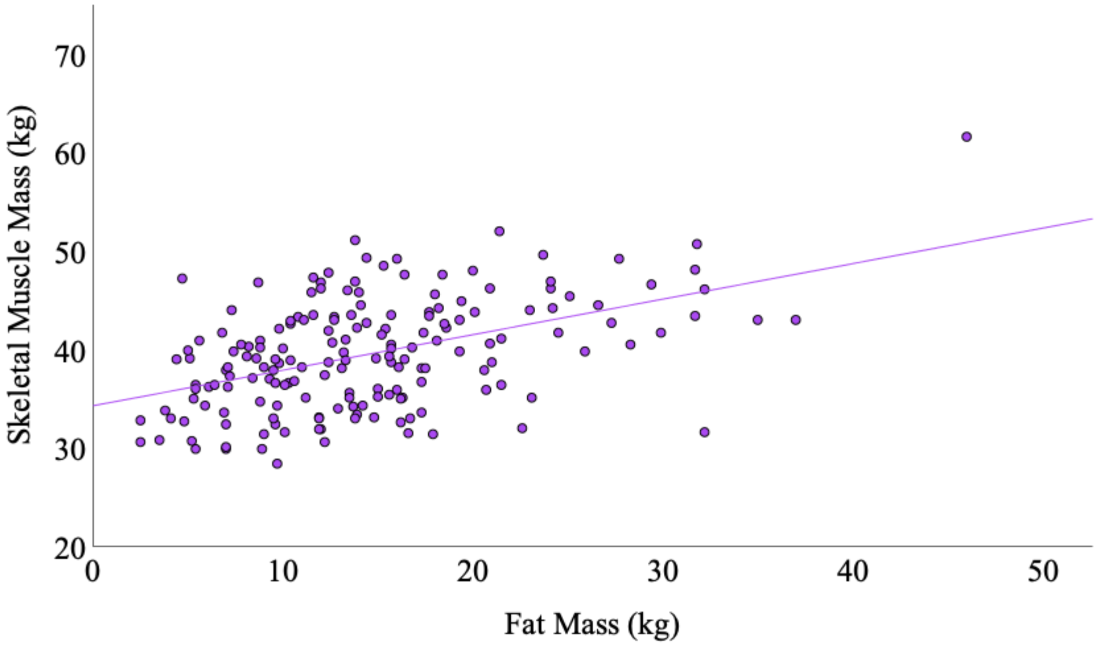
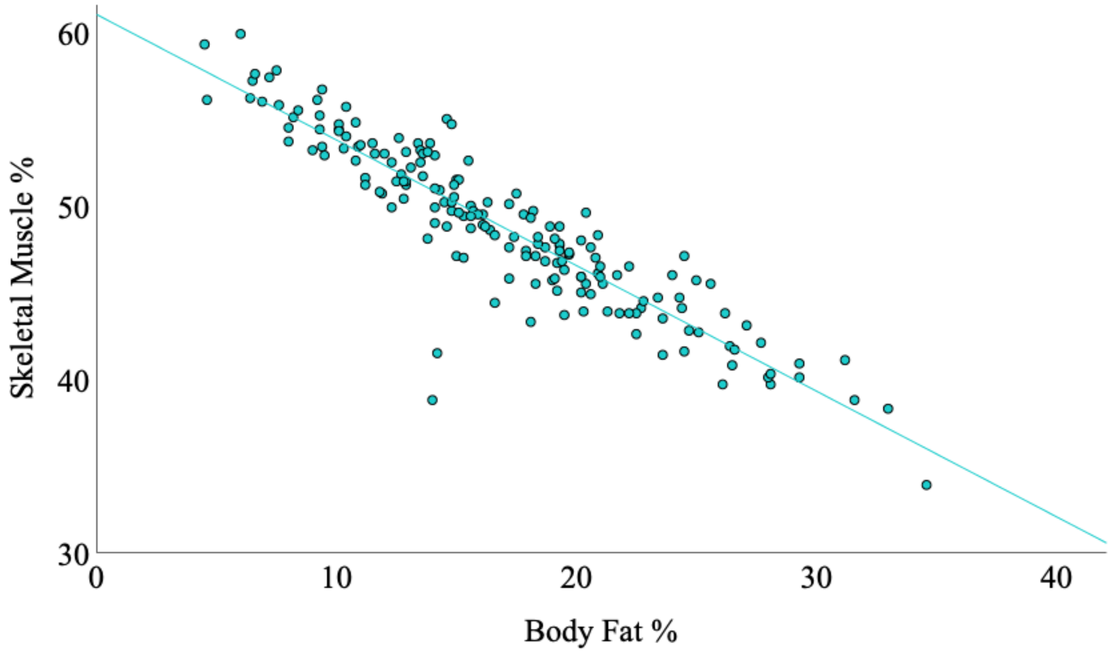


Figure 4.4

Scatter Plot of Negative Relationship Between Fat and Skeletal Muscle Percentages in Sample



Note. This figure presents body fat and skeletal muscle components as relative proportions of total body mass for participants in the sample, and demonstrates the inverse relationship between the two dimensions to that shown in Figure 4.3.

4.4.2.1 Comparisons of Body Composition Between BMI Categories

Differences in levels of fat mass and skeletal muscle mass were explored for participants in each BMI category. Shapiro-Wilk tests revealed a normal distribution for skeletal muscle mass and fat mass across participants within each BMI category and the total sample ($p > .05$). Inspection of stem-and-leaf and normal Q-Q plots for each category revealed two outliers for skeletal muscle mass within the obese BMI group, as shown in Figure 4.5. Similarly, two outliers were also found for measurements of fat mass, one in the overweight BMI category and one in the obese category (Figure 4.6). However, these outliers were not removed due to the small numbers of participants in the obese group and with the aim of capturing a range in body size and shape within these BMI categories. Table 4.3 presents means and standard deviations for the BMI, fat mass and skeletal muscle mass measurements in each BMI category.

A one-way ANOVA and Tukey post-hoc test were used to identify whether there were statistically significant differences between the group means for measurements of skeletal muscle mass. Statistically significant differences were found between participants in all four

BMI categories for measurements of skeletal muscle mass (*F*(3, 172) = 30.65, *p* < .01). Alternatively, Welch ANOVA and Games-Howell post-hoc tests were used to assess group mean differences for measurements of fat mass, as they did not meet the homogeneity of variance assumption. Again, statistically significant differences were found between participants in all four BMI categories for the measurements of fat mass (*F*(3, 21.37) = 140.91, *p* < .01).

Table 4.3

Means and Standard Deviations of Fat Mass and Skeletal Muscle Mass in Each BMI Category

BMI Category	BMI		Fat mass (kg)		Skeletal muscle mass (kg)	
	M	SD	M	SD	M	SD
Underweight	17.75	0.92	4.08	1.46	31.34	1.32
Normal weight	22.50	1.92	9.70	3.71	36.63	4.33
Overweight	27.03	1.40	16.64	3.76	41.71	4.60
Obese	32.60	2.19	29.31	5.90	45.38	5.90

Figure 4.5

Skeletal Muscle Mass Distribution Within Each BMI Category

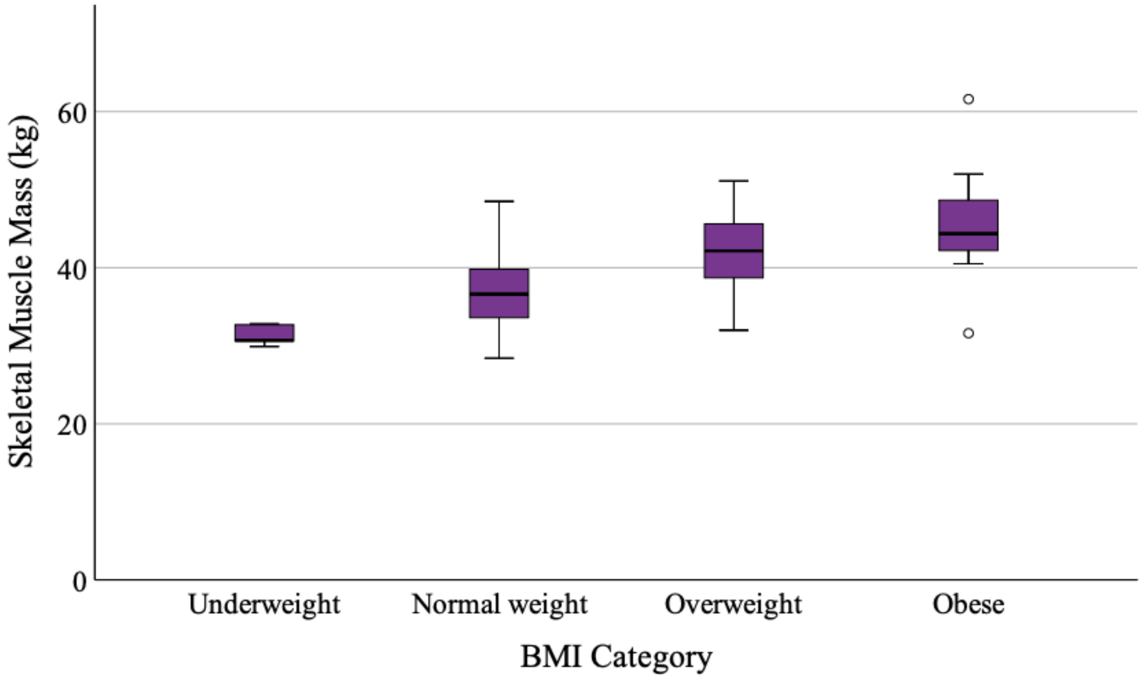
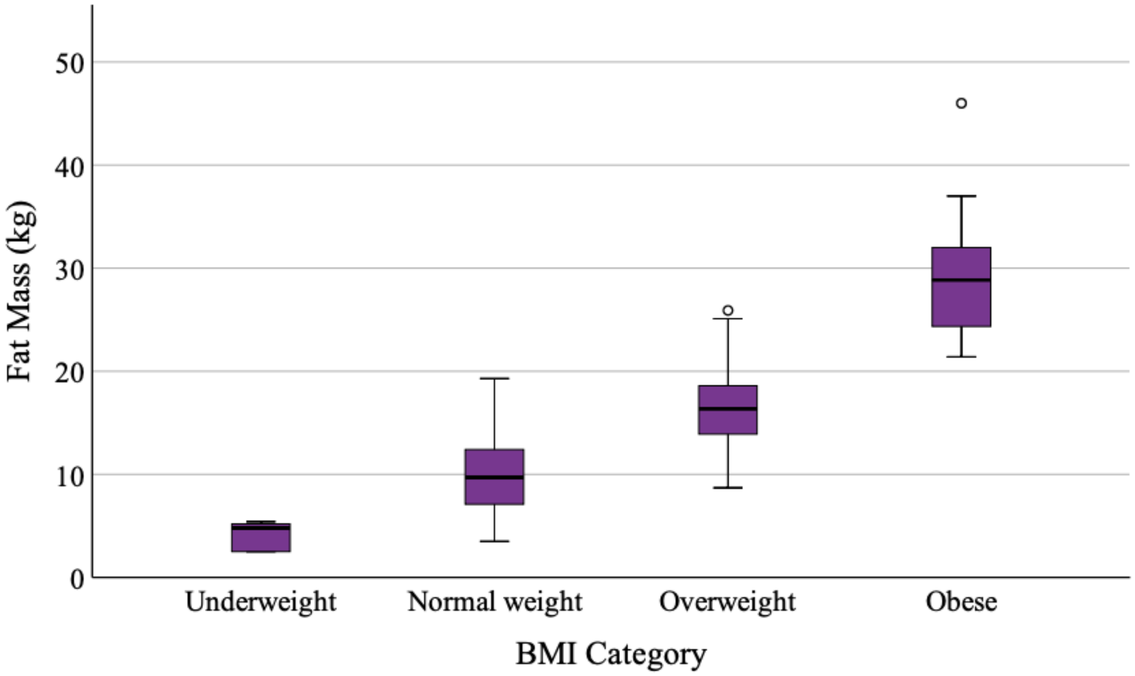


Figure 4.6

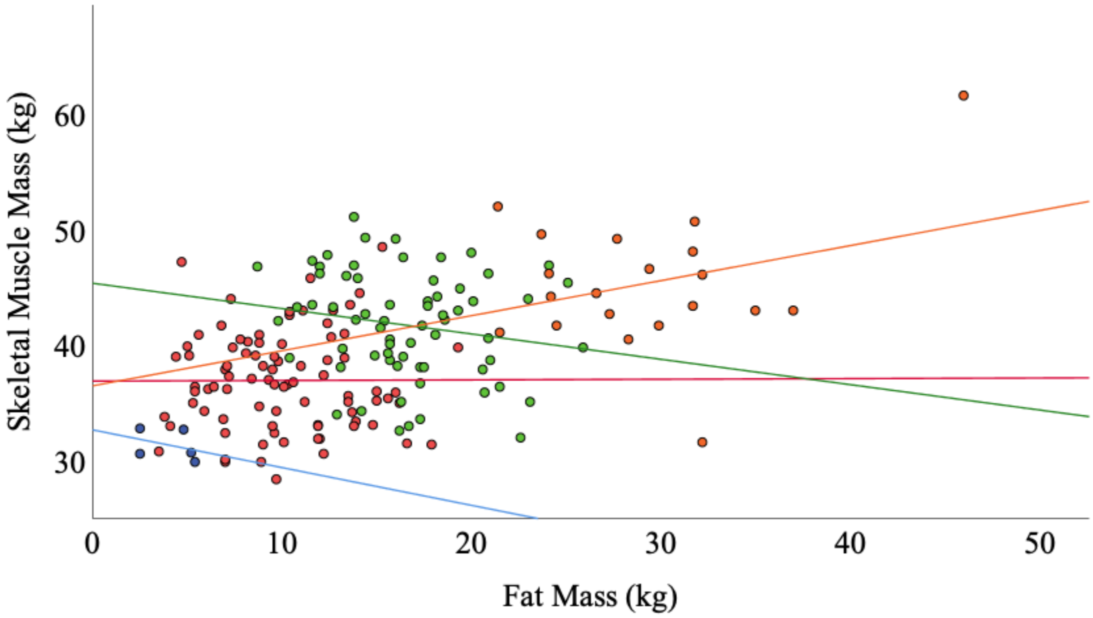
Fat Mass Distribution Within Each BMI Category



Pearson’s correlations were conducted to evaluate the relationships between fat mass and skeletal muscle mass separately for participants in each BMI category. A negative correlation was found between the two dimensions in the underweight group (*r* = -.36, *p* = .552) and the overweight group (*r* = -.18, *p* = .149). No correlation was found between the fat mass and skeletal muscle mass for individuals in the normal weight group (*r* = .00, *p* = .968), while a positive correlation was found between the two dimensions for the obese group (*r* = .30, *p* = .197). However, none of these correlations were statistically significant. Therefore, the relationship between BMI and these two dimensions of body composition represented an example of Simpson’s Paradox for the underweight and overweight groups, but not the normal weight or obese groups. Figure 4.7 presents the relationships between measurements of fat mass and skeletal muscle mass in each BMI category.

Figure 4.7

Scatter Plot of the Relationship Between Fat Mass and Skeletal Muscle Mass in Each BMI Category



Note. The figure presents the relationship between fat mass and skeletal muscle mass for participants in each BMI category: underweight (blue), normal weight (red), overweight (green) and obese (orange). The straight lines represent the least squares regression of muscle mass on fat mass in each BMI category.

4.4.2.2 Body Composition Validity

The validity of the fat mass measurements gained from the BIA was assessed by comparing these to estimates derived from skinfold calliper measurements, taken for a subset of the sample (n = 26). An estimate of body fat percentage was calculated for each participant using the following four-site skinfold equation (Jackson & Pollock, 1985), based on a sum of the tricep, abdominal, front thigh and iliac crest skinfold measurements:

$$\begin{aligned} Body\ fat\ \% = {} & (0.29288 \times sum\ of\ skinfolds) - (0.0005 \times sum\ of\ skinfolds^2) \\ & + (0.15845 \times age) - 5.76377 \end{aligned}$$

An estimate of total fat mass was also calculated for each participant based on their body weight and their body fat percentage estimate from the Jackson and Pollock (1985) equation.

Pearson's correlations were then used to explore the relationship between the total fat mass and percentage estimates from the two measurement techniques; BIA using the bio-impedance scale and skinfold measurements using the callipers (Table 4.4). Significant positive correlations were found between both measurement techniques for total fat mass and fat percentage ($p < .001$). Additionally, the mean total body fat percentage estimates derived from the skinfolds ($M = 14.55$, $SD = 5.04$) and BIA ($M = 15.16$, $SD = 3.81$) were not found to be significantly different from each other $t(25) = -0.87$, $p = .395$. The agreement between the two measurement techniques is illustrated in Figure 4.8. This Bland-Altman plot presents the differences in estimated percent body fat between the skinfold and BIA techniques plotted against the averages of the two techniques.

Table 4.4

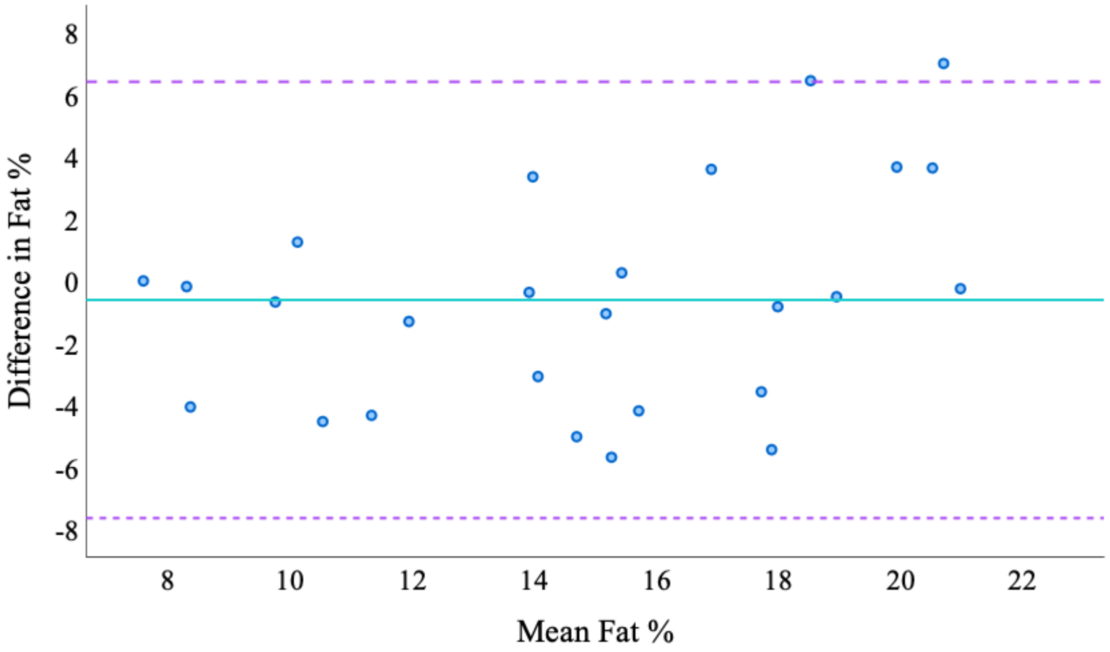
Pearson's Correlations for Body Fat Estimates Using BIA and Skinfolds

BIA estimates	Skinfold estimates	
	Body fat (%)	Body fat mass (kg)
Body fat (%)	.71**	.76**
Body fat mass (kg)	.60**	.74**

** $p < .001$

Figure 4.8

A Bland-Altman Plot of Differences Between the Skinfold and BIA Estimates of Body Fat %



Note. The Bland-Altman plot presents the mean difference of –0.61 for the sample using a solid line. The dotted lines represent the upper and lower limits of agreement (95% confidence intervals).

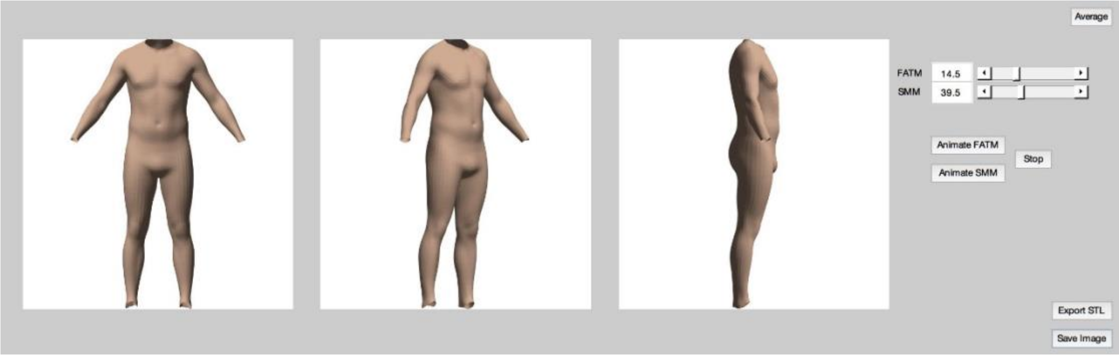
4.4.3 Principal Component Analysis

In order to characterise the spatial variation of male body shape and its relation to body composition, PCA was conducted in MATLAB (2018) using the 3D points of each body scan, in the form of X, Y, and Z coordinates. Firstly, the head, neck, hands and feet of each body scan were excluded, by identifying the coordinates that related to these segments of the body, which resulted in each scan being composed of 26,665 coordinates. The average of the 3D points across the scans was then calculated to find the average 3D male body shape in the sample. A Procrustes analysis was applied to all the scans to fit them to this average shape so that they were aligned as closely as possible, without any scaling to maintain individual body shape. Each individual shape was then converted to a vector of 79,995 data points (26,665 points x 3 coordinates) that were entered into a PCA.

Linear regressions were used to model predicted body shape from actual body composition variables, specifically fat mass and skeletal muscle mass. For each principal component, a linear regression was run to predict the individual's location on that component from their actual measurements of fat and skeletal muscle mass, using the two coefficients of these variables for each component. Therefore, the results of the linear regressions allowed for a predicted location along each principal component for any chosen value of fat mass and skeletal muscle mass. These locations where then used to build and visualise the predicted body shape at three orientations: front-view, profile and three-quarter view (Figure 4.9). This model assumed a linear relationship between fat mass and skeletal muscle mass and was based solely on the database of 3D body scans and body composition data collected. Therefore, the predictive model used in this study did not extend outside of the highest and lowest fat and skeletal muscle mass values measured in the sample. Figure 4.10 presents a 3 x 3 visualisation matrix of the predicted body shape for the lowest, middle and highest values of fat mass and skeletal muscle mass in the sample.

Figure 4.9

Visualisation of Predicted Body Shape Using the Average Fat Mass and Skeletal Muscle Mass



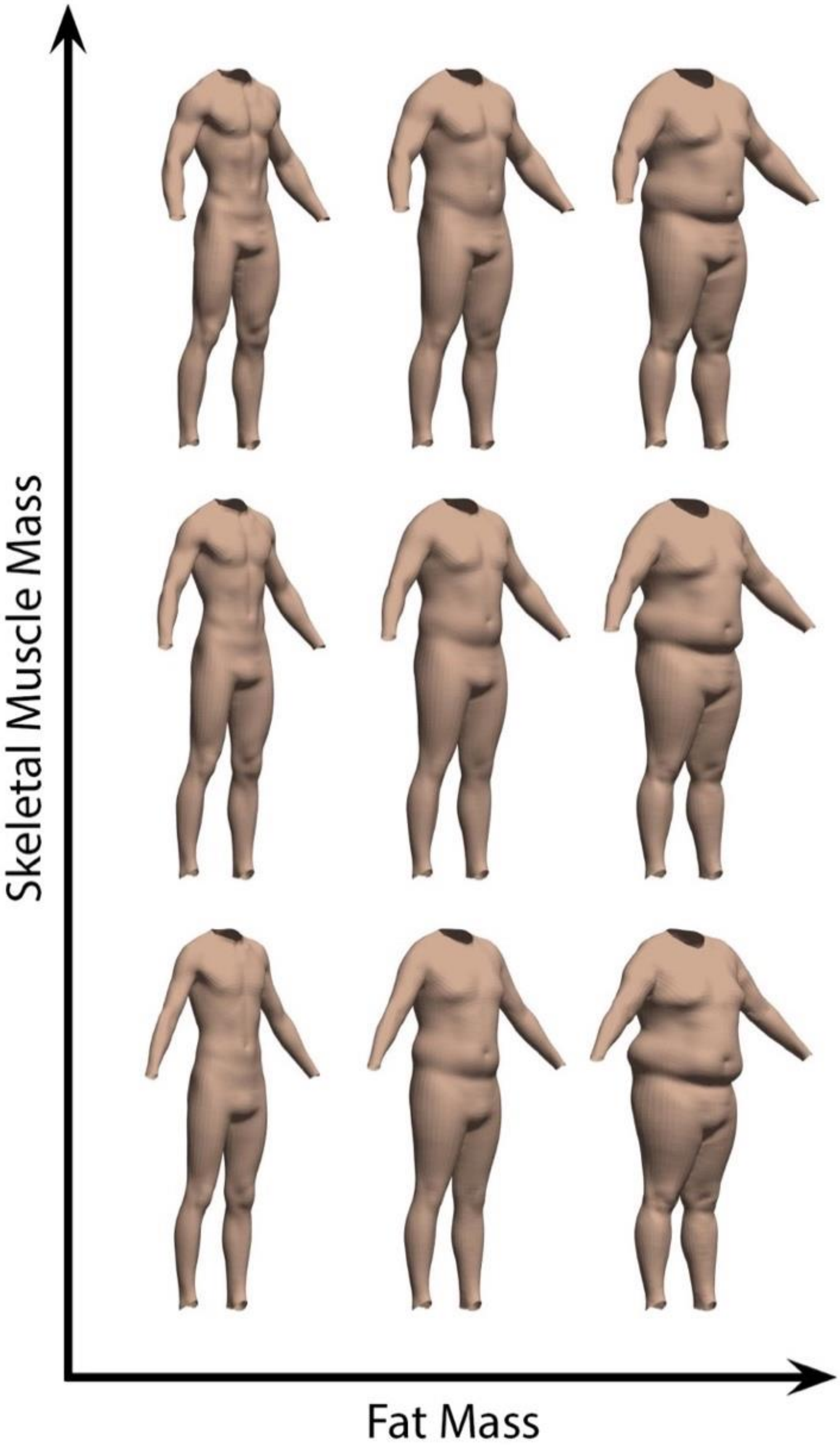
FATM 14.5

SMM 39.5

Note. This figure presents a visualisation of the predicted body shape at the average fat mass (14.5 kg) and skeletal muscle mass (39.5 kg) in the sample.

Figure 4.10

Visualisations of Predicted Body Shape at the Lowest, Middle and Highest Values of Fat Mass and Skeletal Muscle Mass

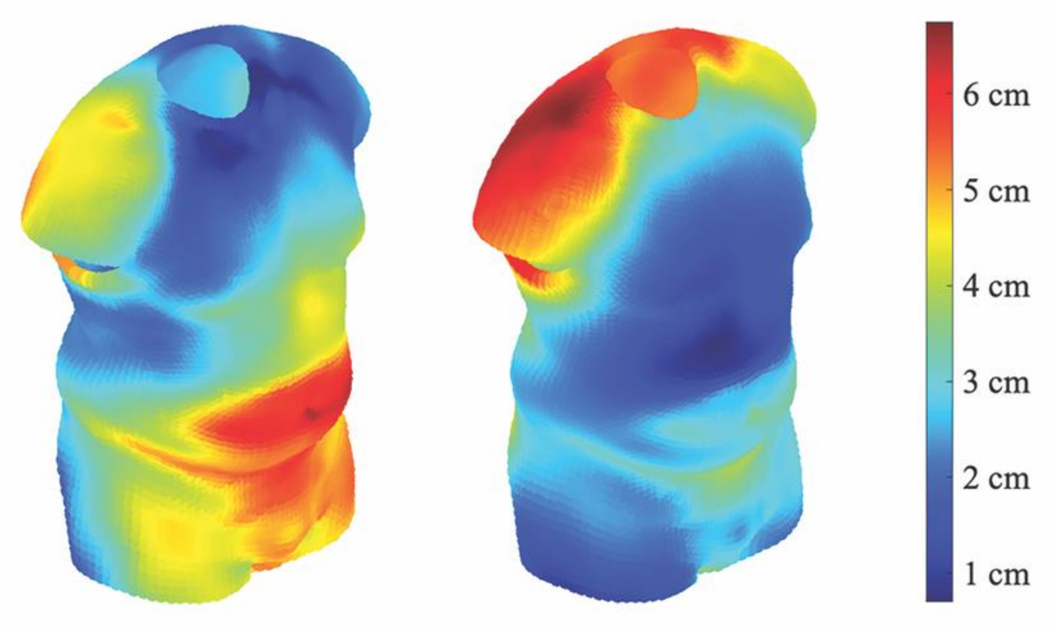


In order to explore how well this linear fat and skeletal muscle model predicted body shape compared to BMI, a ‘leave-one-out' cross validation strategy was used to investigate how well a sample of training body shapes could be applied to predict novel body shapes. This involved systematically removing each individual scan from the total sample and using the remaining scans to predict the 3D body shape of the excluded scan. A predictive body shape model based on the BMI values for each body scan was developed using the same process as the fat and skeletal muscle model, where linear regressions were run to predict locations on each principal component for any BMI value, using the associated coefficient and constant. The predicted shape using each model was then compared to the original scan of the particular individual, based separately on either measurements of actual fat and skeletal muscle mass or BMI.

In order to quantify error between the original and predicted shape using each model, the straight-line distance in 3D space between the original and predicted location for each point was calculated in centimetres, and these were averaged for all points. In this analysis, only points representing the torso of the body were considered (12,697 points) due to the variability in the positioning of arms and legs in the 3D scans. For each individual scan, error was calculated when predicting body shape using the fat mass and muscle mass model, and BMI model separately. A paired samples *t*-test revealed that the fat and muscle mass model produced significantly less error in predicting body shape than the BMI model, $t(175) = 5.82$, $p < .001$, Cohen’s $d = 0.44$. An example of the difference in error for a particular male body scan, using the two predictive models is presented in Figure 4.11. The maximum error for all points of this body shape across both models was found and the error for each individual point was then converted into a proportion of this maximum error. A mean maximum error of 4.29 cm (SD = 1.11) was identified across all 176 body shapes in the sample. The warmer-coloured points in Figure 4.12 present larger prediction errors for the individual body shape using this proportional scale. It is clear that the largest prediction errors for this specific body shape were found in the upper torso for the BMI model, and the lower abdomen for the fat and muscle model.

Figure 4.11

Visual Representation of the Prediction Errors for Male 3D Body Shape



Note. This figure displays the prediction error for a single male body for the fat and skeletal muscle mass model (left) and the BMI model (right), with warmer-coloured points representing larger prediction errors in this shape.

4.5 Study 3: Discussion

4.5.1 Summary and Interpretation of Main Findings

Study 3 has collected a database of 3D body scans and body composition measurements from a non-clinical sample of 176 Caucasian men to achieve a calibrated mapping between fat mass, skeletal muscle mass and 3D body shape. Strong positive associations were found between BMI, fat mass and skeletal muscle mass in the sample. However, when proportions of fat and muscle mass were considered, the two dimensions showed opposite relationships with BMI. Interestingly, correlations between fat mass and muscle mass for individuals in each BMI group were not statistically significant, possibly because of the numbers of participants in each group, although the direction of this relationship was representative of Simpson’s Paradox for those in the underweight and overweight groups. These results demonstrate the issue in using BMI as a proxy for fat mass in perceptual body image measures, as BMI is not a direct measure of this dimension and the relationship between fat mass and skeletal muscle mass changes for individuals in different BMI categories.

PCA was used in this study to identify the main shape variation components across body scans which was applied to visually model changes in body shape as a function of fat mass, and muscle mass independently. The predictive accuracy of this model was compared to a similar model using actual BMI values and the linear fat and muscle mass model was found to have fewer errors in predicting 3D body shape than the equivalent BMI model. Ultimately, this study has led to the development of new biometrically-accurate 3D CGI stimuli that can be used to assess men’s self-estimates of body size and shape. The accurate calibration of the stimuli to measurements of fat mass and muscle mass is important in both research and clinical settings. This is particularly true in men who generally demonstrate higher proportions of muscle mass and a wider variation in fat and muscle ratios than women (Abe et al., 2003; Fomon et al., 1982; de Bruin et al., 1996), as they are more likely to be misclassified when using BMI as an indicator of body size and health status, and men in the same BMI category may have significant differences in their body composition and shape (Mullie et al., 2008; Yajnik & Yudkin, 2004). Furthermore, men’s body concerns and ideals tend to reflect a drive for muscularity and a drive for leanness (Barlett, et al., 2008; Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; Gardner & Brown, 2010; McCabe & Ricciardelli, 2004), and therefore it is critical that both these dimensions are considered and evaluated in assessment tools.

4.5.2 Strengths and Limitations

This new approach of developing an assessment tool to measure men’s perceptual body image avoids many of the inherent issues with the development of existing scales. This method has considered body shape variation as a function of fat mass and skeletal muscle mass independently, based on actual 3D male body shapes and body composition measurements taken using BIA. The use of PCA to calibrate the predicted body model allowed for a precise characterisation of 3D male body shape variation across scans and separate visualisations of each body composition dimension. This overcomes issues with ecological validity in current scales that are calibrated by visually matching bodies to photographs or presenting linear changes in body width (Cafri & Thompson, 2004; Pope Jr et al., 2000; Ralph-Nearman & Filik, 2018). The use of 3D body scans also allows for a presentation of predicted body shape from multiple viewpoints, thus providing a greater range of visual body size and shape information than scales that only present figures from a single view (Talbot et al., 2020). In addition, although muscularity and adiposity are considered separately, they are visualised as a single predicted body shape, unlike existing figure scales that separately present linear shape change according to these two dimensions (Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019).

This is an important and novel approach for estimating male body size and shape perceptions relating to body composition. There are, however, a few limitations to this study. Firstly, there was a greater representation of people in the normal weight and overweight BMI categories in the sample than those at either extreme. This sampling bias was somewhat expected due to the nature of this type of research, particularly as participants were required to have a 3D body scan and measurements taken while wearing little clothing. The potential distress and degree of body exposure related to being body scanned may have discouraged some individuals from volunteering to take part in this study (Grogan et al., 2019). This may have been particularly prominent for men at either end of the weight spectrum, who generally experience higher levels of weight stigma and show greater body exposure avoidance than those in the normal weight category (Griffiths et al., 2018; Himmelstein et al., 2018; Holle, 2004).

There are also limitations relating to the study procedure and equipment used within this study. For example, the anthropometric circumference measurements were not taken by the same measurer across the sample. Participants were given the option to take the tape measurements themselves, rather than by the researcher, in order to ensure comfort and accommodate any religious or cultural issues. Although a protocol was developed for taking the chest, waist, hip and bicep circumferences, and participants were guided by the researcher, there may still be an issue with the interrater reliability of these measurements. However, there is evidence to suggest high correlations between self-measured and researcher-measured body circumferences and no consistent trends of under or overreporting for self-measurements (Barrios et al., 2016; Dekkers et al., 2008; Rimm et al., 1990). In addition, the participants' circumference measurements were not included in the PCA of the 3D body shapes, and therefore did not impact on the development of this new interactive body tool.

There were also practical difficulties in the 3D body scanning process that had implications for the PCA of the 3D body shapes. For example, there was variation in the pose and positioning of the 3D scans that introduced variability into the dataset and, therefore, a lack of correspondence of shapes in the PCA. It was not possible to standardise the angle of the participants' arms and legs for each individual 3D scan, due to inherent variation in individual body size and shape and the type of body scanner used in this study. Some 3D body scanners, such as the TC2-21B 3D body scanner, include height-adjustable handholds to standardise the position of individuals' arms across scans, however this is not a feature of the 3dMD body scanner. In terms of the interactive tool, the texture appearance of the predicted body shapes is not realistic or personalised for any particular user's skin or photographic identity. It was not possible to improve the appearance of these figures due to inherent restrictions in the MATLAB (2018) software, however the predicted body shapes can be exported as object files that can then be imported into other software. Therefore, it would be possible to individually map different textures onto the 3D body shapes using various computer graphics software for use in future research. In addition, the model does not predict body shape change for all areas of the body, such as the head, hands and feet. There is clearly a lack of realism when presenting visualisations of a body with an unrealistic texture and missing body parts, however this does have the benefits of compelling users to focus solely on the size and shape of the body without potential distractions from the face or texture appearance. For example, facial features including shape, skin colour, expression and masculinity have been shown to influence perceptions of health and attractiveness, as well as provide visual cues for body weight (Coetzee et al., 2009, 2010; Henderson et al., 2016; Wen & Guo, 2013). Therefore, not modelling changes in facial shape in this tool prevents individuals' body size and shape estimations from being influenced by potential face-related perceptions and shape concerns (Madsen et al., 2013).

4.5.3 Implications and Future Work

Further work is needed to address some of these limitations and enhance the applicability of the tool to different male populations. For example, the database of 3D body scans and body composition measurements could be expanded to improve the representation of male bodies in the obese and underweight BMI categories, as well as from either end of the fat mass and muscle mass ranges. This would involve collecting further data from participants with very low fat and skeletal muscle, very high fat and skeletal muscle, very low fat and very high skeletal muscle and vice versa. Similar body models could also be developed based on body shape and composition data for non-Caucasian ethnic groups and additional age groups. Previous research has identified differences in the relationship between BMI and body fat proportions in people of Asian ethnicity, as compared to Caucasians, which has led to different WHO BMI categorical cut-offs for these populations (WHO Expert Consultation, 2004). In addition, there seem to be significant ethnic differences in the relationship between BMI, adiposity and related health risks, including cardiovascular disease and type 2 diabetes (Misra & Khurana, 2011; Shiwaku et al., 2004; Vasudev et al., 2004; Wells, Cole, et al., 2008). There is also evidence of associations between age and patterns of body shape and weight distribution

(Wells et al., 2007; Wells, Cole, et al., 2008). Therefore, additional databases would be required to predict body shape change in various ethnic populations and age groups, in order to accurately visualise how body size and shape would alter according to these indices of body composition.

This new biometrically-accurate measure of male body shape and size estimations has potential implications for both research and healthcare contexts. In a research setting, this tool could be used to assess perceived current, ideal-self and ideal-partner body size and shape estimations in clinical and general male populations. It could also be applied to evaluate the role of adiposity and muscularity in a variety of judgments relating to personality traits, sociocultural factors and health. In a clinical context, this resource could be used in the development of clinical interventions to treat distorted body image in males (Gledhill et al., 2017), for the use of health professionals in informing conversations and working with overweight, obese and eating disorder patients, as well as for monitoring the progress of healthy weight maintenance efforts. This new tool may also be valuable as a foundation for developing other similar interactive tools, such as a body image scale for children that can be used to help parents identify the risk of obesity in their offspring (Jones et al., 2017).

4.6 Chapter Conclusion

Study 3 has collected a database of 3D male body scans and body composition measurements that has been used to develop a calibrated mapping between 3D body shape, fat mass and skeletal muscle mass. PCA was used to identify the main components of shape variation in the sample and this shape change was visually modelled as a function of fat mass and muscle mass independently, thus resulting in the creation of appropriately-calibrated 3D male body stimuli. This new approach to developing a perceptual body image measure has overcome some of the critical limitations in ecological validity of existing BMI and body composition-based assessment tools, by accounting for the relationship between BMI, fat mass and skeletal muscle mass in the development of male body shape and presenting precisely-calibrated 3D CGI stimuli. This model using actual measurements of fat mass and skeletal muscle mass was also found to perform significantly better at predicting 3D male body size/shape than the equivalent BMI model.

Chapter 5: Validation of an Interactive 3D Male Body Fat & Muscle Scale

5.1 Introduction

There has been a recent shift in perceptual body image measurement that has moved beyond a traditional focus on BMI, as the main dimension of body variation, towards a representation of body composition (Cafri & Thompson, 2004). This shift has led to the development of a number of figure scales representing body size and shape change associated with both adiposity and muscularity, for the assessment of men's current and ideal body perceptions. As discussed in the Chapter 4 (Section 4.1), some figure scales have considered systematic variation in adiposity and muscularity through separate linear figure sets that represent body shape change relating to each dimension independently (Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019). Other scales have represented variation in adiposity and muscularity simultaneously within a single matrix-style set of figures (Arkenau et al., 2020; Cafri & Thompson, 2004; Hildebrandt et al., 2004; Pope Jr et al., 2000; Talbot, Smith et al., 2019). Many of these scales have demonstrated reliability and validity in estimating men's current and ideal body perceptions (Arkenau et al., 2020; Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019; Talbot, Smith, & Cass, 2019; Talbot, Smith, et al., 2019), as well as body dissatisfaction, indexed by a discrepancy between these current and ideal perceptions (Williamson et al., 1993). They have also shown psychometric properties in relation to several self-reported measures of men's body attitudes, preoccupations and dissatisfaction, such as the DMS (McCreary & Sasse, 2000), the EDE-Q (Fairburn & Beglin, 1994), and the Drive for Leanness Scale (DLS; Smolak & Murnen, 2008). However, there are important limitations in how these scales have been generated, as they are not precisely calibrated for measurements of adiposity, muscularity, and 3D body shape, which limits their ecological validity and specificity in representing men's perceptual body image.

The Visual Body Scale for Men (VBSM; Talbot, Cass, & Smith, 2019) presents two separate linear computer-generated body scales representing variation in body fat percentage from 4-40% and variation in FFMI from 16.5-30 kg/m^2. This scale has exhibited evidence of convergent validity, with significant relationships between men's current body perceptions and their actual body fat percentage, FFMI and BMI. It has also showed concurrent validity with a number of psychometric measures, including the EDE-Q (Fairburn & Beglin, 1994) and the MBAS low body fat and muscularity subscales (Tylka et al., 2005), as well as internal reliability over a period of 1-2 weeks (Talbot, Cass, & Smith, 2019; Talbot, Smith, & Cass, 2019). However, the calibration of this scale is problematic as the body fat and FFMI measurements attributed to the figures were founded on perceived visual correspondence with figures in the Modified Somatomorphic Matrix (Cafri & Thompson, 2004).

The Body Image Matrix of Thinness and Muscularity (BIMTM-MB; Arkenau et al., 2020) consists of 64 computer-generated male figures in an 8 x 8 matrix that systematically increase in adiposity along the x-axis and muscularity along the y-axis. This figure scale has demonstrated significant associations of ideal fat and muscle perceptions with psychometric measures such as the DMS (Waldorf, et al., 2014), DLS (Smolak & Murnen, 2008) and the drive for thinness subscale of the Eating Disorder Inventory – 2 (Thiel & Paul, 2006). The BIMTM-MB has demonstrated some evidence of convergent validity through correlations between men's current, ideal and felt body estimations to those measured using the Bodybuilder Image Grid-Original (Hildebrandt et al., 2004), as well as test-retest reliability of estimations over a period of around 17 days (Arkenau et al., 2020). It must be noted that this scale does not attribute actual measurements of body fat or muscle mass to the figures presented, thus preventing any direct comparison between participants' own body composition and their perceptual responses using the scale.

Similarly, the New Somatomorphic Matrix – Male (NSM-M; Talbot, Smith, et al., 2019) presents a matrix of computer-generated male figures that increase in body fat along the x-axis from 4-40% and increase in FFMI along the y-axis from 16.5-30 kg/m^2. This scale has shown concurrent validity through associations of body dissatisfaction estimations from the scale with psychometric measures of body dissatisfaction and eating disorder pathology, including the Eating Disorders Examination Questionnaire Short (EDE-QS; Gideon et al., 2016) and the Male Body Attitudes Scale – Revised (MBAS-R; Ryan et al., 2011). The NSM-M has also demonstrated excellent test-retest reliability of men's current and ideal body perceptions, and body dissatisfaction over a period of 1-2 weeks (Talbot, Smith, et al., 2019). However, again there is no precise calibration of these figures with actual measurements of body composition, as the figures were developed according to an artist's impression of men's body size and shape using photographs.

