The effect of fibre supplementation on the frequency of eating occasions in overweight individuals.

ABSTRACT

Epidemiological studies have shown dietary fibre to be associated with a number of health benefits, one of which includes preventing obesity development by increasing satiety and reducing energy intake. If fibre supplementation can reduce the number of eating occasions over time, or lengthen the inter-meal interval, then energy regulation and subsequent weight loss may results. The objective of this present study is to determine the effectiveness of the palatable, viscous and gel-forming fibre, PolyGlycopleX (PGX), on frequency of eating occasions in overweight adults (BMI 25 – 29 kg/m^2). The participants will be randomised in a double-blinded fashion to either the test supplement, granular PGX (n = 60), or a rice flour placebo (n = 60), at a dosage of 5 g, three times daily with their breakfast, midday and evening meals for 12 weeks. At baseline and in the final twelfth week, participants will have their height, weight, waist circumference, blood pressure and fasting venous blood samples measured. In addition to this, during the first and final weeks of the study, subjects will keep 4-day mobile device food records to capture all food and drinks consumed. These images will be used to analyse the foods eaten, serving sizes and frequency of eating occasions. It is hypothesised that the fibre supplement will result in reduced frequency of eating occasions and a corresponding reduction in body weight.

TITLE

The effect of fibre supplementation on the frequency of eating occasions in overweight individuals.

OBJECTIVES

1. To investigate the effect of a viscous fibre supplement on frequency of eating occasions in overweight adults, over a 12-week period.
2. To measure body weight, waist circumference, blood pressure and fasting venous blood samples differences between baseline and at the end of the 12-week intervention.

Aim

1. To investigate the effect of a viscous fibre supplement has on frequency of eating occasions in overweight adults

Hypothesis

Fibre supplementation will reduce the frequency of eating occasions.

LITERATURE REVIEW

The link between dietary fibre and its physiological health benefits has been observed for centuries, with figures such as Hippocrates noting its role in improving bowel function (Burkitt 1983). More recently, observation- and intervention-based studies have shown that fibre derived from wholefoods are protective against a range of diseases, including obesity (Mann & Cummings 2009). For isolated and synthetic fibres however, results remain inconclusive (Mann & Cummings 2009). Given that obesity is a pre-disposing factor for a number of other potentially life-threatening conditions such as hypertension, heart disease, stroke, diabetes and certain cancers,

further research into the role of novel fibres is warranted, particularly in regards to their functionality and safety with longer-term use (Mann & Cummings 2009).

Since the 1980s, researchers have endeavoured to understand the association between dietary fibre, satiety and subsequent food intake (Slavin & Green 2007). Fibre has a number of physiological effects at different points throughout the gastrointestinal tract, all of which are able to impact on energy regulation. Energy dilution describes the mechanism by which fibre is able to displace other kilojoules and nutrients from the diet due to it being lower in energy per unit weight (Slavin & Green 2007). As such, for the same volume of food, fibre-rich meals may be able to improve satiety and promote weight loss (Rolls 2000). Greater mastication has been hypothesised as another means by which fibre-rich foods reduce energy intake. The increased time and effort required to chew these foods not only reduces the rate of ingestion but also increases saliva and gastric acid secretion (Howarth, Saltzman & Roberts 2001). It has been suggested that the increase saliva and gastric acid production may be responsible for the increased gastric distension seen after fibre consumption, particularly those that have gel-forming effects (Howarth, Saltzman & Roberts 2001). Recent research has also shown that gel-forming fibres slow both the rate of gastric emptying and nutrient absorption which may delay the onset of hunger signals which are triggered by a lack of circulating nutrients (Howarth, Saltzman & Roberts 2001). The effect of fibre on gut hormones remains speculative however it has been shown that glucagon-like peptide-1 slows gastric emptying in the presence of glucose, fat and fermentable fibres, which may in turn reduce hunger (Howarth, Saltzman & Roberts 2001).

