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Acute effects of video-game playing versus television viewing on stress markers and food intake in overweight and obese young men: A randomised controlled trial☆

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ABSTRACT

Background: Sedentary or near-sedentary activities are associated with overweight/obesity in epidemiological studies. This has traditionally been attributed to physical activity displacement. A little-explored area is whether behavioural stresses alter sensations of appetite and eating behaviour. We examined whether behaviours conducted seated (television viewing, video gaming) induce different eating patterns, associated with differential levels of stress response.

Methods and findings: We conducted a randomized controlled trial in 72 overweight/obese adult males, assigned to three groups (24 per group): (i) non-violent television (control group); (ii) non-violent game (FIFA); (iii) violent game (Call of Duty). Following a standardized breakfast, the 1-h intervention was followed by 25-min rest, with sweet and savoury snacks and drinks available *ad libitum*. Stress markers (heart rate, blood pressure, visual analogue scale (VAS)) were measured throughout. Heart rate, systolic blood pressure, and stress by VAS were significantly higher ($p < 0.05$) playing video games than watching non-violent television, though the two game groups did not differ. Considered separately, only the violent video game group consumed more energy ($\Delta = 208.3$ kcal, 95%CI 16, 400), sweet foods ($\Delta = 25.9$ g, 95%CI 9.9, 41.9) and saturated fat ($\Delta = 4.36$ g, 95%CI 0.76, 7.96) than controls.

Conclusion: Playing video games in overweight/obese adult males is associated with an acute stress response relative to watching non-violent television, associated with greater subsequent food intake. These findings highlight the need to focus on the metabolic effects, as well as the energy costs, of activities involving sitting in relation to obesity risk.

1. Introduction

Over one third of adults worldwide are now overweight or obese (Ng et al., 2014), constituting a public health crisis. The steep increase in obesity prevalence over recent decades implicates a key contribution of environmental factors, but identifying suitable targets for public health policies has proven difficult (Goran & Treuth, 2001; Weinsier, Hunter, Heini, Goran, & Sell, 1998). Research into the aetiology of obesity has focused on the concept of energy balance. This theory is based upon fundamental thermodynamic principles, which state that energy cannot be created or destroyed by an organism, only gained or lost by the body (Hess, 1838). Application of these principles to obesity implicates chronic over-eating and/or chronic physical inactivity (eg sitting, sedentary behaviour), as determinants of 'positive energy balance', resulting in weight gain (Wells & Siervo, 2011). Although this model has been central to public health efforts to prevent obesity, through the promotion of exercise and calorie counting, the success of such schemes has been very modest, reflected in rising rates in most countries (Ng et al., 2014). In particular, the energy balance approach assumes that any two activities with equal caloric cost should affect body weight to the same degree, whereas specific behaviours might vary in their obesity risk. This unfocused

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approach prevents understanding of the metabolic consequences of behaviour among adolescents and young adults (eg 18–30 years), who should be a primary target of obesity prevention campaigns.

Sedentary behaviour has been consistently associated with obesity. For example, television viewing is a well-established risk factor (Robinson, 2001; Viner & Cole, 2005), and interventions to reduce TV viewing have reduced body mass index (BMI) (Otten, Jones, Littenberg, & Harvey-Berino, 2009). Sitting has also been associated with obesity risk (Hu, Li, Colditz, Willett, & Manson, 2003; Kong, Lee, Kim, Sim, & Choi, 2015). Likewise, growth of the video games industry has closely paralleled the obesity epidemic (Wack & Tantleff-Dunn, 2009), and a number of studies have reported associations between time spent playing video games and BMI in children (Mota, Ribeiro, Santos, & Gomes, 2006; Stettler, Signer, & Suter, 2004), adolescents (Schneider, Dunton, & Cooper, 2007) and adults (Weaver et al., 2009). However, playing video games using a hand-held joystick while seated has been associated with greater energy expenditure, similar to mild-intensity exercise, compared to simply sitting or standing still (Segal & Dietz, 1991). Other studies have reported a modest increase in energy expenditure when playing video games compared to resting (Chaput et al., 2011; Mansoubi et al., 2015; Mellecker & McManus, 2008; Wang & Perry, 2006). On this basis, television viewing would be predicted to be a stronger risk factor for obesity than playing video games. Recently, a formal definition of sedentary activity has been proposed of $\leq$1.5 METS (Metabolic Equivalent Task, defined as 3.5 ml O2·kg−1 min−1) (Sedentary Behaviour Research Network, 2012). Studies show that adults playing seated Playstation-type video games typically achieve around 1.4 METs, though there is variability between individuals some of which reflects nutritional status assessed by BMI (Mansoubi et al., 2015).