The Male Body Scale (MBS) and the Male Fat Body Scale (MFBS) present hand-drawn male bodies that systematically increase in steps of 10% body width from underweight to obese (Ralph-Nearman & Filik, 2018). The scales have evidenced construct validity through associations between men's perceived current estimations and their actual BMI, body fat and muscle percentages. Body dissatisfaction estimations using the MFBS have shown significant associations with drive for muscularity, assessed by the DMS (McCreary & Sasse, 2000), while MBS body dissatisfaction estimations have shown strong links with disordered eating pathology, measured according to the EDE-Q (Fairburn & Beglin, 1994). Both scales have also demonstrated test-retest reliability over a period of 2-6 weeks, although the strength of the correlations varied for perceived current and ideal estimations (Ralph-Nearman & Filik, 2018). The scales present unrealistic, linear changes in figure size that do not present detailed body shape information or account for male-specific patterns of body development based on muscularity and adiposity.

Although there is evidence for the reliability and validity of these existing figure scales, there are clear problems in how the scales were generated that are likely to influence their accuracy in estimating men’s current and ideal body perceptions. As discussed previously in Chapter 4, issues with existing scales include a general lack of ecological validity from the use of poor imagery (Gardner et al., 1999; Ralph-Nearman & Filik, 2018), separate considerations of each body composition dimension (Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019), and an absence of precise calibration of figures to actual measurements of adiposity and muscularity (Groves et al., 2019). Existing measures also tend to present limited body size and shape information due to restrictions in the number, range and orientation of figures (Crossley et al., 2012; Gardner et al., 1998). Therefore, there is a need to validate new male figure scales that overcome the limitations of existing measures, in order to improve the accuracy of estimating men’s perceptual body size and shape for both research and clinical practice.

This thesis chapter comprises two studies that pilot test the reliability and validity of a new interactive 3D male body scale in assessing estimations of men’s current and ideal body perceptions. This scale was developed from a database of 176 Caucasian adult male body scans, collected in Study 3 (Chapter 4, Section 4.4), and allows the user to alter body dimensions independently calibrated for fat and skeletal muscle mass. The absence of extraneous characteristics, such as a realistic skin texture, on the body model ensures that participants make judgments based purely on its size and shape. Study 4 examines the face validity of this new interactive scale, in order to evaluate men’s ability to visually perceive changes in fat mass and muscle mass in the presented body model as intended. Study 5 investigates the reliability and validity of the scale in assessing estimations of men’s current and ideal body perceptions, in order to appraise its suitability for use in research and clinical settings, as well as improve our understanding of how body composition influences men’s perceptions of body size and shape.

5.2 Study 4: Aims and Objectives

The present study aimed to evaluate whether independent alterations in the fat and muscle dimensions of the new interactive male body scale result in visually perceptible changes in body size and shape in adult men.

The main objective was to assess the face validity of the new interactive 3D male body scale, based on separate fat and muscle ratings of the predicted male body model at different levels of fat mass and skeletal muscle mass.

5.3 Study 4: Methods

This study received a favourable ethical opinion by LEAS on the 5th November 2019 (2019-0908).

5.3.1 Participants

A total of 31 adult men, aged 18-45, were recruited from staff and students at the University of Lincoln, and the general population, via posters, social media invitations, the University of Lincoln's staff news page, the SONA system, word-of-mouth and Prolific (https://www.prolific.co/). Students who signed up for participation via the SONA system received 2 credit points for taking part, while those recruited through Prolific received an incentive of £1.67 for their participation in this study.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 to 45 years
2. Participants who self-identify as male (cis-gender/as assigned at birth)

Participant exclusion criteria for this study were as follows:

1. Participants with a current or previous diagnosis of an eating or body image disorder

5.3.2 Materials

The 2D body stimuli used in this study were derived from the interactive body tool developed in Study 3 (Chapter 4, Section 4.4.3), that allows a user to independently alter the fat mass and muscle mass of a predicted 3D male body model. A description of how these stimuli were developed from this tool is provided in the general methods section of this thesis (Chapter 2, Section 2.2.3.1). The bodies images presented ten increments of fat mass, ranging from 2.5-46 kg, and five increments of muscle mass dimension, ranging from 28.4-61.6 kg. The predicted body models representing these 50 different combinations of fat and muscle mass were then shown at three orientations; a front, side, and three-quarter view, and displayed as 930 x 290 pixel images within an online survey in this study.

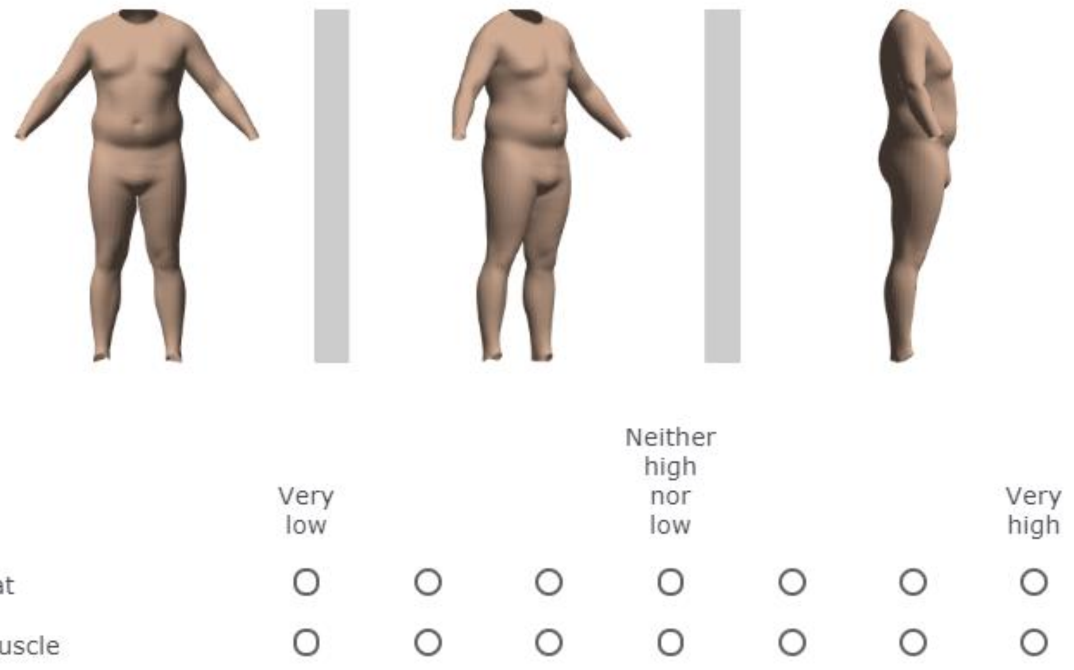
5.3.3 Study Procedures

Participants who showed interest in the study were provided with a link to an online Qualtrics (https://www.qualtrics.com/uk) survey for data collection. The first page of the survey was an information sheet (Appendix B.11) that included the purpose and nature of the study, eligibility criteria, study procedures, confidentiality, relevant support resources and researcher contact information. The second page of the survey included a written consent form (Appendix B.12), where participants were able to confirm that they met all eligibility criteria and provide their informed consent using a multiple-choice dropdown list. They were also asked to confirm that they were completing the survey on a laptop or computer, rather than a mobile phone or tablet, in order to standardise the size of the images seen by participants across the sample, as far as possible. Participants were then required to self-report a range of demographic information, including their sex (cis-gender/as assigned at birth), age, ethnicity, sexual orientation and whether they had a current or previous diagnosis of an eating or body image disorder. Participants who reported that they had a current or previous diagnosis were then shown a disclaimer message reiterating the nature of the study, their right to withdraw or take breaks at any time during participation, and that contact details and support resources could be found in the information and debrief sections of the survey.

Participants were then given instructions explaining that they would be shown images of bodies from three viewpoints and asked to rate each body for its level of fat and muscle using a 7-point response scale from ‘very low’ to ‘very high’, with the middle point labelled as ‘neither high nor low’. They were encouraged to use the full range of this response scale when making their judgements in the survey. Participants were then shown the 50 male bodies one at a time and asked to rate each body for fat and muscle separately. The fat and muscle rating questions were presented underneath the stimulus for each trial, on the same page of the online survey, thus allowing participants to view the bodies while making their responses (see Figure 5.1). This task was randomised in Qualtrics using the ‘Loop & Merge’ function, so that the images within each block were randomly presented to each participant. At the end of the ratings, participants were presented a debrief sheet (Appendix B.13) detailing the aim of the study, their right to withdraw, their personal identification number, relevant resources for support and researchers’ contact details. The online survey took around 30 minutes in total and results were automatically recorded in Qualtrics.

Figure 5.1

Example Fat and Muscle Rating Question



	Very low			Neither high nor low			Very high
Fat	○	○	○	○	○	○	○
Muscle	○	○	○	○	○	○	○

Note. Example of a male body presented at three viewpoints with subsequent response scales for separate ratings of fat mass and muscle mass.

5.3.4 Data Analysis

All data analysis for this study was conducted using IBM SPSS Statistics software (Version 26.0). Descriptive statistics were computed for participant demographics, including age, ethnicity and sexual orientation. Descriptive statistics were also computed for participant fat and muscle ratings at each level of these dimensions in the stimuli, based on responses dummy coded from 1 = ‘very low’ to 7 = ‘very high’.

Given that individual fat and muscle ratings for the stimuli were measured at the ordinal scale level and were not normally distributed, as determined by Shapiro Wilk tests, nonparametric statistical methods were used for the correlational analysis in this study. In order to evaluate the face validity of the interactive body scale, Spearman’s correlations were conducted to assess the relationship between stimuli fat mass and participant fat ratings, and between stimuli muscle mass and participant muscle ratings. Nonparametric partial correlations were also used to evaluate the relationship between stimuli fat mass and participant fat ratings, while controlling for stimuli muscle mass, and between stimuli muscle mass and participant muscle ratings, while controlling for stimuli fat mass. Finally, cumulative odds ordinal logistic regressions with proportional odds were then run to determine the unique effects of stimuli fat mass and muscle mass on participant fat and muscle ratings.

5.4 Study 4: Results

5.4.1 Participant Characteristics

A total of 31 adult men, aged 18 to 45 (*M* = 28.90, *SD* = 7.55), were recruited for this study and completed the online Qualtrics survey. The sample predominantly self-reported as being heterosexual (87.10%) and of White/Caucasian ethnicity (83.87%). Table 5.1 presents the means, standard deviations and frequencies for the participant demographics in the sample.

Table 5.1

Means, Standard Deviations and Frequencies for Participant Demographics

Demographic	Total Sample (N = 31)
Age (years)	
Mean (SD)	28.90 (7.55)
Minimum	18.00
Maximum	45.00
Sexual Orientation	
Heterosexual	27 (87.10%)
Homosexual	1 (3.23%)
Bisexual	2 (6.45%)
Prefer Not to Say	1 (3.23%)
Ethnicity	
White/Caucasian	26 (83.87%)
Mixed	2 (6.45%)
Asian	1 (3.23%)
Chinese	2 (6.45%)

5.4.2 Face Validity

The mean, standard deviation and range of participant fat ratings for each of the 10 levels of stimuli fat mass are presented in Table 5.2. Similarly, Table 5.3 shows the mean, standard deviation and range of participant muscle ratings for each of the 5 levels of stimuli muscle mass. A statistically significant negative relationship was found between participants' fat and muscle ratings across the stimuli range ($r_s = -.59$, $p < .001$), as shown in Figure 5.2.

Table 5.2

Means, Standard Deviations and Range for Participant Fat Ratings

Stimuli Fat Level	Total Sample (N = 31)			
	Mean	SD	Min.	Max.
1	1.99	0.88	1.00	5.00
2	2.47	1.06	1.00	5.00
3	2.99	1.15	1.00	7.00
4	3.63	1.15	1.00	6.00
5	4.24	1.06	1.00	6.00
6	4.84	0.90	2.00	7.00
7	5.35	0.72	2.00	7.00
8	5.60	0.74	2.00	7.00
9	6.01	0.77	2.00	7.00
10	6.35	0.63	5.00	7.00

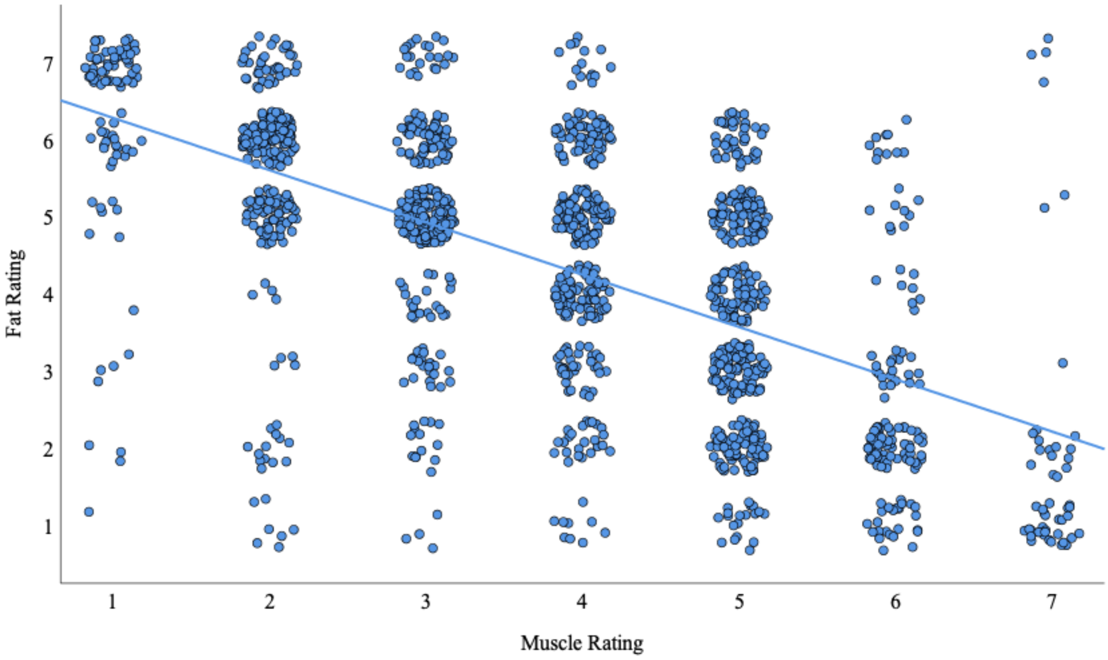
Table 5.3

Means, Standard Deviations and Range for Participant Muscle Ratings

Stimuli Muscle Level	Total Sample (N = 31)			
	Mean	SD	Min.	Max.
1	3.15	1.26	1.00	7.00
2	3.48	1.37	1.00	7.00
3	3.88	1.40	1.00	7.00
4	4.15	1.48	1.00	7.00
5	4.63	1.50	1.00	7.00

Figure 5.2

Scatter Plot of Relationship Between Participant Fat and Muscle Ratings

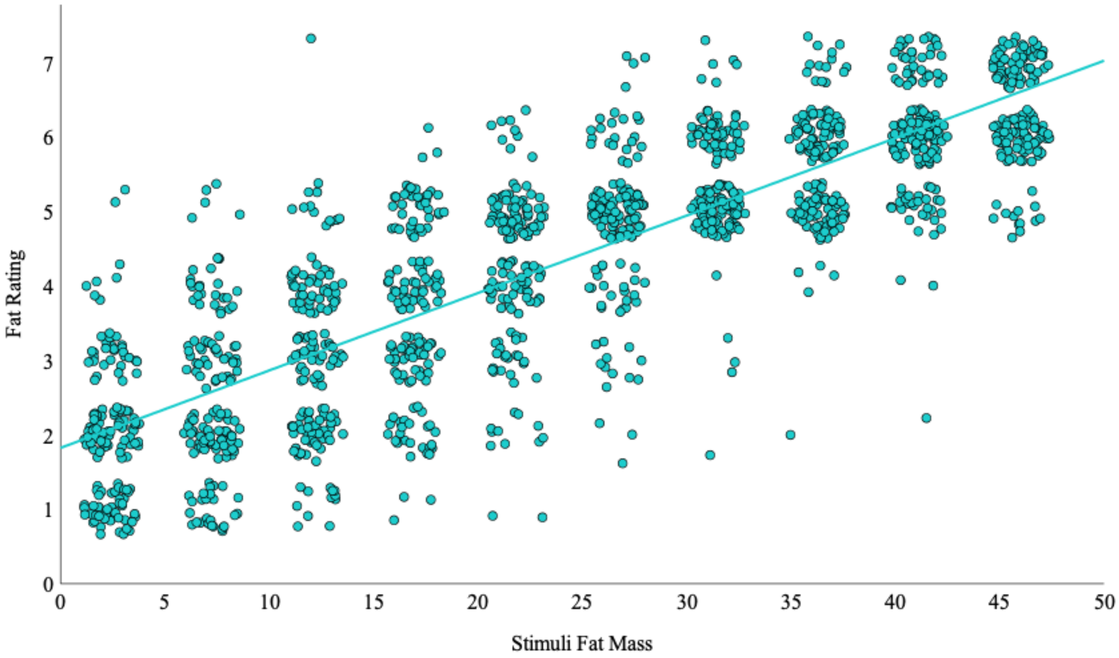


5.4.2.1 Fat Ratings

A Spearman’s correlation revealed a statistically significant positive relationship between stimuli fat mass and participants’ fat ratings in the sample (r_s = .85, p < .001), as shown in Figure 5.3. A nonparametric partial correlation revealed that this association between stimuli fat mass and participant fat ratings was greater when stimuli muscle mass was controlled for ($r_{partial}$ = .86, p < .001).

Figure 5.3

Scatter Plot of Participant Fat Ratings by Stimuli Fat Mass



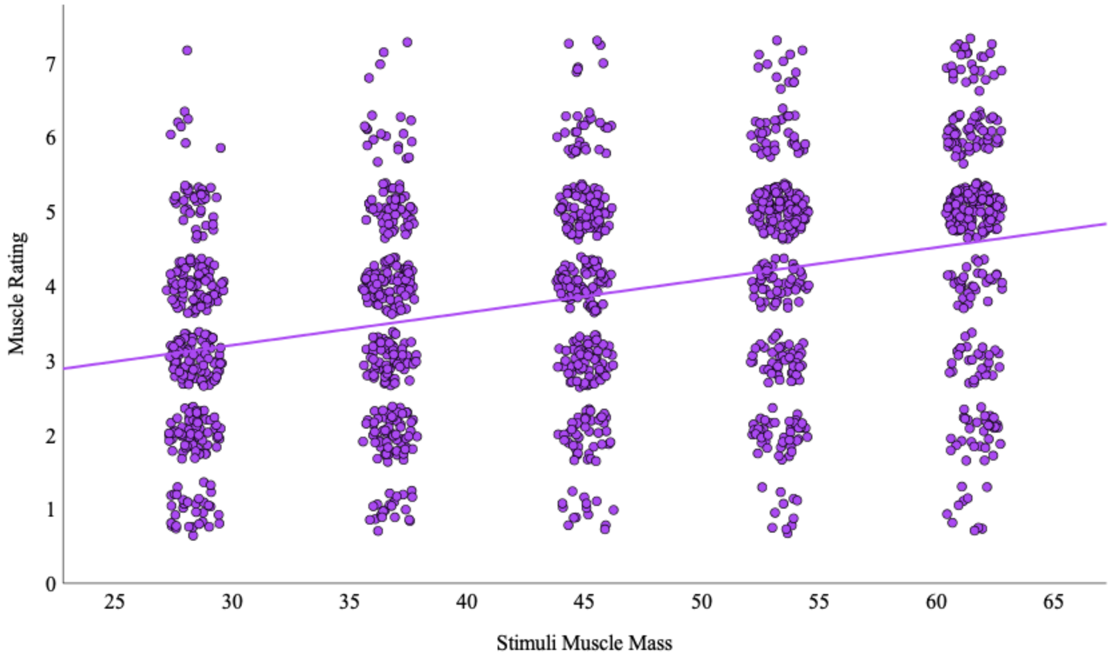
An ordinal logistic regression found that stimuli fat mass had a statistically significant effect on the prediction of participant fat ratings, $\chi^2(1) = 1121.36$, p < .001. Stimuli muscle mass also had a statistically significant effect on the prediction of participant fat ratings, $\chi^2(1) = 115.25$, p < .001. An increase in stimuli muscle mass of 1 kg was associated with a decrease in the odds of a high participant fat rating, with an odds ratio of 0.955, 95% CI [0.948, 0.963], whereas a 1 kg increase in stimuli fat mass was associated with an increase in the odds of a high participant fat rating, with an odds ratio of 1.250, 95% CI [1.234, 1.266].

5.4.2.2 Muscle Ratings

Correlational analysis revealed a statistically significant positive association between participants' muscle ratings and stimuli muscle mass in the sample ($r_s = .35$, $p < .001$). A nonparametric partial correlation revealed that the association between stimuli muscle mass and participant muscle ratings was greater when stimuli fat mass was controlled for ($r_{partial} = .41$, $p < .001$).

Figure 5.4

Scatter Plot of Participant Muscle Ratings by Stimuli Muscle Mass



An ordinal logistic regression found that stimuli muscle mass had a statistically significant effect on the prediction of participant muscle ratings, $\chi^2(1) = 270.48$, $p < .001$. Stimuli fat mass also had a statistically significant effect on the prediction of participant muscle ratings in the sample, $\chi^2(1) = 492.01$, $p < .001$. An increase in stimuli muscle mass of 1 kg was associated with an increase in the odds of a high participant muscle rating, with an odds ratio of 1.072, 95% CI [1.063, 1.081], whereas a 1 kg increase in stimuli fat mass was associated with a decrease in the odds of a high participant muscle rating, with an odds ratio of 0.918, 95% CI [0.911, 0.925].

5.5 Study 4: Discussion

5.5.1 Summary and Interpretation of Main Findings

This pilot study provided a manipulation check for the face validity of the new interactive male body scale, in order to assess whether adult men were able to visually perceive changes in the fat mass and muscle mass of the predicted male body model as intended. Correlational analyses demonstrated evidence to support the face validity of this scale, through significant associations between participant ratings and the levels of fat mass and muscle mass displayed in the model. Visual inspection of Figures 5.3 and 5.4 revealed potential outliers in participant fat and muscle ratings. However, the nonparametric analyses used in this study are considered to be robust to outliers (Croux & Dehon, 2010), and these findings suggest some variability in men's visual perceptions of body composition within the bodies presented. Although correlations between participant ratings and stimuli body composition were statistically significant for both fat mass and muscle mass, a stronger relationship was found between stimuli fat mass and fat ratings in this study. Men were more accurate in visually identifying alterations in the fat mass of the predicted body model, compared to the muscle mass. It could be argued that the stronger association between stimuli fat mass and participant fat ratings was a result of the wider relative range in fat mass across the stimuli. Although, the difference in fat mass between each image was approximately half that of the muscle mass. The relative ranges of fat mass and muscle mass in the stimuli were equivalent to the actual ranges derived from the database of 176 male body scans collected in Study 3 (Chapter 4, Section 4.4.2), which was assumed to approximate the range of each body composition dimension found in the Lincoln population. Another potential explanation could be that changes in fat mass were associated with greater alterations in body size and shape relative to muscle mass, and that visual cues to adiposity, such as stomach depth (Cornelissen et al., 2018), were more salient in the stimuli than potential visual cues to muscularity, such as the WCR (Coy et al., 2014; Swami et al., 2007).

Fat mass and muscle mass generally manifest in different parts of the male body and result in different patterns of body shape (Wells, 2007). However, previous research has evidenced a negative association between the appearance of adiposity and muscularity, suggesting that lower adiposity heightens the appearance of muscularity in male bodies (Cafri & Thompson, 2004). A negative correlation between participant fat and muscle ratings was found in this study, and ordinal logistic regression models revealed that both stimuli fat mass and muscle mass significantly predicted participant fat and muscle ratings separately, but in opposite directions. It could be the case that individuals generally associated increased body size with adiposity rather than muscularity, given that there was a wider relative range in fat mass across the stimuli. Increasing levels of muscularity may have also been visually masked as the adiposity of the stimuli increased (Chittester & Hausenblas, 2009), resulting in this negative relationship between participant fat and muscle ratings.

5.5.2 Strengths and Limitations

This approach to evaluating the face validity of the interactive male body scale enabled separate considerations of visual adiposity and muscularity perceptions in 3D male bodies while presenting variation in both dimensions simultaneously. The use of a 7-point response scale for fat and muscle ratings from ‘very low’ to ‘very high’ allowed for an understanding of individuals’ visual perceptions of the body composition dimensions without attributing a numeric value to these judgements. For example, participants could have been asked to estimate the specific amount of fat mass and muscle mass attributed to each figure or to use a numeric response scale for the stimuli fat and muscle ratings. Instead, the response scale from ‘very low’ to ‘very high’ was intended to evaluate whether they could visually perceive increases or decreases in adiposity and muscularity without bias from any potential preconceived notions of what certain amounts of fat mass and muscle mass look like in a male body. Given that participants were encouraged to use the full range of this response scale when making their ratings, these responses may not reflect their actual perceptions of extreme adiposity and muscularity. For example, participants may have rated muscle mass as ‘very high’ based on the range of bodies they had seen previously in the study, rather than their actual beliefs about what a high level of muscle mass looks like. However, this approach was appropriate for assessing whether participants could visually detect changes in the level of fat and muscle mass within the predicted body model. In addition, the order in which stimuli were presented in the survey was randomised to minimise any potential anchoring effects from the bodies viewed previously in the study (Gardner, 1996).

The sample size in this study was smaller than those in similar research that has conducted manipulation checks to assess the face validity of CGI figures that vary in body composition. For example, Ralph-Nearman and Filik (2018) carried out a manipulation check of the Male Body Scale and Male Fit Body Scale by asking 55 participants to order the figures in each scale, presented in a random order, from thinnest to largest. Similarly, Tovée and colleagues (2012) asked 40 participants to rate the attractiveness of female figures that varied in apparent body fat, from underweight to obese, using a 6-point response scale ranging from ‘very unattractive’ to ‘very attractive’. This pilot study aimed to conduct a simple and efficient manipulation check for the face validity of the scale, prior to its application in evaluating men’s current and ideal body perceptions. Furthermore, rules of thumb relating to acceptable sample sizes for pilot research have recommended 10 to 30 individuals for pilot studies in survey research and at least 30 individuals for correlational research (Hill, 1998). Therefore, the sample size in this study was based on these principles and pragmatic difficulties in recruiting male participants to take part in an online survey.

The sample was predominantly comprised of men who self-reported as being of White or Caucasian ethnicity, however 16.13% of participants represented other ethnic groups. Participants of non-White ethnicity were retained in the sample for data analysis as this study was not concerned with individual current and ideal body size perceptions, or sociocultural attitudes relating to body weight. Instead, it focused purely on whether men could visually perceive differences in the adiposity and muscularity of the body model presented. However, ethnic differences in patterns of adiposity, muscularity and weight distribution have been established (Abe et al., 2012; Shiwaku et al., 2004; Silva et al., 2010; WHO Expert Consultation, 2004). Therefore, ethnicity may have played a role in men's perceptions of adiposity and muscularity in the predicted male body model.

Participants recruited for this study through Prolific may not have been residing in the UK at the time of data collection. Within the context of visual normalisation theory, participants may have based their stimuli ratings on an internalised body template for 'normal' levels of adiposity and muscularity, derived from the types of bodies that they see frequently within their visual diet (Burke et al., 2010; Robinson, 2017). These internalised norms may have differed between individuals from various ethnic groups or those living in diverse sociocultural environments. Individuals may also have used different visual cues for adiposity based on ethnicity-specific patterns of adiposity, muscularity and weight distribution (Abe et al., 2012; Shiwaku et al., 2004; Silva et al., 2010; WHO Expert Consultation, 2004).

5.5.3 Implications and Future Work

Given the novelty of this interactive scale as a measure of men's perceptual body image, it is important to examine its face validity in other groups of interest, including clinical male samples and the female population. This would allow for a preliminary validation of the scale in other populations that would widen the scope for future research using this scale, such as investigations into opposite-sex perceptions of attractiveness in females (Brierley et al., 2016; Yanover & Thompson, 2010) and perceptual body image relating to muscularity and adiposity in clinical male patients (Mangweth et al., 2004). The findings of this study also support applications of the scale in assessing perceptions of adiposity and muscularity norms in male bodies (Grossbard et al., 2011) and exploring the influence of these dimensions on a variety of judgements, such as those relating to men's personality traits, health and sociocultural factors (Furnham et al., 2006; Greenleaf et al., 2004; Swami, Furnham, et al., 2008; Webb et al., 2004).

Although this pilot study was focused on validation of the new scale, it would also be interesting to investigate whether participants used any specific strategies to inform their stimuli fat and muscle ratings. Reference to certain visual cues to body composition (Cornelissen et al., 2018; Coy et al., 2014; Swami et al., 2007), comparisons between the figures presented, or implicit comparisons to internalised body norms (Burke et al., 2010; Grossbard et al., 2011; Robinson, 2017) may have influenced participants' ratings in this study. It could be that the variation in participants' fat and muscle ratings found were a result of different underlying strategies for making these body composition judgements. Overall, this study provides evidence for the face validity of the new interactive body scale, demonstrating that adult men are able to visually perceive changes in predicted body size and shape associated with fat mass and skeletal muscle mass independently. This justifies an evaluation of the reliability and validity of this scale in estimating men's current and ideal body perceptions, in order to determine its suitability for use in research and clinical settings.

5.6 Study 5: Aims and Objectives

Study 5 aimed to pilot test the reliability and validity of the new interactive 3D male body fat and muscle scale in assessing estimations of current and ideal body perceptions among a general sample of adult men.

The main objectives for this study were:

1. To assess men's estimations of their perceived current and ideal body estimations relating to fat mass and muscle mass using the new interactive 3D male body scale
2. To estimate indices of body dissatisfaction and body image distortion relating to fat mass and muscle mass using the new interactive 3D male body scale
3. To evaluate the convergent validity, concurrent validity and test-retest reliability of the new interactive 3D male body scale

5.7 Study 5: Methods

Study 5 received a favourable ethical opinion by LEAS on the 5th November 2019 (2019-0908).

5.7.1 Participants

A total of 25 adult men, aged 18-45, were recruited for this study from staff and students at the University of Lincoln and the general population. Recruitment was carried out using posters, flyers, social media invitations, the University of Lincoln staff news webpage, the SONA system and general word-of-mouth. Students who signed up to take part in this study through the SONA system received 4 credit points in total for their participation; 2 credits for session one and 2 credits for session two.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 to 45 years
2. Participants who self-identify as male (cis-gender/as assigned at birth)

Participant exclusion criteria for this study were as follows:

1. Participants with a current or previous diagnosis of an eating or body image disorder
2. Participants with pacemakers or any other type of electrical implanted devices.

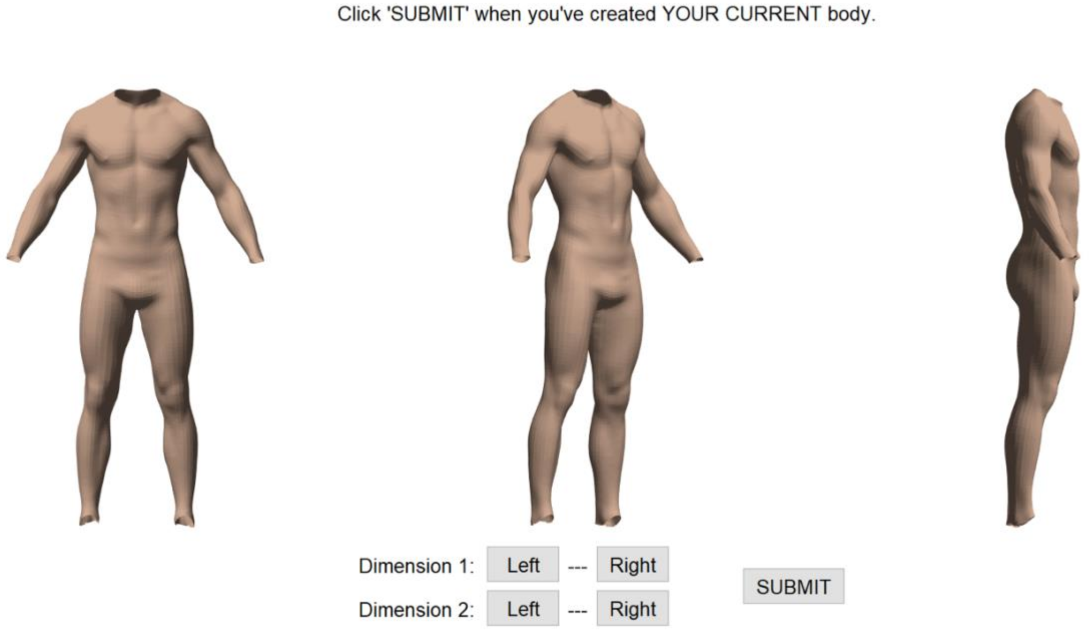
5.7.2 Materials

5.7.2.1 Interactive Fat and Muscle Body Scale

The present study used the new interactive 3D male body scale, that was developed in Study 3 (Chapter 4, Section 4.4.3), to visually model changes in male body size and shape as a function of fat mass and muscle mass independently. This scale was presented to participants on a computer screen using a graphical user interface in MATLAB (2018), with the predicted male body model shown from a front, side and three-quarter view. Two buttons labelled ‘left’ and ‘right’ were presented underneath the body model that allowed participants to alter the predicted body size and shape of the figure based on independent changes in fat mass and muscle mass (Figure 5.5). These two body composition dimensions were labelled as ‘Dimension 1’ and ‘Dimension 2’, in order to conceal the identity of each dimension in the scale from the participants. The first dimension altered the body based on measurements of fat mass and the second dimension corresponded to changes in skeletal muscle mass. These body composition dimensions were presented in an arbitrary random position along the range of fat mass and skeletal muscle mass for each trial of the perceptual body image task in this study. In addition, fat mass and skeletal muscle mass values were not displayed in the scale, to ensure that participants focused on associated changes to the size and shape of the model, rather than on the numeric values of each dimension. A ‘submit’ button was also presented on the screen to record the combination of fat mass and muscle mass values associated with participants' body creations as part of the perceptual body image task in this study.

Figure 5.5

Example of the Interactive Male Body Scale



Click 'SUBMIT' when you've created YOUR CURRENT body.

Note. Example of the interactive scale presenting the predicted male body shape at three viewpoints, with 'left' and 'right' buttons to alter dimension 1 (fat mass) and dimension 2 (skeletal muscle mass).

5.7.2.2 Psychometric Measures

Multiple self-report questionnaires were used to assess psychological factors relating to perceptual body image, including body shape concerns and dissatisfaction, internalisation of the thin- and athletic-ideals, levels of depression and self-esteem, body appreciation and the drive for muscularity. These are described in more detail within the general methods section of this thesis (Chapter 2, Section 2.5).

Body Dissatisfaction. The BSQ-16b (Evans & Dolan, 1993) was used as a measure of general body dissatisfaction and body shape preoccupations, with a Cronbach's alpha of .88 in this study. The DMS (McCreary & Sasse, 2000) was administered to assess participants' motivation and preoccupation with increasing their level of muscularity. The MB subscale had a Cronbach's alpha of .91 and the MBI subscale had a Cronbach's alpha of .95 in this sample. The shape and weight concern subscales of the EDE-Q (Fairburn & Beglin, 1994) were used to assess eating disorder-related attitudes and behaviours, as well as dissatisfaction and distress relating to their own body shape and weight. The Cronbach's alpha for EDE-Q global scores, as well as for the shape concern subscale and weight concern subscale were .86, .77 and .76, respectively.

Body Appreciation. The BAS-2 (Avalos et al., 2005) was administered to measure levels of positive body image, including body acceptance and appreciation, respect and protection of one's body. The Cronbach's alpha for the BAS-2 was .92 in this study.

Internalisation of Appearance Ideals. The SATAQ-4 (Schaefer et al., 2015) was used to assess individual internalisation of the thin-ideal and athletic-ideal. The internalisation-thin/low body fat subscale had a Cronbach's alpha of .82 and the internalisation-muscularity/athletic subscale had a Cronbach's alpha of .90 in the sample.

Depression and Self-Esteem. The BDI (Beck et al., 1961) was administered as a measure of symptoms of depression and the RSE (Rosenberg, 1965) was used to assess levels of self-esteem. The Cronbach's alpha was .71 for the BDI and .88 for the RSE in this sample.

5.7.3 Study Procedures

This was a laboratory-based study held over two sessions, with the second session taking place two-to-three days after the first session. Participants who expressed interest in the study were provided with either an electronic or hard-copy information sheet (Appendix B.14) describing the aims and nature of the study, eligibility criteria, study procedure, confidentiality, relevant support resources and researcher contact information. They were informed that the first session would take approximately 30 minutes and that they would be invited back two-to-three days later for a second session that would take around 15 minutes. The information sheet also explained that people with pacemakers or other implanted electrical devices could not take part due to potential harm from the electrical activity used by the bio-impedance scale.

In the first session, participants provided written informed consent (Appendix B.15) and personal demographic information including their sex (cis-gender/as assigned at birth), sexual orientation, ethnicity, age and whether or not they have a current or previous diagnosis of an eating or body image disorder. These demographics were self-reported on the first page of an online Qualtrics survey and a disclaimer was presented to any participants reporting that they have a current or previous diagnosis that reiterated the study's procedure, their right to withdraw, and that support resources were provided in both the information and debrief forms.

Participants were then asked to complete a perceptual body image task in which they created their perceived current and ideal body size and shape using the interactive male body scale. Participants were guided to follow the instructions on the screen that would tell them whether to create their current or ideal body in each trial. They were also instructed to use the computer mouse to click on the ‘left’ and ‘right’ buttons on the screen to independently alter the body model along two separate dimensions for each body creation. Participants were then told to press the ‘submit’ button on the screen once they had finished their body creation, in order to move on to the next trial. Participants created their perceived current and ideal bodies twice in a row, and the order of these tasks was randomised in the study.

Following the perceptual body image task, participants were asked to refer to the online Qualtrics survey to complete the following self-report questionnaires: BSQ-16b, DMS, EDE-Q, BAS-2, SATAQ-4, BDI and RSE. The names of the questionnaires were not displayed in the survey and they were presented to participants in a random order. Finally, body composition measurements were taken using a Tanita bio-impedance scale, in order to gain an estimate of a participant’s actual fat mass, skeletal muscle mass and BMI (Chapter 2, Section 2.4). In addition, a tape measure and stadiometer were used to take anthropometric measurements, including their height (cm), chest (cm), waist (cm), hips (cm) and relaxed bicep (cm) circumferences (Chapter 2, Section 2.6).

In the second session, participants were asked to repeat the perceptual body image task in which they created their perceived current and ideal body size and shape following an identical procedure to the first session. Again, each task was carried out twice in a row and the order of the tasks was randomised. At the end of this session, participants were given a debrief form (Appendix B.16) detailing the aims of the study, confidentiality, their right to withdraw, their personal identification number, relevant support resources and the researchers’ contact information.

5.7.4 Data Analysis

All data analysis for this study was conducted using IBM SPSS Statistics software (Version 26.0). Descriptive statistics were computed for participant demographics, body measurements and psychometric scores in the sample. Average fat and skeletal muscle mass values were calculated for participants’ perceived current and ideal bodies created in each session, based on recorded values from the two body creations in each perceptual task. An index of BD was then calculated separately for each body composition dimension, by subtracting the participant’s average perceived current self-estimation from their ideal self-estimation in each session. An index of BID was also achieved separately for each body composition dimension, by subtracting the participant’s actual fat or muscle mass measurement from their average perceived current estimation in each session. Participants' actual body composition measurements from session 1 were used to attain the estimates of BID in session 2, given that measurements of fat mass and skeletal muscle mass were only taken in the first session and were unlikely to have changed in the two-to-three day interval between sessions.

Spearman rank correlations were used to assess relationships between the psychometric measures, as well as between participants' attitudinal body image and their measurements of BMI, fat mass and skeletal muscle mass. The concurrent and convergent validity of the interactive tool was evaluated using a series of correlations between participants' body composition measurements, current and ideal body perceptions, BD and BID estimates, and their psychometric scores. Finally, the test-retest reliability of the interactive tool between sessions 1 and 2 was determined using Spearman and interclass correlations, with separate analyses for the reliability of perceived current, ideal, BD and BID estimations in relation to fat mass and skeletal muscle mass. The intraclass correlations used a two-way mixed-effects model based on average ratings and absolute agreement and were compared to a recommended .80 standard for test-retest reliability (Carmines, 1990). The Spearman correlation coefficients were compared to an established cut-off of .70 for acceptable reliability (Terwee et al., 2007; Nunnally, 1970).

5.8 Study 5: Results

5.8.1 Participant Characteristics

A total of 25 adult men were recruited for this study and took part in both the initial and follow-up sessions. However, one participant was excluded from data analysis as they self-reported as having a current or previous diagnosis of an eating or body image disorder. The final sample consisted of 24 adult men, aged 18 to 45 (*M* = 20.33, *SD* = 1.52), who predominantly reported being of Caucasian ethnicity (87.50%), heterosexual (83.33%) and ranged in BMI from 15.80 to 27.40 kg/m^2 (*M* = 21.82, *SD* = 3.11). Table 5.4 presents the means, standard deviations and range of anthropometric measurements for the total sample.

Table 5.4

Means, Standard Deviations and Range for Participant Anthropometrics

Measurement	Total Sample (N =24)			
	Mean	SD	Min.	Max.
Fat Mass (kg)	11.48	5.76	2.00	26.90
Skeletal Muscle Mass (kg)	34.32	3.88	26.40	41.90
BMI (kg/m^2)	21.82	3.11	15.80	27.40
Chest (cm)	90.17	5.34	81.00	100.50
Waist (cm)	79.50	7.36	66.00	93.00
Hip (cm)	97.33	6.21	85.00	109.00
Bicep (cm)	28.58	3.48	23.00	36.00
WHR	0.82	0.05	0.75	0.95
WCR	0.88	0.06	0.79	1.01

5.8.1.1 Psychological Factors

The means, standard deviations and range of sample scores for all psychometric measures are presented in Table 5.5. Spearman's rank correlations were used to assess relationships between the psychometric measures of body shape concerns and dissatisfaction, the internalisation of appearance ideals, levels of depression and self-esteem, body appreciation and the drive for muscularity (Table 5.6). As would be expected, a statistically significant negative correlation was found between measures of depression and self-esteem (p = .009). Body appreciation was significantly correlated with both self-esteem (p < .001) and depression (p = .033), although in opposite directions. Self-esteem was also significantly correlated with the SATAQ-4 thin subscale (p = .014) and the DMS MBI subscale (p = .019). There was high collinearity between the psychometric measures of body dissatisfaction, body shape concern, depression, drive for muscularity and internalisation of appearance ideals. For example, the EDE-Q subscales were significantly correlated with all other scales apart from the DMS MB subscale and BDI (p > .05). Similarly, EDE-Q global scores were significantly correlated with every other psychometric measure apart from the BDI (p = .330). The BSQ-16b was significantly negatively correlated with the RSE (p = .005) and the BAS-2 (p = .004), and significantly positively correlated with the SATAQ-4 internalisation-thin subscale (p = .002) and BDI subscale (p = .004). The two DMS subscales and the two SATAQ-4 subscales were all significantly positively correlated with each other (*p* < .05). The SATAQ-4 thin subscale was additionally significantly correlated with the BAS-2 (*p* = .045).

Spearman's correlations were used to assess associations between participant's psychometric scores and their actual BMI, fat mass and skeletal muscle mass. BMI and fat mass were not found to be significantly correlated with any of the psychometric measures (*p* > .05). However, measurements of skeletal muscle mass were significantly positively correlated with the DMS MB subscale ($r_s = .46$, *p* = .024) and EDE-Q global scores ($r_s = .48$, *p* = .018) in this sample.