More recently, the research focus has shifted to the role of fibre viscosity in improving satiety and reducing energy intake. It has been hypothesised that the gel-forming nature of these fibres thicken the gastrointestinal contents, creating a matrix that traps nutrients, interfering with the normal nutrient-enzyme interactions and retarding their transit from the stomach into the small intestine (Howarth, Saltzman & Roberts 2001). Both *in vitro* and animal studies have produced results showing a reduced rate of nutrient absorption from the small intestine following viscous fibre consumption (El Kossori et al. 2000). More recently, promising results have been gleaned for viscous fibre's effect on hunger and satiety in human clinical trials. Slavin and Green (2007) found that, regardless of dose, soluble fibres that were *not* viscous and had no effect on hunger or satiety. Randomised-control trials by Mattes and Rothacker (2001), Marciani et al. (2001) and Hoad et al. (2004) showed that, when solutions of different viscosities were administered, those that were most viscous prolonged satiety and reduced hunger the most. In a review by Ludwig (2000), at least fifteen studies testing viscous fibres including psyllium, oatmeal, legumes and guar gum, satiety was seen to increase while subsequent food intake decreased. PolyGlycopleX (PGX) is a novel functional fibre that is soluble, viscous and gel-forming (Solah et al. 2014). When PGX was administered as a meal replacement drink in adolescents, Vuksan et al. (2009) found that hunger levels and *ad libitum* food consumption was reduced relative to the low viscosity cellulose beverage. Similarly, Solah et al. (2014) found PGX significantly improved fullness and satiety when compared to the control, with 7.5 g dosages having the greatest effects. Postprandial glycaemia and plasma PYY have also been investigated however further studies are needed to confirm this association. Additionally, the role of PGX in

promoting weight loss in overweight individuals is an area requiring further investigation.

Despite the increase in satiety seen across many of the studies, the effects of viscous fibre on gastric emptying are less conclusive. While clinical trials using pectin have shown it to consistently delay gastric emptying, the effect of alginates and guar gum on this outcome remains variable (Van Nieuwenhoven et al. 2001, Hoad et al. 2004). Ellis and Morris (1991) have noted that the rate of hydration of some guar gum preparations is so slow that, after 5 hours, they had still only reached 60% of their maximum viscosity. This feature applies to other viscous fibres and may explain the lack of clinical effect seen in some studies, particularly those of short durations. Thus, further research is required to test the effects of viscous fibres in the longer term. In addition to this, the way in which gastric emptying was assessed and the vehicle by which the viscous fibre was administered can all impact on the results recorded and are variables that require further investigating to establish a relationship between viscosity and gastric emptying.

Positive metabolic effects have been seen following viscous fibre consumption, most notably the reduced rate of glucose and fat absorption from the small intestine (Kendall, Esfahani & Jenkins 2010). A meta-analysis by Brown et al. (1999) found that other viscous fibres such as pectin, oatbran, guar gum and psyllium at doses of 2 – 10 g/day produced small but significant reductions in both total- and LDL-cholesterol concentrations. Such findings were not observed with other soluble fibres such as wheat bran and resistant starch, highlighting the important physiological impact viscosity has (Brown et al. 1999).

For combatting major chronic diseases such as obesity, evidence suggests that fibre-enriched products have an important role to play. Consensus as to which sources of fibre have the greatest health benefits is yet to be reached and the need for well-designed randomised control trials to investigate these relationships over longer time periods is warranted. In addition to this, the effectiveness of synthetic viscous fibres such as PGX in controlling eating occasions requires further study, along with any potential adverse health outcomes that could be associated with increased intakes. This current project extends previous research on PGX as a dietary fibre supplement by using a randomised, double-blind, placebo-controlled trial with a large sample size and long treatment duration. It is unique in that it investigates the effect of viscous fibre on frequency of eating occasions and inter-meal intervals using a mobile device; a technique that has been shown to improve accuracy and reduce participant burden (Boushey et al. 2009).
The inter-meal interval or the time between meals has an effect on energy intake and the level satiety experienced (Brunstrom et al. 2011). Research has shown viscous fibre is linked to increased satiety but how this link relates to reduced eating occasions is still to be investigated.

METHODOLOGY

Study design

This project will involve developing, implementing and evaluating a nutrition intervention in overweight adults (BMI 25 – 29 kg/m^2), aged 40 to 55 years in Perth, Western Australia. The study will be a 12-week randomised control trial (RCT)

designed primarily to investigate whether viscous fibre supplementation in a 'healthy eating' environment can reduce the frequency of eating occasions and in turn, promote weight-loss. Subjects will be randomly assigned to either the treatment group or placebo (control) group. Those subjects in the treatment group will consume 5 g of the viscous fibre supplement, PolyGlycopleX (PGX), a food grade soluble fibre product composed of glucomannan, sodium alginate and xanthan gum, with their morning and midday meals over the 12-week intervention period. Subjects in the control group will follow the same protocol, consuming 5 g of a rice flour placebo with their morning and midday meals for the duration of the study. All subjects will use an investigator-designed application running on an iPod touch to keep 4-day food records during the first, sixth and twelfth weeks of the study. Participants will take a before and after image of all foods and drinks consumed over 4 consecutive days. At both baseline and at the end of the 12-week study period, height, weight, waist circumference and fasting venous blood samples will also be measured.

