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ORIGINAL ARTICLE

Heightened vagal activity during high-calorie food presentation in obese compared with non-obese individuals—Results of a pilot study

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Summary Eating behaviours are highly cue-dependent. Changes in mood states and exposure to palatable food both increase craving and consumption of food. Vagal activity supports adaptive modulation of physiological arousal and has an important role in cue-induced appetitive behaviours. Using high-frequency heart rate variability (HF HRV), this preliminary study compared vagal activity during positive and negative mood induction, and presentation of preferred high-calorie food items between obese ($n = 12$; BMI ≥ 30) and non-obese individuals ($n = 14$; $18.5 < \text{BMI} < 30$). Participants completed two laboratory sessions (negative vs. positive mood conditions). Following 3-h of food deprivation, all participants completed a mood induction, and then were exposed to their preferred high-calorie food items. HF HRV was assessed throughout. Obese and non-obese individuals were not significantly different in HF HRV during positive or negative mood induction. Obese individuals showed significantly greater levels of HF HRV during presentation of their preferred high-calorie food items than non-obese individuals, particularly in the positive mood

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condition. This is the first study to demonstrate increased vagal activity in response to food cues in obese individuals compared with non-obese individuals. Our findings warrant further investigation on the potential role of vagally-mediated cue reactivity in overeating and obesity.

Introduction

The current global obesity epidemic has been attributed partly to overconsumption of palatable, high-calorie foods [1]. Eating behaviours are known to be highly cue-dependent [2]. Human laboratory studies have demonstrated enhanced consumption of high-calorie foods in response to internal cues, such as psychological stress [3—7] or changes in negative and positive mood states [8—11]. Additional studies have examined the effect of stress on the wanting and liking values of foods [12—15]. Only a few experimental studies have compared the effects of stress or mood induction on eating behaviours by obesity status, and these studies have reported mixed findings [11,16]. Exposure to palatable food cues may also increase food craving [17,18], motivation to eat [19], and subsequent food intake [20], with some of these effects being stronger in obese individuals than lean individuals. Thus, cue-induced overeating of palatable foods may importantly contribute to obesity.

Neuroimaging studies have suggested altered central regulation of cue reactivity in obesity. In response to food cues and stress, obese individuals showed greater activation of brain regions involved in reward and motivation, compared with lean individuals [20—22]. In addition to central regulation of arousal response, autonomic regulation of physiological arousal responses also plays an important role in cue-induced appetitive behaviours [23,24]. In coordination with the sympathetic nervous system, vagal activity (i.e., parasympathetic nervous activity) flexibly responds to internal and external stimuli partly through changes in heart rate [24], which is important for adaptive regulation of affective and cognitive states [25—28].

Animal models of diet-induced obesity reported blunted decreases in vagal activity in response to stress [29,30]. Only a few human studies compared vagal activity to a stressor in obesity. One study reported that a greater body mass index (BMI) was associated with reduced high frequency heart rate variability (HF HRV) reactivity to a mental stressor [31], while another study did not find significant differences in HF HRV reactivity to a physical stressor by obesity status [32]. Thus, evidence for vagal regulation of physiological arousal in obesity is equivocal. It is also unknown whether vagal response to changes in mood states differs by obesity status. Modifying a well-established laboratory model of smoking lapse behaviours [33], our previous study was the first study to demonstrate that obese individuals showed less ability to resist eating (i.e., shorter latency to start eating after preferred food presentation) and increased consumption of high-calorie foods in response to positive mood induction compared with negative mood induction; non-obese individuals, on the other hand, consumed more calories after negative mood induction compared with positive mood induction [11]. When considered along withclinical and empirical obeservations that both positive and negative moods were associated with dieting relapse crisis [34], this supports the importance of positive mood states in overeating and obesity, in addition to negatively valenced cues. The current study further compared vagal activity during mood induction between obese and non-obese individuals to examine whether vagal modulation of mood state might be altered in obese individuals.

In the current study, we also examined vagal response to highly palatable food cue presentation. Vagal activity in response to food cues has not been studied, but elevated vagal response to cue exposure has been observed in other appetitive behaviours, such as alcohol use disorders. For example, greater vagal activity following alcohol cue exposure has been reported in chronic heavy drinkers, compared with healthy samples [35,36]. It is possible that obese individuals would also show heightened vagal activity in response to highly palatable food cues, compared with non-obese individuals.

HRV, changes in the time between beat-to-beat intervals, has been used to measure the influence of autonomic activity on the heart [37,38]. The high frequency range (HF HRV; 0.15—0.4 Hz) of