Table 5.5

Means, Standard Deviations and Range for Psychometric Measures

Measures	Total Sample (N = 24)			
	Mean	SD	Min.	Max.
BAS-2	3.26	0.74	2.18	4.50
SATAQ-4: Athletic	3.38	1.08	1.20	5.00
SATAQ-4: Thin	2.90	0.97	1.40	5.00
DMS: MB	2.31	1.17	1.00	4.38
DMS: MBI	4.18	1.30	1.57	6.00
BDI	7.79	4.45	0.00	20.00
RSE	20.21	5.45	7.00	30.00
BSQ-16b	32.46	11.15	17.00	63.00
EDE-Q: Shape Concern	1.57	1.08	0.00	4.00
EDE-Q: Weight Concern	1.21	1.02	0.00	4.00
EDE-Q: Global	1.02	0.74	0.00	3.15

Table 5.6

Spearman's Correlations Between Psychometric Measures

	Measures									
	1	2	3	4	5	6	7	8	9	10
1. BAS-2	1.00									
2. SATAQ: Athletic	-.11	1.00								
3. SATAQ: Thin	-.41*	.61**	1.00							
4. DMS: MB	.04	.78**	.52**	1.00						
5. DMS: MBI	-.28	.64**	.47*	.43*	1.00					
6. BDI	-.44*	.04	.36	.24	.26	1.00				
7. RSE	.73**	-.27	-.49*	-.23	-.48*	-.52**	1.00			
8. BSQ-16b	-.59**	.34	.60**	.17	.36	.57**	-.56**	1.00		
9. EDE-Q: Shape	-.75**	.44*	.60**	.18	.64**	.37	-.78**	.68**	1.00	
10. EDE-Q: Weight	-.69**	.47*	.62**	.34	.50*	.34	-.74**	.76**	.87**	1.00
11. EDE-Q: Global	-.52*	.59**	.68**	.43*	.62**	.33	-.67**	.64**	.85**	.83**

* $p < .05$, ** $p < .01$

5.8.2 Perceptual Body Creations

5.8.2.1 Current and Ideal Body Estimations

Table 5.7 presents the means and standard deviations of the average body fat and skeletal muscle mass values for participants' perceived current and ideal body creations in sessions 1 and 2. Participants' perceived current fat estimations ranged from 2.50-27.25 kg across the two sessions, while current muscle mass estimations ranged from 28.6-60.5 kg. Participants' ideal fat mass ranged from 2.50-37.35 kg across sessions 1 and 2, while ideal muscle mass ranged from 31.9-61.5 kg. Spearman's correlations were conducted to investigate associations between perceived current and ideal levels of fat mass and skeletal muscle mass in sessions 1 and 2 separately. Responses in session 1 revealed no significant correlations between perceived current and ideal levels of fat mass ($r_s = .10$, $p = .637$) or skeletal muscle mass ($r_s = -.19$, $p = .370$). A significant positive correlation was found in session 2 between perceived current and ideal fat mass ($r_s = .46$, $p = .025$), but not skeletal muscle mass ($r_s = .07$, $p = .745$).

Spearman's correlations were also used to evaluate associations between the average fat mass and muscle mass estimates for the perceived current and ideal tasks. In session 1, the fat mass and skeletal muscle mass estimates were not significantly correlated for the perceived current ($r_s = .27$, $p = .204$) and ideal tasks ($r_s = -.32$, $p = .130$). Similarly, estimates of fat mass and skeletal muscle mass were not significantly correlated for the current ($r_s = .23$, $p = .281$) and ideal perceptions ($r_s = .14$, $p = .530$) in session 2.

Table 5.7

Means and Standard Deviations of Fat and Muscle Mass for Perceptual Tasks in Each Session

Dimension (kg)	Session 1		Session 2	
	Current	Ideal	Current	Ideal
Fat Mass	9.68 (7.01)	11.61 (7.66)	9.68 (6.76)	10.77 (6.78)
Muscle Mass	41.88 (7.47)	48.05 (8.60)	40.77 (9.86)	50.90 (8.20)

5.8.2.2 Body Image Distortion and Dissatisfaction Estimations

Table 5.8 shows the means and standard deviations of the estimations of BD and BID in relation to fat and muscle mass in sessions 1 and 2. Spearman's correlations were conducted to investigate associations between the BD and BID estimations in sessions 1 and 2 separately. In session 1, there were significant negative correlations between BD and BID for the estimations of fat mass ($r_s = -.62$, $p = .001$) and skeletal muscle mass ($r_s = -.82$, $p < .001$). There were also significant negative correlations between BD and BID for the estimations of fat mass ($r_s = -.45$, $p = .028$) and skeletal muscle mass ($r_s = -.67$, $p < .001$) in session 2. Figures 5.6 and 5.7 present the relationship between BD and BID for estimations of fat mass and skeletal muscle mass in each session.

Spearman's correlations were also used to assess relationships between the estimations of BD, BID and participants' actual fat mass and skeletal muscle mass, measured in session 1. No significant correlations were found between the estimations of BD in either session and participants' actual fat mass or skeletal muscle mass ($p > .05$). Similarly, no significant correlations were found between the estimations of BID in either session and actual measurements of fat mass and skeletal muscle mass ($p > .05$).

Table 5.8

Means and Standard Deviations of BD and BID for Fat and Muscle Mass in Each Session

Dimension (kg)	Session 1		Session 2	
	BD	BID	BD	BID
Fat Mass	1.94 (10.25)	-1.81 (4.77)	1.09 (5.86)	-1.80 (4.87)
Muscle Mass	6.19 (13.46)	7.53 (8.50)	10.13 (12.65)	6.45 (9.17)

Figure 5.6

Scatter Plot of the Relationship Between BD and BID Fat Mass Estimations

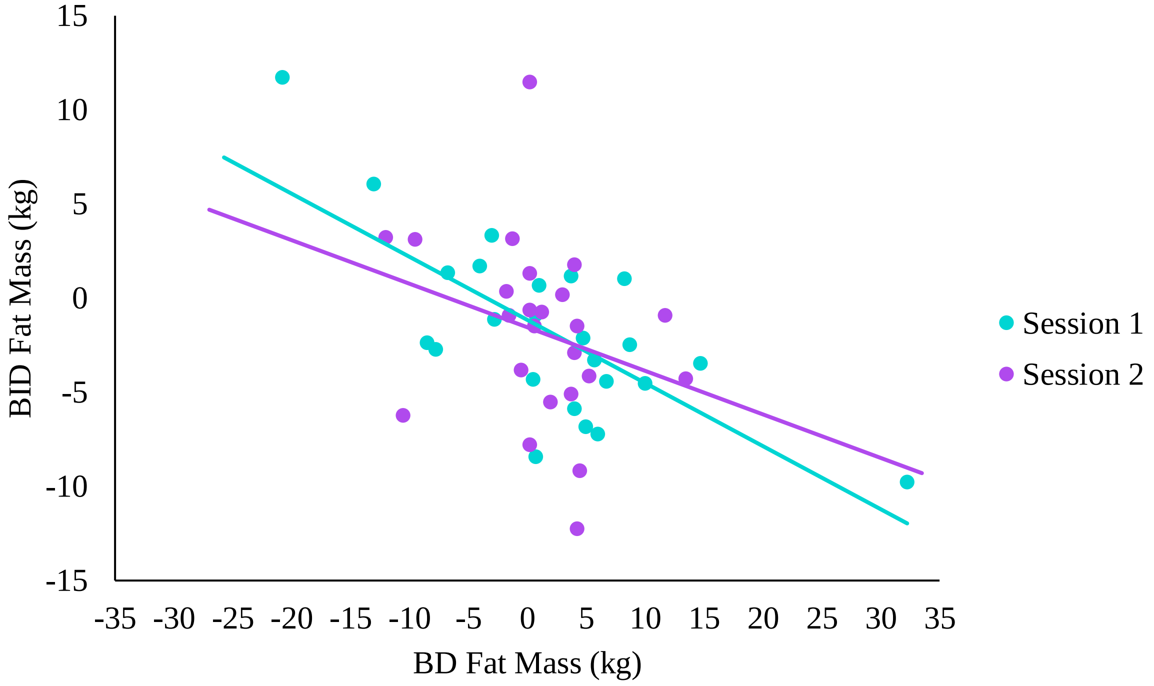
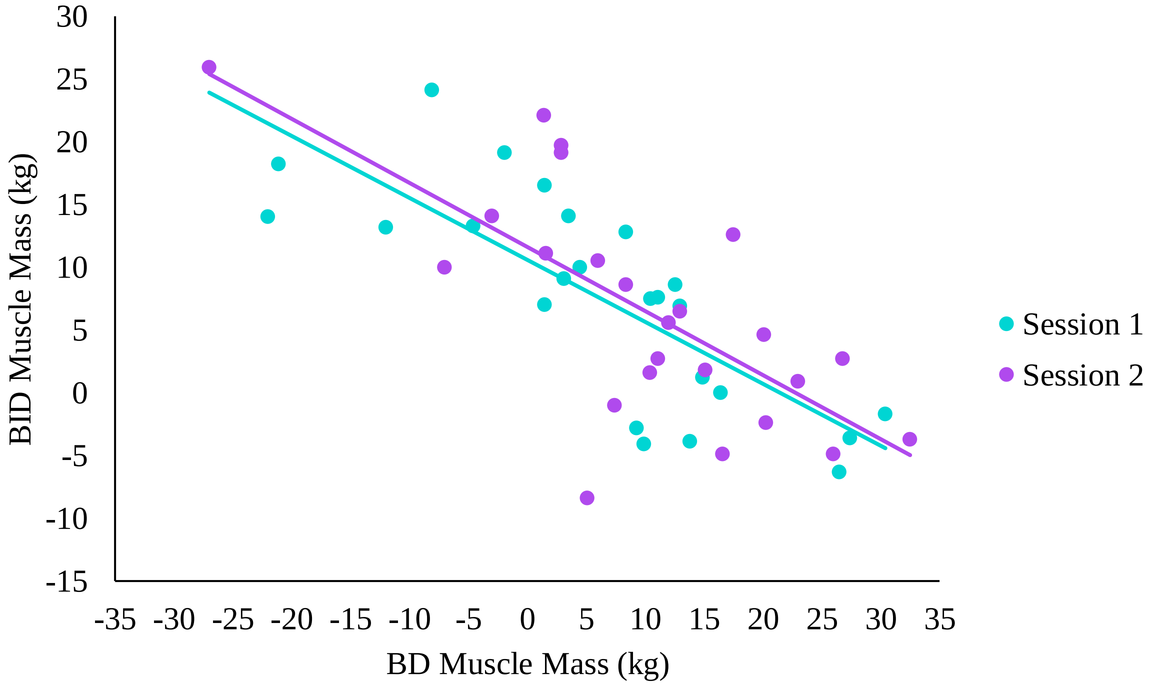


Figure 5.7

Scatter Plot of the Relationship Between BD and BID Muscle Mass Estimations



5.8.3 Convergent Validity

Correlational analysis was used to assess associations between participants' perceived current fat mass and their actual fat mass, as well as between their perceived current muscle mass and their actual skeletal muscle mass. Participants' actual fat mass was significantly positively correlated with their perceived current fat mass in session 1 ($r_s = .77$, $p < .001$) and session 2 ($r_s = .73$, $p < .001$). Figure 5.8 provides a graphical representation of the relationship between participant's actual and perceived current fat mass in sessions 1 and 2.

Participant's actual skeletal muscle mass was not significantly correlated with their perceived current muscle mass in either session 1 ($r_s = .14$, $p = .514$) or session 2 ($r_s = .30$, $p = .156$). Figure 5.9 provides a graphical representation of the relationship between participant's actual and perceived current skeletal muscle mass in each session. To check whether this nonsignificant association was due to a lack of statistical power, a post-hoc power analysis was performed in G*Power 3.1.9.6 (Faul et al., 2009) using the effect size from session 2 of this pilot study. The effect size of .30 was considered to be medium using Cohen's (1988) criteria. Based on a power of .80 and an alpha level of .05, the projected sample size needed to obtain statistical power in future trials with an effect size of .30 was approximately 67 men.

Figure 5.8

Scatter Plot of the Relationship Between Actual and Perceived Current Fat Mass

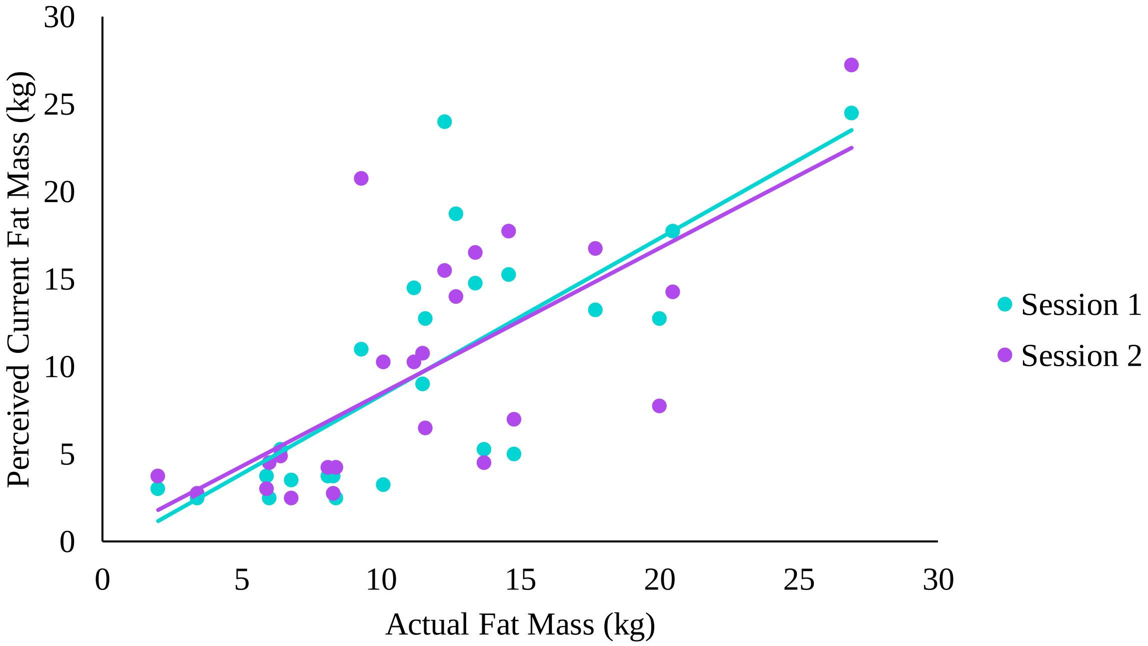
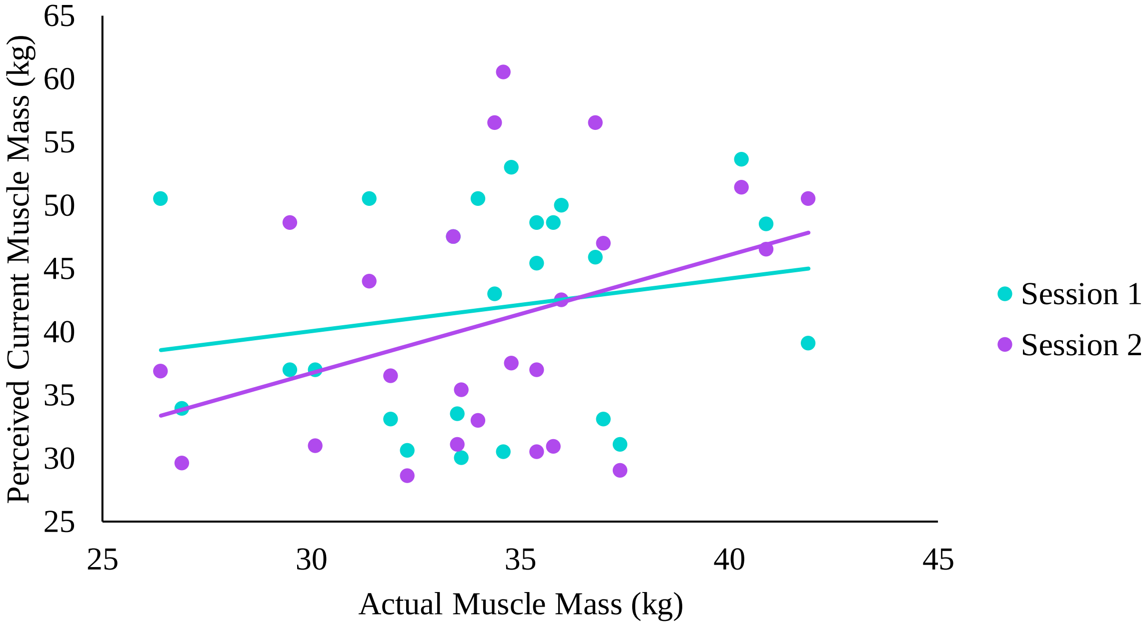


Figure 5.9

Scatter Plot of the Relationship Between Actual and Perceived Current Muscle Mass



5.8.4 Concurrent Validity

To evaluate the concurrent validity of the new interactive scale, Spearman's correlations were used to assess the relationship between participants' perceptual body estimations using the scale in each session and their attitudinal body image measured in session 1.

5.8.4.1 Current and Ideal Body Estimations

Although no significant correlations were found between psychometric scores and the perceived current and ideal fat mass estimations in session 1, a significant negative correlation was found between perceived current fat mass and the DMS MB subscale ($r_s = -.52$, $p = .009$), and between ideal fat mass and the SATAQ-4 thin subscale ($r_s = -.44$, $p = .033$) in session 2. In reference to skeletal muscle mass, significant negative correlations were found between perceived current muscle mass and both the SATAQ-4 thin subscale ($r_s = -.47$, $p = .021$) and the BSQ-16b ($r_s = -.43$, $p = .039$) in session 1. Alternatively, a significant positive correlation was revealed between ideal muscle mass and the SATAQ-4 athletic subscale ($r_s = .43$, $p = .037$) in session 1. In session 2, the perceived current muscle mass estimations were significantly negatively correlated with the DMS MBI subscale ($r_s = -.44$, $p = .032$) and the BSQ-16b ($r_s =$

-.44, $p = .033$), whereas the ideal muscle mass estimations were not significantly correlated with any of the psychometric measures in this session ($p > .05$).

5.8.4.2 Body Dissatisfaction

Estimates of BD for fat mass were significantly positively correlated with the DMS MB subscale ($r_s = .42$, $p = .043$) in session 1. Estimates of BD for skeletal muscle mass were significantly positively correlated with the SATAQ-4 thin subscale ($r_s = .58$, $p = .003$) and the BSQ-16b ($r_s = .44$, $p = .033$) in session 1, and the DMS MBI subscale ($r_s = .55$, $p = .006$) in session 2.

5.8.4.3 Body Image Distortion

No significant correlations were found between psychometric scores and the BID estimates for fat and muscle mass in session 1 ($p > .05$). However, the BID estimates for fat mass were significantly negatively correlated with the DMS MB subscale ($r_s = -.48$, $p = .017$) in session 2. Estimates of BID for skeletal muscle mass were significantly negatively correlated with the EDE-Q weight concern subscale ($r_s = -.49$, $p = .016$), SATAQ-4 thin subscale ($r_s = -.60$, $p = .002$), DMS MB subscale ($r_s = -.41$, $p = .049$) and the BSQ-16b ($r_s = -.52$, $p = .010$) in session 1. In session 2, estimates of BID for skeletal muscle mass were significantly negatively correlated with the SATAQ-4 athletic subscale ($r_s = -.45$, $p = .026$), DMS MBI subscale ($r_s = -.46$, $p = .025$) and the BSQ-16b ($r_s = -.56$, $p = .005$).

5.8.5 Test-Retest Reliability

5.8.5.1 Current and Ideal Body Estimations

Spearman's correlations were conducted to assess the test-retest reliability of the interactive tool in estimating participants' perceived current and ideal fat mass and skeletal muscle mass between sessions 1 and 2. Good internal reliability was found for the perceived current fat mass estimations ($r_s = .81$, $p < .001$), however the reliability of the ideal fat mass estimations ($r_s = .43$, $p = .036$) was below an adequate correlation coefficient of .70 (Terwee et al., 2007; Nunnally, 1970). Similarly, both the perceived current ($r_s = .18$, $p = .405$) and ideal skeletal muscle mass estimations ($r_s = .21$, $p = .336$) showed inadequate internal reliability between sessions 1 and 2. To check whether these results were due to a lack of statistical power, post-hoc power analyses were performed in G*Power 3.1.9.6 (Faul et al., 2009) using the effect sizes from this pilot study. Based on a power of .80, an alpha level of .05 and an effect size of .43, the projected sample size needed to obtain statistical power for the test-retest reliability of ideal fat mass perceptions in future trials was approximately 32 men. A sample size of 138 men was suggested to obtain statistical power for the test-retest reliability of current muscle mass perceptions using a power of .80, alpha level of .05, and effect size of .18. Similarly, a sample size of 189 men was suggested to obtain statistical power for the test-retest reliability of ideal muscle mass perceptions using a power of .80, alpha level of .05, and effect size of .21.

Intraclass correlation coefficients (ICC) were also used to evaluate the test-retest reliability of the perceptual body estimations between the initial session and the follow-up two-to-three days later. Table 5.9 presents the ICC and confidence intervals for perceived current and ideal estimations between sessions 1 and 2. The ICC of .91 for perceived current fat mass was excellent, while the ICC of .44 for ideal fat mass estimates was poor, compared to a recommended .80 standard for test-retest reliability (Carmines, 1990). In addition, both ICC's for current and ideal muscle mass were poor, being .26 and .24 respectively. Only the intraclass correlation for perceived current fat mass was statistically significant ($p < .05$).

5.8.5.2 Body Image Distortion and Dissatisfaction Estimations

Spearman's correlations were also conducted to assess the test-retest reliability of the interactive tool for estimations of BD and BID in relation to fat mass and muscle mass between sessions 1 and 2. For BD estimations, the reliability for estimations relating to fat mass was approaching an adequate level ($r_s = .67$, $p < .001$), while estimations for skeletal muscle mass showed poor reliability ($r_s = .11$, $p = .612$). BID estimations in relation to fat mass showed adequate reliability ($r_s = .72$, $p < .001$), while those for skeletal muscle mass demonstrated poor internal reliability ($r_s = .15$, $p = .492$) between sessions 1 and 2. To check whether the results relating to skeletal muscle mass were due to a lack of statistical power, post-hoc power analyses were again performed in G*Power 3.1.9.6 (Faul et al., 2009) using the effect sizes from this pilot study. Based on a power of .80, an alpha level of .05 and an effect size of .11, the projected sample size needed to obtain statistical power for the test-retest reliability of BD estimations was approximately 509 men. A sample size of 273 men was suggested to obtain statistical power for the test-retest reliability of BID estimations using a power of .80, alpha level of .05, and effect size of .15.

ICC's were also used to assess associations of BD and BID estimations between sessions 1 and 2. Again, Table 5.9 presents the ICC and confidence intervals for estimations between the two sessions. The ICC's of .64 for BD estimates in relation to fat mass and .17 for estimates concerning skeletal muscle mass showed poor internal consistency, compared to the recommended .80 standard (Carmines, 1990). The ICC of .79 for BID estimates relating to fat mass was on the verge of the recommended standard, while the ICC of .16 for BID relating to skeletal muscle mass presented poor test-retest reliability. The intraclass coefficients for the BD and BID fat mass estimates were statistically significant, while those for skeletal muscle mass were nonsignificant (*p* > .05).

Table 5.9

Intraclass Correlations and Confidence Intervals for Current, Ideal, BD and BID Estimations

Estimation	Current		Ideal		BD		BID	
	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI
Fat Mass	.91	.79 - .96	.44	-.33 - .76	.64	.16 - .85	.79	.51 - .91
Muscle Mass	.26	-.77 - .68	.24	-.69 - .67	.17	-.90 - .64	.16	-1.00 - .64

5.9 Study 5: Discussion

5.9.1 Summary and Interpretation of Findings

Study 5 aimed to assess the reliability and validity of the new interactive male body scale in estimating current and ideal body perceptions among a general sample of 24 adult men. A range of psychometric measures were administered to characterise the attitudinal body image of the sample. The mean total score for the BSQ-16b was within the ‘no concern’ category based on commonly used cut-off points (Evans & Dolan, 1993), demonstrating little body dissatisfaction across the sample. However, one participant presented a BSQ-16b score categorised as exhibiting ‘moderate concerns’. The mean scores for the SATAQ-4 subscales suggested slightly higher internalisation and preoccupation with achieving a muscular body ideal than a lean body ideal across the sample. This was also demonstrated by the EDE-Q weight and shape concern subscales, with a marginally higher average score for shape concern than weight concern. The average EDE-Q weight concern, shape concern and global scores in this sample were comparable to those found previously in other non-clinical male samples (Carey et al., 2019; Lavender et al., 2010). Similarly, the average scores for the DMS subscales clearly presented a greater desire to increase levels of muscle mass and attain an idealised muscular body than current engagement in muscularity-enhancing behaviours in the sample. The mean BDI score was within a range that would be expected when experiencing ‘normal ups-and-downs’ (Beck et al., 1961), although one participant reported depression levels in the ‘borderline clinical’ category. Similarly, the mean RSE score in the sample was within the ‘normal self-esteem’ range (Rosenberg, 1965), although 3 participants’ scores were considered to show low self-esteem. Participant exclusion criteria for this study did not include specified levels of depression, self-esteem or body concerns based on the self-reported measures. Therefore, participants with clinically meaningful psychometric scores remained in the sample for data analysis.

In the study, participants were asked to create their perceived current and ideal body twice in each session using the new interactive male body scale. A mean fat mass and skeletal muscle mass was then calculated in each session for participants’ current and ideal body perceptions. No significant associations were found between men’s current and ideal fat mass or skeletal muscle mass in session 1, but there was a significant positive relationship between their current and ideal fat mass in session 2. This relationship between men’s perceived current and ideal adiposity has been evidenced in previous research using existing figure scales (Talbot, Cass, & Smith, 2019). In both sessions, there were no significant associations between men’s perceived current fat mass and skeletal muscle mass, or between their ideal fat mass and skeletal muscle mass, which implies that men’s perceptual body image relating to adiposity and muscularity were separate, unrelated constructs. However, this finding may be a result of the limited sample size or number of trials in the perceptual tasks of this pilot study. If these fat and muscle estimations had been significantly correlated, multivariate regressions could have been used to map the relationship between participant’s actual measurements and their perceived current estimations, or ideal estimations (Maalin et al., 2020). The concept that men can have distinct perceptions relating to adiposity and muscularity is supported by previous research, with evidence of independent neural mechanisms associated with each dimension (Brooks et al., 2019; Sturman et al., 2017). These findings further justify the need to accurately represent and measure men’s body size and shape perceptions relating to these two dimensions of body composition.

Estimations of BD and BID were found to be significantly negatively correlated in relation to both fat mass and skeletal muscle mass. Positive individual BID scores were indicative of current body overestimation relating to their fat mass or muscle mass, and positive BD scores represented ideal body perceptions that were greater in either fat mass or muscle mass than their current body estimations. These negative correlations suggest that as men increasingly underestimated their current fat mass, they selected ideal bodies that were increasingly higher in fat mass compared to their current body perceptions. Similarly, as men increasingly underestimated their current muscle mass, they created ideal bodies that were increasingly higher in muscle mass compared to their current body perceptions. Men’s BD and

BID estimations relating to fat mass and muscle mass were not significantly associated with their actual fat or muscle mass measurements. Although significant relationships between body composition and current-ideal discrepancies for adiposity and muscularity have been evidenced using existing figure scales (Talbot, Cass, & Smith, 2019; Talbot, Smith, & Cass, 2019), this finding mirrors the lack of association between participant body composition and self-reported body dissatisfaction and attitudes from the psychometric measures in this study.

The convergent validity of the interactive male body scale was evidenced through a significant association between participants' actual fat mass and their average perceived current fat mass in sessions 1 and 2. However, the relationship between participant's actual skeletal muscle mass and their average perceived current muscle mass was not significant in either session. This finding is in line with previous research that has identified stronger correlations between men's perceived and actual adiposity than between their perceived and actual muscularity using existing scales (Talbot, Cass & Smith, 2019). It may also be a result of the sample size in this pilot study, as indicated by a post-hoc power calculation based on the effect size from session 2 that suggested a sample size of approximately 67 men for this correlation. Therefore, there is a need for additional research with a larger sample of adult men to further evaluate the convergent validity of this new scale.

The concurrent validity of the scale was evidenced through correspondence of perceptual body estimations with a range of psychometric measures. Estimations of BD and BID were significantly associated with measures of individual body shape concern, drive for muscularity and internalisation of appearance ideals. Men with higher muscularity-related body dissatisfaction showed greater internalisation of the thin-ideal, higher general body shape concerns, and greater desires to increase their muscle mass. There was also some evidence that men with higher levels of adiposity-related body dissatisfaction reported more engagement in behaviours to increase their muscle mass. Men with higher current fat mass overestimation demonstrated less engagement in muscularity-enhancing behaviours, while those with higher muscle mass overestimation presented less body weight concerns, internalisation of the thin-ideal, desire to increase their muscularity and general body shape concerns. Interestingly, men with higher current muscle mass overestimation also showed less internalisation of the athletic ideal in session 2. Given that previous research has established a link between the internalisation of body ideals and body dissatisfaction (Chen et al., 2007; Jones, 2004), it could be interpreted that men who perceived themselves to be more muscular than in reality showed less internalisation of this ideal as they were less dissatisfied with their own level of muscularity. Looking at men's current and ideal body perceptions, men with higher perceived muscle mass demonstrated less internalisation of the thin-ideal and lower general body shape concerns. There was also some evidence that men with higher perceived fat mass reported a lower drive for muscularity, and that those with a higher ideal fat mass presented less internalisation of the thin-ideal. It should be noted that for some of the psychometric measures, the concurrent validity of the scale was evidenced through significant associations in either session 1 or 2, but not both, which is likely a result of participants' somewhat inconsistent perceptual estimations across sessions.

Excellent test-retest reliability was found for estimations of perceived current fat mass using the scale. However, the reliability of perceived current muscle mass, ideal fat mass, and ideal muscle mass estimations were poor. This may be a result of the sample size in this pilot study, as suggested by a series of post-hoc power calculations that suggested sample sizes of 138, 32 and 189 men, respectively. Adequate internal reliability was found for the BD and BID estimations relating to fat mass, but those relating to muscle mass also showed poor reliability. The improved test-retest reliability for the fat mass estimations may have been a consequence of men being better at visually perceiving changes in the fat mass of the predicted body model than the muscle mass, as was found in Study 4 (Section 5.4.2). Variability in the test-retest reliability of existing scales in estimating perceived current, ideal and current-ideal discrepancies for fat mass and muscle mass has been identified in previous research (Cafri et al., 2004; Talbot et al., 2020). A general lack of clarity has also been recognised around what constitutes an appropriate level of test-retest reliability for figure scales and effect sizes below the conventional cut-off have been reported as acceptable (Ralph-Nearman & Filik, 2018). This highlights a need for additional research with a larger sample of adult men to further evaluate the test-retest reliability of this scale and determine whether any scale modifications are required to improve its reliability.

5.9.2 Strengths and Limitations

The perceptual task used in this study was time-efficient, simple to administer and allowed participants to match their perceived current or ideal fat mass and muscle mass to a single computer-generated figure presented from multiple viewpoints. Although muscularity and adiposity were considered separately when assessing the reliability and validity of the scale, these dimensions were modelled as one predicted body shape, unlike existing figure scales that separately present linear shape change according to each dimension (Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019). Previous research has highlighted that presenting figures side-by-side in order of increasing adiposity or muscularity can result in potential reporting bias (Gardner & Brown, 2010; Zitzmann & Warschburger, 2020), and offers constant reference points for the size and shape of bodies at either end of the stimuli range (Groves et al., 2019), that may impact on the validation of figure scales (Talbot, Cass, & Smith, 2019). This interactive scale displayed variation in body size and shape within a single figure, thus preventing participants from directly comparing across different figures and encouraging them to base their perceptual body estimation according to their internalised body templates.

The identity of the adiposity and muscularity dimensions within the scale, as well as their numeric values, were not presented to participants in this study. This was intended to avoid participants from selecting their current and ideal bodies based on socially-driven perceptions or individual attitudes relating to adiposity and muscularity (Barlett et al., 2008; Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; Gardner & Brown, 2010; McCabe & Ricciardelli, 2004). For example, if a participant had any personal desires or motivations to achieve a specific amount of fat mass or muscle mass, this might have driven the body size and shape they selected in the perceptual task, rather than focusing on the visual appearance of the body. In addition, the starting position for each of the body composition dimensions in the scale was randomised, as well as the order of the current and ideal tasks, with the intention of minimising any potential anchoring effects in the study (Gardner, 1996).

This new approach of measuring men’s perceptual body image has resolved many of the inherent issues with existing figure scales. This scale considered shape change as a function of fat mass and skeletal muscle mass independently, which addresses inherent errors in previous estimates using BMI-based perceptual measures for men with the same BMI but different body compositions (Groves et al., 2019), as highlighted in Chapter 4 (Section 4.1). The calibration of figures based on 3D body scans and body composition measurements overcomes problems in the ecological validity of current scales that are calibrated by visually matching bodies to photographs or presenting linear changes in body width (Cafri & Thompson, 2004; Pope Jr et al., 2000; Ralph-Nearman & Filik, 2018). In addition, associations of the predicted body model with actual measurements of fat mass and skeletal muscle mass allowed for an estimate of BID using the scale, which has not been possible in some existing figure scales that do not provide anthropometric data (Arkenau et al., 2020; Gardner & Brown, 2010). This new interactive scale also presents variation in body shape from multiple viewpoints, thus providing a greater range of visual body size and shape information to the user than when figures are displayed from a single view.

Despite evidence for the reliability and validity of this new interactive scale, there are a few limitations to this study. Firstly, the sample size was smaller than in some previous studies assessing the reliability and validity of male figure scales varying in muscularity and adiposity (Arkenau et al., 2020; Pope Jr et al., 2000; Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019). However, this was a pilot study that aimed to conduct an initial assessment of the reliability and validity of the scale, in order to calculate effect sizes and estimate the sample size required for a more in-depth evaluation. In addition, data collection was concluded by the closing of university facilities and social distancing rules being enforced as a result of the COVID-19 pandemic. Another limitation is that none of the participants recruited for this study were within the obese BMI category, with a maximum BMI of 27.4 kg/m^2 in the sample. Therefore, the reliability and validity of this scale in estimating current and ideal body perceptions among men at the extreme upper end of the BMI spectrum has not been assessed.

Although this sample was predominantly of Caucasian ethnicity, 12.5% of individuals self-reported as belonging to other ethnic groups. The participant inclusion and exclusion criteria for recruitment in this study did not hold any restrictions on ethnicity with the pragmatic intention of recruiting widely and optimising sample size. However, given that the interactive scale was achieved through a calibrated mapping between the 3D body shape and composition of Caucasian male bodies, it could be argued that participants from other ethnic groups may not have identified as well with the figure presented (Gardner & Brown, 2010; Ralph-Nearman & Filik, 2018; Talbot, Smith, et al., 2019). For example, previous research has demonstrated different patterns of fat mass deposition and variation in the body fat to muscle ratio for a given BMI between ethnic groups (Shiwaku et al., 2004; WHO Expert Consultation, 2004). Therefore, non-Caucasian individuals may have found it more difficult to create accurate representations of their current or ideal body perceptions using the scale. Finally, the follow-up session for this study was two-to-three days after participant's initial session, and therefore the test-retest reliability of the scale was only evaluated for this short duration of time. Previous research investigating the reliability of existing figure scales that consider adiposity and muscularity have generally appraised the consistency of estimations over longer time periods, ranging from around 1-6 weeks (Arkenau et al., 2020; Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019; Talbot, Smith et al., 2019). However, the short time period between data collection sessions in this study was intended to minimise the risk of participant attrition and allow for increased participant recruitment.

5.9.3 Implications and Future Work

Future work is necessary to address the limitations of this study and further evaluate the suitability of the interactive scale for use in research and clinical practice. This study provided evidence for the convergent validity, concurrent validity, and test-retest reliability of this new scale in estimating men's current and ideal body perceptions. Post-hoc power calculations based on the effect sizes from this pilot study suggested larger sample sizes are needed in future trials for adequate power to conclusively evaluate the reliability and validity of the new scale. Projected sample sizes to obtain statistical power for the convergent validity and test-retest reliability of men's current and ideal body perceptions using the interactive scale ranged widely from approximately 32 to 189 men, based on a power of .80 and an alpha level of .05. In addition, test-retest reliability presented mixed findings over a short period of a few days. Therefore, further research is required to investigate the reliability of the new scale over longer periods of approximately 1-6 weeks (Arkenau et al., 2020; Ralph-Nearman & Filik, 2018; Talbot, Cass, & Smith, 2019; Talbot, Smith et al., 2019). Furthermore, this new scale should be compared to existing matrix-style male figure scales that consider adiposity and muscularity, such as the NSM-M (Talbot, Smith et al., 2019), to evaluate whether the interactive, three-dimensional presentation of this scale allows for more specific and sensitive estimations of men's perceptual body image relating to body composition than are captured using current scales. However, the NSM-M presents figures that vary in measurements of body fat percentage and FFMI, which would make direct comparisons to this scale problematic, given that the body model is calibrated for fat mass and skeletal muscle mass.

Considering the novelty of this interactive scale, it is crucial that its reliability and validity are assessed among men with a wider range in BMI, fat mass and skeletal muscle mass, to determine whether the variation in body size and shape reflected in the figure is suitable in representing body perceptions in men of all shapes and sizes. Given that participants' current and ideal skeletal muscle mass estimations spanned the range presented in the scale, modifications to this dimension may also be necessary to capture individual perceptions outside of this range. Extending the upper and lower limits of the muscle mass dimension would allow for perceptual estimations beyond the actual measurements attained from the 3D body scans, particularly in relation to men's appearance ideals that may not reflect realistic body shape (Barlett et al., 2008; Ridgeway & Tylka, 2005). As discussed in Study 4 (Section 5.5.3), the reliability and validity of the scale should also be tested in additional populations of interest, including females and clinical male samples. This would allow future research to explore the influence of adiposity and muscularity on a range of other perceptions regarding male bodies, such as judgements of health, personality and attractiveness, as has been done with existing scales and visual stimuli (Furnham et al., 2006; Greenleaf et al., 2004; Swami, Furnham, et al., 2008; Webb et al., 2004).

If the reliability and validity of this interactive scale is further supported, it has potential clinical application in supporting existing interventions to assess, manage and treat a range of related health issues in men, including body dysmorphia and obesity (Beechy et al., 2012; Thompson, 1990). It could be used as an additional tool to support health professionals in their conversations with male patients, particularly in discussions around distorted body image, healthy weight, and body shape changes relating to body composition. Given that adiposity and muscularity-related concerns have been identified as key characteristics for the development of AN and muscle dysmorphia in the male population (Klimek et al., 2018), this scale could also be used as a visual tool to assess the presence and severity of these concerns, and evaluate their unique involvement in patient experiences.

5.10 Chapter Conclusion

The studies presented in this chapter have provided evidence of the reliability and validity of a new interactive 3D male body scale in assessing estimations of current and ideal body perceptions among a general sample of adult men. The face validity of this new scale was evaluated in Study 4 through independent fat and muscle ratings of the predicted body model, calibrated for 50 different combinations of fat mass and skeletal muscle mass. Findings from this study indicated that adult men were able to visually perceive changes in fat mass and muscle mass of the male body model as intended, although they were generally more accurate in identifying alterations in fat mass than muscle mass. Preliminary evidence for the convergent validity, concurrent validity and internal reliability of the new scale was then provided in Study 5, based on estimations of men’s perceived current and ideal body using the adiposity and muscularity dimensions of the scale across two sessions. This study highlighted associations between men’s body image perceptions, attitudinal body image and their own measurements of body composition, as well as an occurrence of separate current and ideal body perceptions relating to adiposity and muscularity. This new approach to measuring men’s body size and shape perceptions relating to adiposity and muscularity has overcome some of the main limitations of existing measures by presenting realistic variation in three-dimensional body size and shape that is accurately calibrated for fat mass and muscle mass. Whilst these preliminary findings are promising, future work is needed to further evaluate the reliability, validity and psychometric properties of the new interactive body scale with larger and more varied samples, in order to validate this scale for use in research and clinical contexts. Modifications to the range of fat mass and skeletal muscle mass presented in the scale may also be required to capture the full extent of variation in men’s current and ideal body perceptions.

Chapter 6: Categorical Judgements of Male Body Weight Using 3D Body Scans

6.1 Introduction

The proportion of people who are either overweight or obese is increasing worldwide, and this has been identified as a global public health crisis, particularly in Western societies (Campos et al., 2006; Finucane et al., 2011; Swinburn et al., 2011; WHO, 2018). As a result, individuals in developed countries are being more frequently exposed to larger bodies. Visual normalisation theory proposes that this change in people's 'visual diet', i.e. the bodies that they see regularly within their sociocultural environment, is causing a societal shift in the range of body sizes that are judged as 'normal' or 'healthy', and in people's perceptions of their own and others' body size and shape (Ambroziak et al., 2019; Burke et al., 2010; Robinson & Kirkham, 2014; Yaemsiri et al., 2011). This theory postulates that there is a range of body sizes that people internally perceive as 'normal' and bodies are judged in comparison to this norm. Consequently, it is suggested that an upward shift in visual norms from the increasing prevalence of overweight and obesity is resulting in an underestimation and under-recognition of larger bodies (Brug et al., 2006; Robinson, 2017). Visual normalisation theory is supported by research on visual adaptation indicating that individual's perceptions of body weight can be altered through frequent exposure to certain types of bodies that recalibrate their internal body size norms (Boothroyd et al., 2016; Jucker et al., 2017; Oldham & Robinson, 2016; Robinson & Kirkham, 2014).

An inability to accurately judge body size has important implications for healthcare and clinical interventions directed at weight-loss and healthy-weight maintenance efforts. For example, research has demonstrated that individuals who underestimate their own weight status are less likely to see their weight as a health risk, less driven to alter their weight and, therefore, less likely to engage in related weight-change behaviours (Amaro-Rivera & Carbone, 2020; Duncan et al., 2011; Kuchler & Variyam, 2003). Although BMI is widely used by health professionals as a standard to categorise individual body weight and evaluate health risks associated with extreme weight (Wells, 2007), lay perceptions of what constitutes being overweight or obese may not match these guidelines. A mismatch between clinical guidelines and social views may hinder weight-related communication between patients and health professionals (Johnson et al., 2008). Furthermore, health professionals may themselves not be accurate in visually assessing their patients' weight status, which has potential implications for healthy-weight monitoring, interventions and related treatment outcomes (Bramlage et al., 2004; Caccamese et al., 2002; Johnson et al., 2008; Perrin et al., 2005; Robinson & Kirkham, 2014; Yoong et al., 2014).

A range of methodological approaches have been used previously in research to assess individual and social perceptions of the words ‘overweight’ and ‘obese’, and how these linguistic labels map onto visual body size and shape. One method has been asking people to categorise their own weight status as either ‘underweight’, ‘overweight’ or ‘about right’ (Park, 2011; Robinson & Oldham, 2016; Yaemsiri et al., 2011). Research using this method has generally found that overweight men are more likely to underestimate their own body size than overweight women, and that misperceptions of body weight are more common among the less educated, elderly and those from a lower income level (Harris et al., 2008; Kuchler & Variyam, 2003; Wetmore & Mokdad, 2012). Another method has focused on figure rating scales or photographic stimuli to investigate perceptions of weight and identify how variation in body size relates to BMI-based categorical descriptors of weight. Research using these methods has also demonstrated that men who are overweight or obese are more likely to underestimate their own weight status than women of a similar size (Madrigal et al., 2000).

Although most investigations into weight misperception have focused on perceptions of own body weight, some have evaluated individual perceptions of body weight in others. Research using figure-based stimuli has evidenced that both men and women are prone to visual underestimations of male body weight. For example, Oldham and Robinson (2016) explored whether individuals in the UK were able to accurately identify the weight status of male bodies. The stimuli consisted of 15 photographs of Caucasian men aged 18 to 30, with 5 men in each of the healthy, overweight and obese BMI categories. The photographs displayed individuals in T-shirts and trousers stood by a doorframe and were taken from both a front and side-view. Participants were randomly presented 5 images and asked to categorise the bodies as either underweight, healthy weight, overweight or obese, following provision of the WHO BMI guidelines. Participants were additionally asked to rate whether they thought the person in each photograph should consider weight-loss, using a 5-point response scale from ‘strongly disagree’ to ‘strongly agree’. Participants’ body weight judgements were found to be the least accurate for the overweight and obese bodies with a general inclination towards body weight underestimation, thus revealing perceptions of larger bodies as being healthier than indicated by the WHO BMI classification.