A less intuitive possibility is that activities while sedentary or sitting affect appetite, and potentially in variable ways. A randomized trial reported higher subsequent energy intake in videogame players relative to controls, translating into an energy surplus of 104.2 kcal over the entire day, despite no reported increases in hunger or appetite rating (Chaput et al., 2011). Another trial found that those playing violent video games on a playstation subsequently felt less full and expressed greater desire to eat sweetened foods, compared to those playing non-violent games or watching non-violent television (Siervo, Sabatini, Fewtrell, & Wells, 2013). More generally, activities involving mental effort (Chaput & Tremblay, 2007; Chaput, Drapeau, Poirier, Teasdale, & Tremblay, 2008; Tremblay & Therrien, 2006) and watching television (Bellisle, Dalix, & Slama, 2004; Temple, Giacomelli, Kent, Roemmich, & Epstein, 2007) have been reported to increase food intake without elevating appetite.

It has been postulated that appetite increases following video gaming may be due to stress-induced rewards or impairment in satiety signalling (Chaput et al., 2011). A number of studies have documented a stress response after playing video games, shown by increased heart rate and blood pressure (Barlett & Rodeheffer, 2009; Chaput et al., 2011; Segal & Dietz, 1991), while experimental studies have also linked exposure to stress with altered patterns of food consumption. A small study ($n = 10$) found that exposure to stress significantly increased consumption of carbohydrate, and led to non-significant increases in the consumption of sweet foods, fatty foods and total energy (Hitze et al., 2010). Another study demonstrated greater total energy intake after completing difficult mental arithmetic questions compared to the control state (230.6 vs 189.6 kcal, $p < 0.01$), despite no difference in hunger; a statistically significant greater consumption of sweet foods was also observed 169.2 vs 143.2 kcal, $p < 0.03$) (Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-Plantenga, 2009). Both of these two studies indicate a tendency to consume foods rich in glucose in response to stress (Hitze et al., 2010; Rutters et al., 2009), as also suggested in a trial of violent video games (Siervo et al., 2013). Finally, a study of brain metabolism demonstrated a 12% increase in global cerebral metabolic rate for glucose in response to a behavioural stressor (Lund Madsen et al., 1995). This increased glucose utilization persisted for $\geq$40min after termination of the stressor, despite all physiological stressors having returned to baseline levels (Lund Madsen et al., 1995).

Collectively, these studies suggest that increased energy intake, potentially targeting certain food types, may be an adaptive response to satisfy the brain's demand for extra cerebral energy during periods of stress. However, few studies (Chaput et al., 2011; Hitze et al., 2010; Rutters et al., 2009) have directly measured food intake, hence there is little understanding as yet of how video games might impact eating behaviour through the stress response. This issue can be addressed by probing in greater detail the effect of *different kinds* of video games on sensations of appetite and eating behaviour.

We aimed to examine whether behaviours conducted while sitting (television viewing and playing different Playstation video games) induce different patterns of eating, associated with differential levels of stress response in young overweight men. Our primary hypothesis, specified prior to the trial, was that playing violent video games would induce a stress response, an elevation of appetite, and a heightened consumption for sweet foods or drinks, relative to watching non-violent television or playing a non-violent video game. However, when analysing the data we also tested two secondary hypotheses. First, we tested whether either of the video game groups differed from the non-violent television control group in stress responses, appetite and food consumption. This differs from the primary hypothesis, which not only assumed that the violent game would differ from the non-violent television group, but also assumed that the non-violent game would not show such a difference from the television group. Second, we also tested the hypothesis that all videogame players combined into a single group had different stress responses, appetite and food consumption compared to those watching non-violent television. These hypotheses are illustrated in Supplementary online Fig. S1. We tested these hypotheses experimentally using a randomized controlled trial, which we undertook in overweight and obese men aged 18–30 years, as many regular video gamers are overweight (Wack & Tantleff-Dunn, 2009).

2. Methods

A three-arm, parallel, randomized control trial was carried out at the Childhood Nutrition Research Centre, University College London (Clinical-Trials.gov NCT01809470). Participants were blinded to the main aim of the study, in order to minimise any influence of individual expectations. After the study the participants were fully informed about the outcomes that were measured and monitored. The study was approved by the 'UCL Research Ethics Committee' (0326/011), and all participants provided written informed consent. All data was anonymized and stored in accordance with the Data Protection Act 1998. The study was run from 18th February to 24th May 2013, and finished due to completion. The trial registration was completed 8th March 2013, due to delays in providing supporting information, but no changes to the protocol were made. Funding was provided by University College London in support of JG. The trial protocol can be accessed as supplementary online material (S1 File). The authors confirm that all ongoing and related trials for this intervention are registered.