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Randomized control trials

A randomised trial of the impact of energy density and texture of a meal on food and energy intake, satiation, satiety, appetite and palatability responses in healthy adults

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SUMMARY

Background & aims: Texture modified diets may be enriched to optimise the opportunity for individuals to meet their required energy intakes; however there is insufficient evidence supporting this strategy. Thus we sought to investigate the effect of texture and energy density on food (g) and energy intakes (kcal), appetite (satiation and satiety), and palatability in healthy adults.

Methods: A single blind within-subjects randomised crossover design, where 33 healthy adults consumed a test meal with either its texture and/or energy density altered, until satiation was reached whilst rating their appetite parameters. Subsequent intakes were recorded in a food diary to determine the effect of the treatments on satiety and identify any evidence of energy compensation.

Results: Test meal energy intakes (kcal) were significantly higher with energy enrichment of both meals (standard texture; 315 kcal and texture modified; 303 kcal ($p = 0.001$)) and remained higher over the day for both (260 kcal/d and, 225 kcal/d respectively ($p < 0.05$)). Area under the curve (AUC) did not differ between meals for hunger, fullness, or desire to eat however palatability was significantly reduced with texture modification.

Conclusions: Enriching meals (standard texture and texture modified) is an effective method to increase short term energy intakes in healthy adults over a 24 h period and may have application to optimise energy intakes in a clinical setting.

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1. Introduction

Texture modified diets (TMD) are prescribed globally for the nutritional management of a range of conditions including dysphagia in order to promote a safer swallow by avoiding the risk of aspiration, however the terms used to describe these diets can vary worldwide.[1–4] The International Dysphagia Diet Standardisation Initiative (IDDSI) is currently in place which aims to develop global terminology and definitions for texture modified foods and thickened liquids for individuals with dysphagia, of all ages, in all care settings and all cultures.[5] The current study followed the guidelines for producing texture modified meals in the United Kingdom, namely the "Dysphagia Diet Food Descriptors".[1] This document outlines a range of suitable textures which vary from what is subjectively described as "fork mashable" to "thin puree". A detailed description of each of the subjective descriptors can be found elsewhere.[1,5] It is acknowledged that an issue with these descriptors is the lack of quantitative definition to further describe the textures potentially leading to large variations in the textures produced within each of the subjective descriptions. Whilst there has been an attempt to quantitatively define acceptable ranges of viscosity for stages of liquids within the American guidelines issued for the dysphagia diet,[2] no such measurements have been issued for foods. Few experimental studies have attempted to quantify the textures of different TMD categories[6,7] and some information regarding particle size of foods within different categories also exist.[5] However due to differences in defined textural categories and subjective terminology used, it is difficult to fully translate these across to all foods. These may however provide a reference range of textures to which a particular texture category could belong. Although it should be acknowledged

Abbreviations: AUC, area under curve; CHO, carbohydrate; ED, energy dense; SE, standard energy; SSS, sensory specific satiety; ST, standard texture; TFEQ, three factor eating questionnaire; TM, texture modified; TMD, texture modified diet; VAS, visual analogue scale.

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that the texture of the food will undergo further changes with the addition of saliva, mastication and the shear rate applied with swallowing, all which can vary between and within individuals. Aside from issues with the preparation of these meals, it has been observed that individuals receiving TMD have lower food intakes compared to those receiving a normal texture diet.[8,9] It is however unclear if these reduced intakes are attributed solely to the disease state which warrants the dietary prescription, to the aesthetics and nutrient content of these meals or a combination of these.

Although the evidence is equivocal, it appears that the texture in which a food is consumed can elicit different appetitive responses and subsequently affect food intake.[10] Studies in healthy subjects demonstrate that solids evoke greater feelings of fullness than foods in less solid states.[11] This is however not always the case, especially with the example of soups[12] which despite their typical liquid form have been found not only to induce a satiating effect but in some cases produce a greater affect than solids matched for energy density.[13] It is acknowledged that these studies investigated textures that differ from those that may be used/defined within a TMD, however as far as we are aware, no studies have looked at effects on appetite in an experimental setting assessing specifically designed meals which have been developed to meet different textural categories which can be prescribed for a TMD. Zijlstra[11] proposed that the texture of a meal potentially impacts on satiation due to the differences in oral exposure time with solids and more viscous material resulting in greater oral exposure times compared to less solid/viscous material. Foods of higher viscosity are said to provide longer oro-sensory stimulation[14] and this may contribute to sensory fatigue, early satiation and consequently reduced food intakes. It is known that the oral exposure to food can enhance the effects of gastric and intestinal exposure to food, influencing appetite and subsequent food intake.[15] Dysphagic individuals may experience longer periods of oral exposure to foods caused by difficulty with mastication and fear of swallowing.[16]