Similarly, Oldham and Robinson (2018) investigated the accuracy of weight perceptions of both male and female bodies with BMIs within the normal, overweight and obese categories. Participants were shown photographs of Caucasian men and women and were asked to select the BMI category that each body belonged to, based on the WHO guidelines. Again, the photographs presented individuals in T-shirts and trousers, standing next to a doorframe. The stimuli consisted of 21 male and 21 female bodies ranging in BMI, with 7 bodies in each of the normal weight, overweight and obese categories. All male bodies had a body fat percentage greater than 8% and all female bodies were above 21% body fat. It was found that the weight status of male bodies was more frequently underestimated than the female bodies, particularly in the overweight stimuli. In addition, as the BMI of both the male and female stimuli increased, so did the likelihood of weight status underestimation.

Cross-cultural differences in people's ability to accurately categorise body weight in others have also been considered using similar methods. Robinson and Hogenkamp (2015) asked male and female students from the UK, USA and Sweden to estimate the weight status of 15 Caucasian male bodies ranging in BMI, again with bodies photographed separately from a front and side-view. The men who were photographed reported not playing any strength-enhancing sports, and were visually evaluated by the researchers as not having muscular physiques. The stimuli included 5 bodies in each of the healthy weight, overweight and obese BMI categories, and participants reported whether they thought the bodies were either underweight, healthy weight, overweight or obese. They also rated whether the person in the image should consider losing weight on a 5-point response scale. Again, participants were poor at accurately determining the weight category of the male bodies, particularly with the overweight and obese stimuli. As a result, participants tended not to report that these males should consider losing weight, particularly in the USA sample. The UK sample was found to be marginally more accurate in categorising the weight status of the obese bodies than the other samples, but there were no significant between-group differences for the healthy weight or overweight male bodies.

There is a plethora of evidence that people tend to underestimate the weight of male bodies, particularly those at the upper end of the BMI range (Oldham & Robinson, 2016, 2018; Robinson & Hogenkamp, 2015). However, there are some critical limitations in existing methodologies used to assess the accuracy of people's categorical body weight judgements. Previous research has predominantly presented participants with photographs of real people wearing standardised clothing from either a single or front and side-view. The clothes provided are often not form-fitting and, therefore, cover established visual cues to BMI that may hinder the ability for individuals to accurately categorise body weight (Cornelissen, Hancock, et al., 2009; Tovée & Cornelissen, 2001). In addition, the presentation of bodies from only one or two viewpoints restricts the degree of body size and shape information available to users when making these judgements. For example, presenting bodies from a front-view has been shown to obscure visual cues for assessing BMI, including stomach depth and adiposity in the thighs and buttocks (Cornelissen et al., 2018).

Although existing stimuli tend to have known BMIs associated with the images, this does not discriminate between levels of adiposity and muscularity in the bodies. Attempts have been made to minimise the presentation of muscularity by selecting bodies that appear low in muscularity or only inviting individuals who do not take part in muscle-building activities to be photographed (Robinson & Hogenkamp, 2015). However, the levels of muscularity in these stimuli seem to be evaluated visually and this approach does not account for any quantifiable measurements of muscle mass. Those that have considered body composition focus on proportions of adiposity as an indirect indication of muscularity and do not report actual measurements of muscle mass associated with the stimuli (Oldham & Robinson, 2018). Finally, relying on photographs of real bodies does not generally allow for standardisation of the texture or identity of the stimuli presented. Research has suggested that facial features and clothing can distract individuals from focusing solely on body size and shape when making categorical BMI discriminations (Altabe, 2001; Thompson, 2001). Individual facial features and skin tone could also drive perceptions of weight, health, and attractiveness that may play a role in judgements of BMI (Coetzee et al., 2009, 2010; Henderson et al., 2016; Tovée et al., 2000; Wen & Guo, 2013).

Clearly, there is a need to develop stimuli to evaluate the accuracy of male body weight status estimations that present a wide range in BMI and overcome the limitations of previous methodological approaches. It is important that stimuli present a clear visual representation of body size and shape information from multiple viewpoints, as well as a standardised texture, form-fitting clothing, and a lack of facial attributes that may otherwise influence user responses. It may be the case that more accurate male weight status perceptions are demonstrated when stimuli are not restricted by current limitations. Therefore, Study 6 addressed this issue by investigating the view-dependent accuracy of categorical male body weight judgements in men and women. The stimuli used in this study were based on 3D male body scans presented from either 2 or 8 different viewpoints, in order to determine whether the degree of body size and shape information available influenced the accuracy of people's weight judgements.

6.2 Study 6: Aims and Objectives

This study aimed to evaluate the view-dependent accuracy of men's and women's categorical body weight judgements and weight-loss beliefs using stimuli derived from 3D male body scans. The accuracy of adiposity judgements, indexed by BMI, was compared when stimuli were presented at either 2-orientations or 8-orientations.

The main objectives for this study were:

1. To compare the view-dependent accuracy of men's and women's categorical weight status perceptions, indexed by BMI, of male bodies seen as 2D figures on a computer screen
2. To investigate men's and women's view-dependent weight-loss judgements for male bodies seen as 2D figures on a computer screen
3. To determine whether the accuracy of male body weight judgements across the BMI spectrum are influenced by individual characteristics, including sex and attitudinal body image.

6.3 Study 6: Methods

Study 6 was granted a favourable ethical opinion by LEAS on the 11th September 2019 (2019-0709).

6.3.1 Participants

A total of 106 men and 121 women, aged 18 to 45, were recruited for this study from staff and students at the University of Lincoln, and the wider general population. This sample size was based on previous research exploring categorical weight judgements of male bodies (Oldham & Robinson, 2018; Robinson & Hogenkamp, 2015). Recruitment was carried out using the University of Lincoln online staff page, the SONA system, social media and email invitations, posters, leaflets and Prolific (https://www.prolific.co). Students who signed up to participate through the SONA system were given 3 credit points towards their degree requirements for their efforts. Similarly, individuals who accessed the online survey through Prolific were compensated £3.34 for their participation in this study.

Participant inclusion criteria for this study were as follows:

1. Participants aged 18 to 45 years
2. Participants who self-identify as male or female (cis-gender/as assigned at birth)
3. Participants currently residing in the UK

Participant exclusion criteria for this study were as follows:

1. Participants with a current or previous diagnosis of an eating or body image disorder

6.3.2 Materials

6.3.2.1 2D Body Stimuli

The 2D images used in this study were derived from the 3D body scans that were collected in Study 3 (Chapter 4, Section 4.4). The stimuli set contained images of 24 men, with six individuals in each of the underweight, normal weight, overweight and obese BMI categories. Figure 6.1 presents an example front-view image of one individual within each BMI category. The 3D body scans were chosen from a large sample of 176 Caucasian men aged 18 to 45, and were selected based on their height, BMI, muscularity and the quality of the scan. A set of 2D images was then developed for the 3D body scans in each BMI category and presented from both 2- and 8-orientations in an online survey, as described in Chapter 2 (Section 2.2.3.2). Table 6.1 presents the means and standard deviations for the height (cm), WHR, WCR and BMI of the bodies selected in each BMI category for this study. In addition, Table 6.2 presents means and standard deviations of the measurements of adiposity and muscularity for the bodies in each stimuli BMI category.

Figure 6.1

Example of a Male Image in Front-View for Each BMI Category

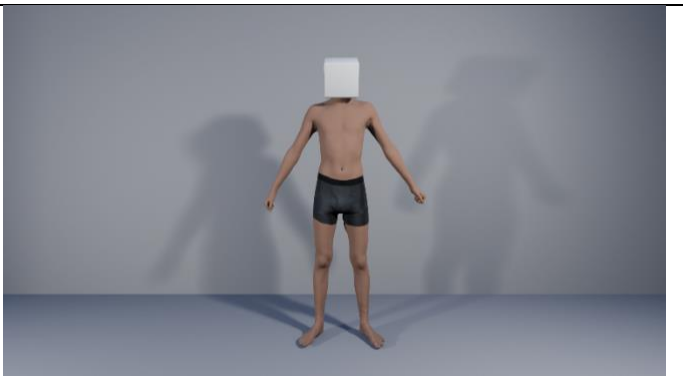
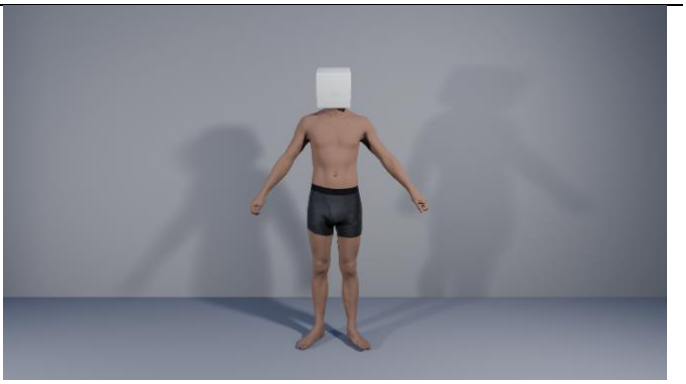
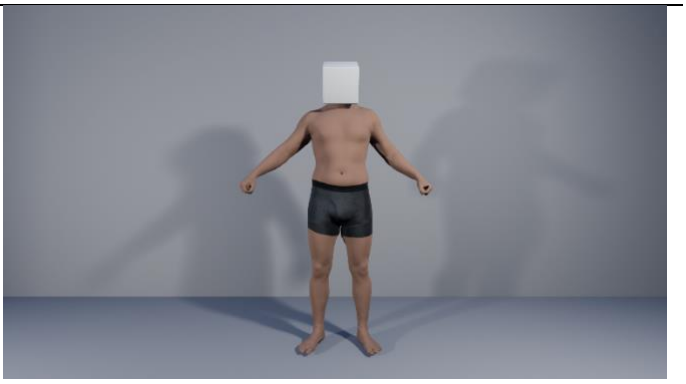
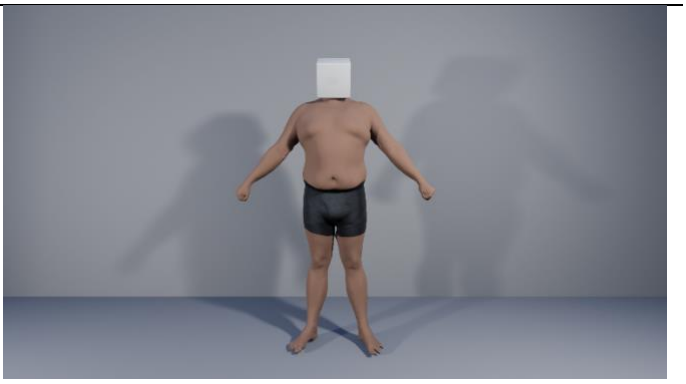
BMI Category	Example of 2D Male Image
Underweight	
Normal Weight	
Overweight	
Obese	

Table 6.1

Anthropometric Measurements for Stimuli in Each BMI Category

	Height		WHR		WCR		BMI	
BMI Category	M	SD	M	SD	M	SD	M	SD
Underweight	177.92	4.26	0.81	0.04	0.86	0.04	17.75	0.82
Normal weight	177.33	2.15	0.89	0.03	0.92	0.03	21.99	1.75
Overweight	176.42	4.47	0.89	0.04	0.90	0.03	26.84	1.26
Obese	177.22	4.58	0.94	0.08	0.93	0.07	33.10	1.83

Table 6.2

Body Composition Measurements for Stimuli in Each BMI Category

	Fat Mass		Fat %		Skeletal Muscle Mass		Skeletal Muscle %	
BMI Category	M	SD	M	SD	M	SD	M	SD
Underweight	4.03	1.31	7.13	2.15	31.00	1.45	55.25	2.34
Normal weight	11.07	3.59	15.77	4.50	33.50	4.07	48.63	4.23
Overweight	15.80	2.42	18.87	2.41	40.65	3.33	48.58	2.01
Obese	30.28	5.66	28.90	3.34	42.78	1.22	41.32	3.01

6.3.2.2 Psychometric Measures

Several self-report questionnaires were administered to measure participants' levels of depression and self-esteem, body shape concerns and dissatisfaction, their internalisation of appearance ideals and weight bias. These are described in more detail within the general methods section of this thesis (Chapter 2, Section 2.5).

Body Concerns and Dissatisfaction. The BSQ-16b (Evans & Dolan, 1993) was used as a measure of general body shape preoccupations and weight concerns. Wording of the fourth item in the BSQ-16b was altered depending on whether the participant was male or female. This item asked 'Have you noticed the shape of other women and felt that your own shape compared favourably?", and was re-worded from 'women' to 'men' for male participants. The EDE-Q (Fairburn & Beglin, 1994) was also given to participants as an assessment of eating disorder symptoms with its four subscales measuring related psychopathology, including eating concern, weight concern, shape concern and restraint.

Internalisation of Appearance Ideals. The SATAQ-4 (Schaefer et al., 2015) was administered to measure the internalisation of sociocultural appearance ideals, including the thin-ideal and the athletic-ideal.

Depression and Self-Esteem. The BDI (Beck et al., 1961) was used in this study to evaluate the presence and severity of characteristic depression symptoms in the sample, while the RSE (Rosenberg, 1965) was administered to assess individual levels of self-esteem.

Weight Bias. The AFA (Crandall, 1994) was used to measure individual levels of internalised weight bias, including self-concerns regarding fat people, beliefs about the controllability of weight and aversions toward overweight and obese individuals. The WBIS-M (Pearl & Puhl, 2014) assessed the self-acceptance and internalisation of weight stigma and stereotypes in people of diverse body weights.

6.3.3 Study Procedures

Participants who showed interest in the study were provided with a link to an online Qualtrics survey for data collection. The first page of the survey was an information sheet (Appendix B.17) that briefed participants on the purpose and nature of the study, including the inclusion and exclusion criteria, study procedure, possible benefits and risks, confidentiality, relevant support resources and researcher contact information. Participants were asked not to complete this online survey on a tablet or mobile phone, in order to regulate the size of the images shown to participants across different screens. Written informed consent (Appendix B.18) was then obtained on the following page using a multiple-choice dropdown list and participants were asked to confirm that they met all specified inclusion criteria. They were also asked to corroborate that they were completing the survey on either a laptop or computer, rather than on a mobile phone or tablet. They were then provided with their personal identification number, randomly allocated through the online Qualtrics system. Participants were required to self-report a range of demographic information, including their age, sex (cis-gender/as assigned at birth), ethnicity and sexual orientation. They were also asked to identify their perceived current weight status as either underweight, normal weight, overweight or obese.

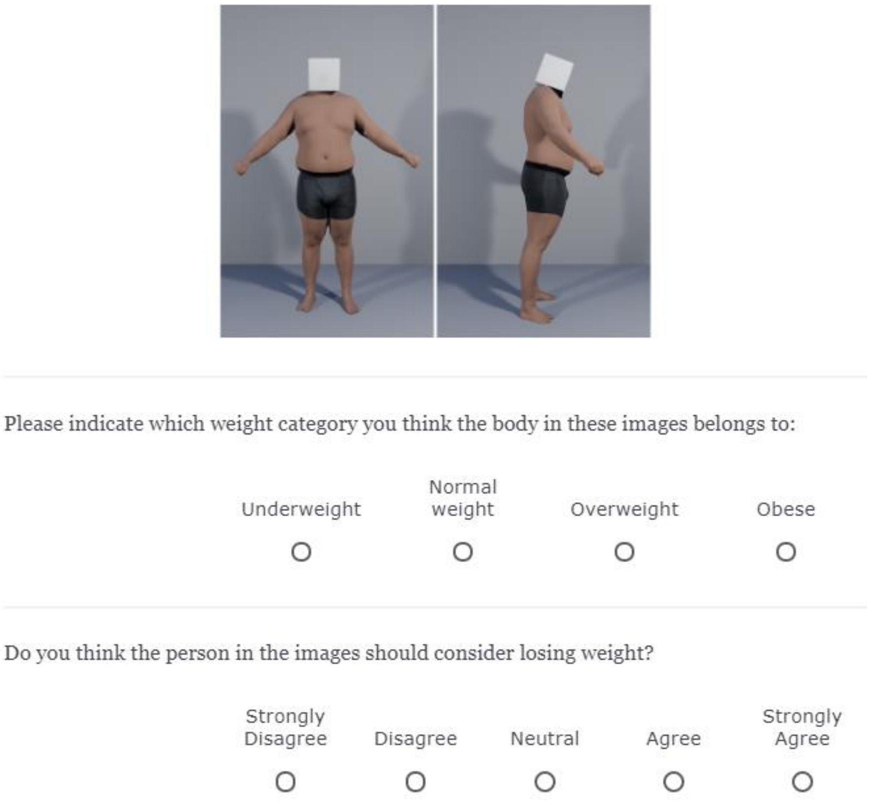
Participants then completed a weight categorisation task in which they were shown the images of male bodies ranging in BMI from underweight to obese and asked to select the BMI category that they thought it belonged to; underweight, normal weight, overweight or obese. For each body, participants were also asked whether they thought the individual in the images should consider losing weight using a 5-point response scale, ranging from 1 = ‘strongly disagree’ to 5 = ‘strongly agree’. This task consisted of 2 individual stimuli blocks; 2-

orientation male bodies and 8-orientation male bodies. The task was randomised in Qualtrics using the ‘Loop & Merge’ function, so that the order of the blocks and stimuli within each block were randomly presented to each participant. The BMI categorisation and weight-loss questions were presented underneath the images of the bodies for each trial, on the same page of the online survey, thus allowing participants to view the bodies while making their responses (Figure 6.2).

Following the weight categorisation task, participants were asked to respond to the AFA, BDI, BSQ-116b, EDE-Q, RSE, SATAQ-4, and WBIS-M. The order in which these questionnaires were presented in the online survey was randomised, without any of the questionnaire names being visible to participants. A debrief sheet (Appendix B.19) was then given at the end of the survey, which reiterated the overall aim of the study, the participant’s identification number, researcher contact details and relevant support resources and helplines. This online survey took approximately 30 to 40 minutes per participant and results were automatically recorded in Qualtrics.

Figure 6.2

Example of the Weight Categorisation Task in Qualtrics Survey, with BMI Categorisation and Weight-Loss Questions



Please indicate which weight category you think the body in these images belongs to:

Underweight	Normal weight	Overweight	Obese
○	○	○	○

Do you think the person in the images should consider losing weight?

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

6.3.4 Data Analysis

Data analysis for this study was conducted using IBM SPSS Statistics software (Version 26.0) and RStudio software (https://rstudio.cloud/). Descriptive statistics were computed separately for male and female demographics, psychometrics and self-reported weight status in the sample. Mann-Whitney U and Fisher's exact tests were conducted to highlight any significant differences in participant demographics and psychometrics between the male and female samples. In addition, Spearman's correlations were used to assess the relationship between participant's self-reported weight status and their BMI. A PCA with orthogonal rotation was also run on the psychometric data in order to reduce the large number of questionnaire scores into fewer uncorrelated components.

In order to analyse the weight categorisation responses, accuracy scores were calculated for each weight status judgement by subtracting the actual stimulus BMI category from the participant's categorical response. The BMI categories were dummy coded from 1 = 'underweight' to 4 = 'obese', and therefore, accuracy scores ranged from -3 to 3, with positive scores representing an overestimation of body weight, negative scores indicating an underestimation. It should be noted that given the four available categorical responses for this question, negative accuracy scores were not possible for underweight stimuli and positive accuracy scores were not possible for the obese stimuli, i.e. it was not possible to underestimate underweight bodies or overestimate obese bodies. The proportion of underestimation, overestimation and accurate weight responses were calculated for each stimuli BMI category and a series of Spearman's correlations were used to assess the relationship between these categorical responses, psychometric factors, stimuli BMI and participant demographics. Furthermore, Mann-Whitney U tests and Wilcoxon signed rank tests were conducted to determine the individual effects of participant sex and stimuli viewpoint on accuracy scores for each BMI category.

In order to analyse participant weight-loss judgements, the proportion of responses from 1 = 'strongly agree' to 5 = 'strongly disagree' were calculated in each stimuli BMI category for the male and female participants. Correlational analysis was used to explore relationships between weight-loss judgements, stimuli BMI and participant characteristics, such as age, self-reported BMI and psychometric factors. Again, Mann-Whitney U tests and Wilcoxon signed rank tests were conducted to determine the individual effects of participant sex and stimuli viewpoint on weight-loss judgements.

Linear mixed-effects models were then run to explore the influence of participant sex, stimuli BMI, stimuli viewpoint and psychometric factors on participant categorical weight status perceptions and weight-loss judgements separately. These models were used to account for any unexplained error variances associated with the participants and stimuli presented, and therefore, to reduce the risk of Type I errors. The models were built using a minimal to maximal approach in which the random effects were included first, followed by the fixed effects. Stimuli BMI was added as a fixed effect initially, and then stimuli viewpoint, participant sex, factor 1 and factor 2 were included to the model one-by-one. Model fit was compared using a pairwise approach through comparisons of the AIC, BIC, and LL across models, with lower values indicating better model fit. In addition, the models were significance tested after the addition or alteration of one predictor at a time, using a likelihood-ratio chi-squared test. When comparing models with varying fixed effects, models were generated using maximum likelihood (ML) estimation. Alternatively, when comparing models with differing random effects, they were generated using REML estimation. The final mixed-effects models were optimised by only retaining predictors in the model if they showed a significant Type III test of fixed effects, were part of a significant interaction term, or allowed for a significant improvement in model fit. Lastly, pairwise comparisons for each of the highest-order significant interactions were run for each mixed-effects model. The minimum, maximum, mean and ±1 SD points along the stimuli BMI range, as well as the mean and ±1 SD factor 1 and 2 scores were selected for these pairwise comparisons.

6.4 Study 6: Results

6.4.1 Participant Characteristics

A total of 227 participants, aged 18 to 45 (*M* = 23, *SD* = 7.12), were recruited for this study, with a sample of 106 men and 121 women. Table 6.3 presents the means, standard deviations and frequencies of the participant demographics for the male and female participants separately. Across the sample, 95% (n = 115) of the women self-identified as being of White/Caucasian ethnicity, while 84.9% (n = 90) of the men reported the same. The majority of both men (85.8%) and women (81.0%) self-identified as being heterosexual. Participant BMI was calculated using self-reported estimations of height (cm) and weight (kg), given as part of the EDE-Q (Fairburn & Beglin, 1994), by all male participants and most of the female participants (n =119) in the sample.

Table 6.3

Participant Demographics for the Male and Female Samples

	Males (n = 106)	Females (n = 121)
Age (years)**		
Mean (SD)	26.56 (7.44)	21.60 (5.97)
Minimum	18.00	18.00
Maximum	44.00	45.00
BMI (kg/m^2)		
Mean (SD)	24.04 (4.52)	23.68 (4.46)
Minimum	16.13	15.70
Maximum	38.94	37.64
Weight Status		
Underweight	7 (6.6%)	2 (1.7%)
Normal Weight	76 (71.7%)	89 (73.6%)
Overweight	21 (19.8%)	26 (21.5%)
Obese	2 (1.9%)	4 (3.3%)
Sexual Orientation**		
Heterosexual	91 (85.8%)	98 (81.0%)
Homosexual	10 (9.4%)	2 (1.7%)
Bisexual	4 (3.8%)	20 (16.5%)
Prefer Not to Say	1 (0.9%)	1 (0.8%)

*p < .05, ** p < .01

A statistically significant difference between the males and females was found for participant age, U = 3443, z = -6.125, p < .001. In addition, there was a significant difference in the multinomial probability distributions between the two groups for participant sexual orientation (p < .001). Post-hoc analysis involving pairwise comparisons of multiple Fisher's exact tests (2 x 2) with a Bonferroni correction was carried out. Given that four pairwise comparisons were used, an adjusted statistical significance of p < .0125 was accepted. This revealed a statistically significant difference in the proportion of participants who self-reported as being bisexual between the males and females (p = .002). The difference in the proportion of individuals who self-reported as being homosexual between the males and females was reaching significance (p = .014).

6.4.1.1 Self-Reported Weight Status

Table 6.4 presents the frequency and proportion of men and women in each BMI category, based on their self-reported height and weight, who identified their own weight status as either underweight, normal weight, overweight or obese. Participants' self-reported weight status and BMI matched most frequently among individuals in the normal weight category. A high proportion of the obese male (81.8%) and female (66.7%) participants underestimated their own weight status. In addition, a high incidence of weight status overestimation was found in the underweight participants, particularly for the female sample (75.0%). However, statistically significant positive relationships were found between self-reported weight status and BMI for both the male ($r_s = .72$, $p < .001$) and female samples ($r_s = .71$, $p < .001$). Figure 6.5 presents a graphical representation of the proportion of male and female participants in each BMI category who self-reported their current weight status as either underweight, normal weight, overweight or obese

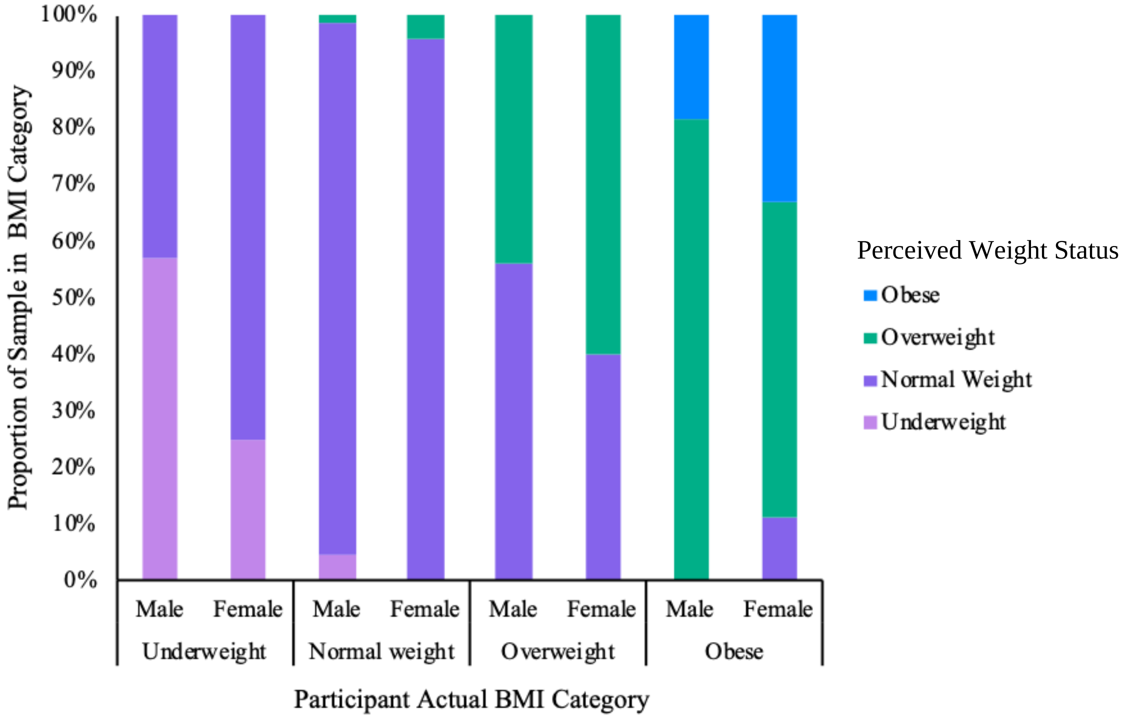
Table 6.4

Self-Reported Weight Status for Male and Female Participants in Each BMI Category

			Self-Reported Weight Status			
	BMI Category	N	Underweight	Normal weight	Overweight	Obese
Male	Underweight	7	4 (57.1%)	3 (42.9%)	-	-
	Normal weight	63	3 (4.8%)	59 (93.7%)	1 (1.6%)	-
	Overweight	25	-	14 (56.0%)	11 (44.0%)	-
	Obese	11	-	-	9 (81.8%)	2 (18.2%)
Female	Underweight	8	2 (25.0%)	6 (75.0%)	-	-
	Normal weight	72	-	69 (95.8%)	3 (4.2%)	-
	Overweight	30	-	12 (40.0%)	18 (60.0%)	-
	Obese	9	-	1 (11.1%)	5 (55.6%)	3 (33.3%)

Figure 6.3

Weight Status Responses for Male and Female Participants in Each BMI Category



6.4.2 Psychological Factors

Table 6.5 presents means, standard deviations and Cronbach's alphas for the psychometric measures of body shape concerns and dissatisfaction, depression, self-esteem, eating behaviours, weight bias and internalisation of body ideals in the sample. The Cronbach's alphas revealed adequate to excellent internal consistency for all psychometric scales and subscales in both the male and female samples in this study ($\alpha > .70$). Mann-Whitney U tests demonstrated statistically significant differences between males and females for all the psychometric measures (Table 6.6). Overall, the male sample presented significantly higher scores for the RSE, SATAQ-4 athletic subscale, AFA dislike and willpower subscales, than the female sample. In contrast, the female sample revealed significantly higher scores for the BDI, BSQ-16b, SATAQ-4 thin subscale, AFA fear of fat subscale, WBIS-M, and EDE-Q subscales, than the male sample.

Table 6.5

Means, Standard Deviations and Cronbach's Alphas for the Psychometric Measures

Measures	Males (n = 106)			Females (n = 121)		
	Mean	SD	α	Mean	SD	α
BSQ-16b**	35.35	14.67	.94	49.09	18.51	.96
BDI**	8.80	8.58	.91	12.13	9.80	.92
RSE**	19.33	5.83	.91	17.19	5.73	.92
AFA: Dislike**	2.25	1.99	.90	1.26	1.47	.86
AFA: Fear of Fat**	3.35	2.52	.83	5.03	2.85	.90
AFA: Willpower**	5.41	2.22	.86	3.57	2.23	.83
WBIS-M**	32.18	14.84	.93	41.11	15.48	.94
SATAQ-4: Thin*	2.84	0.85	.78	3.09	0.94	.81
SATAQ-4: Athletic**	3.25	1.02	.90	2.67	1.04	.90
EDE-Q: Restraint**	0.97	1.22	.81	1.39	1.33	.82
EDE-Q: Eating Concern**	0.69	0.93	.79	1.18	1.23	.80
EDE-Q: Shape Concern**	1.67	1.26	.85	2.87	1.63	.91
EDE-Q: Weight Concern**	1.32	1.23	.79	2.48	1.64	.86

*p < .05, ** p < .01

Table 6.6

Mann-Whitney U Test Results for the Psychometric Measures

Measures	U	*z*	*p*
BSQ-16b	9228.5	5.705	.000
BDI	7804.0	2.821	.005
RSE	4962.0	-2.944	.003
AFA: Dislike	4298.5	-4.291	.000
AFA: Fear of Fat	8577.5	4.390	.000
AFA: Willpower	3543.0	-5.819	.000
WBIS-M	8509.5	4.248	.000
SATAQ-4: Thin	7589.0	2.388	.017
SATAQ-4: Athletic	4228.0	-4.028	.000
EDE-Q: Restraint	7877.5	2.998	.003
EDE-Q: Eating Concern	8077.5	3.405	.001
EDE-Q: Shape Concern	9157.0	5.562	.000
EDE-Q: Weight Concern	9068.5	5.389	.000

6.4.2.1 Principal Component Analysis

Spearman correlations revealed high collinearity between the psychometric measures of body shape concerns and dissatisfaction, appearance ideal internalisation, depression, self-esteem and weight bias in the sample (Table 6.7). Therefore, a PCA was run on these psychometric measures, with the aim of reducing the large number of variables into fewer uncorrelated components. The overall Kaiser-Meyer-Olkin (KMO) measure was .87 with all individual KMO measures above the minimum of .50 (Kaiser, 1974). The Bartlett's Test of Sphericity was statistically significant ($p < .001$), demonstrating that the correlations between measures were suitable for PCA. The PCA revealed three components that had eigenvalues greater than Kaiser's criterion of 1, explaining 46.75%, 14.93% and 8.71% of the total variance. However, visual inspection of the scree plot (Figure 6.4) and a parallel analysis both suggested that two components should be retained (Cattell, 1966). Therefore, a two-factor component solution was chosen that explained 61.67% of the total variance, of which 76% was explained by latent factor 1 and 24% by factor 2. Factor loadings and the communalities of this rotated solution are presented in Table 8.

Table 6.7

Correlations Between the Psychometric Measures

	Measures											
	1	2	3	4	5	6	7	8	9	10	11	12
1. BSQ-16b	1.00											
2. BDI	.54**	1.00										
3. RSE	-.51**	-.71**	1.00									
4. AFA: Dislike	.01	-.01	.03	1.00								
5. AFA: Fear of Fat	.72**	.41**	-.43**	.23**	1.00							
6. AFA: Willpower	-.70	-.04	.14*	.58**	.16*	1.00						
7. WBIS-M	.80**	.59**	-.63**	-.03	.60**	-.10	1.00					
8. SATAQ-4: Thin	.51**	.41**	-.33**	.21**	.50**	.09	.47**	1.00				
9. SATAQ-4: Athletic	.00	-.04	.03	.18**	.12	.27**	-.05	.25**	1.00			
10. EDE-Q: Restraint	.52**	.20**	-.15*	.06	.42**	.04	.38**	.38**	.24**	1.00		
11. EDE-Q: Eating Concern	.71**	.45**	-.37**	.02	.49**	-.02	.62**	.43**	.10	.49**	1.00	
12. EDE-Q: Shape Concern	.83**	.54**	-.49**	.00	.70**	-.02	.81**	.54**	.07	.56**	.69**	1.00
13. EDE-Q: Weight Concern	.82**	.49**	-.44**	-.03	.65**	-.06	.83**	.48**	.05	.52**	.69**	.92**

*p < .05, ** p < .01

Figure 6.4

Scree Plot of the Total Variance Explained by Each Component

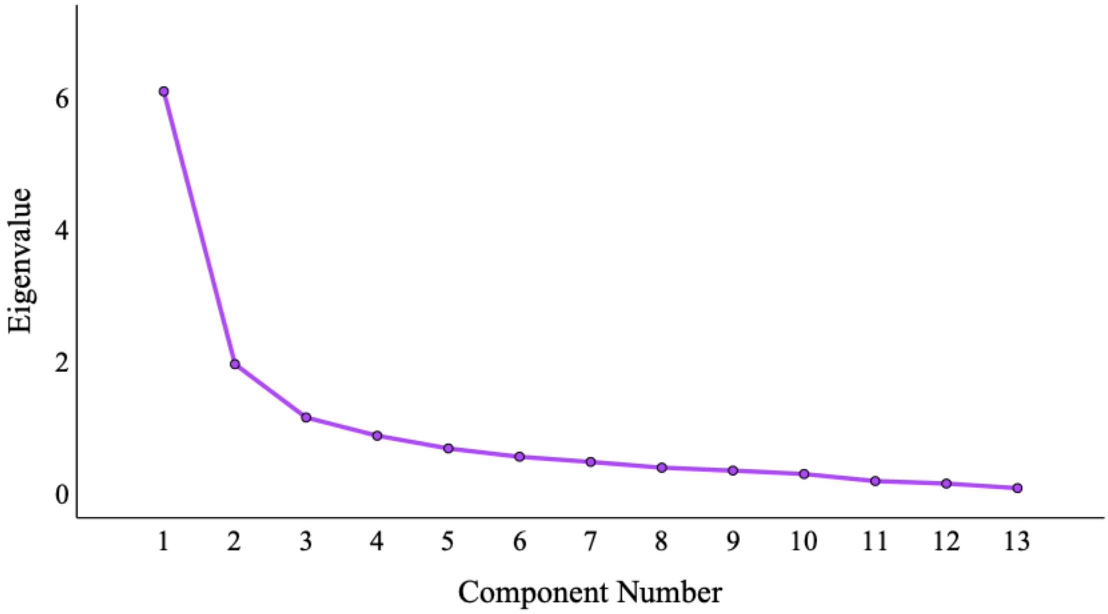


Table 6.8

Rotated Structure Matrix for PCA with Varimax Rotation

Items	Factor 1	Factor 2	Communalities
BSQ-16b	.923		.853
BDI	.671		.467
RSE	-.659		.478
AFA: Dislike		.778	.605
AFA: Fear of Fat	.754		.641
AFA: Willpower		.801	.647
WBIS-M	.887		.803
SATAQ-4: Thin	.591		.466
SATAQ-4: Athletic		.620	.387
EDE-Q: Restraint	.564		.373
EDE-Q: Eating Concern	.766		.590
EDE-Q: Shape Concern	.933		.872
EDE-Q: Weight Concern	.914		.836

6.4.3 Weight Categorisation

The proportion of underestimation, overestimation and accurate participant responses by stimuli BMI category and participant sex are presented for the 2-orientation stimuli and 8-orientation stimuli (Tables 6.9 and 6.10). Weight status judgements were most accurate in the normal weight bodies for males and females in each stimuli block. In addition, high levels of weight underestimation were found for the overweight and obese bodies, and relatively even distributions between accurate responses and overestimations for the underweight bodies.

Mann-Whitney U tests indicated that median accuracy scores were not statistically significantly different between males and females for the underweight, U = 922915.0, $z = -0.032$, $p = .975$, normal weight, U = 937453.0, $z = 1.10$, $p = .313$, and overweight stimuli, U = 905195.0, $z = -1.389$, $p = .165$. However, male participants showed statistically significantly higher accuracy scores for the obese bodies, U = 867412.5, $z = -3.313$, $p = .001$. Wilcoxon signed rank tests were used to determine the effect of viewpoint on accuracy scores for each BMI category. The 8-orientation stimuli elicited a statistically significant median increase in accuracy scores compared to the 2-orientation stimuli for the underweight, $z = 4.674$, $p < .001$, and normal weight bodies, $z = 7.118$, $p < .001$. Alternatively, the 8-orientation stimuli elicited a statistically significant median decrease in accuracy scores compared to the 2-orientation stimuli for the overweight, $z = -3.101$, $p = .002$, and obese bodies, $z = -18.969$, $p < .001$.

Table 6.9

Weight Categorisation Accuracy of the 2-Orientation Male Stimuli Across the Sample

Participant Sex	Stimuli BMI Category	Underweight (%)	Normal weight (%)	Overweight (%)	Obese (%)
Male	Underweight	61.2	37.7	0.9	0.2
	Normal weight	10.8	79.2	9.9	-
	Overweight	0.5	81.0	18.6	-
	Obese	-	12.1	60.1	27.8
Female	Underweight	61.7	36.8	1.5	-
	Normal weight	7.7	82.9	9.0	0.4
	Overweight	-	83.1	16.1	0.8
	Obese	-	16.7	58.1	25.2

Table 6.10

Weight Categorisation Accuracy of the 8-Orientation Male Stimuli Across the Sample

Participant Sex	Stimuli BMI Category	Underweight (%)	Normal weight (%)	Overweight (%)	Obese (%)
Male	Underweight	57.7	39.8	2.5	-
	Normal weight	7.9	80.7	3.6	7.9
	Overweight	0.8	82.7	16.5	-
	Obese	-	20.3	79.7	-
Female	Underweight	57.0	41.5	0.1	1.4
	Normal weight	6.3	82.9	3.6	7.2
	Overweight	-	87.1	12.9	-
	Obese	-	27.3	72.7	-

Spearman’s correlations were conducted to explore associations of stimuli BMI, using both the actual BMI and BMI category, with participant categorical weight status responses and accuracy scores for males and females using the 2-orientation and 8-orientation stimuli (Tables 6.11 and 6.12). Statistically significant positive relationships were found between stimuli BMI category, stimuli actual BMI and participant categorical weight responses for both males and females using the 2-orientation and 8-orientation stimuli ($p < .001$). In addition, significant negative associations were found between participant accuracy scores and both stimuli actual BMI and category ($p < .001$).

Similarly, Spearman’s correlations were used to assess relationships between participants’ accuracy scores and their individual characteristics, including their age, BMI, self-reported weight status and attitudinal body image. Statistically significant negative associations were found between accuracy scores and both the participant’s BMI ($r_s = -.04$, $p = .002$) and self-reported weight status ($r_s = -.03$, $p = .037$) for the female sample. No other significant associations were found between accuracy scores and participant demographics for males and females using the two sets of stimuli ($p > .05$). Statistically significant positive associations were found between accuracy scores and both latent factor 1 ($r_s = .031$, $p = .027$) and 2 scores ($r_s = .081$, $p < .001$) for the male sample. Significant associations were also found between accuracy scores and both factor 1 ($r_s = .037$, $p = .004$) and factor 2 scores ($r_s = .109$, $p < .001$) for the females.

Table 6.11

Correlations for the 2-Orientation Stimuli

	Male (n = 106) / Female (n =121)	
	Weight Status Response	Accuracy Score
Stimuli BMI	.79**/ .77**	-.64**/ -.66**
Stimuli BMI Category	.77**/ .75**	-.70**/ -.72**

** p < .01

Table 6.12

Correlations for the 8-Orientation Stimuli

	Male (n = 106) / Female (n =121)	
	Weight Status Response	Accuracy Score
Stimuli BMI	.70**/ .69**	-.79**/ -.81**
Stimuli BMI Category	.67**/ .68**	-.85**/ -.86**

** p < .01

A linear mixed-effects model was then run to explore the effects of participant sex, stimuli BMI, stimuli viewpoint and latent factor scores on participant weight categorisation accuracy scores. A model with random intercepts of both stimuli and subjects showed the best fit and significant improvement in the model compared to a model with a random variance of stimuli only ($\chi^2(1) = 355.87$, $p < .001$) or subjects only ($\chi^2(1) = 12164.15$, $p < .001$). The final model was generated using REML and included participant sex, stimuli BMI, stimuli viewpoint and the two latent factors as fixed effects, with random variation of participants and the stimuli on the intercept. Although, latent factor 1 was not a significant main effect or part of a significant interaction in the final model, the addition of this predictor significantly improved model fit ($\chi^2(16) = 81.10$, $p < .001$) and was therefore retained. Table 6.13 provides a summary of the final model, including fixed effects, random effects and model fit.

