Appetite 113 (2017) 116–123

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Suprathreshold measures of taste perception in children - Association with dietary quality and body weight

Emma L. Feeney [a,*], Sinead A. O'Brien [a], Amalia G.M. Scannell [b], Anne Markey [b], Eileen R. Gibney [a]

[a] UCD Centre for Molecular Innovation, University College Dublin, Dublin, Ireland
[b] UCD Centre for Agriculture and Food Science, Ireland

ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form
18 January 2017
Accepted 18 February 2017
Available online 21 February 2017

Keywords:
Taste perception
Genetics
Dietary quality
Healthy Eating Index
HEI score
BMI
Body weight

ABSTRACT

Childhood obesity is an increasing problem in the Western world, and is affected by a multitude of interacting factors. Recent evidence suggests that taste perception may differ between obese and normal weight children. Evidence also suggests that perception of sweet and bitter taste is linked to differential food liking of various foods. To date, most studies have focused on single food items or food groups, rather than an overall view of dietary quality, and mainly on bitterness. Thus it is unclear whether taste perception is associated with dietary quality in children. Our objective was to examine the link between taste perception, dietary quality and body weight in Irish school children, in conjunction with other known influences of body weight. Taste perception was measured using the gLMS for bitter, salty and sweet stimuli. Detailed dietary intake data were collected from 525 children aged 7–13 via a 3-day diet history. Energy misreporters were identified and excluded from the dietary analyses, leaving $n = 483$ children. Dietary quality was assessed using Healthy Eating Index. Salivary DNA was collected and analyzed for variations in the bitter receptor gene TAS2R38. Sex differences were observed whereby intensity perception of sweetness was lower in the overweight/obese males, while no association was observed for sweet taste in the females. Despite the differences in weight status, taste perception was not associated with differences in overall dietary quality, measured via HEI score, in this cohort. Prospective cohort studies in children are necessary to better understand the association between taste intensity, food intake and weight over time.

1. Introduction

The current climate of rising overweight and obesity in Western society is well-documented (Chakraborty, Balanda, Perry, & Kabir, 2015; Flegal, Carroll, Kuczmarski, & Johnson, 1998), and attributable in part to an overall increased consumption of energy dense foods, such as those high in fat and refined sugar (Mendoza, Drewnowski, & Christakis, 2007), as well as a general decrease in physical activity, WHO (2003). Diets that are more energy dense also tend to be lower in nutritive quality (Drewnowski, 2010; Joyce & Gibney, 2008) and may pave the way for diet-related disease later in life such as obesity, cardiovascular disease (CVD), type 2 diabetes, hypertension and stroke as well as certain types of cancers (Lock, Pomerleau, Causer, Altmann, & McKee, 2005; Popkin, Kim, Rusev, Du, & Zizza, 2006; WHO, 2003). In line with the general increase in obesity, the incidence of such non-communicable diseases is also rising across Europe (including Ireland), and the USA (Alwan et al., 2010; Wagner & Brath, 2012), placing a considerable cost burden on the respective healthcare systems that is essentially avoidable (Beaglehole et al., 2011; Chakraborty et al., 2015; Must et al., 1999; Popkin et al., 2006). Because of the strong link between diet and health, a great deal of research has focused on the development and use of indices to assess overall diet quality, including but not limited to, dietary diversity scores (Hoddinott & Yohannes, 2002; WPF, 2009) the Diet Quality Index (Haines, Siega-Riz, & Popkin, 1999; Kennedy, Ohls, Carlson, & Fleming, 1995; Patterson, Haines, & Popkin, 1994) and the Healthy Eating Index (Kennedy et al., 1995). These various indices are based on measurements from a range of aspects within the overall diet, such as servings of fruits and vegetables and/or nutrient measures, which tend to improve the scores, percentage energy from various macronutrients, as well as

* Corresponding author.
E-mail address: emma.feeney@ucd.ie (E.L. Feeney).

http://dx.doi.org/10.1016/j.appet.2017.02.026
0195-6663/

added salt and sugar (which tend to deteriorate the scores, once intakes surpass the recommended limits), to generate a single summative score. Assessing the diet in this way can give a more accurate view of an individual's overall diet quality than a reliance on single foods, food groups or nutrients (Kant, 1996).

Dietary quality is an important predictor of overall health, and of health later in life (Haveman-Nies, de Groot, & van Staveren, 2003). In a society where energy-dense but nutrient-poor foods are readily available (Drewnowski & Darmon, 2005; Drewnowski & Specter, 2004), a better understanding of the factors that influence food choice and lifestyle decisions to help combat rising levels of weight-related disease is necessary. A complex range of interacting factors are involved in food purchasing and consumption decisions, including food availability, socioeconomic considerations, health, cost, and taste (Connors, Bisogni, Sobal, & Devine, 2001; Glanz, Basil, Maibach, Goldberg, & Snyder, 1998; IFIC, 2016). Of the food-related values, 'taste' and 'cost' are often highlighted as the two most influential factors (Connors et al., 2001), and 'taste' has been consistently rated as having the greatest influence on Americans' food purchases since 2006 (IFIC, 2016).

Within the recognised taste qualities of sweet, sour, salty, bitter and umami; bitter and sweet tastes are arguably the most important for food acceptance; sweet tastes are inherently liked (Rosenstein & Oster, 1988), while bitter tastes are inherently disliked (Rosenstein & Oster, 1988; Steiner, Glaser, Hawilo, & Berridge, 2001). Foods such as vegetables are important contributors to dietary quality, as rich sources of vitamins, minerals and fibre, while providing minimal energy, but can often taste bitter (Drewnowski & Gomez-Carneros, 2000). Therefore, this could contribute to their rejection, particularly by children. On the other hand, some sweet-tasting foods such as confectionary and sugar-sweetened carbonated drinks are sources of 'empty' calories – providing energy with little other nutritive value. Therefore, sweet and bitter taste perception may be of particular importance for dietary quality.