Study participants

To be eligible for participation in the study, subjects must be adults, 40 – 55 years as of their last birthday, overweight as defined by a body weight index (BMI) of 25 – 29 kg/m^2 and not under current medical supervision. Subjects will be excluded if (a) pregnant; (b) unable to complete the 12 week study; (c) undertake extreme forms of exercise or dieting; or (d) unable to attend the study centre on four occasions (two at baseline for satiety training and dietary training and for fasting blood, weight height and waist circumference and final visit at 12 weeks; e) are smokers; f) have an allergy to any food ingredients used in the study; g) current use of lipid-lowering or antihypertensive drugs, insulin injection use; h) renal, liver or respiratory failure; i) previous gastric or weight-loss surgery; j) any malabsorptive conditions and current or recent dietary fibre supplementation. Subjects must be weight stable – i.e. weight fluctuations not greater than +/- 5 kg in last 12 months. Subject will not be restrained eater on entry to the study.Subjects will be recruited through advertisements on Curtin University radio as well as email communication systems.

Individuals that express interest will complete a questionnaire to determine whether they meet the selection criteria. If they do, further details of the study will be explained to them and they can decide whether they are willing to participate. Those that agree will be required to attend an information session at Curtin University during which informed consent will be obtained and the study objectives and participant requirements will be further explained. Subjects will be informed of the importance of consuming water with the supplement as well as the possible gastrointestinal effects of fibre. In addition to this, research staff will record height, weight, waist circumference and blood pressure and take a fasting venous blood sample to measure serum cholesterol. Training on the use of the mobile phone food record (mdFR) will also take place.

Sample size

The sample will consist of one hundred and twenty (120) adults. It was estimated that 60 participants would be needed per treatment group to provide significance (80%, P , 0.05)(Bringworth et al 2009).

Randomisation

Participants will be randomised to either the test treatment, PGX (n = 60) or the rice flour placebo (n = 60) using a computer-generated random block number of 12.The randomisation sequence will not be known or accessible by researchers and study participants and research staff will be blinded to the intervention. The supplement and placebo will be supplied in coded individual dose foil packs and participants will receive their 12-week supply at the baseline visit. The randomisation was generated using compute generalised codes.

Blinding

This study will be double-blinded in nature. First, subjects will be blinded to the treatment that they receive in the trial.The product will be provided to subjects in identical foil sachets labelled with a code. The product is in powder form and similar in appearance, texture, smell and flavour. Secondly, the research staff will be blinded to the treatment allocation until all analyses are completed.

Intervention

Participants will be randomised to either the test treatment, PGX (n = 60), or the rice flour placebo (n = 60). Test subjects will be required to consume 5 g of granular PGX fibre three times daily with their breakfast, midday and evening meals, for 12 weeks. Controls will follow the same protocol, consuming 5 g of a rice flour placebo over the study period.

Training on use of the mobile device food record

Before commencement of the study, subjects will receive a 30-minute training session on how to operate the Connecting Health and Technology (CHAT) app. The CHAT App is designed to allow food images collected by participants to be automatically uploaded from their mobile device to a secure server, for analysis. The training session will take place at Curtin University in a room that has Wi-Fi access. The session will be interactive and use a PowerPoint presentation to explain to participants how to use the device, for example; checking that the WiFi is connected, capturing food images with fiducial markers and sending the images to the server. Participants will also receive a small paper booklet to record any foods they forget to photograph. There will be time in the session for participants to familiarise themselves with these functions.

Dietary analysis

A student dietitian will review the 4-day mdFRs via a password-protected server and will enter the types of foods and serving sizes into an access database specifically designed for this purpose. The frequency of eating occasions will be determined from the image metadata which has the time and date stamp of when the image was taken. An eating occasion will be defined as the number of food image pairs, where one image pair represents the before eating and after eating image. The number of images taken per person will be assessed to see if there is a change. Images "eating occasion" will be classified as a meal or snack.

Blood sampling

Each participant will have fasting venous blood samples (15 mL) collected by a trained phlebotomist both at baseline and at the end of the 12-week intervention. The blood parameters being measured will be: glucose, insulin, changes in insulin sensitivity (using the HOMA index), triglycerides, cholesterol (LDL, HDL and total)

and apoB48. The blood test results will provide insight into the effect of fibre on a number of risk factors associated with metabolic syndrome. Testing will take place in a clinical laboratory at the School of Public Health, Curtin University.