Table 6.13

Summary of the Final Model with Fixed Effects, Random Effects and Model Fit

Fixed Effects	*b*	*b* SE	*95%* CI	*t*	*p*
(Intercept)	1.09	0.39	0.32, 1.86	2.77	.006
BMI	-0.06	0.02	-0.09, -0.03	-3.82	.001
Viewpoint	0.12	0.02	0.07, 0.16	5.53	.000
Sex	0.22	0.08	0.06, 0.38	2.63	.008
Factor 1	-0.04	0.14	-0.32, 0.23	-0.31	.753
Factor 2	0.21	0.12	-0.03, 0.45	1.75	.080
BMI * Viewpoint	-0.00	0.00	-0.01, -0.00	-5.71	.000
BMI * Sex	-0.01	0.00	-0.01, -0.00	-1.98	.048
Viewpoint * Sex	0.00	0.01	-0.02, 0.03	0.17	.869
BMI * Factor 1	0.00	0.01	-0.01, 0.01	0.47	.637
Viewpoint * Factor 1	0.00	0.02	-0.04, 0.04	0.05	.959
Sex * Factor 1	-0.08	0.08	-0.24, 0.08	-0.98	.326
BMI * Factor 2	-0.01	0.00	-0.02, -0.00	-2.15	.032
Viewpoint * Factor 2	-0.01	0.02	-0.04, 0.03	-0.32	.752
Sex * Factor 2	-0.19	0.08	-0.35, 0.04	-2.44	.015
Factor 1 * Factor 2	0.13	0.12	-0.11, 0.38	1.08	.280
(BMI*Viewpoint) * Sex	-0.00	0.00	-0.00, 0.00	-0.63	.527
(BMI*Viewpoint) * Factor 1	0.00	0.00	-0.00, 0.00	0.29	.770
(BMI*Sex) * Factor 1	0.00	0.00	-0.00, 0.01	0.92	.358
(Viewpoint*Sex) * Factor 1	0.01	0.01	-0.02, 0.03	0.65	.513
(BMI*Viewpoint) * Factor 2	0.00	0.00	-0.00, 0.00	0.83	.407
(BMI*Sex) * Factor 2	0.01	0.00	0.01, 0.02	3.72	.000
(Viewpoint*Sex) * Factor 2	0.02	0.01	0.00, 0.05	1.97	.049
(BMI*Factor 1) * Factor 2	-0.01	0.00	-0.02, 0.00	1.26	.208
(Viewpoint*Factor 1) * Factor 2	-0.01	0.02	-0.05, 0.03	-0.43	.669
(Sex*Factor 1) * Factor 2	-0.13	0.08	-0.28, 0.02	-1.70	.089
(BMI*Viewpoint*Sex) * Factor 1	-0.00	0.00	-0.00, 0.00	-0.90	.368
(BMI*Viewpoint* Sex) * Factor 2	-0.00	0.00	-0.00, -0.00	-2.59	.010
(BMI*Viewpoint*Factor 1) * Factor 2	0.00	0.00	-0.00, 0.00	0.63	.527
(BMI*Sex*Factor 1) * Factor 2	0.00	0.00	-0.00, 0.01	1.63	.103

(Viewpoint*Sex*Factor 1) * Factor 2	0.01	0.01	-0.02, 0.03	0.65	.518
(BMI*Viewpoint*Sex*Factor 1) * Factor 2	0.00	0.00	-0.00, 0.00	0.63	.527
Random Effects	Variance	*SD*			
Subject (Intercept)	0.053	0.229			
Stimulus (Intercept)	0.161	0.402			
Model Fit					
AIC	13207.29				
BIC	13462.55				
LL	-6568.64				

The final model presented significant main effects of stimuli BMI (*F*(1, 22) = 14.60, *p* = .001), viewpoint (*F*(1, 5432) = 30.53, *p* < .001) and participant sex (*F*(1, 5410) = 6.94, *p* = .008) on participant accuracy scores, but not significant main effects of factor 1 (*F*(1, 5410) = 0.10, *p* = .753) or factor 2 (*F*(1, 5410) = 3.07, *p* = .080). Therefore, as the BMI of the stimuli increased, the accuracy of weight category responses become more negative towards an underestimation of weight status. In addition, as stimuli viewpoint increased from 2 to 8 orientations, accuracy scores increased towards an overestimation of weight status. Furthermore, given that participant sex was dummy coded as 1 = ‘male’, 2 = ‘female’, the positive coefficient for the main effect of participant sex showed that as participant sex increased from male to female, accuracy scores became more positive towards an overestimation of weight status.

A number of statistically significant interactions were revealed in the final linear mixed-effects model. Firstly, a significant interaction was found between stimuli BMI and participant sex (*F*(1, 5410) = 3.90, *p* = .048), where female participants showed greater overestimation of the lower BMI bodies and underestimation of the higher BMI bodies, compared to the male participants (Figure 6.7). A significant interaction between stimuli BMI and viewpoint was also revealed (*F*(1, 5432) = 32.61, *p* < .001), where participants presented greater overestimation of the lower BMI bodies and underestimation of the higher BMI bodies when using the 8-orientation stimuli, compared to the 2-orientation stimuli (Figure 6.8). Therefore, participant responses were generally more accurate across the BMI range when using the 2-orientation stimuli than the 8-orientation stimuli. There was a significant interaction between stimuli BMI and latent factor 2 (*F*(1, 5410) = 4.63, *p* = .032), indicating that individuals with high latent factor 2 scores showed more accurate weight judgements for the high BMI bodies, whereas those with low factor 2 scores showed more accurate responses for the low BMI bodies (Figure 6.9). Also, a significant interaction was found between participant sex and factor 2 ($F(1, 5410) = 5.97$, $p = .015$), indicating that although both men and women with high factor 2 scores showed more accurate weight judgements, and those with low factor 2 scores showed greater weight underestimation, this difference in weight categorisation was found to a greater extent in the female sample (Figure 6.10).

Figure 6.5

Two-Way Interaction Between Participant Sex and Stimuli BMI on Predicted Accuracy

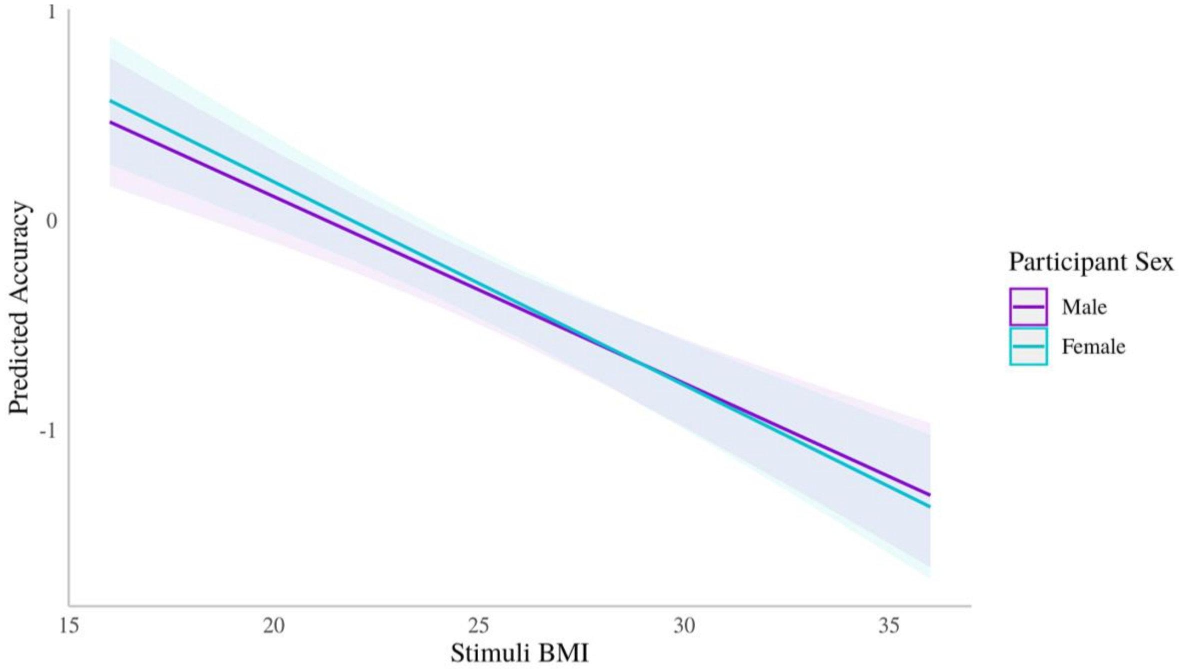


Figure 6.6

Two-Way Interaction Between Stimuli BMI and Stimuli Viewpoint on Predicted Accuracy

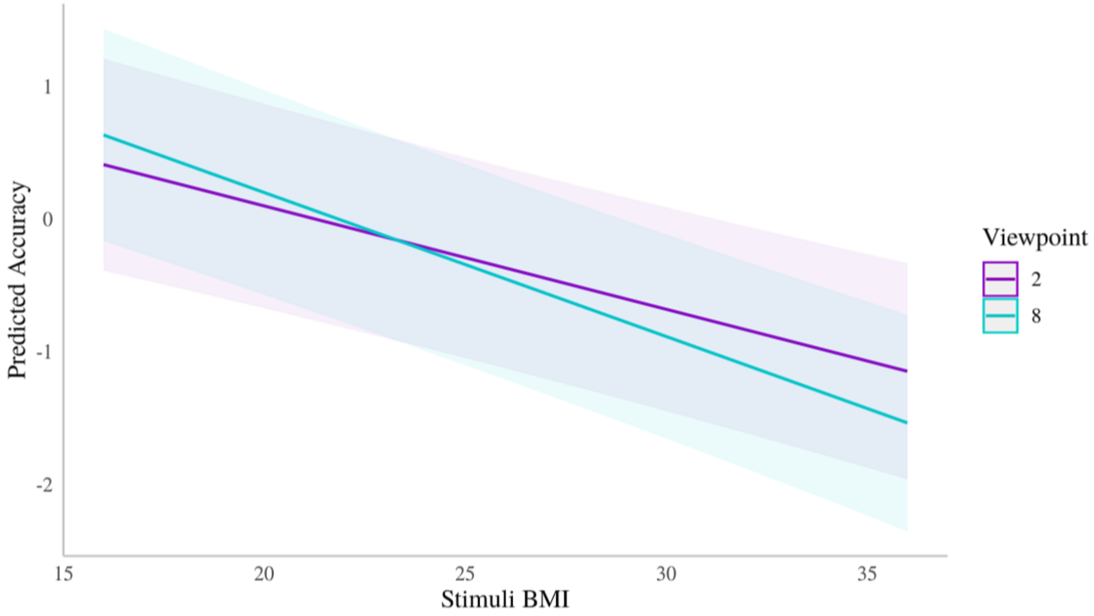


Figure 6.7

Two-Way Interaction Between Stimuli BMI and Factor 2 on Predicted Accuracy

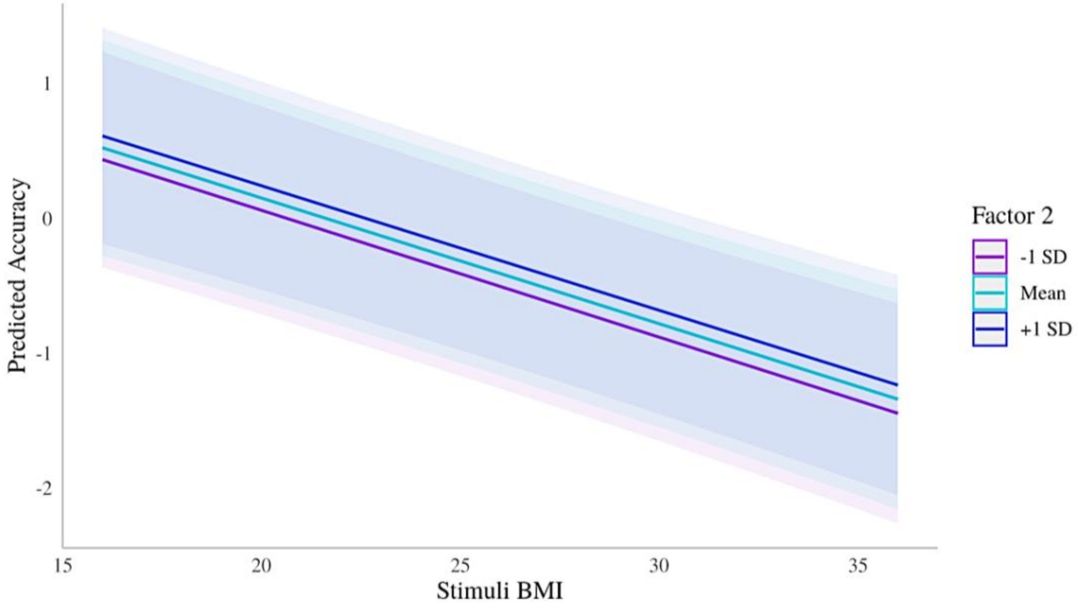
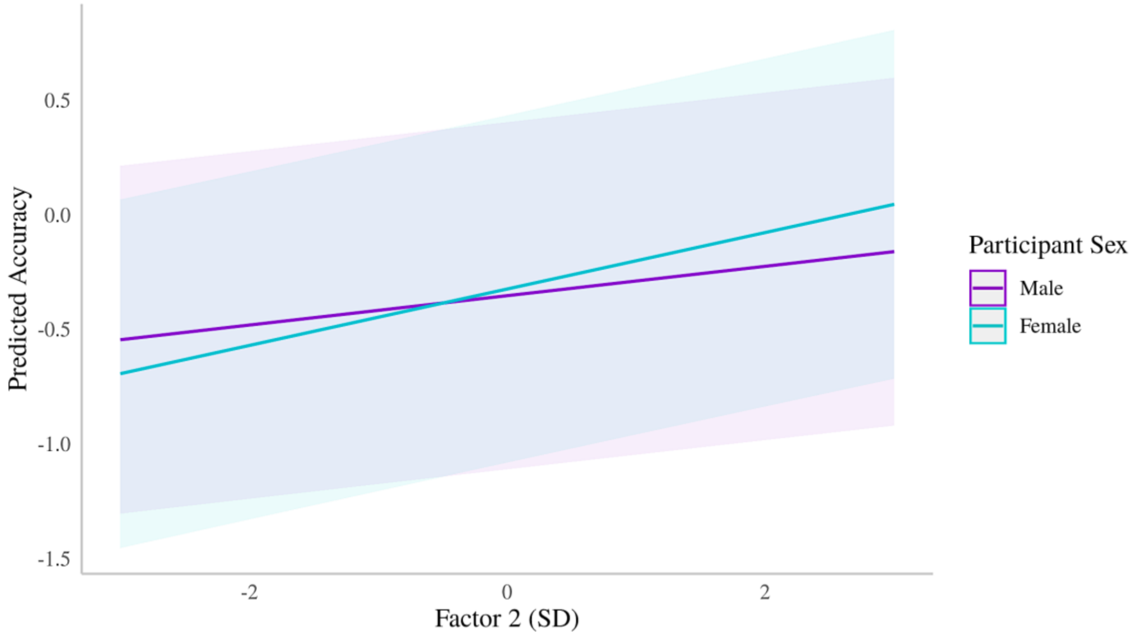


Figure 6.8

Two-Way Interaction Between Participant Sex and Factor 2 on Predicted Accuracy



Furthermore, significant three-way interactions were present between stimuli BMI, participant sex and factor 2 scores ($F(1, 5410) = 13.82$, $p < .001$), as well as between viewpoint, participant sex and factor 2 scores ($F(1, 5432) = 3.86$, $p = .049$). The former interaction revealed that male participants with varying factor 2 scores showed more similar levels of weight underestimation as stimuli BMI increased than the females, with female participants showing greater differences in accuracy between those with ±1 SD factor 2 scores (Figure 6.11). The latter interaction indicated that although both men and women with low factor 2 scores showed greater weight underestimation than those with high factor 2 scores, female participants with high factor 2 scores showed higher accuracy scores towards weight overestimation using the 2-orientation stimuli than with the 8-orientation stimuli (Figure 6.12). Whereas, the male participants showed more similar trends in responses across both sets of stimuli. However, it must be noted that this three-way interaction was only just statistically significant ($p = .049$).

Figure 6.9

Three-Way Interaction Between Participant Sex, Stimuli BMI and Factor 2 on Predicted Accuracy

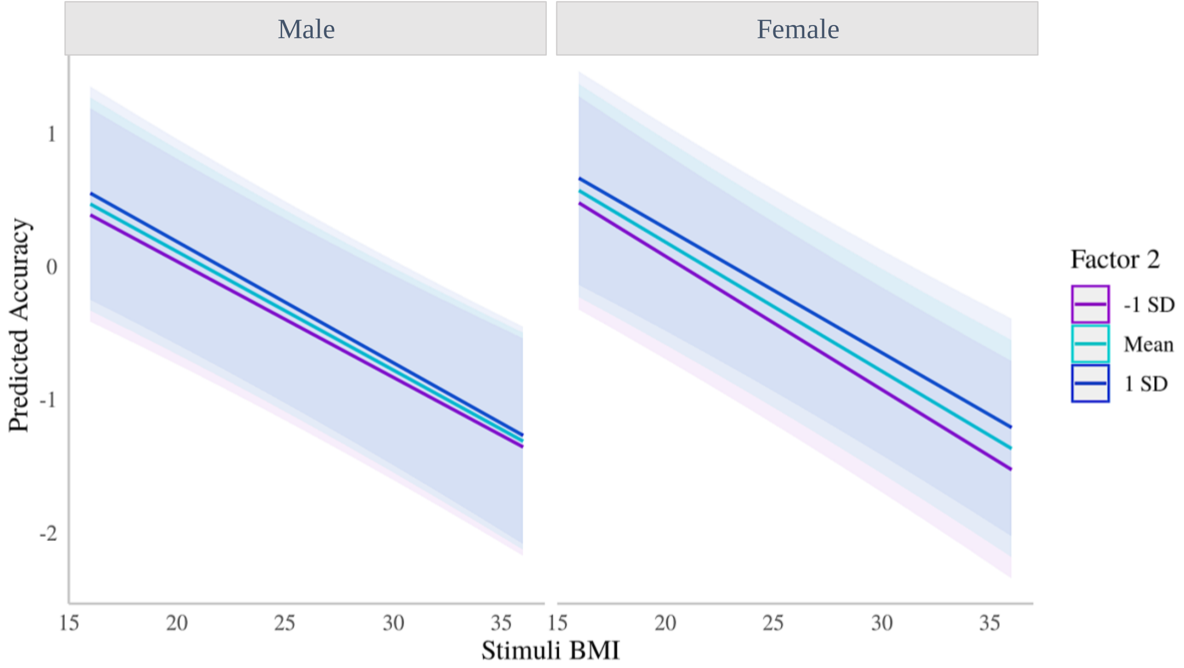
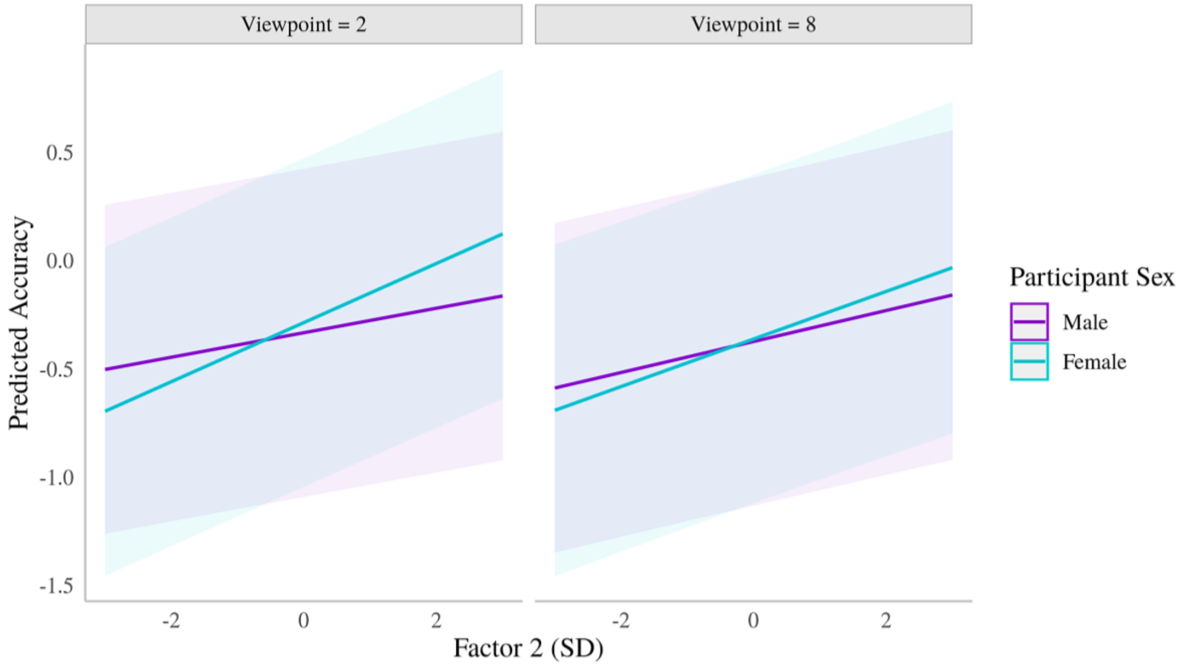


Figure 6.10

Three-Way Interaction Between Stimuli Viewpoint, Participant Sex and Factor 2 on Predicted Accuracy



Finally, a significant four-way interaction was found between stimuli BMI, viewpoint, participant sex and factor 2 scores (*F*(1, 5432) = 6.69, *p* = .010). Post-hoc pairwise comparisons for the mean predicted accuracy scores between the 2- and 8-orientation stimuli at different levels of stimuli BMI, participant sex and factor 2 scores were run. Table 6.14 reiterates that accuracy scores were more extreme for the 8-orientation stimuli than the 2-orientation stimuli, with more positive scores for underweight bodies and more negative scores for the obese bodies. Both sets of stimuli demonstrated a shift from positive to negative accuracy scores at the mean stimuli BMI, which represented the categorical boundary from normal weight to overweight. In the female sample, the pairwise comparisons demonstrate that there was a significant difference in accuracy between the two stimuli sets at each chosen stimuli BMI (*p* > .05), except for the mean and -1 SD BMIs among women with -1 SD factor 2 scores. In the male sample, there was a significant difference in accuracy between the two stimuli sets at each stimuli BMI (*p* > .05), except for the mean BMI among men at each point along the factor 2 score range, as well as at the -1 SD stimuli BMI for men with -1 SD factor 2 scores.

Table 6.14

Pairwise Comparisons Between 2- and 8-Viewpoint Accuracy for Each Level of Stimuli BMI, Participant Sex and Factor 1 Scores

		Predicted Accuracy					
Factor 2	Stimuli BMI	M_2	M_8	$M_{\text{Difference}}$	*SE*	*t-ratio*	*p*
			Males (n = 106)				
-1 SD	16.19	0.28	0.46	-0.18	0.04	-4.83	.002
	19.37	0.05	0.14	-0.10	0.03	-3.40	.370
	25.23	-0.39	-0.44	0.06	0.02	2.81	.856
	31.09	-0.82	-1.03	0.21	0.03	7.44	< .001
	36.02	-1.19	-1.52	0.33	0.04	7.95	< .001
Mean	16.19	0.34	0.57	-0.23	0.02	-9.63	< .001
	19.37	0.10	0.24	-0.13	0.02	-7.37	< .001
	25.23	-0.33	-0.37	0.04	0.02	3.21	.536
	31.09	-0.77	-0.98	0.21	0.02	11.86	< .001
	36.02	-1.13	-1.49	0.36	0.03	13.38	< .001
+1 SD	16.19	0.40	0.67	-0.28	0.03	-11.05	< .001
	19.37	0.16	0.33	-0.17	0.02	-8.89	< .001

	25.23	-0.28	-0.30	0.03	0.01	1.91	.100
	31.09	-0.71	-0.93	0.22	0.02	11.56	< .001
	36.02	-1.08	-1.46	0.39	0.03	13.5	< .001
Females (n = 121)							
-1 SD	16.19	0.39	0.53	-0.13	0.02	-5.70	< .001
	19.37	0.11	0.18	-0.07	0.02	-3.87	.103
	25.23	-0.42	-0.47	0.03	0.01	1.91	.100
	31.09	-0.95	-1.12	0.22	0.02	11.56	< .001
	36.02	-1.39	-1.66	0.39	0.03	13.53	< .001
Mean	16.19	0.45	0.66	-0.21	0.02	-9.59	< .001
	19.37	0.19	0.30	-0.11	0.02	-6.53	< .001
	25.23	-0.29	-0.36	0.08	0.01	6.47	< .001
	31.09	-0.76	-1.02	0.26	0.02	15.58	< .001
	36.02	-1.16	-1.58	0.42	0.03	16.69	< .001
+1 SD	16.19	0.50	0.79	-0.28	0.04	-7.52	< .001
	19.37	0.27	0.42	-0.15	0.03	-5.12	< .001
	25.23	-0.15	-0.25	0.10	0.02	5.05	< .001
	31.09	-0.57	-0.93	0.35	0.03	12.18	< .001
	36.02	-0.93	-1.49	0.56	0.04	13.06	< .001

Note. M_2 = predicted mean accuracy score for 2-orientation stimuli, M_8 = predicted mean accuracy score for 8-orientation stimuli, $M_{\text{Difference}}$ = difference in predicted mean accuracy score between the 2- and 8-orientation stimuli, calculated as $M_2 - M_8$.

6.4.4 Weight-Loss Judgements

Participants were asked to make a judgement about whether the individuals presented in the stimuli should consider losing weight using a 5-point response scale, ranging from 1 = ‘strongly disagree’ to 5 = ‘strongly agree’. The proportion of participant responses for each point in the response scale separated by stimuli BMI category and participant sex are presented in Table 6.15 for the 2-orientation stimuli and Table 6.16 for the 8-orientation stimuli. Mann-Whitney U tests were conducted to determine whether there were any differences between male and female weight-loss judgements in each BMI category. A statistically significantly higher median weight-loss response was found in the male sample for the overweight, U = 861902.5, $z = -3.198$, $p = .001$, and obese bodies, U = 762775.0, $z = -8.380$, $p < .001$, but no significant differences between males and females were present for the underweight, U = 939559.0, z = 0.882, p = .378, and normal weight stimuli, U = 903459.0, z = -1.037, p = .300.

Wilcoxon signed rank tests were used to determine the effect of viewpoint on weight-loss judgements for stimuli in each BMI category. Across the total sample, the 8-orientation stimuli elicited a statistically significant median increase in weight-loss responses compared to the 2-orientation stimuli for the underweight, z = 4.783, $p < .001$ and normal weight bodies, z = 3.021, p = .003. There were no significant differences between weight-loss judgements for the overweight, z = 1.424, p = .154, and obese bodies, z = -1.144, p = .265.

Table 6.15

Weight-Loss Judgements for the 2-Orientation Male Stimuli in Each BMI Category

Participant Sex	Stimuli BMI Category	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
Male	Underweight	59.7	27.8	9.9	2.4	0.2
	Normal weight	19.2	38.1	33.2	9.3	0.3
	Overweight	9.9	31.1	42.9	15.4	0.6
	Obese	1.3	3.8	18.7	48.4	27.8
Female	Underweight	57.7	31.8	9.2	1.2	-
	Normal weight	16.7	45.9	28.9	8.1	0.4
	Overweight	7.2	41.2	39.0	11.4	1.2
	Obese	1.5	9.6	24.2	44.5	20.1

Table 6.16

Weight-Loss Judgements for the 8-Orientation Male Stimuli in Each BMI Category

Participant Sex	Stimuli BMI Category	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
Male	Underweight	55.0	31.1	10.7	3.1	-
	Normal weight	17.6	38.2	32.4	11.8	-
	Overweight	8.8	31.3	41.4	18.4	0.2
	Obese	1.9	4.6	15.9	47.8	29.9
Female	Underweight	51.1	36.5	10.6	1.8	-
	Normal weight	13.8	46.1	30.3	9.2	0.6
	Overweight	7.6	29.8	38.3	13.4	1.0
	Obese	2.1	10.1	24.5	45.6	17.8

Spearman’s correlations were conducted to explore associations of stimuli BMI, based on their actual BMI and BMI category, with participant weight-loss judgements for males and females using the 2-orientation and 8-orientation stimuli (Tables 6.17 and 6.18). Statistically significant positive relationships were found between stimuli BMI category, stimuli actual BMI and participant weight-loss judgements for both males and females using the 2-orientation and 8-orientation stimuli (*p* < .001).

Table 6.17

Correlations Between Weight-Loss Judgement and Stimuli BMI for 2-Orientation Stimuli

	Weight-Loss Judgement	
	Male (n = 106)	Female (n = 121)
Stimuli BMI	.711**	.682**
Stimuli BMI Category	.692**	.664**

** *p* < .01

Table 6.18

Correlations Between Weight-Loss Judgement and Stimuli BMI for 8-Orientation Stimuli

	Weight-Loss Judgement	
	Male (n = 106)	Female (n = 121)
Stimuli BMI	.699**	.656**
Stimuli BMI Category	.675**	.630**

** *p* < .01

Spearman's correlations were again administered to assess relationships between participants' weight-loss judgements and their individual characteristics, including age, BMI and self-reported weight status. A statistically significant correlation was found between weight-loss judgements and participant BMI among the males (r_s = .029, p < .041) and females (r_s = -.036, p < .007), although in opposing directions. Spearman's correlations were also used to determine the relationship between participant weight-loss judgements and the two latent factors from the PCA. Significant positive associations were found between weight-loss judgements and both factor 1 (r_s = .066, p < .001) and factor 2 scores (r_s = .132, p < .001) in the male sample. Significant positive relationships were also found between weight-loss judgements and both factor 1 (r_s = .097, p < .001) and 2 scores (r_s = .242, p < .001) in the female sample.

A linear mixed-effects model was then run to explore the effects of participant sex, stimuli BMI and stimuli viewpoint on participant weight-loss judgements, accounting for unexplained error variance associated with participants and the stimuli used. This model was carried out using the same method as previously described for the model with participant weight accuracy scores as the outcome. Again, a model with random intercepts of both stimuli and subjects showed the best fit and significant improvement in the model, compared to a model with either a random variance of stimuli only ($\chi^2(1)$ = 2348.40, p < .001) or subjects only ($\chi^2(1)$ = 10025.07, p < .001). The same fixed effects of stimuli BMI, participant sex, stimuli viewpoint and both latent factors were selected for this model. Table 6.19 provides a summary of the final model, including fixed effects, random effects and the model fit. The final model yielded significant main effects of stimuli BMI (F(1, 22) = 126.71, p < .001) and factor 1 scores (F(1, 5410) = 5.82, p = .016) on weight-loss judgements, but not significant main effects of participant sex (F(1, 5410) = 1.36, p = .244), viewpoint (F(1, 5432) = 1.03, p = .310) or factor 2 scores (F(1, 5410) = 0.05, p = .825). Therefore, as the BMI of the stimuli increased, participants demonstrated stronger beliefs that the individual presented should consider losing weight. In addition, individuals with more negative self-directed body attitudes reported stronger weight-loss agreement towards the male bodies shown.

Table 6.19

Summary of the Final Model with Fixed Effects, Random Effects and Model Fit

Fixed Effects	*b*	*b* SE	*95%* CI	*t*	*p*
(Intercept)	-1.39	0.36	-2.09, -0.68	-3.86	.000
BMI	0.16	0.01	0.13, 0.19	11.26	.000
Viewpoint	-0.03	0.03	-0.08, 0.03	-1.01	.310
Sex	0.15	0.13	-0.10, 0.39	1.16	.244
Factor 1	0.51	0.21	0.10, 0.92	2.41	.016
Factor 2	-0.04	0.19	-0.40, 0.32	-0.22	.825
BMI * Viewpoint	0.00	0.00	-0.00. 0.00	1.42	.156
BMI * Sex	-0.00	0.00	-0.01, 0.01	-0.91	.361
Viewpoint * Sex	0.04	0.02	0.00, 0.07	2.15	.032
BMI * Factor 1	-0.02	0.01	-0.03, 0.00	-1.91	.056
Viewpoint * Factor 1	-0.04	0.03	-0.09, 0.02	-1.26	.207
Sex * Factor 1	-0.30	0.12	-0.54, -0.06	-2.42	.016
BMI * Factor 2	-0.00	0.01	-0.01, 0.01	-0.06	.955
Viewpoint * Factor 2	0.01	0.03	-0.03, 0.06	0.56	.573
Sex * Factor 2	-0.05	0.12	-0.28, 0.19	0.38	.705
Factor 1 * Factor 2	-0.04	0.19	-0.41, 0.33	-0.23	.816
(BMI*Viewpoint) * Sex	-0.00	0.00	-0.00, -0.00	-2.35	.019
(BMI*Viewpoint) * Factor 1	0.00	0.00	-0.00, 0.00	1.43	.154
(BMI*Sex) * Factor 1	0.01	0.00	0.00, 0.02	2.22	.026
(Viewpoint*Sex) * Factor 1	0.02	0.02	-0.01, 0.05	1.17	.243
(BMI*Viewpoint) * Factor 2	-0.00	0.00	-0.00, 0.00	-0.44	.656
(BMI*Sex) * Factor 2	0.01	0.00	0.00, 0.02	2.10	.035
(Viewpoint*Sex) * Factor 2	0.00	0.02	-0.03, 0.03	0.17	.864
(BMI*Factor 1) * Factor 2	0.00	0.01	-0.01, 0.02	0.13	.893
(Viewpoint*Factor 1) * Factor 2	0.07	0.03	0.02, 0.12	2.87	.004
(Sex*Factor 1) * Factor 2	0.00	0.11	-0.22, 0.23	0.01	.990

(BMI*Viewpoint*Sex) * Factor 1	-0.00	0.00	-0.00, 0.00	-1.30	.193
(BMI*Viewpoint*Sex) * Factor 2	-0.00	0.00	-0.00, 0.00	-0.29	.769
(BMI*Viewpoint*Factor 1) * Factor 2	-0.00	0.00	-0.00, -0.00	-2.45	.014
(BMI*Sex*Factor 1) * Factor 2	-0.00	0.00	-0.01, 0.01	-0.06	.955
(Viewpoint*Sex*Factor 1) * Factor 2	-0.04	0.02	-0.07, -0.01	-2.34	.019
(BMI* Viewpoint*Sex*Factor 1) * Factor 2	0.00	0.00	-0.00, 0.00	1.89	.059
Random Effects	Variance	*SD*			
Subject (Intercept)	0.278	0.527			
Stimulus (Intercept)	0.104	0.322			
Model Fit					
AIC	22454.62				
BIC	22709.89				
LL	-11192.31				

A number of statistically significant interactions were observed in the final linear mixed-effects model. Firstly, a significant interaction was found between viewpoint and participant sex (*F*(1, 5432) = 4.62, *p* = .032). Figure 6.11 demonstrates that although both the males and females reported higher weight-loss scores using the 8-orientation stimuli than the 2-orientation stimuli, the influence of viewpoint was more pronounced among the male participants. A significant interaction between participant sex and factor 1 scores was also revealed (*F*(1, 5410) = 5.86, *p* = .016), indicating that although both men and women with high factor 1 scores reported higher weight-loss scores than those with low factor 1 scores, the male participants showed a greater difference in their weight-loss beliefs with varying factor 1 scores (Figure 6.12). A significant three-way interaction between stimuli BMI, viewpoint and participant sex was found in the model (*F*(1, 5432) = 5.51, *p* = .019), showing that although males showed lower weight-loss scores than females as the BMI of the bodies decreased and higher weight-loss scores as stimuli BMI increased, the difference between males and females was more prominent when using the 8-orientation stimuli than the 2-orientation stimuli (Figure 6.13). Another significant three-way interaction was present between stimuli BMI, participant sex and factor 1 scores (*F*(1, 5410) = 4.94, *p* = .026), indicating that females with varying factor 1 scores showed similarly low weight-loss beliefs for the low BMI bodies, while those with high factor 1 scores showed stronger weight-loss agreement as stimuli BMI increased (Figure

6.14). Alternatively, the male participants with high factor 1 scores showed higher weight-loss scores across the BMI range, compared to those with low factor 1 scores.

Figure 6.11

Two-Way Interaction Between Participant Sex and Stimuli Viewpoint on Predicted Weight-Loss Belief

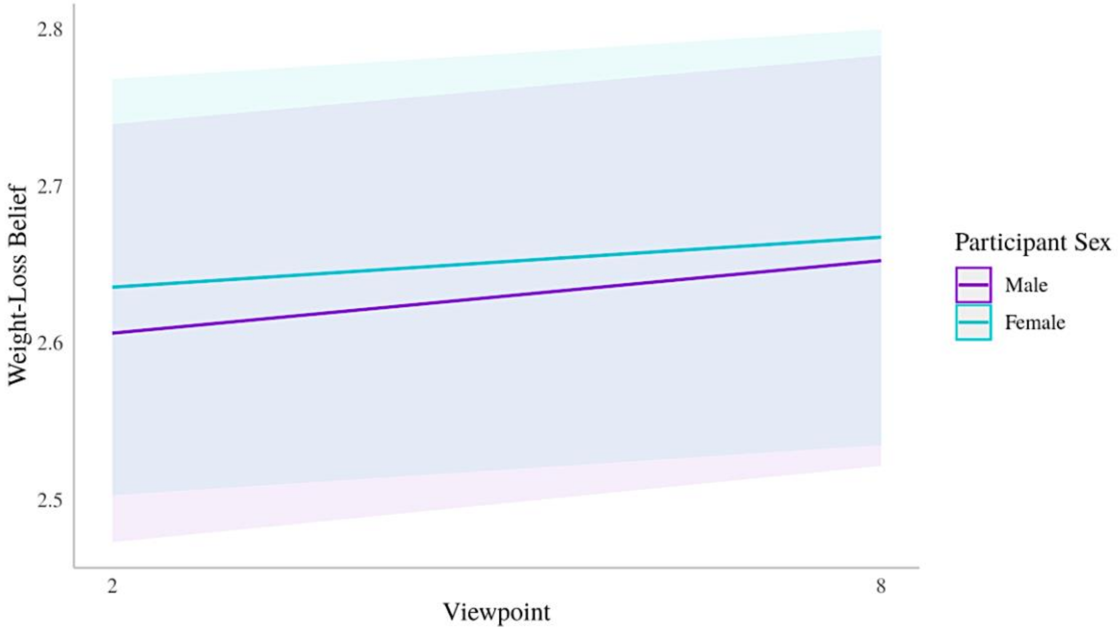


Figure 6.12

Two-Way Interaction Between Participant Sex and Factor 1 on Predicted Weight-Loss Belief

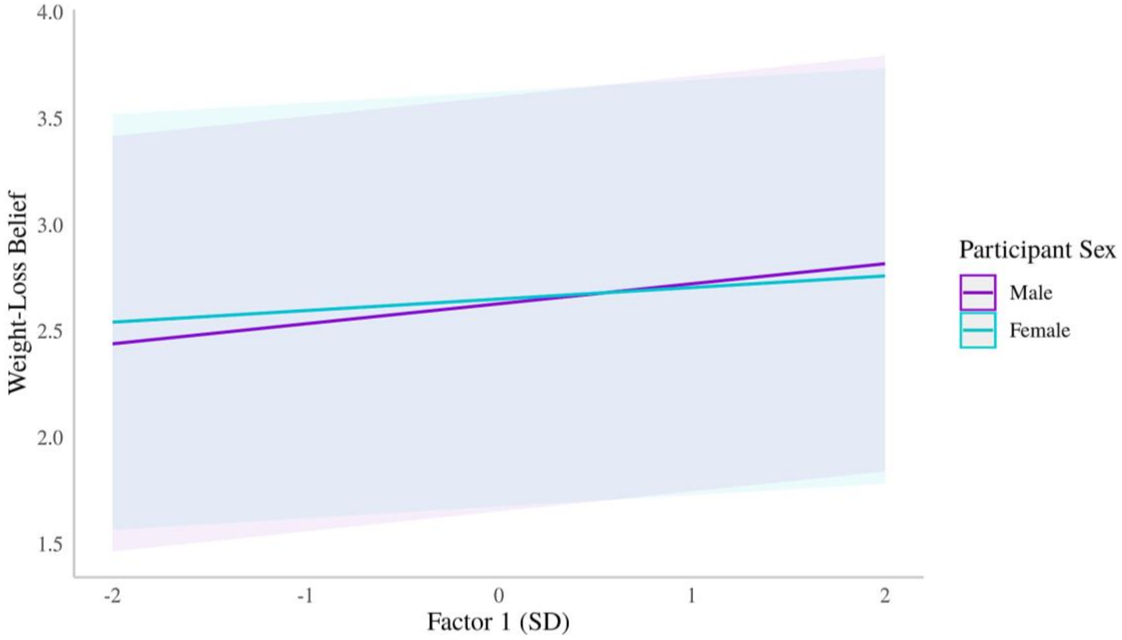


Figure 6.13

Three-Way Interaction Between Stimuli BMI, Viewpoint and Participant Sex on Predicted Weight-Loss Belief

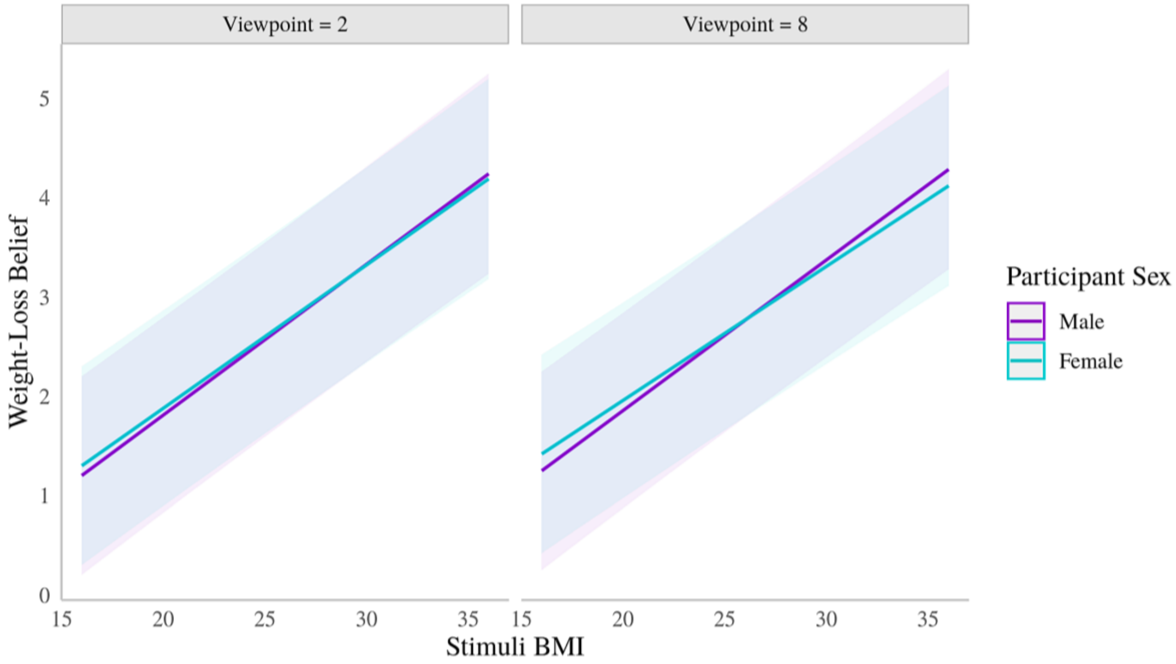
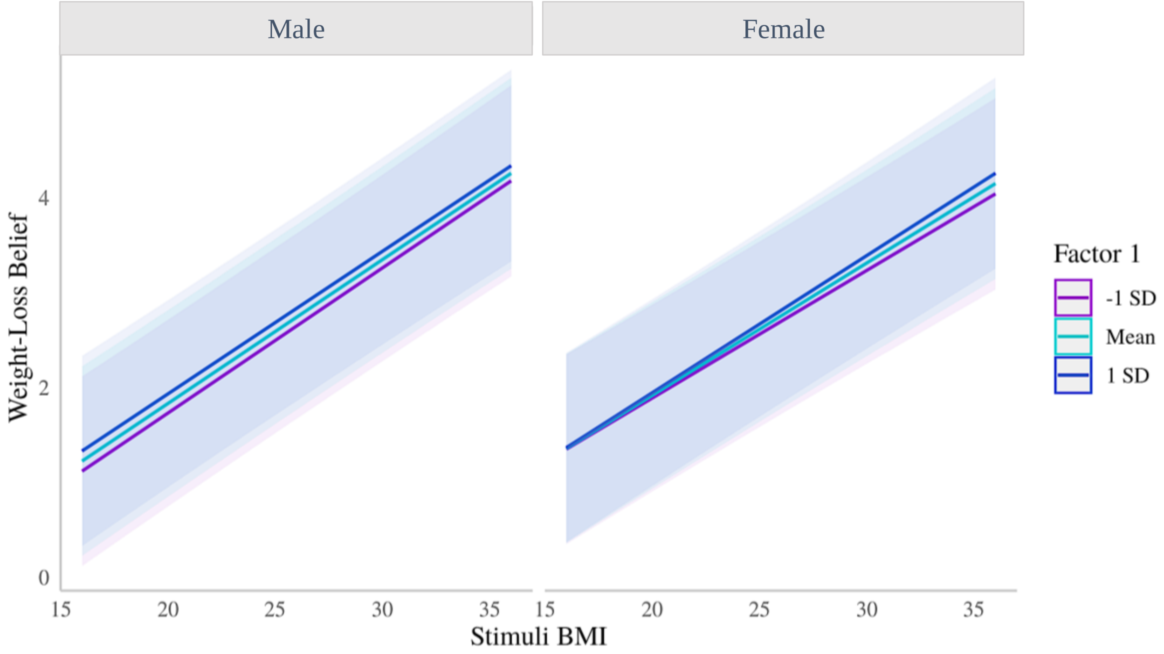


Figure 6.14

Three-Way Interaction Between Stimuli BMI, Factor 1 and Participant Sex on Predicted Weight-Loss Belief



A significant interaction was found between stimuli BMI, participant sex and factor 2 scores (*F*(1, 5410) = 4.42, *p* = .036). This three-way interaction demonstrates that although both men and women show a trend in strong weight-loss disagreement for the low BMI bodies and agreement for the high BMI bodies, there was a greater difference in weight-loss scores for the high BMI bodies in females with varying factor 2 scores (Figure 6.15). Therefore, females with high anti-fat attitudes and athletic-ideal internalisation showed much stronger weight-loss agreement in these bodies than those with low anti-fat attitudes and athletic-ideal internalisation. In addition, a significant interaction was revealed between viewpoint, factor 1 and factor 2 scores (*F*(1, 5432) = 8.26, *p* = .004). Figure 6.16 shows that the relationship between weight-loss beliefs and factor 1 scores was more similar between participants with varying factor 2 scores when using the 8-orientation stimuli than the 2-orientation stimuli. Therefore, when using the 2-orientation stimuli, there were greater differences in weight-loss beliefs between individuals of varying factor 2 scores with low factor 1 scores, compared to those with high factor 1 scores.