The perception of these (and other) tastes can vary from person-to-person (Feeney, O'Brien, Markey, Scannell, & Gibney, 2011; Feeney & Hayes, 2014; Hayes, Feeney, & Allen, 2013), and some of these variations are known to affect liking and/or intake for a number of individual foods (Hayes et al., 2013). One relatively well-studied aspect is the perception of bitterness from 6-*n*-propylthiouracil, which is linked to variations in the bitter taste receptor gene *TAS2R38* (Bufe et al., 2005; Duffy, Davidson, Kidd, Kidd, & Speed, 2004). Three groups of PROP tasters exist; super, medium or non-tasters of PROP, depending on their intensity perception (Bartoshuk et al., 1992), and a number of studies have examined variations in *TAS2R38* and in PROP perception with regard to liking and/or intake of a range of different bitter-tasting foods and beverages, with varying results (See Tepper (2008) for a comprehensive review). PROP bitterness is also correlated with sweet intensity in some studies, e.g (Duffy, Peterson, Dinehart, & Bartoshuk, 2003), and there is considerable interest in the link between taste and weight (Bartoshuk, Duffy, Hayes, Moskowitz, & Snyder, 2006; Donaldson, Bennett, Baic, & Melichar, 2009).

Although the focus of many studies is on bitter taste in relation to BMI (Tepper, 2008), other tastes have also been examined, including: sweet (Bertoli et al., 2014; Low, Lacy, McBride, & Keast, 2016; Martinez-Cordero, Malacara-Hernandez, & Martinez-Cordero, 2015; Smith, Ludy, & Tucker, 2016), sour (Park et al., 2015) (Bertoli et al., 2014; Martinez-Cordero et al., 2015) umami (Pepino, Finkbeiner, Beauchamp, & Mennella, 2010), and the taste of fat (Tucker et al., 2017). Results have been mixed, likely due in part to differences in the ages of the cohorts examined, the methods used (perception vs identification), and the scale used (Bartoshuk et al., 2006), among others. Studies (in adults) suggest that prolonged exposure to different levels of sweetness in the diet may alter intensity perception (Sartor et al., 2011; Wise, Nattress, Flammer, & Beauchamp, 2016), although not all studies have observed an association (Cicerale, Riddell, & Keast, 2012). Some evidence, in children, suggests that perception of sweet taste may be altered in the overweight and obese, compared to those of normal weight (Overberg, Hummel, Krude, & Wiegand, 2012; Pasquet, Frelut, Simmen, Hladik, & Monneuse, 2007; Sauer et al., 2017), although the methods used and age groups of the children involved are mixed. One recent weight loss study in children aged 9–17 (Sauer et al., 2017) observed that obese children scored lower on a taste identification task for sweet, sour, salt and bitter (total taste score) compared to normal weight children, and taste performance changed over the weight loss intervention. It was suggested that this could be an exposure-related effect, possibly due to reduced sugar consumption during the intervention, but actual dietary intakes were not examined in that report (Sauer et al., 2017). Further, the task was identification of taste quality rather than intensity perception, and the children were in controlled eating conditions, making it difficult to translate these results more generally. Thus, the aim of the present paper was to address this knowledge gap by examining the association between taste perception and children's weight status and dietary quality, as measured via a healthy eating index, in an existing cohort.

2. Materials and methods

2.1. Recruitment of subjects

Children and parents were recruited through schools in the Irish counties of Dublin, Westmeath and Louth, as described previously (Feeney, O'Brien, Scannell, Markey, & Gibney, 2014; O'Brien, Feeney, Scannell, Markey, & Gibney, 2013). A letter explaining the study was sent home to the parents of all children aged between 7 and 13 years, requesting permission for their children to participate. Parents returned a signed, informed consent form to the school on behalf of their children, and for themselves if they also wished to participate, after which they were contacted to arrange an after-school visit. Children also completed an assent form. University College Dublin's Human Research Ethics Committee approved the study.

2.2. Anthropometry

Weight and height was measured in duplicate using a Seca 770 digital personal weighing scale for weight (Chasmores Ltd, UK), to the nearest 0.1 kg and the Leicester portable height measure, to the nearest 0.1 cm, for height. Subjects were weighed whilst wearing light clothing and without shoes. Body Mass Index (BMI) was used to indirectly assess adiposity in adults, and was calculated by weight/kg divided by height squared/m^{2}. In children, BMI z-scores were calculated using UK reference curves (Cole, Freeman, & Preece, 1995). Children's BMI z-scores were used to categorize them into 4 groups, "thin", "normal", "overweight" and "obese", by standard definitions (Cole, Flegal, Nicholls, & Jackson, 2007; FerroLuzzi et al., 1995).

2.3. Taste perception measures

PROP taster status was determined via PROP-impregnated filter paper discs, which participants rated on the general Labelled Magnitude Scale (gLMS) (Bartoshuk, Duffy, Green, Hoffman, & Ko, 2004). PROP paper discs were prepared as previously described (Zhao, Kirkmeyer, & Tepper, 2003), by soaking filter paper discs in a 50 mM PROP solution. These were oven-dried at 121° C for 1 h. Salt