Individuals at nutritional risk (which may include those prescribed TMD), often require a meal that is described as “energy dense” to help improve energy intakes.[17] It is known that the energy density of food can influence energy intakes, with studies in healthy individuals generally demonstrating that food intakes (g) remain similar regardless of energy density.[18–20] This potentially has a profound effect on short term energy intake such that the provision of a high energy dense meal may result in greater energy intakes compared to lower energy dense meal versions.[21] Previous studies have demonstrated that energy enrichment of standard texture diets can be effective for increasing energy intakes.[22,23] One study[21] found that enriching main meals (with natural ingredients) to increase their energy content (by 50%) as a strategy to maximise nutritional intakes increased net energy intake (450 kcal/day, $p < 0.0001$), although it also led to prolonged satiety and reduced between meal food intakes. Thus the potential of energy compensation needs to be evaluated in order to determine the overall effectiveness of providing an energy dense diet It is also unknown if this strategy of energy enrichment is effective in actually increasing energy intakes in those prescribed TMD.[24]

Whilst it is reported that those prescribed a TMD have reduced food intakes[8,9] it is unknown if healthy individuals who are not compromised by disease will also reduce their intakes of a TMD meal. It is hypothesised that enrichment of a TMD meal will result in increased energy intakes at a single eating occasion but it is unknown whether individuals will compensate by reducing energy intakes at eating occasions later in the day. The aim of this research was therefore to investigate the effect of texture modification, and/or energy enrichment (energy density) of a standard meal on appetite parameters, satiation and satiety, total daily energy intake (kcal) as well as palatability in healthy adults. In the context of this study, satiation refers to the quantity of food (g) and energy (kcal) consumed to reach a point of comfortable fullness within a test meal eating occasion, where as satiety refers to the period between the test meal occasion and the next easting occasion (minutes).[18]

2. Material and methods

2.1. Study population

Healthy adults were recruited to the study between May 2011 and June 2012 through advertisements in local newsletters (QMU News, The Centre of Older Persons Agenda (COPA) Newsletter, Care for Carers Newsletter), posters displayed in relevant local community centres, at the Scottish Older People’s Assembly (SOPA) conference, through the University of the Third Age (U3A) and through mailings to staff, students and alumni of QMU. Potential subjects were initially screened to determine that they were not allergic or intolerant to any of the test meal ingredients, were not suffering from any medical condition or taking medication that may affect appetite, were capable of feeding themselves, had no metabolic disorders, were not receiving special or therapeutic diets, were not using dentures, and were able to give informed consent. Potential subjects were then invited to complete the restraint section of the Three Factor Eating Questionnaire (TFEQ)[25] to ensure that they were not exercising dietary restraint. Individuals who scored >13 on the restraint questionnaire were not permitted in the study on the basis that their eating behaviour may be confounded by a conscious effort to restrict food intake.[25] Weight and height were measured to determine BMI (kg/m^2). Potential participants with a BMI > 30 kg/m^2 were not included in the study as obese individuals may have altered appetite responses compared to lean individuals.[26] Ethical approval for this research was granted by the Human Research Ethics Committee of Queen Margaret University, Edinburgh.

2.2. Power analysis

Within subject effects were analysed using Repeated Measures Analysis of Variance (RM ANOVA). The implied single-group RM ANOVA, for a sample size of 30, with a 0.05 significance level would have 80% power to detect a difference in means across the levels of the repeated measures factors characterized by an effect size of 0.1. Following any significance here, post hoc tests (paired *t*-tests) for the four planned analyses (*i.e.* between each pair of conditions namely, texture and energy density combinations), were undertaken to identify where significance lies. The sample size calculation has therefore been determined for unadjusted post hoc paired *t*-tests. A sample size of 30 would have 80% power to detect an effect size of 0.5 using a paired *t*-test with a 0.05 two-sided significance level (nQuery Advisor® 7.0). It was intended to recruit a sample size of 35, allowing for attrition of approximately 15%. This should allow detection of a clinically significant difference in energy intakes of ~200 kcal.

2.3. Experimental design

A single blind randomised crossover within-subject experimental design was used to assess the effect of four meal conditions, where each subject acted as his or her own control. On four test days, each separated by at least three days and not greater than six weeks (median (IQR) 7 (7, 14) days), subjects attended the feeding laboratory (Queen Margaret University) to consume ad libitum a midday test meal consisting of a savoury pie (minced beef, topped with potato, “cottage pie” (see Fig. 1)) with either altered texture and/or enrichment level (energy density). Both independent

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