Figure 6.15

Three-Way Interaction Between Stimuli BMI, Factor 2 and Participant Sex on Predicted Weight-Loss Belief

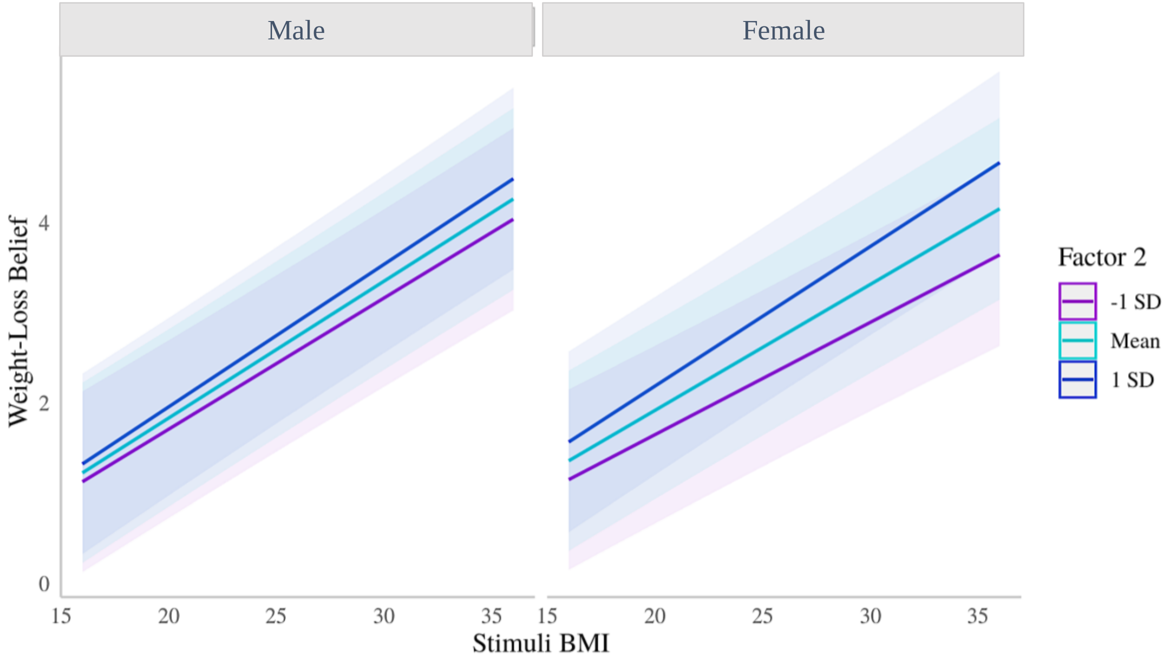
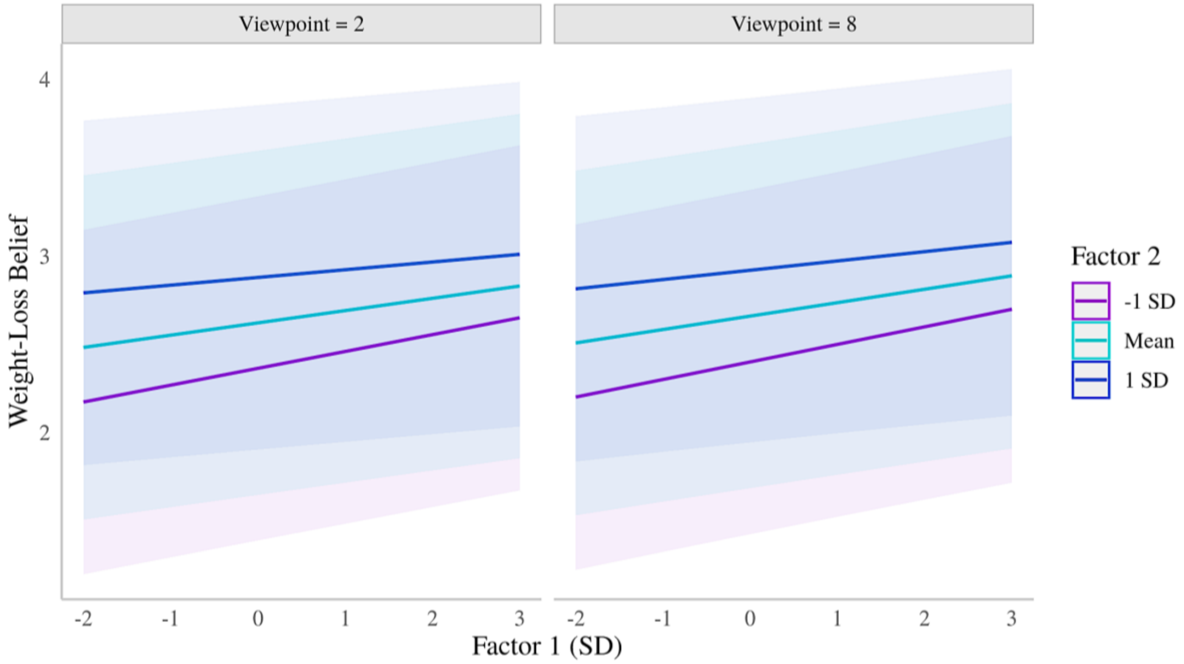


Figure 6.16

Three-Way Interaction Between Stimuli Viewpoint, Factor 1 and Factor 2 on Predicted Weight-Loss Belief



Finally, two significant four-way interactions were found in the final linear mixed-effects model. There was an interaction between stimuli BMI, viewpoint, factor 1 and factor 2 scores (*F*(1, 5432) = 6.02, *p* = .014), and another between viewpoint, participant sex, factor 1 and factor 2 scores (*F*(1, 5432) = 5.47, *p* = .019). Post-hoc pairwise comparisons for the mean predicted weight-loss judgements between the 2- and 8-orientation stimuli at different levels of stimuli BMI and latent factor scores were run (Table 6.20). These comparisons further demonstrate that mean weight-loss judgements were generally higher when using the 8-orientation stimuli than the 2-orientation stimuli, among individuals across the range of factor 1 and 2 scores. Among individuals with low factor 1 scores, there was a significant difference in weight-loss judgements between the two stimuli sets for stimuli at the mean BMI or higher for individuals with ±1 SD factor 2 scores, and for stimuli at +1 SD BMI and higher for those with average factor 2 scores. For individuals with mean factor 1 scores, there was a significant difference in weight-loss judgements between the 2- and 8-orientation stimuli for figures across the BMI range, except for the average BMI bodies among individuals with low factor 2 scores and for obese bodies among those with average and high factor 2 scores. For individuals with high factor 1 scores, there were also significant differences in weight-loss judgements between the two stimuli sets for the underweight and normal weight figures among individuals with low factor 2 scores, and again for obese bodies among those with average and high factor 2 scores.

Table 6.20

Pairwise Comparisons Between 2- and 8-Viewpoint Weight-Loss Judgements for Each Level of Stimuli BMI, Participant Sex and Factor 2 Scores

		Predicted Weight-Loss Judgement					
Factor 2	BMI	M_2	M_8	$M_{\text{Difference}}$	*SE*	*t-ratio*	*p*
Factor 1 = -1 SD							
-1 SD	16.19	1.07	1.16	-0.10	0.04	-2.68	.984
	19.37	1.49	1.56	-0.07	0.03	-2.70	.981
	25.23	2.27	2.30	-0.03	0.02	-1.77	< .001
	31.09	3.05	3.04	0.01	0.03	0.24	< .001
	36.02	3.70	3.66	0.04	0.04	0.99	< .001
Mean	16.19	1.23	1.32	-0.09	0.03	-3.32	.630
	19.37	1.69	1.76	-0.07	0.02	3.34	.612
	25.23	2.55	2.58	-0.03	0.02	-2.15	1.000
	31.09	3.41	3.40	0.01	0.02	0.33	< .001
	36.02	36.02	4.09	0.04	0.03	1.26	< .001
+1 SD	16.19	1.38	1.48	-0.09	0.04	-2.11	1.000
	19.37	1.89	1.97	-0.07	0.03	-2.12	1.000
	25.23	2.84	2.87	-0.03	0.03	-1.35	< .001
	31.09	3.78	3.77	0.01	0.03	0.24	< .001
	36.02	4.57	4.52	0.04	0.05	0.82	< .001
Factor 1 = Mean							
-1 SD	16.19	1.15	1.19	-0.04	0.03	-1.45	< .001
	19.37	1.57	1.62	-0.04	0.02	-1.81	< .001
	25.23	2.36	2.40	-0.04	0.02	-2.37	.999
	31.09	3.15	3.18	-0.03	0.02	-1.51	< .001
	36.02	3.82	3.84	-0.03	0.03	-0.92	< .001
Mean	16.19	1.29	1.37	-0.08	0.02	-3.93	-.154
	19.37	1.76	1.82	-0.07	0.02	-4.18	.067
	25.23	2.62	2.66	-0.04	0.01	-3.47	.491

	31.09	3.49	3.50	-0.01	0.02	-0.67	< .001
	36.02	4.22	4.20	0.01	0.02	0.539	< .001
+1 SD	16.19	1.42	1.55	-0.12	0.03	-4.17	.069
	19.37	1.94	2.03	-0.09	0.02	-4.18	.068
	25.23	2.88	2.92	-0.04	0.02	-2.63	.999
	31.09	3.82	3.81	0.01	0.02	0.50	< .001
	36.02	4.62	4.56	0.06	0.03	1.66	< .001
Factor 1 = +1 SD							
-1 SD	16.19	1.22	1.22	0.01	0.05	0.26	< .001
	19.37	1.66	1.67	-0.01	0.03	-0.17	< .001
	25.23	2.46	2.50	-0.04	0.03	-1.61	< .001
	31.09	3.26	3.33	-0.07	0.04	-2.07	1.000
	36.02	3.93	4.03	-0.10	0.05	-1.93	1.000
Mean	16.19	1.34	1.42	-0.07	0.03	-2.34	1.000
	19.37	1.82	1.88	-0.06	0.02	-2.66	.986
	25.23	2.69	2.74	-0.05	0.02	-2.77	.969
	31.09	3.56	3.59	-0.03	0.02	-1.21	< .001
	36.02	4.30	4.31	-0.01	0.04	-0.40	< .001
+1 SD	16.19	1.46	1.62	-0.16	0.04	-4.18	.068
	19.37	1.98	2.10	-0.12	0.03	-4.18	.068
	25.23	2.92	2.97	-0.05	0.02	-2.61	.991
	31.09	3.87	3.85	0.02	0.03	0.52	< .001
	36.02	4.66	4.59	0.07	0.04	1.68	< .001

Note. M_2 = predicted mean weight-loss judgement for 2-orientation stimuli, M_8 = predicted mean weight-loss judgement for 8-orientation stimuli, $M_{\text{Difference}}$ = difference in predicted mean weight-loss judgements between the 2- and 8-orientation stimuli, calculated as $M_2 – M_8$.

Post-hoc pairwise comparisons for the mean predicted weight-loss judgements between the 2- and 8-orientation stimuli at different levels of latent factor scores and participant sex were also run. Table 6.21 demonstrates that participants’ weight-loss judgements became more positive as factor 2 scores increased among individuals with varying factor 1 scores, except for women with mean factor 1 scores when using the 2-orientation stimuli. In the male sample, there was a significant difference in weight-loss judgements between the two stimuli sets among men with low factor 1 scores and high factor 2 scores, as well as for those with high factor 1 scores and low factor 2 scores. In the female sample, there was a significant difference in weight-loss judgements between the 2- and 8-orientation stimuli among women with low factor 1 scores and varying factor 2 scores, as well as for women with either average or high factor 1 scores and high factor 2 scores.

Table 6.21

Pairwise Comparisons Between 2- and 8-Viewpoint Weight-Loss Judgements for Each Level of Participant Sex, Factor 1 and Factor 2 Scores

		Predicted Weight-Loss Judgement					
Factor 1	Factor 2	M_2	M_8	$M_{\text{Difference}}$	*SE*	*t-ratio*	*p*
			Males (n = 106)				
-1 SD	-1 SD	2.35	2.40	-0.05	0.03	-1.76	1.000
	Mean	2.52	2.55	-0.03	0.02	-1.81	.999
	+1 SD	2.69	2.70	-0.02	0.02	-0.70	< .001
Mean	-1 SD	2.45	2.49	-0.04	0.03	-1.51	1.000
	Mean	2.61	2.65	-0.05	0.02	-2.79	.648
	+1 SD	2.76	2.81	-0.05	0.02	-3.03	.443
+1 SD	-1 SD	2.56	2.58	-0.03	0.04	-0.64	< .001
	Mean	2.69	2.75	-0.06	0.03	-2.04	.989
	+1 SD	2.83	2.93	-0.09	0.03	-2.91	.548
			Females (n = 121)				
-1 SD	-1 SD	2.20	2.21	-0.01	0.03	-0.48	< .001
	Mean	2.58	2.61	-0.03	0.02	-1.13	< .001
	+1 SD	2.97	3.01	-0.04	0.04	-1.03	< .001
Mean	-1 SD	2.99	2.32	-0.03	0.02	-2.01	1.000
	Mean	2.64	2.67	-0.03	0.02	-1.87	.997
	+1 SD	2.99	3.01	-0.02	0.03	-0.90	< 0.001
+1 SD	-1 SD	2.37	2.43	-0.05	0.02	-2.53	.839
	Mean	2.69	2.72	-0.03	0.02	-1.91	.996
	+1 SD	3.00	3.01	-0.01	0.03	-0.23	< .001

Note. M_2 = predicted mean weight-loss judgement for 2-viewpoint stimuli, M_8 = predicted mean weight-loss judgement for 8-viewpoint stimuli, $M_{\text{Difference}}$ = difference in predicted mean weight-loss judgements between the 2- and 8-viewpoint stimuli, calculated as $M_2 – M_8$.

6.5 Study 6: Discussion

6.5.1 Summary and Interpretation of Findings

Study 6 evaluated the accuracy of categorical male body weight judgements in a general sample of 106 men and 121 women, using stimuli based on 3D body scans across a BMI range from underweight to obese. Across the sample, 71.7% of men and 76.0% of women accurately categorised their own weight status, based on self-reported height and weight measurements. Individuals in the normal weight category were most accurate in categorising their own weight status. A large proportion of underweight participants overestimated their own body weight, particularly in the females, and many of the overweight and obese participants underestimated their body weight, particularly in the males. This trend in weight misperception has been commonly found in previous research evaluating men and women's estimations of their own body weight across the BMI spectrum (Kuchler & Variyam, 2003; Robinson & Kersbergen, 2017).

Participant demographics demonstrated statistically significant differences in age and attitudinal body image between the males and females, with the male sample being older and self-reporting higher average levels of self-esteem, anti-fat attitudes towards others, and athletic-ideal internalisation than the female sample. Whereas, the females presented higher average levels of depression, body shape and adiposity concerns, internalisation of the thin-ideal, weight stigma and eating disorder psychopathology than the males. Sex differences in these psychological attributes have been widely evidenced in previous literature (Albert, 2015; Bleidorn et al., 2016; Carey et al., 2019; Magallares & Morales, 2013; Schaefer et al., 2015; Schaefer et al., 2017).

The PCA of the psychometric data revealed a two-factor component solution across the measures used in this study. Latent factors 1 and 2 are interpretable based on the particular measures that loaded onto each factor. Factor 1 incorporated questionnaires that considered individual body attitudes and feelings relating to the self. This factor included measures of general body dissatisfaction, body shape preoccupations, eating disorder psychopathology and related behaviours regarding a person's own body. It also included levels of self-esteem and depression, as well as internalisations of weight stigma and personal fears relating to their own body weight and adiposity. Alternatively, factor 2 included the dislike and willpower subscales of the AFA that consider individuals' aversions and beliefs about controllability regarding other people's body weight. Therefore, factors 1 and 2 can be theoretically separated into body image attitudes towards the self and towards others. Interestingly, the thin subscale of the SATAQ-4 loaded onto factor 1, while the athletic subscale loaded onto factor 2. The athletic subscale correlated significantly with the AFA dislike and willpower subscales in this study (Table 7), proposing a link between anti-fat attitudes towards others and an internalisation of the athletic-ideal. This internalisation has been evidenced as a predictor of weight bias and obesity stereotypes in previous research, with suggestions that people who adopt a muscular appearance standard tend to blame individuals with high BMIs for their weight and consider their body size and shape to be unacceptable (Klaczynski et al., 2009; Langdon et al., 2016).

6.5.1.1 Weight Categorisation

This research aimed to investigate whether the accuracy of people's weight judgements was influenced by factors relating to the stimuli, such as the number of viewpoints and BMI presented, as well as factors relating to the individual, including their attitudinal body image and sex. The weight categorisation task revealed the accuracy of people's weight status judgements was poorer for the overweight and obese male bodies than for the normal weight bodies, as shown in previous research (Oldham & Robinson, 2016; 2018; Robinson & Hogenkamp, 2015). In fact, people were inaccurate in their weight status categorisations for bodies at both ends of the BMI spectrum, with a general underestimation of higher BMI bodies and overestimation of lower BMI bodies. These findings provide evidence of contraction bias, as the accuracy of people's judgements reduced as the size of the bodies became increasingly more extreme. They are also in line with visual normalisation theory, as individuals demonstrated perceptions of overweight and obese bodies as being of a healthier weight than they are. Visual normalisation theory proposes that people judge bodies based on an internal reference template, informed by the bodies they are exposed to in their visual diet (Poulton & Poulton, 1989; Winkler & Rhodes, 2005). Therefore, given that the prevalence of overweight and obesity is rising in society (Campos et al., 2006; Finucane et al., 2011; Swinburn et al., 2011; WHO, 2018), it could be that individuals compared the stimuli presented in this study to a pre-existing internalised body template.

A linear mixed-effects model was carried out to investigate the effects of participant sex, attitudinal body image, stimuli BMI and viewpoint on the accuracy of these weight status judgements, while accounting for potentially unexplained variance from the stimuli and participants. This was based on the principal that responses from a participant are likely to be correlated, as some individuals may be more or less accurate on average than others. Similarly, responses relating to a certain stimulus are also likely to be correlated, as some stimuli may be generally more or less difficult to categorise than others. The final model revealed that the BMI and viewpoint of the stimulus, as well as the participant's sex, had a direct effect on categorical weight perceptions. In general, male participants showed more accurate responses across the BMI range, although both samples showed a similar trend in misperception of body weight. There has been scarce previous research exploring sex differences in the accuracy of male body weight judgements, and little evidence that this characteristic plays a role in body size and weight perceptions (Oldham & Robinson, 2016; Robinson & Kirkham, 2014). One interpretation of this novel finding is that men may be more accustomed to viewing other male bodies, and therefore could be more in tune to male body weight across the BMI range. Given that the male sample generally reported greater anti-fat attitudes towards others, it could also be argued that men were more willing or inclined to use the 'overweight' and 'obese' labels for the larger bodies than women.

Significant interactions in the model highlighted that individuals with higher athletic-ideal internalisation and anti-fat attitudes towards others were more accurate in their weight judgements for the higher BMI bodies. Although, this was found to be more prominent among the female sample than the male sample. In addition, participants demonstrated more accurate perceptions using the 2-orientation stimuli than the 8-orientation stimuli. Previous research has supported the use of both a front and side-view for differentiating body size and weight (Cohen et al., 2015; Cornelissen et al., 2018). Pairwise comparisons between the two sets of stimuli demonstrated a shift from weight overestimation to underestimation for stimuli at the BMI categorical boundary from normal weight to obese. In addition, statistically significant differences in accuracy between the two stimuli sets were found along the stimuli BMI range, except at the mean and -1 SD BMI stimuli in women with low athletic-ideal internalisation and anti-fat attitudes towards others. Significant differences were also not found at the mean stimuli BMI in men with varying levels of athletic-ideal internalisation and anti-fat attitudes, as well as at the -1 SD stimuli BMI in men with low scores on these attitudinal traits. Therefore, equivalent accuracy was found between the two sets of stimuli for figures in the normal weight BMI category, especially among individuals with lower athletic-ideal internalisation and anti-fat attitudes.

It was anticipated that the accuracy of weight perceptions would improve with the amount of body size and shape information available to the viewer in this study, given that this is closer to how bodies are seen in real life. It could be that presenting 8 distinct viewpoints provided participants with conflicting information about individual body weight that led to confusion when making categorical judgements. Research has demonstrated that if an individual attempts to process too much information, it can result in sensory overload that may influence their decision making (Malhotra, 1984). Therefore, it may be that 8 images of a single body were too many to process together and this might have led to less accurate visual weight judgements. As the stimuli were based on 3D body scans of Caucasian men, it could also be argued that these additional viewpoints may be more beneficial when presenting body shape variation in other ethnic groups that have different weight distribution patterns and visual cues to BMI, such as adiposity in the buttocks (Cohen et al., 2015; Cornelissen et al., 2018), that may not be observable from a front or side-view. Nevertheless, this unexpected finding has implications for figure scale development and research practice, suggesting that the presentation of computer-generated bodies from two viewpoints is sufficient to visualise a wide range in male body weight.

6.5.1.2 Weight-Loss Judgements

This study also explored people's weight-loss beliefs towards the male CGI stimuli, and investigated whether factors relating to the stimuli and participants themselves influenced these beliefs. When asked whether the bodies presented should consider losing weight, the most common response among the male and female participants was 'strongly disagree' for the underweight bodies, 'disagree' for the normal weight bodies, 'neutral' for the overweight bodies and 'agree' for the obese bodies. Correlational analysis revealed that as male participants' BMIs increased, their weight-loss beliefs also increased toward stronger agreement. Whereas, as female participants' BMIs increased, they were less likely to agree that the individual presented should consider weight-loss. This finding could be interpreted as a form of self-serving bias in which female participants who were overweight or obese presented less weight-loss agreement, in order to protect their psychological wellbeing and attitudes toward their own body size (Robinson & Hogenkamp, 2015). However, these correlations had very small effect sizes indicating subtle relationships between participant BMI and their weight-loss beliefs toward the male bodies presented.

Again, a linear mixed-effects model was carried out to investigate the effects of participant sex, attitudinal body image, stimuli BMI and viewpoint on these weight-loss judgements, while accounting for unexplained variance from the stimuli and participants. This model revealed significant main effects of stimuli BMI and participant factor 1 scores on weight-loss beliefs. As has been found in previous research (Robinson & Hogenkamp, 2015), participants' beliefs that an individual should consider losing weight became stronger as the BMI of the individual increased. In addition, stronger weight-loss agreement was generally shown in people with higher levels of body dissatisfaction and concern, internalisation of the thin-ideal, depression and lower self-esteem. Although women reported higher levels of these psychological traits on average, men with factor 1 scores above the mean showed stronger weight-loss agreement in general. Significant interactions in the model revealed that the influence of these factor 1 scores on weight-loss beliefs was prominent across the full BMI range among the male participants, whereas factor 1 scores were most influential for the high BMI bodies among females. Also, higher athletic-ideal internalisation and anti-fat attitudes towards others was associated with stronger weight-loss agreement for the high BMI bodies, and this was particularly evident in the female participants. Therefore, negative body attitudes towards the self and others seemed to influence weight-loss judgements of the overweight and obese bodies in the female participants, and more generally across the BMI range for the male participants.

Although marginally stronger weight-loss beliefs were presented when using the 8-orientation stimuli than the 2-orientation stimuli, viewpoint was particularly influential in the male sample. Pairwise comparisons of weight-loss judgements between the 2- and 8-orientation stimuli demonstrated significant differences across the stimuli BMI range, except for the obese bodies among individuals with average or higher factor 1 and 2 scores, and for normal weight bodies among individuals with average or higher factor 1 scores and low factor 2 scores. Nonsignificant differences between the two stimuli sets were also found for the underweight and normal weight bodies in those with low factor 1 scores. Furthermore, pairwise comparisons highlighted that significant differences in weight-loss judgements were apparent in men with high factor 1 scores and low factor 2 scores, or vice versa. Therefore, the number of viewpoints presented seemed to significantly influence weight-loss judgements in men with opposing body attitudes towards the self and others. Whereas, significant differences were found among women with either low factor 1 scores, or average or higher factor 1 scores and high factor 2 scores. These findings illustrate the role of men and women's body image attitudes towards the self and towards others on whether stimuli viewpoint influenced their weight-loss beliefs across a wide range in BMI.

It must be noted that although numerous significant main effects and interactions were found in both linear mixed-effects models run in this study, the actual effect sizes were often very small and, therefore, presented subtle differences in the accuracy of weight status categorisations and weight-loss beliefs. In addition, some of the significant interactions were not apparent when visualised graphically (see Figures 6.9 and 6.18), and it could be argued that statistical significance in some cases may have been a result of the large sample size in this study (Brown & Prescott, 2014; Khalilzadeh & Tasci, 2017).

6.5.2 Strengths and Limitations

This study adhered to a common approach of assessing the accuracy of categorical weight status perceptions in male bodies and used stimuli that overcame many of the limitations of previous measures. Research in this area has predominantly presented photographic images of bodies from either a front-view, side-view or both. The stimuli used in this study allowed for a comparison of accuracy between stimuli presented at 2-orientations and 8-orientations, therefore providing variability in the amount of body size and shape information available to participants. In addition, the stimuli were derived from a set of 3D body scans that presented realistic variation in body size and shape in each BMI category, and were calibrated for actual measurements of BMI, fat mass and skeletal muscle mass. The association of stimuli with actual measurements of muscularity and adiposity allowed for a stimuli selection process that moved beyond purely subjective visual assessments. The use of these 3D body scans also enabled the application of a standardised texture across the images, which is not possible when using 2D photographic stimuli, and allowed the individual faces to be fully blocked from view. This prevented participants from being distracted away from the size and shape of the body or being influenced by potential skin and face-related visual cues to BMI and health when making their categorical body weight judgements (Coetzee et al., 2009, 2010; Henderson et al., 2016; Thompson, 2001; Wen & Guo, 2013).

This evaluation of categorical weight status perceptions in male bodies resulted in clear and interpretable findings, however, there are several limitations to the study design and sample recruited. Firstly, although all participants were residing in the UK at the time of data collection, and were therefore exposed to a similar sociocultural environment, they represented a range of ethnic groups that may hold different views and attitudes towards body weight and weight-loss. There is evidence to suggest ethnic and cultural differences in the assessment of body weight and obesity that may have played a role in individual perceptions of categorical weight and weight-loss beliefs. For example, some cultures generally link being underweight with disease and low socioeconomic status, and associate being overweight with prosperity and wealth (Tovée et al., 2006). This assumption then develops a cultural appreciation of larger body sizes and weight gain, in contrast to the view of adiposity being linked with poor health, a lack of willpower and poverty. Furthermore, the male and female samples revealed statistically significant differences in their psychological profiles in relation to their body concerns, depression, self-esteem, eating behaviours, weight bias and internalisation of body ideals. This attitudinal component was accounted for within the linear mixed-effects models in this study and was found to directly influence people's weight-loss beliefs, but not the accuracy of their categorical weight judgements.

With regards to the study design, self-reported height and weight were relied upon for calculations of participant BMI, as data was collected through an online survey. However, it is well-established that self-reported measurements of height and weight are subject to error, both in terms of biased reporting and problems with individual recall (Gorber et al., 2007; Kuczmarski et al, 2001; Taylor et al., 2006). Previous research has suggested that people tend to overestimate their own height, especially among men, and underestimate their weight, particularly among women, when self-reporting these measurements (Cameron & Evers, 1990; Kovalchik, 2009; Truesdale & Stevens, 2008; Wen & Kowaleski-Jones, 2012). Therefore, it is possible that the prevalence of overweight and obesity were underestimated in both the male and female samples in this study. Another limitation is that the labels of 'overweight' and 'obese' may have been viewed negatively by some participants. Previous research has demonstrated that these labels can be perceived as medically-driven, offensive, extreme, and flawed, and are associated with weight stigma, negative stereotypes and anti-fat attitudes (Ellis et al., 2014; Kennedy & Markula, 2011; Puhl & Heuer, 2009; Warin et al., 2008). Therefore, individuals may have been reluctant to use these labels when categorising body weight, thus promoting the weight underestimation of stimuli in this study.

Although participants were not instructed to make comparisons between their own body size and shape and that of the stimuli presented, this might have influenced individual judgements of categorical weight and weight-loss. It could be argued that the high prevalence of body weight underestimation was a result of a self-serving bias, where individuals, who recognised similarities between their own body size and the larger BMI stimuli presented, underestimated the size of these bodies in order to protect their psychological wellbeing. This phenomenon has been evidenced in people's underestimations of their own body size (Herman et al., 2013; Thurston et al., 2017; Roberts & Duong, 2013; Robinson & Hogenkamp, 2015), and therefore this may have also occurred if individuals were implicitly comparing their own body to those of others. It is not possible to determine whether an unprompted comparison between the self and others was influential in people's responses, but it may have been a factor in the high prevalence of weight underestimation of the larger BMI bodies in this study.

There were several advantages to conducting this research using an online survey, including the ability to recruit a large sample size and access participants from across the UK (Lefever et al., 2007). However, there is often a potential risk of unreliable or biased responses when conducting web-based research (Mathy et al., 2003). It might have been beneficial to have included attention checks within the online survey in the study (Abbey & Meloy, 2017; Kung et al., 2018), however, participants' responses were visually inspected for careless responding or missing data prior to data analysis, to ensure that the survey had been completed as intended. Finally, although all the 3D body scans presented male bodies in a standard A-pose, there was some variation in the body posture and arm positioning across images. Therefore, the accessibility of specific visual cues of BMI varied across stimuli and viewpoints, which may have played a role in the view-dependent accuracy of weight categorisations. For example, variability of the angle of individuals' arms in the A-pose may have blocked certain parts of the torso from view. Previous research has found that the outline and landmarks within the torso are strong visual cues for body weight and health perceptions (Cornelissen, Hancock, et al., 2009; Tovée & Cornelissen, 2001), and therefore this disparity in the extent of the torso shown may have influenced participant responses.

6.5.3 Implications and Future Work

The present study established clear and interpretable findings for specific individual characteristics and methodological factors that influence weight-loss beliefs and the accuracy of weight judgements of male bodies. It provided further evidence for a general trend in male body weight misperception that has implications in clinical health settings. For example, weight misperception may influence the ability of healthcare professionals in accurately perceiving and monitoring weight change in their underweight, overweight and obese male patients. This in turn may hinder individuals from being screened for weight-related health concerns or being provided with necessary information and interventions to support healthy weight management (Bramlage et al., 2004; Caccamese et al., 2002; Johnson et al., 2008; Perrin et al., 2005; Robinson et al., 2014; Yoong et al., 2014). Findings from this study also supported the use of a front and side-view, as opposed to 8 viewpoints around the body, when presenting male bodies as visual stimuli. This is in line with previous research exploring optimal viewpoints for assessing BMI and body size (Cohen et al., 2015; Cornelissen et al., 2018), however, it also contradicts previous arguments for additional viewpoints to visualise greater variation in body size and shape (Gardner & Brown, 2010). Therefore, although it seems logical that increasing the amount of visual body information available to viewers would result in more accurate weight perceptions, there may be a limit to the amount of information that is sufficient or helpful in facilitating these judgements (De Coster et al., 2020).

This study was novel in its application of 3D body scans as the basis of the visual stimuli used to assess people's weight perceptions and beliefs, overcoming some of the main limitations of existing photographic stimuli and figure scales that have been used in previous research. Given that there were measurements of adiposity and muscularity associated with these 3D body scans, future work should aspire to move beyond considerations of BMI in relation to weight perceptions and instead focus on the role that these dimensions of body composition play on people's judgments toward weight. Further investigations could compare the influence of body fat measurements to the BMI measurements associated with the stimuli, in order to investigate whether adiposity has a similar direct effect on participants' weight perceptions. An emerging concept within current literature in this research area is a subclassification of obesity known as normal weight obesity, which describes individuals with a BMI in the normal weight category who have a high level of adiposity that puts them at increased risk of health outcomes, such as heart failure, metabolic syndrome, hypertension and mortality (Oliveros et al., 2014). Body fat percentages of above 20% in men and 30% in women are generally considered to be high enough for this increased risk (Zhang et al., 2018). Two of the 3D body scans selected for the normal weight stimuli in this study were of individuals with body fat percentages above 20%. Therefore, it cannot be assumed that the body size and shape of normal weight stimuli presented to participants in this study were indicative of optimal health and this variation in adiposity may have been influential in participant's responses.

It would also be beneficial to explore the relationship between the accuracy of people's own body weight perceptions and their judgements of other bodies. The accuracy of participant's own weight status categorisations was not included in the linear mixed-effects models in this study, due to the specific research aims of this chapter and a likely bias in the self-reported BMI measurements across the sample. It would be valuable to conduct a similar study, in which height and weight are measured in-person, to evaluate whether individuals who misperceive their own body weight are also inaccurate in their perceptions of other bodies, and how this relates to their own BMI. A norm comparison approach to understanding self-perceptions of body weight suggests that the accuracy of people's own weight status judgements is dependent on their internalised body norms, which in turn may also be used when assessing body weight in others' bodies (Burke et al., 2010; Robinson, 2017; Robinson & Kersbergen, 2017; Robinson & Kirkham, 2014; Yaemsiri et al., 2011). Therefore, it is conceivable that there would be a strong association between the accuracy of people's weight status perceptions towards the self and others.

Given the unexpected finding that more accurate categorical weight perceptions were found when using the 2-orientation stimuli than the 8-orientation stimuli, further research into the influence of stimuli presentation is needed in this area. An advantage of using 3D stimuli is that they can be presented within a virtual reality (VR) environment and shown as life-size objects that can be viewed from 360° at any specified distance from the viewer. It would be interesting to investigate potential differences in the accuracy of people's weight perceptions and weight-loss beliefs when bodies are viewed in this manner, compared to when they are presented as smaller 2D objects. Recent research comparing VR-based figure scales to more traditional 2D scales has demonstrated equivalency in evaluating body image in a clinical female sample (Fisher et al., 2019).

Future studies could also seek to apply eye-tracking technologies to identify whether certain areas of the male bodies were used when making these weight judgements across the BMI range, as has been found previously for body size judgements of female bodies (Cornelissen, Hancock, et al., 2009; George et al., 2011; Irvine, McCarty, Pollet, 2019; Tovée & Cornelissen, 2001), and compare the use of visual cues when bodies are presented from different viewpoints. This may provide a justification for the improved accuracy of categorical weight perceptions in the 2-orientation stimuli, compared to the 8-orientation stimuli, or indicate specific viewpoints that play a role in these judgements. Previous literature has also suggested the application of video footage of real bodies rather than static images or scans of bodies when conducting research in this area (Oldham & Robinson, 2016). There is some evidence that dynamic stimuli are perceived as more attractive than static stimuli and that implied motion influences perceptions of adiposity and body weight (Cazzato et al., 2012). Therefore, a similar study using animated 3D body scan stimuli, rather than static images, could also be conducted to determine whether visualisations of body motion improve the accuracy of people's weight status judgements or alter beliefs around weight-loss.

6.6 Chapter Conclusion

Overall, Study 6 provided evidence that the accuracy of men and women's categorical male body weight perceptions, indexed by BMI, are directly related to the BMI and viewpoint of the stimuli, as well as the participant's sex. The findings confirmed a general trend in weight overestimation of underweight male bodies and underestimation of overweight and obese male bodies. Improved accuracy in categorical weight judgement was revealed when using the 2-orientation stimuli, compared to the 8-orientation stimuli in both male and female participants. This study also highlighted that people's beliefs regarding whether weight-loss should be considered were directly influenced by the BMI of the male body and the individual's attitudinal body image. A positive relationship was found between stimuli BMI and participants’ weight-loss beliefs, while stronger beliefs were generally presented in people with higher levels of body dissatisfaction and concern, internalisation of the thin-ideal, depression and low self-esteem. Again, significant differences in weight-loss judgements were highlighted between the 2- and 8-orientation stimuli, particularly for the overweight and obese male figures. This study applied a common method of assessing perceptions of body weight in others, whilst presenting novel 3D male body scan stimuli that overcame many of the limitations of measures used in previous research. Findings were indicative of view-dependent accuracy in categorical weight judgements and weight-loss beliefs, and suggestions were made for future work to further investigate the influence of stimuli presentation, body composition, and the accuracy of self-perceptions of BMI on perceptions of male body weight in others.

Chapter 7: General Discussion

7.1 Thesis Overview

The research studies presented in this thesis aimed to address and overcome some of the critical limitations in existing measures of perceptual body image in the male population. Several novel visual scales and male body stimuli have been developed that present high-quality imagery, a wide variation in body size and shape, a precise calibration to measurements of body composition, and account for male-specific visual body weight perceptions. This thesis evaluated the reliability, validity and suitability of these newly developed measures in estimating current and ideal body perceptions among community-based male samples. It has also enhanced our understanding of individual and methodological factors that play a role in the accuracy of male body weight judgements.

This chapter summarises and discusses the main aims, findings, strengths, limitations, and wider contributions of the research presented in this thesis. Firstly, an overview of the specific aims, methods and key findings of each of the individual research studies in this thesis is provided (Section 7.2). The general strengths and limitations of this research are then considered and discussed (Section 7.3). Finally, implications of the main research findings of this thesis are addressed and recommendations are proposed for future research in the field of male perceptual body image (Section 7.4).

7.2 Summary and Main Findings of Research Studies

The following section summarises the aims, methods, and main findings for the research studies presented in this thesis.

7.2.1 Studies 1 and 2

Study 1 (Chapter 3, Section 3.2) aimed to identify the JND of BMI across a wide range of body sizes, to inform the development of perceptually-driven male figure scales. The accuracy of men's visual discriminations of male CGI bodies, varying in BMI from 16.5-43 kg/m^2, was investigated using a method of constant stimuli. A linear function was then applied to determine the BMI spacing between bodies for the development of two male figure scales, based on the JNDs multiplied by a factor of 2 or 3. The key findings for Study 1 were:

1. As the BMI of the stimuli increased, progressively larger differences in BMI between pairs of bodies were required for the difference to be visually detectable, which provided evidence of Weber's law.
2. The model-predicted JNDs for the male stimuli were smaller across the BMI range than have been previously found with female CGI bodies (Cornelissen et al., 2016).

Study 2 (Chapter 3, Section 3.6) evaluated the reliability and validity of these two new JND-based figure scales in estimating men's current and ideal body size perceptions and compared them to an interactive scale presenting smaller incremental changes in figure BMI. The key findings for Study 2 were:

1. There were no statistically significant differences in the mean estimates of perceived current body size and ideal body size, as well as levels of body dissatisfaction and body image distortion, between the three scales.
2. Participants demonstrated high accuracy in ordering the figures in each JND-based scale from smallest to largest, with some errors concentrated in the normal weight and obese bodies.
3. There was preliminary evidence to support the concurrent validity of the JND-based scales, with correspondence of men's current body size perceptions and estimated body dissatisfaction with psychometric measures of body shape concern, body dissatisfaction, and preoccupations with adiposity and muscularity. However, no significant associations were found between the psychometric measures and men's ideal body size perceptions using either scale.
4. Convergent validity was not evidenced for either JND-based scale as there was a lack of association between men's perceived current and actual BMI.
5. Test-retest reliability was supported over a period of 2-3 days, particularly for estimations of body dissatisfaction, body image distortion, and perceived current BMI.

7.2.2 Studies 3, 4 and 5

Study 3 (Chapter 4, Section 4.2) aimed to develop a set of 3D CGI male body stimuli that were precisely calibrated for measurements of fat mass and skeletal muscle mass. A large database of 247 3D body scans and bio-impedance measurements was collected from a non-clinical adult male sample, and body shape variation across 176 of the scans was characterised using PCA. A linear regression model was then run for each principal component to predict male body shape independently for different levels of adiposity, ranging from 2.5-46.0 kg, and muscularity, ranging from 28.4-61.6 kg. The key findings for Study 3 were:

1. Statistically significant positive associations were found between men's BMI, fat mass and skeletal muscle mass. When considering fat mass and skeletal muscle mass as proportions of total body weight, a positive relationship was revealed between BMI and body fat percentage, while negative relationships were found between BMI and skeletal muscle percentage, and between body fat percentage and skeletal muscle percentage.
2. The relationship between BMI and the two dimensions of body composition represented an example of Simpson's Paradox for men in the underweight and overweight categories, but not for those in the normal weight or obese categories.
3. Fewer errors were found in the prediction of male body shape using a linear regression model based on measurements of fat mass and skeletal muscle mass than BMI.

Study 4 (Chapter 5, Section 5.2) aimed to evaluate the face validity of the interactive 3D body scale, developed in Study 3 (Chapter 4, Section 4.4.3), to determine whether men were able to visually perceive changes in fat mass and muscle mass in the body model, based on separate ratings of each body composition dimension. The key findings for Study 4 were:

1. There was a significant negative relationship between men's fat and muscle ratings across the stimuli range.
2. The face validity of the scale was supported through significant associations between men's ratings and the levels of fat mass and muscle mass of the body model. However, men were more accurate in visually perceiving variation in the fat mass of the body than the muscle mass.
3. Both stimuli fat mass and muscle mass significantly predicted men's fat and muscle ratings separately, but in opposite directions.

Study 5 (Chapter 5, Section 5.6) aimed to investigate the reliability and validity of the interactive 3D body scale, developed in Study 3 (Chapter 4, Section 4.4.3), in estimating men's current and ideal body perceptions relating to adiposity and muscularity. The key findings for Study 5 were:

1. Men demonstrated distinct perceptions relating to adiposity and muscularity through nonsignificant associations between their perceived current fat mass and skeletal muscle mass, and between their ideal fat mass and skeletal muscle mass.

2. Indices of body dissatisfaction and body image distortion from the scale were not significantly associated with men’s actual fat or muscle mass measurements.
3. As men increasingly underestimated their current fat mass and skeletal muscle mass, they selected ideal bodies that were increasingly higher in fat mass and muscle mass compared to their current body perceptions.
4. The convergent validity of the scale, assessed through the relationship between men’s actual and perceived current estimations, was supported for fat mass but not for muscle mass.
5. There was preliminary evidence to support the concurrent validity of the scale through correspondence between men’s body estimations and the psychometric measures of body shape concern, drive for muscularity, and the internalisation of appearance ideals.
6. Test-retest reliability was supported over a period of 2-3 days for men’s perceived current fat mass, and estimations of their body dissatisfaction and body image distortion relating to adiposity using the scale. However, it was not evidenced for men’s ideal fat mass, or any perceptual estimations relating to muscularity.

7.2.3 Study 6

Study 6 (Chapter 6, Section 6.2) aimed to evaluate the view-dependent accuracy of men’s and women’s categorical body weight judgements and weight-loss beliefs using stimuli derived from 3D male body scans. The influence of the BMI and number of viewpoints of the stimuli, as well as participant sex and attitudinal body image, on visual weight judgements and beliefs were investigated. The key findings for Study 6 were:

1. The BMI and viewpoint of the male body stimulus, and the participant’s sex, had a direct effect on categorical weight perceptions.
    - 1.1. There was a general trend in weight overestimation of underweight male bodies and underestimation of overweight and obese male bodies, which provided evidence of contraction bias.
    - 1.2. Participants demonstrated more accurate categorical weight judgements using stimuli presented at 2 viewpoints than 8 viewpoints.
    - 1.3. Men generally showed more accurate responses than women across the BMI range.
2. Weight-loss beliefs were directly influenced by the BMI of the stimulus and participant’s own psychometric profile.

