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Research report

The relationship between fat mass, eating behaviour and obesity-related psychological traits in overweight and obese individuals ☆

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ABSTRACT

Behavioural and psychological factors related to eating have been associated with obesity, although their relationship to anthropometric measures, more specifically fat mass, has not been fully examined. This study examined the relationship between fat mass ($n = 98$; 75M, 23 F) and behavioural measures of eating and obesity related psychological traits ($n = 337$; 226M, 111 F) in overweight and obese individuals (Mean BMI 30.5 ± 4.0; BMI range 25–46 kg/m^2). Two sets of principal component analyses (PCA) were performed: one on validated questionnaires of eating behaviour and psychological traits and a second on fat mass and body weight related anthropometric measures (BMI, weight) and the aforementioned questionnaire measures. From the initial PCA ($n = 337$), the primary principal component, P1 (R^2 value of 0.33), represented a latent variable associated with overeating or binge eating behaviour. In a second PCA (questionnaire measures augmented by anthropometric variables, $n = 98$), a single component was identified, P1$^+$ (R^2 of 0.28), similar to that identified as P1 in the previous analysis and this component was highly correlated with fat mass ($\rho = 0.68$). These findings suggest that levels of body fat and eating behaviour (namely, binging or overeating) are strongly related and, at least in a subgroup of individuals, obesity may be driven by behavioural factors associated with eating in combination with pre-existing environmental and genetic factors.

Introduction

Obesity is one of the most prevalent disorders in western society and represents a major public health problem. Obesity is often described as an "epidemic" that is increasing in prevalence and is currently estimated to affect up to 33% of the United States adult population (Ogden, Yanovski, Carroll, & Flegal, 2007). In combined numbers from 10 European countries, 16% of men and 18% of women are obese (Meisenere, 2008) while in the United Kingdom 61% of the population can now be classified as overweight or obese (UK Obesity Statistics, 2010). It is generally accepted that overconsumption of food, specifically highly processed, heavily marketed, strongly obesogenic foods, is a major cause of current obesity levels (Kessler, 2009). Despite this abundant availability of obesogenic foods and aggressive marketing by the food industry, not all people become obese; some remain lean, suggesting that certain individuals are susceptible to weight gain and others are resistant (Blundell & Cooling, 2005; Hetherington, 2007). It has been proposed that there are biological differences between these groups of individuals and that lean people manage to stay this way through mechanisms that are influenced by heritable differences in neurobehavioural traits influencing eating behaviour such as hunger, satiety, response to food cues and hedonic effects of food (O'Rahilly & Farooqi, 2008). In addition, psychological traits commonly associated with obesity such as reward sensitivity and impulsivity are thought to play a role (Davis, 2009). The current epidemic of obesity has also highlighted the importance of body composition in understanding the metabolic consequences of energy imbalance. Excessive fat mass is considered to play a critical role in the metabolic dysregulation that leads to diseases such as type 2 diabetes mellitus, dyslipidemia and hypertension (Chuang et al., 2012; Napolitano et al., 2008). However, alterations in muscle mass may also contribute due to its role in glycaemic regulation through insulin-stimulated glucose disposal (Napolitano et al.,

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Conflict of interest: All authors are employees of GlaxoSmithKline and are involved in the development of anti-obesity drugs that alter eating behaviour.

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2008). In order to improve treatment regimens and optimise drug development to combat this rising tide of obesity, the identification of significant predictors of susceptibility to gain weight and the resistance to lose weight is of vital importance. The study of the relationship between body composition, particularly fat mass, neurobehavioural and psychological traits may provide the answers.

Previous work has identified relationships between anthropometric measures (i.e. body weight, body mass index (BMI)) and eating behaviour/psychological traits (Davis, 2009; Davis & Fox, 2008; Dykes, Brunner, Martikainen, & Wardle, 2004; Hays et al., 2002). Within this research, studies that have examined the relationship between behavioural factors and obesity suggest that binge eating or over eating behaviour, either in combination with or independent of, a susceptibility to periodic disinhibition of control over eating (disinhibition), are key components of obesity in a subgroup of individuals (Bryant, King, & Blundell, 2008; de Zwaan, 2001; de Zwaan & Mitchell, 1992; Stunkard, Grace, & Wolff, 1955). A review of studies in obese patients suggests that a high frequency of binge eating occurs in 23–46% of those patients seeking treatment for weight reduction (Yanovski, 2003); two-thirds of obese binge eaters report the onset of binge eating prior to obesity (Wilson, Nonas, & Rosenblum, 1993) and there is a significant association between binge eating and extreme obesity (BMI >40 kg/m^2) (de Zwaan, 2001). Amongst psychological traits, it has been suggested that high impulsivity and reward responsiveness play a prominent role in the development and maintenance of obesity (Davis, 2009). Besides the aforementioned studies, a significant body of research has attempted to delineate the psychological correlates of excess weight (for review see Friedman & Brownell, 1995; McGuire, Jeffery, & French, 2002). These studies identified several psychological consequences of obesity that can occur in some individuals and their relationship to eating behaviour (i.e. binge eating) but the relationship between eating related behavioural measures or psychological traits commonly associated with obesity and anthropometric measures, namely fat mass, have not yet been fully characterised.