2.1. Participants' beliefs that an individual should consider losing weight became stronger as the BMI of the stimulus increased.
2.2. Stronger weight-loss agreement was reported by participants with higher levels of body dissatisfaction and concern, internalisation of the thin-ideal, depression and lower self-esteem.
2.3. Negative body attitudes towards the self and others influenced weight-loss judgements across the stimuli BMI range for the male participants, and predominantly in the overweight and obese stimuli for the female participants.

7.3 Strengths and Limitations

The following section identifies and discusses the general strengths and limitations of the research presented in this thesis.

7.3.1 Strengths

The research presented in this thesis applied both common and novel approaches to assessing men's current and ideal body perceptions. It also evaluated the accuracy of men's visual body size and weight judgements using newly-developed body scales and stimuli. These new measures were quick to administer, easy to use, designed specifically for application in the general male population, and considered both 2D and 3D presentations through up-to-date technology and 3D data analysis techniques. A number of critical limitations in existing methods of male perceptual body image measurement were discussed in Chapter 1 (Section 1.4.3). Many of these issues have been overcome by the innovative measures examined within this thesis, with the aim of improving upon existing BMI, and fat and muscle-based methods.

A critical problem with existing measures is that they do not provide an accurate visual representation of men's body composition and their patterns of weight distribution in the real world (Gardner & Brown, 2010; Talbot et al., 2020; Wells, 2007). Instead, they often present systematic changes in body width (Ralph-Nearman & Filik, 2018) or are calibrated for levels of adiposity and muscularity by visually matching figures to photographs of real bodies (Talbot, Smith, et al., 2019). This lack of ecological validity is often furthered by poor imagery, such as through the use of hand-drawn silhouette figures that fail to provide detailed body shape information and are often hindered by bilateral body asymmetry (Talbot et al., 2020). These issues have been considered within the design of stimuli and scales tested within this thesis, with the aim of developing realistic, ecologically-valid measures that provide comprehensive visual body size and shape information. The JND-based scales developed in Study 1 (Chapter 3, Section 3.4.3) consist of symmetrical, high-definition CGI body stimuli that are aesthetically realistic, present important visual cues to body size and shape, and are calibrated using the HSE (2008) average body measurements for Caucasian men aged 18 to 45. The interactive fat and muscle scale developed in Study 3 (Chapter 4, Section 4.4.3) presents a precise, calibrated mapping between 3D body shape, fat mass and skeletal muscle mass measurements. This biometrically-accurate scale uses high-quality imagery to demonstrate realistic variation in male body size and shape, and was modelled according to actual body composition measurements.

Many existing male figure rating scales are unidimensional in design, meaning they present variation in a single dimension across figures, such as BMI or body fat percentage (Cohen et al., 2015; Harris et al., 2008). In a recent critical review, 17 of the 20 male figure scales examined were unidimensional (Talbot et al., 2020). This limits the representation of male-specific body concerns, dissatisfaction and appearance ideals that have been shown to encompass desires for both leanness and muscularity (Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; McCabe & Ricciardelli, 2004). The interactive fat and muscle scale evaluated in Study 5 (Chapter 5, Section 5.6) is bidimensional, as it allows for estimates of men’s current and ideal perceptions relating to both adiposity and muscularity. These perceptions are considered separately and presented within a single predicted body model in the scale. However, this tool can be used to develop sets of images, presented as a bidimensional matrix-style figure scale, with different combinations of adiposity and muscularity.

Finally, another common limitation of perceptual measures and figure rating scales is that they are comprised of a restricted range of bodies, normally presented from a single viewpoint (Gardner et al., 1998). When designing figure scales, there is often a trade-off between presenting images with small enough increments along the dimension of body variation for specificity in participant responses, and not presenting an excessive number of images that may be problematic for scale reliability and application in clinical settings (Talbot et al., 2020). Again, these methodological limitations were addressed within the scales developed within the research in this thesis. The JND-based scales developed in Study 1 (Chapter 3, Section 3.4.3) present a wide range in BMI from underweight to obese and are comprised of different numbers of figures to meet potential necessities of both research and clinical settings. The interactive fat and muscle scale evaluated in Study 5 (Chapter 5, Section 5.6) presents a body model from three distinct orientations; front, side and three-quarter views, thus providing greater body size and shape detail than when figures are shown from a single view. It also displays small incremental changes in fat mass and skeletal muscle mass across a wide community sample-based range for each body composition dimension.

7.3.2 Limitations

Although the novel body stimuli and scales developed in this thesis aimed to overcome many of the major limitations in existing perceptual body image measures, they still hold some methodological issues. The JND-based scales developed in Study 1 (Chapter 3, Section 3.4.3) consisted of CGI male body stimuli that were developed in Daz Studio 4.10 modelling software. Although CGI body models are more realistic and present more detailed body size and shape information than traditional hand-drawn figures (Gardner & Brown, 2010; Talbot et al., 2020), the use of Daz Studio to create these artificial models is somewhat problematic in terms of its ecological validity. The body size and shape variation presented in these scales was dependent on the specific, predetermined adiposity and body weight sliders selected for manipulation in the software. There is uncertainty around how these sliders have been calibrated and their true representativeness of male-specific body weight distribution. Although Daz Studio allows for size and shape alterations of distinct body parts, the JND-based scales only presented variation in the body as a whole. This is a common limitation across figure rating scales, as this methodological approach requires participants to select a figure from a discrete set of images (Gardner et al., 1998). Pragmatically, it would be challenging to display variation in different areas of the body within the same figure rating scale without presenting many images. This would be time-consuming and, as such, this approach would have limited use in certain contexts including clinical settings.

Although the JND-based scales were novel in their consideration of men’s visual body size judgements when determining the spacing between figures, they still focused on BMI as the primary dimension of variation across bodies. These scales did not present variation in muscularity, and therefore cannot be applied to investigate men’s current or ideal perceptions relating to muscle mass, or people’s muscularity preferences for their ideal male partner. This is an important limitation given that men’s appearance ideals tend to reflect not only a desire for leanness, but also for high levels of muscularity (Barlett et al., 2008; Brierley et al., 2016; Crossley et al., 2012; Dakanalis et al., 2015; Gardner & Brown, 2010; McCabe & Ricciardelli, 2004), and that muscular definition in the arms, chest and abdomen have been identified as central to men’s body ideals (Grogan & Richards, 2002; Ridgeway & Tylka, 2005).

Furthermore, these 9-figure and 13-figure scales did not represent a full range of BMI, and were somewhat restrictive in the underweight category, with a lower limit of 16.5 kg/m^2. Again, this was a limitation of the specific sliders used in Daz Studio to create the figures. These scales also restricted the presentation of figures to a single viewpoint, thus limiting the abundance of body size and shape information available to the user. Participants were only able to base their current and ideal body perceptions, as well as their discriminations of body size, on the visual cues available from a three-quarter orientation. Although the presentation of figures from a single viewpoint has been recognised as a limitation of figure ratings scales (Talbot et al., 2020), a three-quarter view has been identified as being optimal for differentiating male body size (Cornelissen et al., 2018) and the findings from Study 6 (Chapter 6, Section 6.4) indicate that increasing the number of viewpoints available to users may not result in more accurate body weight judgements.

The interactive 3D body scale developed in Study 3 (Chapter 4, Section 4.4.3) presented a body model that was independently calibrated for fat mass and skeletal muscle mass, based on a set of 3D male body scans and anthropometric measurements. There was an underrepresentation of underweight and obese male bodies in this database, as well as a limited number of individuals with very high or low levels of fat mass and skeletal muscle mass. Therefore, calibration of the predicted body model at the upper and lower limits of fat mass, muscle mass and BMI was based on fewer 3D body scans than in the centre of the distribution, thus limiting the accuracy of this scale in representing the general population at these extremes. The scale also presents a body model with an arbitrary texture and with the head, hands and feet missing. Although this has potential benefits for use in perceptual body image research, as described in Chapter 4 (Section 4.5.2), it gives the model an unrealistic, and potentially distracting, appearance. Furthermore, calibration of the predicted body model to measurements of fat mass and skeletal muscle mass makes the suitability of this scale difficult to compare directly to existing figure scales that tend to present variation in body fat percentage and FFMI (Cafri & Thompson, 2004; Pope Jr et al., 2000; Talbot, Smith, et al., 2019).

Given that the interactive fat and muscle scale was generated using PCA to predict 3D body shape from actual body composition measurements, this measure was limited by the inherent issues of PCA and practical difficulties of 3D body scanning. The initial processing of the 3D body scans filled in any missing segments, smoothed scattered fragments and removed noise from the data (Chapter 2, Section 2.2.2). The PCA then compressed the X, Y, and Z coordinates of each individual body scan to compute a mean vector and covariance matrix (Chapter 4, Section 4.4.3). The covariance matrix was used to define the significance of each principal component representing the main ways in which the 3D bodies varied in shape. Therefore, both the scan processing and use of PCA resulted in a general smoothing of 3D body shape that may have reduced the accuracy and ecological validity of the predicted body model. Differences in individual body pose and positioning, particularly in the arms, were also evident across the scans, as a consequence of the scanning process and specific 3D body scanner used. This introduced a lack of correspondence between scans in the dataset that is likely to have hindered the PCA output. Variability in body posture and arm positioning may have also resulted in differences in the availability of visual cues to BMI (Cornelissen, Hancock, et al., 2009; Tovée & Cornelissen, 2001) and adiposity (Cornelissen et al., 2018) when scans were used directly as stimuli in Study 6 (Chapter 6, Section 6.3.2.1). Therefore, this lack of standardisation across the male body scans resulted in a number of potential methodological limitations in the 2D visual body stimuli (Chapter 6, Section 6.3.2.1) and interactive fat and muscle scale (Chapter 4, Section 4.4.3) developed in this thesis.

There were also a couple of global methodological limitations to the studies reported in this thesis. Firstly, Study 2 (Chapter 3, Section 3.6) and Study 5 (Chapter 5, Section 5.6), evaluating the reliability, validity and suitability of the new measures, were limited by relatively small sample sizes. However, these pilot studies aimed to conduct an initial assessment of the use of these new measures in the general male population, in order to estimate potential effect sizes to calculate appropriate sample sizes required for more extensive, in-depth evaluations in future research. The sample sizes in these studies were acceptable when considering established rules of thumb for pilot surveys and correlational research (Hill, 1998). Data analysis for some of these studies was also concluded prematurely by the closing of university facilities and social distancing rules enforced as a result of the COVID-19 pandemic in March 2020. Additionally, the new stimuli and scales described in this thesis were developed with an emphasis on Caucasian men's body shape and anthropometric measurements. For example, the 3D body scans used to develop 2D stimuli in Study 6 (Chapter 6, Section 6.3.2.1). and the interactive fat and muscle scale developed in Study 3 (Chapter 4, Section 4.4.3) consisted solely of Caucasian male body shapes. Furthermore, the standard CGI body developed in Study 1 (Chapter 3, Section 3.3.2.1) was designed to match average measurements recorded in the HSE (2008) for Caucasian men of normal weight (Chapter 2, Section 2.1.1). Therefore, these measures only represent and account for Caucasian male patterns of weight distribution, body composition and variation in body shape (Abe et al., 2012; Misra & Khurana, 2011; Silva et al., 2010; Wells, Cole, et al., 2008; WHO Expert Consultation, 2004).

7.4 Implications and Future Work

The following section addresses the broader implications of the main research findings of this thesis and provides recommendations for future research in the field of male perceptual body image measurement.

7.4.1 Implications of Research Findings

The main findings from the empirical studies presented in this thesis provide further evidence of trends in visual body perceptions that have been established in previous research. For example, Study 1 (Chapter 3, Section 3.4) demonstrated that men's visual discriminations of body size in other male bodies were consistent with Weber's law, which has also been previously identified in women's visual judgements of female bodies (Cornelissen et al., 2016). Another common pattern of weight misperception was found in Study 6 (Chapter 6, Section 6.4), in which many of the underweight participants overestimated their own body weight, particularly among the females, and many of the overweight or obese participants underestimated their body weight, especially among the males. This trend in weight misperception in men's and women's self-estimations of body weight has been identified in previous research (Kuchler & Variyam, 2003; Robinson & Kersbergen, 2017). A similar pattern was also found in participants' categorisations of body weight in others, as the accuracy of weight status judgements was poorer for the underweight, overweight and obese male bodies shown than for the normal weight bodies, which also corroborates what has previously been observed (Oldham & Robinson, 2016, 2018; Robinson & Hogenkamp, 2015).

The inaccuracy of people's visual weight judgements may have implications in a healthcare context. If healthcare professionals are not able to accurately detect changes in a patient's weight, they may be less likely to provide appropriate information and/or interventions to support healthy weight management, and consequently, may not screen their patient for weight-related health concerns (Bramlage et al., 2004; Caccamese et al., 2002; Johnson et al., 2008; Perrin et al., 2005; Robinson et al., 2014; Yoong et al., 2014). Similarly, if individuals themselves are inaccurate in their self-perceptions of body weight, they may be less concerned with their weight, and therefore, less motivated or willing to engage in healthy weight-change behaviours or interventions (Wardle et al., 2006; Wetmore & Mokdad, 2012; Yost et al., 2010). Visual biases in judgements of body size also have implications for weight-change efforts in overweight or obese men, as Weber's law suggests they may need to lose more weight than men with a lower BMI for it to be visually detected. This finding should be considered within the management of obesity in healthcare settings and in interventions to support healthy weight-loss. A systematic review of exercise and weight-loss interventions has revealed that perceived appearance changes are more consistently associated with improvements in body image and self-esteem than actual physical changes in appearance (Ginis, Bassett-Gunter, & Conlin, 2012). Therefore, patients with obesity could be made aware of this visual bias at the start of weight-loss programs to alter their appearance goals and expectations. This may help them to feel more positively about small perceived reductions in weight and prevent them from losing motivation early on in their weight-loss efforts (Ginis, McEwan, et al., 2012).

Visual bias should also be considered within the design of figure scales and other visual measures, as was described in Chapter 3 (Section 3.1). The consideration of body size discriminations in the design of perceptual measures may be particularly important in the male population, given that the findings of Study 1 (Chapter 3, Section 3.4.2) demonstrated smaller JNDs across the stimuli BMI range than was found previously in females (Cornelissen et al., 2016). This suggests that male- and female-specific figure scales may require a different number of figures, as well different standard spacing between figures in the dimension of body variation, for an equivalent perceptual ability to distinguish between figures in the scale. In addition, the findings from the ordering task in Study 2 (Chapter 2, Section 3.8.3) indicated that use of the JND of BMI multiplied by at least a factor of 3 may be necessary when designing figure scales, to ensure that the differences in body size between the larger figures are visually detectable.

The optimal design of perceptual measures for assessing visual judgements of weight was also addressed in Study 6 (Chapter 6). The findings of this study suggested that the presentation of male bodies from a front and side-view may be more suitable for judgements of categorical weight status than from 8 distinct viewpoints at every 45° angle around the body. It seems instinctual that increasing the number of viewpoints and, therefore, the amount of visual body size and shape information available to users would result in more accurate judgements of weight. However, the findings from Study 6 (Chapter 6, Section 6.4) indicate that there may be a limit to the amount of information that is required or advantageous in facilitating body weight judgements of male bodies. This finding is in agreement with the work of De Coster and colleagues (2020), despite prior contradicting arguments for additional viewpoints in perceptual body image measures (Gardner & Brown, 2010). It may be the case that different viewpoints are beneficial for achieving accurate estimates of different perceptual components, such as an individual’s ideal body size self-estimates compared to their weight judgements of others' bodies. However, this would require further investigation to understand the degree of male body information necessary for these specific perceptual judgements.

Chapters 4 and 5 discussed the importance of a precise calibration of visual stimuli to measurements of adiposity and muscularity in both research and clinical settings. In Study 3 (Chapter 4, Section 4.4.3), the linear fat and skeletal muscle mass model performed significantly better at predicting 3D male body shape and size than the equivalent BMI model. This highlighted the need to use body composition rather than BMI to index variation in the size and shape of male bodies in future research. The findings of Study 3 (Chapter 4, Section 4.4.2) also demonstrated critical issues in using BMI as a proxy for fat mass in perceptual body image measures, through significant correlations between BMI, fat mass, and skeletal muscle mass, as well as differences in these relationships for individuals in different BMI categories. Study 5 (Chapter 5, Section 5.8.2.1) evidenced separate current and ideal body perceptions relating to adiposity and muscularity in men, which further highlights the importance of visually representing variation in these two dimensions of body composition. This is particularly critical for measures that are targeted at the male population, as men tend to demonstrate higher proportions of muscle mass and greater variation in their fat to muscle ratios than women (Abe et al., 2003; Fomon et al., 1982; de Bruin et al., 1996). Therefore, men are more likely to be misclassified when using BMI as an indicator of body size and health status, as they can have significant differences in their body composition and, consequently, their body size and shape (Mullie et al., 2008; Yajnik & Yudkin, 2004).

Whilst further research is needed, the novel measures developed and evaluated in this thesis have potential to advance clinical interventions relating to body image and weight in men. There is currently a gap in the healthcare provision for male eating disorder patients from a lack of understanding, minimisation or misdiagnosis of symptoms, and absence of male-tailored treatments (Thapliyal et al., 2020). These novel visual scales could be used to evaluate and monitor the presence and severity of male-specific body concerns, body dissatisfaction and distortion in patients, given that these play a key role in the development of eating disorders (Klimek et al., 2018). They could also be used in support of existing interventions to assess, manage, and treat a range of other body image and weight-related health issues in men, such as obesity and BDD (Beechy et al., 2012; Gledhill et al., 2017; Thompson, 1990). Simple visual tools have been used previously to aid conversations between parents and paediatricians relating to weight development in toddlers (Tommerup et al., 2020). Therefore, these scales could be used to support health professionals in their conversations with adult male patients about their body perceptions and concerns, variation in body shape associated with body weight, and realistic body shape changes relating to adiposity and muscularity. They may even have applications in supporting similar conversations within more commercial settings, such as in professional sports coaching and personal training in fitness centres. There are generally high levels of body dissatisfaction, body image distortion, eating pathology, and steroid use among men who engage in regular gymnasium use, bodybuilding, or professional sport (Blouin & Goldfield, 1995; Devrim et al., 2018; Goldfield et al., 1998; Stapleton et al., 2016). These visual tools could help to identify body dissatisfaction and distorted body image in these settings, as well as potentially help to address weight stigma, unhealthy weight-change behaviours, and promote weight considerations beyond BMI.

7.4.2 Recommendations for Future Work

From the pilot data obtained in Study 2 (Chapter 3, Section 3.8) and Study 5 (Chapter 5, Section 5.8), it is clear that future research with larger sample sizes is required to further evaluate the reliability, validity, and suitability of the new measures described in this thesis in assessing current and ideal body perceptions in community-based male samples. Based on the findings from Study 2 (Chapter 3, Section 3.8), it is important to determine whether the lack of convergent validity of the two figure scales with equally spaced bodies along the perceptual dimension was a methodological limitation or a result of the restricted sample size and range of BMIs in the sample. In addition, the test-retest reliability of the 13-figure scale for ideal body size estimations was poor in this pilot study. There is a need to identify whether this is an inherent problem with the scale or a result of poor statistical power, and to assess the test-retest reliability of these scales over a longer period of time. In consideration of the findings from Study 5 (Chapter 5, Section 5.8), there was also a lack of convergent validity of the interactive fat and muscle scale, specifically for the perceived muscle mass estimates, as well as poor test-retest reliability for men’s ideal fat mass estimates and all perceptual estimates relating to muscularity. Again, it is vital to determine whether these findings are a result of issues with the interactive scale or a lack of statistical power in this study. This may require not only larger sample sizes but also a greater number of trials for the current and ideal perceptual tasks when evaluating each of these scales.

If the findings from Study 2 (Chapter 3, Section 3.8) and Study 5 (Chapter 5, Section 5.8) were replicated in further evaluations, then modifications to these scales may be essential to improve their properties. For example, extending the upper and lower limits of the muscle mass dimension of the interactive scale would allow for perceptual estimations beyond the measurements obtained from the database of 3D scans in Study 3 (Chapter 4, Section 4.4.2).

Given that the male participants in Study 5 (Chapter 5, Section 5.8.2.1) used approximately the full range of skeletal muscle mass in the scale when selecting their current and ideal body perceptions, extension of this range may be critical to capture more extreme perceptions and ideals that may not reflect realistic male body shape (Barlett et al., 2008; Ridgeway & Tylka, 2005). The range of the body composition dimensions in this scale could be increased by adding to the original database of 3D body scans and body composition measurements to include individuals with more extreme levels of adiposity and muscularity. Another option would be to predict 3D body shape in the linear regression models described in Study 3 (Chapter 4, Section 4.4.3) beyond what was actually captured in the database. The latter would allow for extension of the range to any amount of fat mass or skeletal muscle mass of interest. However, the ecological validity of the predicted body shape at these extremes would be limited and could not be verified (Maalin et al., 2020). The interactive male body scale could also be modified to appear more realistic and present a full 3D body model without any missing body parts. Given that the predicted body shape from this scale can be exported as an object file, a more realistic standard texture could be applied to the body model using a variety of computer graphics software, such as Autodesk Maya (Autodesk, 2019), while still presenting a wide range of body shapes and sizes. This standard skin texture could be derived from the photographic images taken in a single 3D body scan, or specifically designed in a graphics software, and then mapped directly onto the object file. In addition, similar methods could be used to add a standard head, hands and feet to the body model to make it more representative of how bodies are seen in real life.

Once these novel measures have been further tested in general male samples, it would be beneficial to investigate their utility among other groups of interest, such as the female population and clinical male samples, to widen the scope of future research using these measures and their potential applications for clinical interventions. It would be of interest to evaluate opposite-sex appearance ideals and sociocultural judgements of health, attractiveness and personality traits using these scales, as has been assessed using existing measures (Brierley et al., 2016; Furnham et al., 2006; Greenleaf et al., 2004; Henss, 1995; Swami, Furnham, et al., 2008; Webb et al., 2004). In particular, the interactive fat and muscle scale could be used to evaluate the independent influences of muscularity and adiposity on these visual judgements and male body ideals. This may help to enhance our understanding of men’s experiences of weight stigma, appearance pressures, body dissatisfaction, and social perceptions of masculine identity.

Complementary versions of the new scales that are based on men from non-Caucasian ethnic background should be developed and validated in future research. The development of ethnicity-specific scales is important for visualising different patterns of body composition and shape development that are present among various groups (Misra & Khurana, 2011; Shiwaku et al., 2004; Vasudev et al., 2004; Wells, Cole, et al., 2008) and should enhance participants' identification with the figures presented (Gardner & Brown, 2010; Ralph-Nearman & Filik, 2018; Talbot, Smith, et al., 2019). For the JND-based scales developed in Study 1 (Chapter 3, Section 3.4.3), an alternative standard CGI body would need to be created using normative anthropometric measurements, such as hip circumference, waist circumference, height and BMI, that are representative of other ethnic groups (Holmqvist & Frisén, 2010; Ruff, 2002). To develop alternative versions of the interactive fat and muscle scale developed in Study 3 (Chapter 4, Section 4.4.3), additional databases of 3D male body scans and body composition measurements that are specific to other ethnic groups would be required, in order to predict and visualise 3D body shape change independently related to adiposity and muscularity in these non-Caucasian populations.

Chapters 3 and 4 described the importance of perceptual body image measures moving toward a visual representation of variation in body composition, rather than general body size or adiposity, indexed by BMI. With this in mind, some of the research studies presented in this thesis could be used as the basis of future work to improve how men's perceptions relating to adiposity and muscularity are assessed. For example, the method of constant stimuli used in Study 1 (Chapter 3, Section 3.7.3) could be applied to a set of CGI figures that vary in muscularity, rather than BMI, to identify the JND of muscle mass. This would require calibration of the CGI figures to measurements of muscle mass. This calibration is likely to be problematic when using figures created in Daz Studio, as the body morphs relating to muscularity in this software are not associated with actual measurements of muscle mass. However, the figures could potentially be calibrated based on the 3D male body shapes and associated measurements of skeletal muscle mass obtained in Study 3 (Chapter 4, Section 4.4.2). Perceptually-spaced figure scales could then be developed based on multiples of the JNDs across a wide range of muscle mass, that allow for an equivalent perceptual ability to distinguish between bodies in the scale. These scales could then be used to evaluate men's current and ideal body perceptions relating to muscularity. A similar method could also be applied using the interactive scale developed in Study 3 (Chapter 4, Section 4.4.3) to identify the JNDs of fat mass and skeletal muscle mass in this predicted body model. This would require taking screenshots of the predicted body shape at small increments of fat mass, while controlling for muscle mass, and vice versa. The resultant scales may allow for more specific and sensitive estimates of men’s current and ideal body perceptions than those derived from existing figure scales (Cornelissen et al., 2016).

Given that the innovative measures presented in this thesis are based on CGI and 3D body stimuli, it is possible for these images to be used in conjunction with virtual reality (VR) technologies to assess components of perceptual and attitudinal body image. Benefits of VR as a way of presenting 3D bodies include the high level of control and customisation that is possible through this form of technology (Riva et al., 2019). It is often referred to as an ‘embodied technology’ as it can induce a feeling of immersion and presence within a virtual setting, which may result in both emotional and perceptual experiences of a body from outside and within. Comparisons of perceptual body image estimates using VR-based figure scales to paper-based figure scales have presented mixed findings. For example, one study asked 31 female adolescents with AN to select the figure representing their perceived ideal and current body using both a paper-based figure scale and VR-based avatar scale (Fisher et al., 2019). No significant differences in the BMI of the selected current and ideal bodies were found between the two scales. Similarly, there were no statistically significant differences in body dissatisfaction, calculated as the difference in BMI between their perceived current and ideal body, when comparing the scales. Therefore, there is still some uncertainty surrounding the efficacy of using VR technologies over and above other methods of presenting bodies.

Future research could present the CGI figures of the JND-based scales (Chapter 3, Section 3.4.3), the predicted body model from the interactive scale (Chapter 4, Section 4.4.3), or the 3D scan stimuli (Chapter 6, Section 6.3.2.1), in a VR environment. It would be interesting to explore potential differences in the reliability and validity of the figure scales when bodies are presented as life-size, 3D objects that can be viewed from 360° at any specified distance from the user, rather than in a 2D format from restricted viewpoints. Study 6 (Chapter 6, Section 6.3.3) could be replicated with stimuli presented in VR to investigate differences in the accuracy of people’s weight perceptions and weight-loss beliefs when bodies are viewed in a manner that is closer to how they are seen in real life. Similarly, the method of constant stimuli used in Study 1 (Chapter 3, Section 3.3.3) could be simulated with pairs of CGI bodies presented in VR, to determine whether there are differences in men’s ability to visually discriminate between body sizes compared to when they are displayed in 2D on a computer screen.

7.5 Thesis Conclusion

The studies presented in this thesis have addressed many of the critical limitations in existing measures of perceptual body image in the male population. Several novel visual stimuli and scales have been developed that overcome these limitations through the presentation of high-quality imagery, a wide variation in body size and shape, precise calibration of stimuli to measurements of body composition, and consideration of visual discriminations of male body weight. The reliability, validity, and suitability of these innovative measures in assessing men’s current and ideal body perceptions have been evaluated among community-based male samples. This thesis has also provided important insights into individual and methodological factors that play a role in the accuracy of male body weight judgements and has given further evidence to support the visual representation of male body composition, rather than solely BMI, in perceptual body image measures. Limitations of this research have been highlighted, particularly relating to sample size, restrictions in the range and visual presentation of stimuli, calibration of stimuli at the extremes of body variation, and the practical implications of 3D body scanning. Future work has been proposed to address these limitations, including evaluations with larger sample sizes and more diverse groups, modifications to the range of body variation presented in the new measures, and the development of similar scales for use with non-Caucasian men. Ultimately, the innovative visual measures in this thesis have potential to advance the assessment, management and treatment of men’s body image- and weight-related health issues in general, commercial, and clinical settings.

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Appendix A: Questionnaires

Appendix A includes copies of all the psychometric questionnaires used in the studies presented in this thesis.

A.1 Anti-Fat Attitudes Questionnaire (AFA)

The AFA is scored using a Likert-type response format (0 = very strongly disagree; 9 = very strongly agree). Higher scores indicate stronger anti-fat attitudes.

Dislike

1. I really don't like fat people much.
2. I don't have many friends that are fat.
3. I tend to think that people who are overweight are a little untrustworthy.
4. Although some fat people are surely smart, in general, I think they tend not to be quite as bright as normal weight people.
5. I have a hard time taking fat people too seriously.
6. Fat people make me somewhat uncomfortable.
7. If I were an employer looking to hire, I might avoid hiring a fat person.

Fear of Fat

8. I feel disgusted with myself when I gain weight.
9. One of the worst things that could happen to me would be if I gained 25 pounds.
10. I worry about becoming fat.

Willpower

11. People who weigh too much could lose at least some part of their weight through a little exercise.
12. Some people are fat because they have no willpower.
13. Fat people tend to be fat pretty much through their own fault.

A.2 Beck Depression Inventory (BDI)

1.
0 I do not feel sad.
1 I feel sad
2 I am sad all the time and I can't snap out of it.
3 I am so sad and unhappy that I can't stand it.

2.
0 I am not particularly discouraged about the future.
1 I feel discouraged about the future.
2 I feel I have nothing to look forward to.
3 I feel the future is hopeless and that things cannot improve.

3.
0 I do not feel like a failure.
1 I feel I have failed more than the average person.
2 As I look back on my life, all I can see is a lot of failures.
3 I feel I am a complete failure as a person.

4.
0 I get as much satisfaction out of things as I used to.
1 I don't enjoy things the way I used to.
2 I don't get real satisfaction out of anything anymore.
3 I am dissatisfied or bored with everything.

5.
0 I don't feel particularly guilty
1 I feel guilty a good part of the time.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

6.
0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

7.
0 I don't feel disappointed in myself.
1 I am disappointed in myself.
2 I am disgusted with myself.
3 I hate myself.

8.
0 I don't feel I am any worse than anybody else.
1 I am critical of myself for my weaknesses or mistakes.
2 I blame myself all the time for my faults.
3 I blame myself for everything bad that happens.

9.
0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

10.
0 I don't cry any more than usual.
1 I cry more now than I used to.
2 I cry all the time now.
3 I used to be able to cry, but now I can't cry even though I want to.

11.
0 I am no more irritated by things than I ever was.
1 I am slightly more irritated now than usual.
2 I am quite annoyed or irritated a good deal of the time.
3 I feel irritated all the time.

12.
0 I have not lost interest in other people.
1 I am less interested in other people than I used to be.
2 I have lost most of my interest in other people.
3 I have lost all of my interest in other people.

13.
0 I make decisions about as well as I ever could.
1 I put off making decisions more than I used to.
2 I have greater difficulty in making decisions more than I used to.
3 I can't make decisions at all anymore.

14.
0 I don't feel that I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel there are permanent changes in my appearance that make me look unattractive
3 I believe that I look ugly.

15.
0 I can work about as well as before.
1 It takes an extra effort to get started at doing something.
2 I have to push myself very hard to do anything.
3 I can't do any work at all.

16.
0 I can sleep as well as usual.
1 I don't sleep as well as I used to.
2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
3 I wake up several hours earlier than I used to and cannot get back to sleep.

17.
0 I don't get more tired than usual.
1 I get tired more easily than I used to.
2 I get tired from doing almost anything.
3 I am too tired to do anything.

18.
0 My appetite is no worse than usual.
1 My appetite is not as good as it used to be.
2 My appetite is much worse now.
3 I have no appetite at all anymore.

19.
0 I haven't lost much weight, if any, lately.
1 I have lost more than five pounds.
2 I have lost more than ten pounds.
3 I have lost more than fifteen pounds.

20.
0 I am no more worried about my health than usual.
1 I am worried about physical problems like aches, pains, upset stomach, or constipation.
2 I am very worried about physical problems and it's hard to think of much else.
3 I am so worried about my physical problems that I cannot think of anything else.

21.
0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I have almost no interest in sex.
3 I have lost interest in sex completely.

A.3 Body Appreciation Scale – 2 (BAS-2)

For each item, the following response scale should be used: 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Always.

Directions for participants: Please indicate whether the question is true about you never, seldom, sometimes, often, or always.

1. I respect my body.
2. I feel good about my body.
3. I feel that my body has at least some good qualities.
4. I take a positive attitude towards my body.
5. I am attentive to my body's needs.
6. I feel love for my body.
7. I appreciate the different and unique characteristics of my body.
8. My behavior reveals my positive attitude toward my body; for example, I hold my head high and smile.
9. I am comfortable in my body.
10. I feel like I am beautiful even if I am different from media images of attractive people (e.g., models, actresses/actors).

A.4 Body Shape Questionnaire-16b (BSQ-16b)

We should like to know how you have been feeling about your appearance over the **PAST FOUR WEEKS**. Please read each question and circle the appropriate number to the right. Please answer <u>all</u> the questions.

OVER THE PAST <u>FOUR WEEKS:</u>	Never	Rarely	Sometimes	Often	Very often	Always
1. Have you been so worried about your shape that you have been feeling you ought to diet?	1	2	3	4	5	6
2. Have you been afraid that you might become fat (or fatter)?	1	2	3	4	5	6
3. Has feeling full (e.g. after eating a large meal) made you feel fat?	1	2	3	4	5	6
4. Have you noticed the shape of other women and felt that your own shape compared unfavourably?	1	2	3	4	5	6
5. Has thinking about your shape interfered with your ability to concentrate (e.g. while watching television, reading, listening to conversations)?	1	2	3	4	5	6
6. Has being naked, such as when taking a bath, made you feel fat?	1	2	3	4	5	6
7. Have you imagined cutting off fleshy areas of your body?	1	2	3	4	5	6
8. Have you not gone out to social occasions (e.g. parties) because you have felt bad about your shape?	1	2	3	4	5	6
9. Have you felt excessively large and rounded?	1	2	3	4	5	6
10. Have you thought that you are in the shape you are because you lack self-control?	1	2	3	4	5	6
11. Have you worried about other people seeing rolls of fat around your waist or stomach?	1	2	3	4	5	6
12. When in company have your worried about taking up too much room (e.g. sitting on a sofa, or a bus seat)?	1	2	3	4	5	6
13. Has seeing your reflection (e.g. in a mirror or shop window) made you feel bad about your shape?	1	2	3	4	5	6
14. Have you pinched areas of your body to see how much fat there is?	1	2	3	4	5	6
15. Have you avoided situations where people could see your body (e.g. communal changing rooms or swimming baths)?	1	2	3	4	5	6
16. Have you been particularly self-conscious about your shape when in the company of other people?	1	2	3	4	5	6

A.5 Drive for Muscularity Scale (DMS)

1	2	3	4	5	6
Always	Very Often	Often	Sometimes	Rarely	Never

1. I wish that I were more muscular.
2. I lift weights to build up muscle.
3. I use protein or energy supplements.
4. I drink weight gain or protein shakes.
5. I try to consume as many calories as I can in a day.
6. I feel guilty if I miss a weight training session.
7. I think I would feel more confident if I had more muscle mass.
8. Other people think I work out with weights too often.
9. I think that I would look better if I gained 10 pounds in bulk.
10. I think about taking anabolic steroids.
11. I think that I would feel stronger if I gained a little more muscle mass.
12. I think that my weight training schedule interferes with other aspects of my life.
13. I think that my arms are not muscular enough.
14. I think that my chest is not muscular enough.
15. I think that my legs are not muscular enough.

A.6 Eating Disorder Examination-Questionnaire (EDE-Q)

Instructions: The following questions are concerned with the past four weeks (28 days) only.

ON HOW MANY OF THE PAST 28 DAYS ...

0	1	2	3	4	5	6
No Days	1-5 Days	6-12 Days	13-15 Days	16-22 Days	23-27 Days	Every Day

1. Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?
2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?
3. Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?
4. Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?
5. Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?
6. Have you had a definite desire to have a totally flat stomach?
7. Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?
8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?
9. Have you had a definite fear of losing control over eating?
10. Have you had a definite fear that you might gain weight?
11. Have you felt fat?
12. Have you had a strong desire to lose weight?
13. Over the past 28 days, how many times have you eaten what other people would regards as an unusually large amount of food (given the circumstances)?
14. … On how many of these times did you have a sense of having lost control over your eating (at the time you were eating)?
15. Over the past 28 days, on how many DAYS have such episodes of overeating occurred (i.e. you have eaten an unusually large amount of food and have had a sense of loss of control at the time)?
16. Over the past 28 days, how many times have you made yourself sick (vomit) as a means of controlling your shape or weight?
17. Over the past 28 days, how many times have you taken laxatives as a means of controlling your shape or weight?
18. Over the past 28 days, how many times have you exercised in a “driven” or “compulsive” way as a means of controlling your weight, shape or amount of fat, or to burn off calories?
19. Over the past 28 days, on how many days have you eaten in secret (ie, furtively)? … Do not count episodes of binge eating
20. On what proportion of the times that you have eaten have you felt guilty (felt that you’ve done wrong) because of its effect on your shape or weight? … Do not count episodes of binge eating.

21. Over the past 28 days, how concerned have you been about other people seeing you eat? … Do not count episodes of binge eating.
22. Has your weight influenced how you think about (judge) yourself as a person?
23. Has your shape influenced how you think about (judge) yourself as a person?
24. How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?
25. How dissatisfied have you been with your weight?
26. How dissatisfied have you been with your shape?
27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?
28. How uncomfortable have you felt about others seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?

What is your weight at present? (Please give your best estimate.): …………………………
What is your height? (Please give your best estimate.): …………………………………….

A.7 Male Body Attitudes Scale (MBAS)

		Never	Rarely	Some times	Often	Usually	Always
1	I think I have too little muscle on my body						
2	I think that my body should be leaner						
3	I wish that my arms were stronger						
4	I feel satisfied with the definition in my abs (stomach muscles)						
5	I think that my legs are <u>not</u> muscular enough						
6	I think my chest should be broader						
7	I think my shoulders are too narrow						
8	I am concerned that my stomach is too flabby						
9	I think that my arms should be more muscular						
10	I feel dissatisfied with my overall body build						
11	I think that my calves should be more muscular						
12	I wish I were taller						
13	I think I have too much fat on my body						
14	I think that my abs are not thin enough						
15	I think my back should be larger and more defined						
16	I think my chest should be larger and more defined						
17	I feel satisfied with the definition in my arms						
18	I feel satisfied with the size and shape of my body						

19	I am satisfied with my height						
20	Has eating sweets, cakes, or other high calorie foods made you feel fat or weak?						
21	Have you felt excessively large and rounded (fat)?						
22	Have you felt ashamed of your body size or shape?						
23	Has seeing your reflection (e.g., in a mirror) made you feel bad about your size or shape?						
24	Have you been feeling so worried about your body size or shape that you have been feeling that you ought to diet?						

A.8 Modified Weight Bias Internalisation Scale (WBIS-M)

1 = Strongly disagree
2 = Disagree
3 = Somewhat disagree
4 = Neither agree nor disagree
5 = Somewhat agree
6 = Agree
7 = Strongly agree

1. Because of my weight, I feel that I am just as competent as anyone.
2. I am less attractive than most other people because of my weight.
3. I feel anxious about my weight because of what people might think of me.
4. I wish I could drastically change my weight.
5. Whenever I think a lot about my weight, I feel depressed.
6. I hate myself for my weight.
7. My weight is a major way that I judge my value as a person.
8. I don't feel that I deserve to have a really fulfilling social life, because of my weight.
9. I am OK being the weight that I am.
10. Because of my weight, I don't feel like my true self.
11. Because of my weight, I don't understand how anyone attractive would want to date me.

A.9 Rosenberg Self-Esteem Scale (RSE)

Please record the appropriate answer for each item, depending on whether you Strongly agree, agree, disagree, or strongly disagree with it.

1 = Strongly agree
2 = Agree
3 = Disagree
4 = Strongly disagree

1. On the whole, I am satisfied with myself.
2. At times I think I am no good at all.
3. I feel that I have a number of good qualities.
4. I am able to do things as well as most other people.
5. I feel I do not have much to be proud of.
6. I certainly feel useless at times.
7. I feel that I'm a person of worth.
8. I wish I could have more respect for myself.
9. All in all, I am inclined to think that I am a failure.
10. I take a positive attitude toward myself.

A.10 Sociocultural Attitudes Toward Appearance Questionnaire – 4 (SATAQ-4)

Directions: Please read each of the following items carefully and indicate the number that best reflects your agreement with the statement.

Definitely Disagree = 1
Mostly Disagree = 2
Neither Agree Nor Disagree = 3
Mostly Agree = 4
Definitely Agree = 5

1. It is important for me to look athletic.
2. I think a lot about looking muscular.
3. I want my body to look very thin.
4. I want my body to look like it has little fat.
5. I think a lot about looking thin.
6. I spend a lot of time doing things to look more athletic.
7. I think a lot about looking athletic.
8. I want my body to look very lean.
9. I think a lot about having very little body fat.
10. I spend a lot of time doing things to look more muscular.

Answer the following questions with relevance to your FAMILY (include parents, brothers, sisters, relatives):

11. I feel pressure from family members to look thinner.
12. I feel pressure from family members to improve my appearance.
13. Family members encourage me to decrease my level of body fat.
14. Family members encourage me to get in better shape.

Answer the following questions with relevance to your PEERS (include close friends, classmates, and other social contacts):

15. My peers encourage me to get thinner.
16. I feel pressure from my peers to improve my appearance.
17. I feel pressure from my peers to look in better shape.
18. I get pressure from my peers to decrease my level of body fat.

Answer the following questions with relevance to the MEDIA (include television, magazines, the internet, movies, billboards, and advertisements):

19. I feel pressure from the media to look in better shape.
20. I feel pressure from the media to look thinner.
21. I feel pressure from the media to improve my appearance.
22. I feel pressure from the media to decrease my level of body fat.

Appendix B: Research Documentation

Appendix B includes the information sheets, consent forms, and debrief forms presented to participants in Studies 1-6 of this thesis.

B.1 Study 1: Information Sheet

Visual Perception of Body Size and Weight.

Thank you for your interest in this study. You are being asked to take part in this study because you are a male or female aged between 18 and 45 years old with no current diagnosis or history of an eating disorder. Before you decide to participate, it is important that you know what the study will involve. Please take the time to read the following information, before deciding if you wish to participate.

What is the purpose of the study?
The main aim of this research is to identify the smallest change in BMI that participants can detect (the just noticeable difference; JND) in computer generated, same-sex bodies. The findings from this study will be used to generate and validate body scales for use in future body image and body size perception research.

Who is organizing the research?
The research is being organised by the Psychology School of the University of Lincoln.

Is my taking part confidential?
Yes. All data collected and recorded will be kept confidential and you will be assigned a participant ID to ensure your data remains anonymous.

Do I have to take part?
No. You do not, participation is voluntary.
Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed. No identifiable details will be forwarded to the researchers and your anonymity to the researcher will remain intact.

What will I have to do?
Thank you for considering taking part in our study. During the session, we will first take some personal details (age, sex, and ethnicity) and your body measurements (body composition using a bio impedance scale, standing height, and waist, hip, chest and bicep circumference using a tape measure). Next, you will be asked to complete some questionnaires regarding body image, eating habits, self-esteem and depression. Then you will be asked to complete a computerised two-alternative choice task, where you will be

shown a pair of bodies on a screen and asked to respond using a button press which of the pair is a larger body. The whole procedure should take up to 90 minutes to complete.

Your participation is completely voluntary and you have the right to withdraw from participation at any time throughout the process, without prejudice and without having to give any reason. All the information you give will be stored in secure files to which only the research team will have access. It will later be collated into data that does not reveal the particulars of any individual taking part in the research, but produces an overall picture of the results. The anonymous statistical data generated may be shared or published both within and outside of a university context.
Do you have any questions? If not, are you happy to continue?

Are there any risks in taking part?
There are no significant risks in taking part.

Are there any benefits in taking part?
There are no direct benefits for taking part in this study but we hope that understanding the research will help understand body image perception.

What will happen to the results of the study?
They will be analysed and written up for publication.

What if there is a problem?
If you do find anything about the research upsetting or stressful you can discontinue at any point or discontinue for any other reason. You do not have to give a reason or an explanation for stopping.

Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed. No identifiable details will be forwarded to the researchers and your anonymity to the researcher will remain intact.

If you have any concerns about this study or what you have been asked to, then please contact the School of Psychology Research Ethics Committee on SOPREC@lincoln.ac.uk

What if I have other questions or queries?
If you have any other questions or queries about the study then please feel free to ask the researchers (sMohamed@lincoln.ac.uk or nMaalin@lincoln.ac.uk) or their supervisor (mtovee@lincoln.ac.uk)

If you find anything about the research upsetting, please seek additional support:

- University of Lincoln Student Wellbeing Centre:
    - Studentwellbeing@lincoln.ac.uk
    - 01522 886400
    - Drop in Mon-Fri 12-2pm and Thursday 5-7pm

- BEAT (for support relating to disordered eating and body image):
    - https://www.beateatingdisorders.org.uk/
    - Adult Helpline: 0808 801 0677
    - Studentline: 0808 801 0811
    - Youthline: 0808 801 0711
    - Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays.

- Mind helpline
    - https://www.mind.org.uk/
    - 0300 123 3393
    - Text: 86463
    - Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

https://ethics.sites.lincoln.ac.uk/research-privacy-notice/

B.2 Study 1: Consent Form

Visual Perception of Body Size and Weight

UNIVERSITY OF
LINCOLN

Informed Consent
If you are happy to take part, please initial the following boxes and sign below.

V1. 11.10.2018

- I confirm that I am aged 18 or over and that I have read and understand the information above pertaining to this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
- I understand that my participation is voluntary and I understand that I can withdraw my data at any point up until two weeks after completing the study ☐
- I understand that data will be kept confidential and securely and will be anonymised throughout. ☐
- I understand if I have any questions or concerns, that I can contact the researcher supervisor using the contact details given. ☐
- I understand that if I want to withdraw or view my data at a later date, I am responsible for providing my participant ID number, given to me by the researcher. ☐
- I am aware that my data may be shared with research collaborators at another university for data processing purposes. The data will be stored and shared in compliance with the General Data Protection Regulation (GDPR). ☐

By proceeding with participation I am confirming that I wish to take part in this study and confirm that I agree to all the above statements.

Printed name: ………………………………………………………………..

Signature…………………………………………….............................

Date ……………………………………………………………………….

B.3 Study 1: Debrief Form

Visual perception of body size and weight - Part 1.

Thank you for participating in this study.

What is the aim of this study?
Obesity levels in Western countries are on the rise, and a contributing factor to this may be people's inability to accurately recognise changes in weight. What we determine to be to be an acceptable body weight or size is influenced by a range of factors, including our culture, social values, the media and the types of bodies we have been exposed to in our life. The aim of this study is to identify the smallest change in BMI that people can detect using computer-generated stimuli, this is known as the Just Noticeable Difference (JND). These results will then be used to inform the development of male and female body scales to assess individual's current and ideal body perceptions.

What happens with the information you provide?
All data is encoded in a confidential manner and is only used for research purpose. Any information that you have given that may give away your identity will not be used in any published material. Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed.

Your participant ID number is ____________________________________.

If you find anything about the research upsetting, please seek additional support.

- University of Lincoln Student Wellbeing Centre:
    - Studentwellbeing@lincoln.ac.uk
    - 01522 886400
    - Drop in Mon-Fri 12-2pm and Thursday 5-7pm

- BEAT (for support relating to disordered eating and body image):
    - https://www.beateatingdisorders.org.uk/
    - Adult Helpline: 0808 801 0677
    - Studentline: 0808 801 0811
    - Youthline: 0808 801 0711
    - Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays.

- Mind helpline
    - https://www.mind.org.uk/
    - 0300 123 3393

B.4 Study 2: Information Sheet

Participant Information Sheet.
(Final Version 6.0: 14/10/2019).
Title of study: Visual Perception of Body Size and Weight - Part 2.

Names of researchers: Nadia Maalin and Sophie Mohamed.
Supervisor: Martin Tovée.

We'd like to invite you to take part in our research study. You are being asked to take part in this study because you are a male or female (cis/as assigned at birth), aged between 18 and 45 years old with no current diagnosis or history of an eating disorder. Before you decide to participate, it is important that you know what the study will involve. Please take the time to read the following information, before deciding if you wish to participate.

What is the purpose of the study?
The main aim of this research is to validate body scales using photo-realistic, computer generated bodies for use in future body image and body size perception research.

Who is organizing the research?
The research is being organised by researchers in the School of Psychology at the University of Lincoln. You will be given a copy of the ID code.

Is my taking part confidential?
Yes. All data collected and recorded will be kept confidential and you will be assigned a unique participant ID to ensure your data remains anonymous.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. This would not affect your legal rights.

What will I have to do?
Thank you for considering taking part in our study. During the first session, we will take some personal details (age, sex (cis/as assigned at birth), ethnicity and history/current diagnosis of an eating disorder) and your body measurements (body composition using a bio-impedance scale, standing height, and waist, hip, chest and bicep circumference using a tape measure). You will be shown a series of same-sex bodies and you will be asked to select which body you think best represents your current body size and which body is most like your ideal body size. You will be asked to make these selections four times, twice with cards and twice on a computer screen using an interactive tool. You will also be asked to order the bodies on the cards in size from smallest to largest. Lastly, you will be asked to complete some questionnaires about body image, eating habits and mood on Qualtrics. We'd suggest this should take around 35 minutes.

In the second session, two to three days later, you will be asked to complete the same body size selection tasks that you completed in the first session. We'd suggest this should take about 15 minutes.

What will happen if I don’t want to carry on with the study?
Your participation is voluntary and you are free to withdraw at any time up until data analysis has begun, without giving any reason, and without your legal rights being affected. If you withdraw from the study, we may keep the data collected that we have already obtained in accordance with our Research Participant Privacy Notice. To safeguard your rights, we will delete all personal details/use the minimum personally identifiable information possible.
To withdraw please inform the researcher or their supervisor (contact details are given at the end). Please quote your unique participant ID code and the title of the study.

Where will my data be stored?
The data obtained from the study will be stored securely on the university OneDrive in a password protected file. Only the researcher/researchers will have access to it. The data from this study may be put in an Open Access repository. If so, any personal data (e.g. contact details) will be removed.

Privacy notice
The University of Lincoln is the lead organisation for this study and will be the data controller for this study. This means that we are responsible for looking after your information and using it properly. The university’s Research Participant Privacy Notice https://ethics.lincoln.ac.uk/research- privacy-notice/ will explain how we will be using information from you in order to undertake this study.

Are there any risks in taking part?
There are no significant risks in taking part, but please note that pacemakers (or any other electrical implants) are unsafe to use on the bio-impedance scale, please let the researcher know and an alternative scale will be used.

Are there any benefits in taking part?
There are no direct benefits for taking part in this study but we hope that understanding the research will help understand body image perception.

What will happen to the results of the study?
They will be analysed, included in the researchers’ theses and written up for publication. Data will be treated confidentially and any publication resulting from this study will report only data that does not identify individual participants (unless you have agreed to be identified). Anonymised responses, however, may be shared with other researchers or made available in online data repositories.

What if there is a problem?
If you do find anything about the research upsetting or stressful you can discontinue at any point or discontinue for any other reason. You do not have to give a reason or an explanation for stopping. You can speak to the researchers who will do their best to answer your questions. The researchers contact details are given at the end of this information sheet. If you have any concerns about this study or what you have been asked to and wish to complain formally, you can do this by contacting ethics@lincoln.ac.uk.

What if I have other questions or queries?
If you have any other questions or queries about the study then please feel free to ask the researchers (sMohamed@lincoln.ac.uk or nMaalin@lincoln.ac.uk) or their supervisor (mtovee@lincoln.ac.uk).

If you find anything about the research upsetting, please seek additional support:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- https://www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811
- Youthline: 0808 801 0711
- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

Mind helpline
- https://www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive
- https://thebodypositive.org

B.5 Study 2: Consent Form

Visual Perception of Body Size and Weight

Informed Consent
If you are happy to take part, please initial the following boxes and sign below.

- I confirm that I am aged 18 or over and that I have read and understand the information above pertaining to this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
- I understand that my participation is voluntary and I understand that I can withdraw my data at any point up until data analysis has begun. ☐
- I understand that data will be kept confidential and securely and will be anonymised throughout. ☐
- I understand if I have any questions or concerns, that I can contact the researcher supervisor using the contact details given. ☐
- I understand that if I want to withdraw or view my data at a later date, I am responsible for providing my participant ID number, given to me by the researcher. ☐
- I am aware that my data may be shared with research collaborators at another university for data processing purposes. The data will be stored and shared in compliance with the General Data Protection Regulation (GDPR). ☐

By proceeding with participation I am confirming that I wish to take part in this study and confirm that I agree to all the above statements.

Printed name: ....

Signature...

Date ....

B.6 Study 2: Debrief Form

Participant Debrief Sheet.
(Final Version 6.0: 14/19/2019).

Title of study: Visual perception of body size and weight - Part 2.

Name of researchers: Nadia Maalin and Sophie Mohamed.
Supervisor: Martin Tovée.

Thank you for participating in this study. This research will provide crucial information and broaden our understanding of body size perception.

What was the aim of this study?
The aim of this study was to validate new male and female body scales created using computer generated images, developed from the results of a previous study, to assess individual's current and ideal body perceptions. To validate the scales, we asked you to order the bodies in BMI to ensure that the bodies were perceptually distinguishable in size. We also asked you to select your perceived current and ideal body size. To assess the test-retest reliability of the scales, we asked you to complete the same tasks at a second session a few days later.

Questions and withdrawing
If you have any further questions about the study, please feel free to ask the researcher/s before you finish or alternatively contact the researcher/s or their supervisor at any time (contact details can be found at the end of the debrief form). You can withdraw anytime up until data analysis has begun. Please quote your participant ID number and the title of the study.

Your participant ID number is ____________________________________.

Further help and support
If you have any ethical concerns regarding the current research, your treatment as a participant or your involvement in the study please feel free to contact ethics@lincoln.ac.uk. If you have been affected by any of the issues raised by taking part in this study the following organisations may be able to provide help and advice:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811
- Youthline: 0808 801 0711
- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays.

Mind helpline

- www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive

- www.thebodypositive.org

Contact details of the researchers:
Researchers - smohamed@lincoln.ac.uk and nmaalin@lincoln.ac.uk
Supervisor - mtovee@lincoln.ac.uk

B.7 Study 3: Information Sheet

Understanding Body Image Distortion

We would like to invite you to take part in a research study to create a new way of assessing body image perception in men and women. Before you decide to participate, it is important that you know what the study will involve. Please take the time to read the following information, before deciding if you wish to participate.

What is the purpose of the study?

Body image matters to all of us. Influenced by bio-social factors as diverse as genetics, the mass media, family and peers, and even children's toys, the internalisation of negative body 'ideals' can be detrimental to health for both men and women. Perceptual body image distortion (BID) is often characterised by altered self-perceptions and has been assessed in the past using a variety of scales. However, body shape measurement scales are severely limited by poor imagery. Body shape derives from a complex interaction between three attributes: adiposity, muscle mass and muscle tone. Therefore, there is a need to develop biometrically accurate, ecologically valid images with which to measure estimates of body size and shape. To do this, we will combine 3D body shape scanning technology with state of the art body composition measurements (bio-impedance) to generate the required high quality, CGI stimuli. Using these images, we will shed new light on the perceptual, psychological and social dimensions of body image, in health and disease.

Who is organizing the research?

The research is being organised by the University of Lincoln.

Is my taking part confidential?

Yes. All data collected and recorded will be kept confidential and you will be assigned a participant ID to ensure your data remains anonymous.

Do I have to take part?

No. You do not, participation is voluntary.

Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed. No identifiable details will be forwarded to the researchers and your anonymity to the researcher will remain intact

What will I have to do?

You will be scanned in a 3D scanner in the School of Psychology (Sarah Swift Building), which creates a 3D representation of that person and a measure of their body size and shape. For your scan, we ask men to wear shorts and women to wear shorts and a crop-top. You will then stand on a bio-impedance plate which will take a measure of your body fat and muscle content. You will also be asked to take body measurements including waist, hip, chest and bicep using a tape measure.

Are there any risks in taking part?

There are no significant risks in taking part.

Please note that if you have a pacemaker/electrical implant, photosensitive epilepsy or are prone to migraines it is not safe for you to take part.

If you do find anything about the research upsetting or stressful you can discontinue at any point or you can discontinue for any other reason. You do not have to give a reason or an explanation for stopping.

If you find anything about the research upsetting please seek additional support from the University of Lincoln Student Wellbeing Centre:

- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

Are there any benefits in taking part?

There are no direct benefits for taking part in this study but we hope that the research will help our understanding of the interaction between body composition and body shape and size.

What will happen to the results of the study?

Taking 3D scans and body composition measures from a large population of volunteers means that we can model how people's size and shape changes when their body composition changes. We will be able to create photorealistic, biometrically accurate, calibrated 3D avatars for use in body image research and treatment. We will be able to 'dial up' the body shape, for example, of a 36-year-old 1.83m tall male, who has 19% body fat, 72kg of lean muscle mass, and a BMI 27.5.

What if there is a problem?

If you do find anything about the research upsetting or stressful you can discontinue at any point or discontinue for any other reason. You do not have to give a reason or an explanation for stopping.

Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed. No identifiable details will be forwarded to the researchers and your anonymity to the researcher will remain intact.

If you have any concerns about this study or what you have been asked to, then please contact the School of Psychology Research Ethics Committee on SOPREC@lincoln.ac.uk

This topic may be of a sensitive nature to some participants. If you find anything about the research upsetting please seek additional support from the University of Lincoln Student Wellbeing Centre:

- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

B.8 Study 3: Consent Form

Understanding Body Image Distortion

Informed Consent
If you are happy to take part, please initial the following boxes and sign below.

- I confirm that I am aged 18 or over and that I have read and understand the information above pertaining to this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
- I understand that my participation is voluntary and I understand that I can withdraw my data at any point up until two weeks after completing the study ☐
- I understand that data will be kept confidential and securely and will be anonymised throughout. ☐
- I understand if I have any questions or concerns, that I can contact the researcher supervisor using the contact details given. ☐
- I understand that if I want to withdraw or view my data at a later date, I am responsible for providing my participant ID number, given to me by the researcher. ☐
- I am aware that my data may be shared with research collaborators at another university for data processing purposes. The data will be stored and shared in compliance with the General Data Protection Regulation (GDPR). ☐

By proceeding with participation I am confirming that I wish to take part in this study and confirm that I agree to all the above statements.

Name: …………………………………………………………..

Signature……………………………………………..................

Date ………………………………………………………………

B.9 Study 3: Photo Permission Form

Understanding Body Image Distortion

Photo permission form

We are collecting 3D body scans to create a large database of different body shapes and sizes. The data collected from this study will be used to generate photorealistic, biometrically valid, calibrated 3D avatars. The avatars will be covered using a computer generated 'skin'. *However*, for future body, face and person perception research it would be beneficial to use avatars that maintain a photo-realistic texture and individual differences. 3D bodies and faces are increasingly being used as opposed to the traditional 2D photographs that have been previously used. This data will provide us with 3D avatars of bodies and heads that will inform future face, body and person perception research.

If you give permission on this consent sheet your 3D body scan with photographic identity may be used in future body, face and person perception research.

There are a few points we would like to emphasise to you at this time:

- You do not have to agree to your face/body *with* photographic identity being used
- You can request that your images be destroyed by contacting soprec@lincoln.ac.uk and giving the title of the study "Understanding Body Image Distortion"
- All images are anonymous; your name or identifying information will never be attached
- Any scientific publications that arise from our lab make no reference to individuals in ways that could compromise the anonymity of those taking part in our research.

Please indicate below in which ways you consent for us to use your face photographs by **initialling** the boxes below

	Yes, I consent	No, I do not consent
I consent for my 3D body scan taken for this project to be shown to participants in **studies run by Ms Nadia Maalin, Ms Sophie Mohamed, Prof Martin Tovee (University of Lincoln).**		
I consent for my 3D body scan to be shown to participants in **other laboratory studies** (i.e. follow-up research) run by Ms Nadia Maalin, Ms Sophie Mohamed, and Prof Martin Tovee.		
I consent for my 3D body scan to be used in **web-based** studies run Ms Nadia Maalin, Ms Sophie Mohamed, and Prof Martin Tovee.		
I consent for **the body section only** of my 3D scan (i.e. not the head) to be shown to participants in other studies run by Ms Nadia Maalin, Ms Sophie Mohamed, and Prof Martin Tovee.		
I consent for **the head section only** of my 3D scan to be shown to participants in other laboratory studies run by Ms Nadia Maalin, Ms Sophie Mohamed, and Prof Martin Tovee.		
I consent for my 3D body scan to be used to **illustrate research** (e.g. in scientific journals, or scientific presentations)		

Printed name ………………..………… Signature ……………………

Date … ………………………………….

B.10 Study 3: Debrief Form

Understanding Body Image Distortion

Thank you for participating in this study.

What is the aim of this study?

Body image matters to all of us. Influenced by bio-social factors as diverse as genetics, the mass media, family and peers, and even children's toys, the internalisation of negative body 'ideals' can be detrimental to health for both men and women. Perceptual body image distortion (BID) is often characterised by altered self-perceptions and has been assessed in the past using a variety of scales. However, body shape measurement scales are severely limited by poor imagery. Body shape derives from a complex interaction between three attributes: adiposity, muscle mass and muscle tone. Therefore, there is a need to develop biometrically accurate, ecologically valid images with which to measure estimates of body size and shape. To do this, we will combine 3D body shape scanning technology with state of the art body composition measurements (bio-impedance) to generate the required high quality, CGI stimuli. Using these images, we will shed new light on the perceptual, psychological and social dimensions of body image, in health and disease.

What happens with the information you provide?

All data is encoded in a confidential manner and is only used for research purpose. Any information that you have given that may give away your identity will not be used in any published material. Should you change your mind about participating in the study later, you have two weeks in which to withdraw your data. If you decide that you wish to have your data withdrawn please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with your participant ID code and the name of the study. SOPREC will then arrange with the researcher for your data to be removed

Your participant ID number is ____.

If you find anything about the research upsetting please seek additional support from the University of Lincoln Student Wellbeing Centre:

- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

If you have any concerns about the ethics of this study or you wish to complain about the study or how you have been treated, then please contact the School of Psychology ethics committee on soprec@lincoln.ac.uk with details of your complaint and it will be investigated

If you have any further questions about the study, please feel free to ask the researchers before you finish or alternatively contact the researchers (smohamed@lincoln.ac.uk or nmaalin@lincoln.ac.uk) or their supervisor (mtovee@lincoln.ac.uk).

THANK YOU AGAIN FOR YOUR TIME

B.11 Study 4: Information Sheet

Participant Information Sheet/Information about the research
(Draft version 02 / Final version 1.0: 05/11/2019)

Title of Study: Validation of a new interactive 3D tool –
Ratings of fat and muscle mass in 3D heads and bodies

Name of Researcher(s): Sophie Mohamed and Nadia Maalin
Contact details of the researcher(s) are given at the end of this Participant Information Sheet.

We'd like to invite you to take part in our research study. Joining the study is entirely up to you. Before you decide, we would like you to understand why the research is being done and what it would involve for you. Please take the time to read the following information before deciding if you wish to take part. This study will take approximately 30 minutes in total and should be completed in one session. Please feel free to talk to others about the study if you wish.

What is the purpose of the study?
The main aim of this study is to test the reliability and validity of new interactive 3D male and female head and body scales for use in perceptual research. Most scales in body image research are based on body mass index (BMI) and do not consider body compositional factors such as fat and muscle. Furthermore, current scales that do consider fat and muscle tend not to show realistic changes in body size and shape or have not been validated properly. Therefore, this research will help us to validate new head and body scales that can be used to understand how body composition affects size and shape judgements in both heads and bodies. This study will be conducted online using a Qualtrics survey.

Why have I been invited?
You are being invited to take part because you are a male or female (cis-gender/as assigned at birth) aged between 18 and 45 years old. This means that your gender identity matches the sex you were assigned at birth (male/female). Due to the nature of this research, you cannot take part if you have a current or previous diagnosis of an eating or body image disorder. We are inviting 50 male and 50 female participants like you to take part.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part, you will be asked to sign a consent form on the next page of this Qualtrics survey. If you decide to take part, you are still free to withdraw at any time and without giving a reason. This would not affect your legal rights.

What will happen to me if I take part?
If you decide to take part, you will first be asked to provide demographic information including your sex (cis/as assigned at birth), sexual orientation, age, ethnicity and whether you have a current or previous diagnosis of an eating or body image disorder. You will then be asked to rate same-sex and opposite-sex images of either heads or bodies on their level of fat and muscle mass using a 7-point rating scale.

This task will be completed via an online Qualtrics survey. Please ensure that you are completing this survey on a laptop or a computer screen, not on a tablet or a mobile phone. This will consist of one session and you will not be asked to complete any follow up sessions for this particular study. This will take approximately 30 minutes in total.

Expenses and payments

You will not be paid to participate in the study.

What are the possible disadvantages and risks of taking part?

There are no significant risks in taking part. This research has been approved by the University of Lincoln research ethics committee. If you are uncomfortable at any time, you can discontinue at any point with no explanation for stopping. You can also contact any of the researchers directly using the contact information provided.

What are the possible benefits of taking part?

There are no direct benefits for taking part in this study, however this research will help to validate new ecologically valid male and female head and body scales for use in perception research and clinical settings. Therefore, this will indirectly benefit the participants through potential improvements in public health.

Will my taking part in the study be kept confidential?

We will follow ethical and legal practice and all information about you will be handled in confidence.

Privacy notice

The University of Lincoln is the lead organisation for this study and will be the data controller for this study. This means that we are responsible for looking after your information and using it properly. The university's Research Participant Privacy Notice https://ethics.lincoln.ac.uk/research-privacy-notice/ will explain how we will be using information from you in order to undertake this study.

What will happen if I don't want to carry on with the study?

Your participation is voluntary and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected. As your participation is anonymous it will not be possible to withdraw your data once submitted, as we have no way of identifying you.

Where will my data be stored?

The data obtained from the study will be stored securely on the university OneDrive in a password protected file and/or an encrypted hard-drive that has been bought via the university, following the necessary guidelines. Only the researchers and their supervisor will have access to it.

What will happen to the results of the research study?

The results of this study will be analysed and written up for inclusion in our PhD theses and for publication. Data will be treated confidentially and any publication resulting from this study will report only data that does not identify individual participants. Participants' anonymised responses, however, may be shared with other researchers or made available in online data repositories.

Who is organising and funding the research?
This research is being organised by the University of Lincoln.

Who has reviewed the study?
All research conducted by the University of Lincoln is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests.

What if there is a problem?
If you have a concern about any aspect of this study, you should ask to speak to the researchers, who will do their best to answer your questions. The researchers' contact details are given at the end of this information sheet. If you remain unhappy and wish to complain formally, you can do this by contacting ethics@lincoln.ac.uk.

If you feel that we have let you down in relation to your information rights then please contact the Information Compliance team by email on compliance@lincoln.ac.uk or by post at Information Compliance, Secretariat, University of Lincoln, Brayford Pool, Lincoln, LN6 7TS.

You can also make complaints directly to the Information Commissioner's Office (ICO). The ICO is the independent authority upholding information rights for the UK. Their website is ico.org.uk and their telephone helpline number is 0303 123 1113.

Further information and contact details
University contact details of the research team:
Sophie Mohamed: sMohamed@lincoln.ac.uk
Nadia Maalin: nMaalin@lincoln.ac.uk

University contact details of the supervisor:
Martin Tovée: mTovee@lincoln.ac.uk

If you find anything about the research upsetting, please seek additional support:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- https://www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811
- Youthline: 0808 801 0711
- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

Mind helpline
- https://www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive
    - https://thebodypositive.org

B.12 Study 4: Consent Form

Project ID: 2019-0908

CONSENT TO PARTICIPATE IN RESEARCH

Title of Project: Validation of a new interactive 3D tool – Ratings of fat and muscle mass in 3D heads and bodies

Name of Researchers: Nadia Maalin and Sophie Mohamed

1. I confirm that I have read the information sheet dated 05/11/2019 (version 001) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. I understand that should I withdraw then the information collected so far may not be erased and that this information may still be used in the project analysis. ☐

3. I understand that individuals may look at research data collected during the study, from the University of Lincoln, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records; I understand that my personal details shall be kept confidential. ☐

4. I understand that the information collected about me will be used to support other research in the future and may be shared anonymously with other researchers. ☐

5. I agree to take part in the above study. ☐

B.13 Study 4: Debrief Form

Participant Debrief Sheet

(Draft Version 02 / Final version 1.0: 05/11/2019)
Title of Study: Validation of a new interactive 3D tool – Ratings of fat and muscle mass in 3D heads and bodies

Name of Researcher(s): Nadia Maalin and Sophie Mohamed
Contact details of the researcher(s) are given at the end of this Participant Debrief Sheet.

We'd like to thank you for taking part in our research study. This research will help us to validate new head and body scales that can be used in perceptual body image research to improve our understanding of how body composition affects size and shape judgements of heads and bodies.

What was the aim of the study?
The main aim of this study is to test the reliability and validity of new interactive 3D male and female head and body scales for use in perceptual research. Most scales in perception research are based on body mass index (BMI) and do not consider body compositional factors such as fat and muscle. Furthermore, current scales that do consider fat and muscle tend not to show realistic changes in body size and shape or have not been validated properly. Therefore, this research will help us to validate new head and body scales that can be used to understand how body composition affects size and shape judgements in both heads and bodies.

Questions and withdrawing
If you have any further questions about the study, please feel free to ask the researchers before you finish or alternatively contact the researchers or their supervisor Martin Tovée at any time on mTovee@lincoln.ac.uk.

If you have submitted your data anonymously then it will not be possible to withdraw your data, as we will be unable to identify your responses.

Further help and support
If you have any ethical concerns regarding the current research, your treatment as a participant or your involvement in the study please feel free to contact ethics@lincoln.ac.uk.
If you have been affected by any of the issues raised by taking part in this study the following organisations may be able to provide help and advice:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- https://www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811
- Youthline: 0808 801 0711

- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

Mind helpline

- https://www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive

- https://thebodypositive.org

Contact Details of Researcher(s)
Nadia Maalin: nMaalin@lincoln.ac.uk
Sophie Mohamed: sMohamed@lincoln.ac.uk

B.14 Study 5: Information Sheet

Participant Information Sheet/Information about the research
(Draft version 03 / Final version 1.0: 06/03/2020)

UNIVERSITY OF
LINCOLN

Title of Study: Validation of a new interactive 3D tool – Assessing perceptions of bodies using an interactive 3D tool.

Name of Researcher(s): Nadia Maalin and Sophie Mohamed
Contact details of the researcher(s) are given at the end of this Participant Information Sheet.

We'd like to invite you to take part in our research study. Joining the study is entirely up to you. Before you decide, we would like you to understand why the research is being done and what it would involve for you. Please take the time to read the following information before deciding if you wish to take part. This study will consist of two sessions taking approximately 40 minutes in total (Session one – 30 minutes and Session two – 10 minutes). Please feel free to talk to others about the study if you wish.

What is the purpose of the study?
The main aim of this study is to test the reliability and validity of new interactive 3D male and female body scales for use in perceptual research. Most scales in body image research are based on body mass index (BMI) and do not consider body compositional factors such as fat and muscle. Furthermore, current scales that do consider fat and muscle tend not to show realistic changes in body size and shape or have not been validated properly. Therefore, this research will help us to validate new body scales that can be used to understand how body composition affects body size and shape judgements. This study will take place at the University of Lincoln in the Sarah Swift building.

Why have I been invited?
You are being invited to take part because you are a male or female (cis-gender/as assigned at birth) aged between 18 and 45 years old. This means that your gender identity matches the sex you were assigned at birth (male/female). Due to the nature of this research, you cannot take part if you have a current or previous diagnosis of an eating or body image disorder. You also cannot take part if you have a pacemaker or any other electrical implanted device due to the electrical activity from the bioimpedance scale. We are inviting 40 male and 40 female participants like you to take part.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason. This would not affect your legal rights.

What will happen to me if I take part?
If you decide to take part, you will be asked to take part in two sessions which will take place two – three days apart.

In the first session, you will be asked to create your perceived current, ideal and ideal partner body using two sliders that alter the size and shape, using an interactive 3D tool. Each creation will be made twice. You will be asked to provide some demographic information including your sex (cis/as assigned at birth), sexual orientation, age, ethnicity and whether you have a current or previous diagnosis of an eating or body image disorder and complete some questionnaires about your eating habits, body image and psychological well-being using an online Qualtrics survey. Finally, body measurements will be taken using a bio-impedance scale, a stadiometer (height) and a tape measure (chest, waist, low hip and relaxed arm circumferences).

In the second session, you will be asked to create your perceived current, ideal and ideal partner body estimations following the same procedure as in session one.
This study will take approximately 40 minutes in total. Session one will take around 30 minutes and session two will take around 10 minutes.

Expenses and payments
You will not be paid to participate in the study.

What are the possible disadvantages and risks of taking part?
There are no significant risks in taking part. This research has been approved by the University of Lincoln research ethics committee. If you are uncomfortable at any time, you can discontinue at any point with no explanation for stopping. You can also contact any of the researchers directly using the contact information provided.

What are the possible benefits of taking part?
There are no direct benefits for taking part in this study, however this research will help to validate new ecologically valid male and female body scales for use in perception research and clinical settings. Therefore, this will indirectly benefit the participants through potential improvements in public health.

Will my taking part in the study be kept confidential?
We will follow ethical and legal practice and all information about you will be handled in confidence.

Privacy notice
The University of Lincoln is the lead organisation for this study and will be the data controller for this study. This means that we are responsible for looking after your information and using it properly. The university's Research Participant Privacy Notice https://ethics.lincoln.ac.uk/research-privacy-notice/ will explain how we will be using information from you in order to undertake this study.

What will happen if I don't want to carry on with the study?
Your participation is voluntary and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected. If you withdraw from the study, we may keep the data collected that we have already obtained in accordance with our Research Participant Privacy Notice. To safeguard your rights, we will delete all personal details/use the minimum personally identifiable information possible.

Where will my data be stored?

The data obtained from the study will be stored securely on the university OneDrive in a password protected file and/or an encrypted hard-drive that has been bought via the university, following the necessary guidelines. Only the researchers and their supervisor will have access to it.

What will happen to the results of the research study?

The results of this study will be analysed and written up for inclusion in our PhD theses and for publication. Data will be treated confidentially and any publication resulting from this study will report only data that does not identify individual participants. Participants' anonymised responses, however, may be shared with other researchers or made available in online data repositories.

Who is organising and funding the research?

This research is being organised by the University of Lincoln.

Who has reviewed the study?

All research conducted by the University of Lincoln is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests.

What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the researchers, who will do their best to answer your questions. The researchers' contact details are given at the end of this information sheet. If you remain unhappy and wish to complain formally, you can do this by contacting ethics@lincoln.ac.uk.

If you feel that we have let you down in relation to your information rights then please contact the Information Compliance team by email on compliance@lincoln.ac.uk or by post at Information Compliance, Secretariat, University of Lincoln, Brayford Pool, Lincoln, LN6 7TS.

You can also make complaints directly to the Information Commissioner's Office (ICO). The ICO is the independent authority upholding information rights for the UK. Their website is ico.org.uk and their telephone helpline number is 0303 123 1113.

Further information and contact details

University contact details of the research team:
Sophie Mohamed: sMohamed@lincoln.ac.uk
Nadia Maalin: nMaalin@lincoln.ac.uk

University contact details of the supervisor:
Robin Kramer: rKramer@lincoln.ac.uk

If you find anything about the research upsetting, please seek additional support:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- https://www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811
- Youthline: 0808 801 0711
- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

Mind helpline
- https://www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive
- https://thebodypositive.org

B.15 Study 5: Consent Form

Project ID: 0908

Participant Identification Number for this study:

CONSENT TO PARTICIPATE IN RESEARCH

Title of Project: Validation of a new interactive 3D tool – Assessing perceptions of bodies using an interactive 3D tool.

Name of Researcher: Nadia Maalin and Sophie Mohamed

Name of Participant:

Please initial box

1. I confirm that I have read the information sheet dated 06/03/2020 (version 002) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. I understand that should I withdraw then the information collected so far may not be erased and that this information may still be used in the project analysis. ☐
3. I understand that individuals may look at research data collected during the study, from the University of Lincoln, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records; I understand that my personal details shall be kept confidential. ☐
4. I understand that the information collected about me will be used to support other research in the future, and may be shared anonymously with other researchers. ☐
5. I agree to take part in the above study. ☐

______________________	____________________	____________________
Name of Participant	Date	Signature
______________________	____________________	____________________
Name of Person taking consent	Date	Signature

B.16 Study 5: Debrief Form

Participant Debrief Sheet

(Draft Version 02 / Final version 1.0: 05/11/2019)
Title of Study: Validation of a new interactive 3D tool –
Assessing perceptions of heads and bodies using an interactive 3D tool.

Name of Researcher(s): Nadia Maalin and Sophie Mohamed
Contact details of the researcher(s) are given at the end of this Participant Debrief Sheet.

We'd like to thank you for taking part in our research study. This research will help us to test the reliability and validity of new interactive 3D male and female head and body scales for use in perceptual research.

What was the aim of the study?
Most scales in body image research are based on body mass index (BMI) and do not consider body compositional factors such as fat and muscle. Furthermore, current scales that do consider fat and muscle tend not to show realistic changes in body size and shapeor have not been validated properly. Therefore, the aim of this study is to validate new head and body scales that can be used to understand how body composition affects size and shape judgements in both heads and bodies.

Questions and withdrawing
If you have any further questions about the study, please feel free to ask the researchers before you finish or alternatively contact the researcher or their supervisor Martin Tovée at any time on mTovee@lincoln.ac.uk.
If you wish to withdraw your data please also contact the researchers on the details provided below.

Your participant ID number is ______________________________.

Further help and support
If you have any ethical concerns regarding the current research, your treatment as a participant or your involvement in the study please feel free to contact ethics@lincoln.ac.uk.
If you have been affected by any of the issues raised by taking part in this study the following organisations may be able to provide help and advice:

University of Lincoln Student Wellbeing Centre:
- Studentwellbeing@lincoln.ac.uk
- 01522 886400
- Drop in Mon-Fri 12-2pm and Thursday 5-7pm

BEAT (for support relating to disordered eating and body image):
- https://www.beateatingdisorders.org.uk/
- Adult Helpline: 0808 801 0677
- Studentline: 0808 801 0811

- Youthline: 0808 801 0711
- Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

Mind helpline

- https://www.mind.org.uk/
- 0300 123 3393
- Text: 86463
- Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

The Body Positive

- https://thebodypositive.org

Contact Details of Researcher(s)

Nadia Maalin: nMaalin@lincoln.ac.uk
Sophie Mohamed: sMohamed@lincoln.ac.uk

B.17 Study 6: Information Sheet

Participant Information Sheet/Information about the research
(Draft Version 3/Final version 1.0: 27/08/19)

Title of Study: Categorical perceptions of body weight in 2D images.

Name of Researchers: Nadia Maalin and Sophie Mohamed (contact details of the researchers are given at the end).

We'd like to invite you to take part in our research study. Joining the study is entirely up to you, before you decide we would like you to understand why the research is being done and what it would involve for you. Please read through this information sheet to help you decide whether or not you would like to take part. If you have any questions, please email the researchers using the contact details given at the end. We'd suggest this study should take about 40 minutes. Please feel free to talk to others about the study if you wish.

What is the purpose of the study?
This research will be looking at body size and weight perception in adult bodies. The purpose of this study is to investigate categorical perceptions of body weight according to body mass index (BMI) labels. This will help us to gain a better understanding of how accurate adults are at categorising the weight of both same-sex and other-sex bodies. This study will be completed on Qualtrics.

Why have I been invited?
You are being invited to take part because you are a male or female (sex as assigned at birth/cis) aged between 18 and 45 years old and English is your first language. Due to the nature of the study, you cannot take part if you do not currently live in the UK and you have a current or previous diagnosis of an eating disorder. We are inviting approximately 150 male and 150 female participants to take part.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part, you will be asked to sign a consent form on the next page of this link. If you decide to take part, you are still free to withdraw at any time and without giving a reason. This would not affect your legal/employment rights.

What will happen to me if I take part?
If you decide to take part, you will be asked to complete a body size perception task. In this task you will be presented with photographs of male and female adult bodies at different body sizes. You will be asked to categorise these bodes into BMI labels (underweight, normal weight, overweight or obese). You will also be asked whether you think this person should consider losing weight on a 5-point scale. This will be completed twice using photographs presented at 2 angles and from 8 angles. You will also be asked to provide some demographic details (sex, age, ethnicity, income and highest level of education), complete some questionnaires about body image, mood, eating habits and weight bias and provide some details about your own body size/weight. All these tasks will be completed via an online Qualtrics questionnaire. Please ensure that you are completing this Qualtrics survey on a laptop or

computer screen. This will consist of one session and you will not be asked to complete any follow up sessions for this particular study. This will take up to 40 minutes to complete.

Expenses and payments
You will not be paid to participate in the study unless you are completing this questionnaire via Prolific.

What are the possible disadvantages and risks of taking part?
There are no significant risks in taking part. This research has been approved by the University of Lincoln research ethics committee. If you are uncomfortable at any time, you can discontinue at any point with no explanation for stopping. You can also contact any of the researchers directly using the contact information provided.

What are the possible benefits of taking part?
There are no direct benefits of taking part in this study, however, this research will provide crucial information and broaden our understanding of people's perceptions of body weight and the accuracy of these judgements, according to categorisations of BMI.

Will my taking part in the study be kept confidential?
We will follow ethical and legal practice and all information about you will be handled in confidence. All participants' data will be associated with an individual participant ID to ensure that data remains anonymous.

Privacy notice

The University of Lincoln is the lead organisation for this study. The university's Research Participant Privacy notice https://ethics.lincoln.ac.uk/research-privacy-notice/ will explain how we will be using information from you in order to undertake this study and will be the data controller for this study. This means that we are responsible for looking after your information and using it properly.

We will keep identifiable information about you for up to 3 months after the study has finished.

What will happen if I don't want to carry on with the study?
Your participation is voluntary and you are free to withdraw up until data analysis begins, without giving any reason, and without your legal rights being affected. If you withdraw from the study, any data and information obtained will be deleted. To safeguard your rights, we will use the minimum personally-identifiable information possible.

What will happen to the results of the research study?
The results from this study will be analysed and written up for inclusion in our PhD theses and for publication. You will not be identified in any report or publication.

Who is organising and funding the research?
This research is being organised by the University of Lincoln.

Who has reviewed the study?
All research conducted by the University of Lincoln is looked as by an independent group of people, called a Research Ethics committee, to protect your interests.

What if there is a problem?

If you have a concern about any aspect of this study, you should contact the researchers who will do their best to answer your questions. The researchers contact details are given at the end of this information sheet. If you remain unhappy and wish to complain formally, you can do this by contacting ethics@lincoln.ac.uk.

If you feel that we have let you down in relation to your information rights then please contact the Information Compliance team by email on compliance@lincoln.ac.uk or by post at Information Compliance, Secretariat, University of Lincoln, Brayford Pool, Lincoln, LN6 7TS.

You can also make complaints directly to the Information Commissioner's Office (ICO). The ICO is the independent authority upholding information rights for the UK. Their website is ico.org.uk and their telephone helpline number is 0303 123 1113.

Further information and contact details

If you have any further questions about the study, please feel free to ask the researchers Sophie Mohamed (sMohamed@lincoln.ac.uk) and Nadia Maalin (nMaalin@lincoln.ac.uk) or their supervisor Martin Tovee (MTovee@lincoln.ac.uk) at any time.

If you find anything about the research upsetting, please seek additional support:

- University of Lincoln Student Wellbeing Centre:
    - Studentwellbeing@lincoln.ac.uk
    - 01522 886400
    - Drop in Mon-Fri 12-2pm and Thursday 5-7pm

- BEAT (for support relating to disordered eating and body image):
    - https://www.beateatingdisorders.org.uk/
    - Adult Helpline: 0808 801 0677
    - Studentline: 0808 801 0811
    - Youthline: 0808 801 0711
    - Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays

- Mind helpline
    - https://www.mind.org.uk/
    - 0300 123 3393
    - Text: 86463
    - Lines are open 9am to 6pm, Monday to Friday (except for bank holidays)

- The Body Positive
    - https://thebodypositive.org

B.18 Study 6: Consent Form

Project ID: 709

Participant Identification Number for this study:

CONSENT FORM

UNIVERSITY OF LINCOLN

Title of Project: Categorical perceptions of body weight in 2D images.

Name of Researchers: Nadia Maalin and Sophie Mohamed

Name of Participant:

Please initial box

1. I confirm that I have read the information sheet dated 24/06/2019 (version 1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. I understand that should I withdraw then the information collected so far may not be erased and that this information may still be used in the project analysis. ☐
3. I understand that relevant sections of data collected during the study, may be looked at by individuals from the University of Lincoln, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records, I understand that my personal details will be kept confidential. ☐
4. (If appropriate) I understand that the information collected about me will be used to support other research in the future, and may be shared anonymously with other researchers. OPTIONAL ☐
5. I would like to receive a summary of the results of the study Yes ☐ No ☐
6. I agree to take part in the above study. ☐

____________________	____________________	____________________
Name of Participant	Date	Signature
____________________	____________________	____________________
Name of Person taking consent	Date	Signature

B.19 Study 6: Debrief Form

Participant Debrief Sheet
(Draft Version 02 / Final version 1.0: 18/07/2019)

Title of Study: Categorical perceptions of body weight in 2D images.
Name of Researcher(s): Sophie Mohamed, Nadia Maalin.
Contact Details of the Researcher(s) are given at the end.

UNIVERSITY OF LINCOLN

We'd like to thank you for taking part in our research study. This research will provide crucial information and broaden our understanding of people's perceptions of body weight and the accuracy of these judgements, according to categorisations of body mass index (BMI).

What was the aim of the study?

People in Western society are becoming more regularly exposed to larger body sizes, due to increasing rates of overweight and obesity. Visual normalisation theory argues that this change in what people see daily is causing a shift in body sizes judgements. The aim of this study was to understand and compare the view-dependent accuracy of visual body weight judgements of male and female bodies in two-dimensions (2D), as well as to investigate how people's judgements relate to the accuracy of their own body weight perceptions.

Questions and withdrawing

If you have any further questions about the study, please feel free to ask the researcher before you finish or alternatively contact the researchers Sophie Mohamed (sMohamed@lincoln.ac.uk) and Nadia Maalin (nMaalin@lincoln.ac.uk) or their supervisor Martin Tovée (MTovee@lincoln.ac.uk) at any time. If you wish to withdraw your data please also contact the researchers or supervisor with your unique participant number. In cases where your participation was anonymous please contact ethics@lincoln.ac.uk with your unique participant number. Please note you will only be able to withdraw up until the point of data analysis.

Your unique participant number is ______________________________________

Further help and support

If you have any ethical concerns regarding the current research, your treatment as a participant or your involvement in the study please feel free to contact ethics@lincoln.ac.uk. If you have been affected by any of the issues raised by taking part in this study the following organisations may be able to provide help and advice:

- University of Lincoln Student Wellbeing Centre:
  - Studentwellbeing@lincoln.ac.uk
  - 01522 886400
  - Drop in Mon-Fri 12-2pm and Thursday 5-7pm
- BEAT (for support relating to disordered eating and body image):
  - https://www.beateatingdisorders.org.uk/
  - Adult Helpline: 0808 801 0677
  - Studentline: 0808 801 0811

  - Helplines are available 365 days a year from 12- 8 pm during the week, and 4 – 8pm on weekends and bank holidays.
- Mind helpline
  - https://www.mind.org.uk/
  - 0300 123 3393
- The Body Positive
  - https://thebodypositive.org