However, an outstanding issue with this body of research lies in the fact that individuals can have a wide range of body composition types for similar body weights and body mass indices. Also, body mass and BMI though being simple, accurate, and precise measures, cannot elucidate changes in the discrete components of body composition. As such, these parameters are poor indicators of the amount of fuel-burning tissue (muscle) and fuel storing tissue (fat) (Heymsfield, Scherzer, Pietrobelli, Lewis, & Grunfeld, 2009; Okorodudu et al., 2010) and their relationship with eating behaviour traits may not be as robust as more sensitive measures of body composition i.e. fat mass. Utilising increasingly sensitive imaging measures and the appropriate eating behaviour measures may provide more accurate predictors of susceptibility to gain weight and to resistance to losing weight. In order to explore this hypothesis further, our behavioural and anthropometric data were analysed using principal component analysis (PCA). PCA is a dimensionality-reduction method for related multivariate analysis and can be useful to study multiple correlated phenotypes (He et al., 2008). PCA was selected as a methodology ahead of factor analysis because firstly it does not rely on normally distributed variables to be valid, and secondly does not require a (somewhat subjective) choice of rotation method. These analyses were carried out in two stages:

1. PCA to explore the degree of association and commonality purely within the behavioural questionnaires (n = 337).
2. PCA including both anthropometric and behavioural measures to identify common components, and learn which behavioural measures are most strongly correlated with these common components (n = 98).

This two-step procedure was applied with the intention of gaining the maximal understanding of the underlying relationships between the questionnaires from the full data set, before applying this knowledge to the data set including fat mass and other anthropometric measures. To capture the behavioural and psychological data we used questionnaires that represent some of the most frequently used and well validated instruments in the obesity/eating behaviour literature and these questionnaires are outlined in more detail in the methods section. In addition, we utilised a novel methodology to measure fat mass, that is, a recently developed instrument that uses the differences in the nuclear magnetic resonance properties of hydrogen atoms in organic and non-organic environments to fractionate signals originating from fat, lean tissue and free water (Taicher, Tinsley, Reiderman, & Heiman, 2003). This quantitative magnetic resonance (QMR) instrument, Echo-MRI, (Echo Medical Systems, LLC, Houston, TX) offers unrivalled precision in the measurement of body composition in animals, and has up to triple the precision for measuring body composition changes in humans compared to other regularly used methods (Napolitano et al., 2008). Accordingly, in an attempt to delineate the relationship between fat mass and behavioural measures of eating and psychological traits commonly associated with obesity, to possibly provide novel approaches for the treatment of obesity, this study examined the relationship between these variables in a cohort of overweight to obese individuals.

Methods

Participants

Three hundred and thirty-seven otherwise healthy, overweight and obese participants (226 males, 111 females) aged between 18 and 71 years (mean age = 41.6 ± 10.3 years) were recruited for this study. All participants had a body mass index (BMI) of greater than or equal to 25 kg/m^2 (mean = 30.5 ± 4.0; range 25–46 kg/m^2). Participants were recruited from the general population of the Cambridge, UK area through local newspaper and radio advertisements and were considered for inclusion if they had no personal or family history of psychiatric disorders, had no history of substance abuse, had no history of head injury or neurological disorders based on screening investigations, physical examination and a semi-structured clinical interview by a medical physician. All participants gave written informed consent for participation in the study, which was approved by the Local ethics committee.

Procedure

This study involved only medical and behavioural screening, which consisted of a single study visit for screening and enrolment onto the Clinical Unit Cambridge (CUC) volunteer panel. The study was conducted at GlaxoSmithKline, CUC, Addenbrookes Centre for Clinical Investigation, Cambridge, UK. Participants arrived at the unit and exclusion criteria were assessed during a semi-structured interview with a physician and they then underwent basic medical screening (ECG, Vital Signs, medical history and safety bloods), anthropometric measurement (height, weight, body composition analysis) followed by completion of five questionnaires related to eating behaviour and personality traits. The Echo-MR facility for measurement of body composition within the CUC was in use for other projects during a large part of data collection; consequently only 98 participants (29%) had body composition measured. Summary statistics for demographic and anthropometric measures are given in Table 1, and for behavioural measures of eating and psychological trait questionnaires in Table 2.