Outcome measures

All research staff will receive training on the study protocol. Continuous outcome variables will be reported as the mean ± standard deviation (SD). Age, gender and baseline values for BMI, waist circumference, blood pressure and serum cholesterol will be considered as covariates. The significance level for the statistical tests will be set at 0.05 and 95% confidence intervals will be reported for each. Statistical analyses will be completed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS for Windows, 2012).

Primary outcome measures

The key outcome measure is the frequency of eating occasions. This will be determined using the image metadata from the 4-day mdFR. Mean within-group changes in frequency of eating occasions will be assessed using repeated-measures analysis, while time-by-treatment analysis of covariance will be used to determine between-group differences over time. Within-group changes, paired sample t test will be used as there are only two time points. Treatment effect can be examined by analysis of time-by-treatment variables.

Secondary outcome measures

Subjects (height, weight, waist circumference) will be characterised before and after the intervention, blood pressure and serum cholesterol will be measured at both baseline and at the end of the twelfth week. Prior to the anthropometric measurements, subjects will be asked to remove their shoes, wear a lightweight uniform and urinate and defecate. A portable stadiometer will be used to measure height to the nearest 0.5 cm while weight will measured to the nearest 0.1 kg using a pre-calibrated X scale. Using general linear models, regression analysis will be used to determine the extent to which body weight changed between baseline and the final week of the study.

The *3-Factor Eating Questionnaire* developed by Stunkard and Messick (1985) will be used to assess three different aspects of eating behaviour: ‘cognitive restraint of eating’, ‘disinhibition’ and ‘hunger’.

ETHICAL CONSIDERATIONS

The food images are stored by participant ID only and no personal information is kept with the images. The research will be conducted in accordance with the principles proposed by the Australian Association for Research in Education (AARE), the Australian Vice-Chancellor’s Committee (AVCC) and the National Health and Medical Research Council (NHMRC). Despite the study being of low risk to humans, a Form A will be submitted to Ethics due to the potential hazards associated with finger prick blood collection. All participants will provide voluntary informed consent before commencement of the study; at no stage will they be subject to coercion or pressure in making their decision to participate. Approval from both the Human

Research Ethics Committee and the Pro Vice-Chancellor of Academic Services will be sought for study participants who are either Curtin staff or students. Subjects will be provided with a study ID and all data collected from each individual throughout the study will remain strictly confidential to avoid personal and social harm. All raw data, in electronic form, will be kept for five years in a secure location at the Faculty of Health Sciences, Curtin University. Only researchers will have access to this data. No reference to individual participants will be made in any of the resulting publications. Should issues regarding intellectual property emerge, the University Solicitor will be consulted and the School informed immediately. The authors uphold their declaration that they have no conflicts of interest and will abide by the principles of the *Australian Code for the Responsible Conduct of Research 2007*.
Whilst there are no direct ethical implications of recording food intake, the use of camera mobile devices may be inappropriately used for other non-approved purposes. The University proposes to address such issues by the user signing an agreement about its proper use, and their consent in recording their personal details, which includes their food consumption. Informed consent will be obtained both the subject and their legal guardian. It will be made clear to the participant that all data will be kept confidential and that they can withdraw without penalty at any time

Australian Mobile Telecommunications Association (http://www.amta.org.au/?Page=261) – has developed the following statement for "Mobile Manners':
'Respect others' privacy when using in-phone cameras: In-phone cameras shouldn't be used anywhere a normal camera would be considered inappropriate, such as in change rooms or toilets. You should ask for permission before you take someone's picture. Also bear in mind that some venues do not allow the use of cameras and may refuse entry o anyone with one.'

TIMELINE

Step	**Goal**	**Major task/s**	**Completion date**
1	Submission of clinical trial register and ethics approval.	Writing of 5-page research proposal and application for ethics approval, submitted to Graduate Studies Committee.	June 2014
2	Data collection	Recruit subjects and record height, weight, waist circumference, blood pressure, serum cholesterol at baseline and during the twelfth week. Also obtain 4-day mdFRs for	July/ August 2014

		the first and final study weeks.	
3	Analysis, review and reporting	Data collected will be analysed in several ways to determine changes in frequencies of eating occasions and body weight.	September / October 2014
4	Preparation of publication		November 2014

FACILITIES, RESOURCES and BUDGET

Both the information session and training on the use of the mdFR will take place in the seminar room, 400.305, at the School of Public Health, Curtin University. The fasting venous blood samples will be collected in the clinical laboratory, 400.135, at the School of Public Health, Curtin University. The proposed budget is outlined below.

APPROVALS

An application for ethics approval has been lodged to the Curtin University Human Research Ethics Committee.

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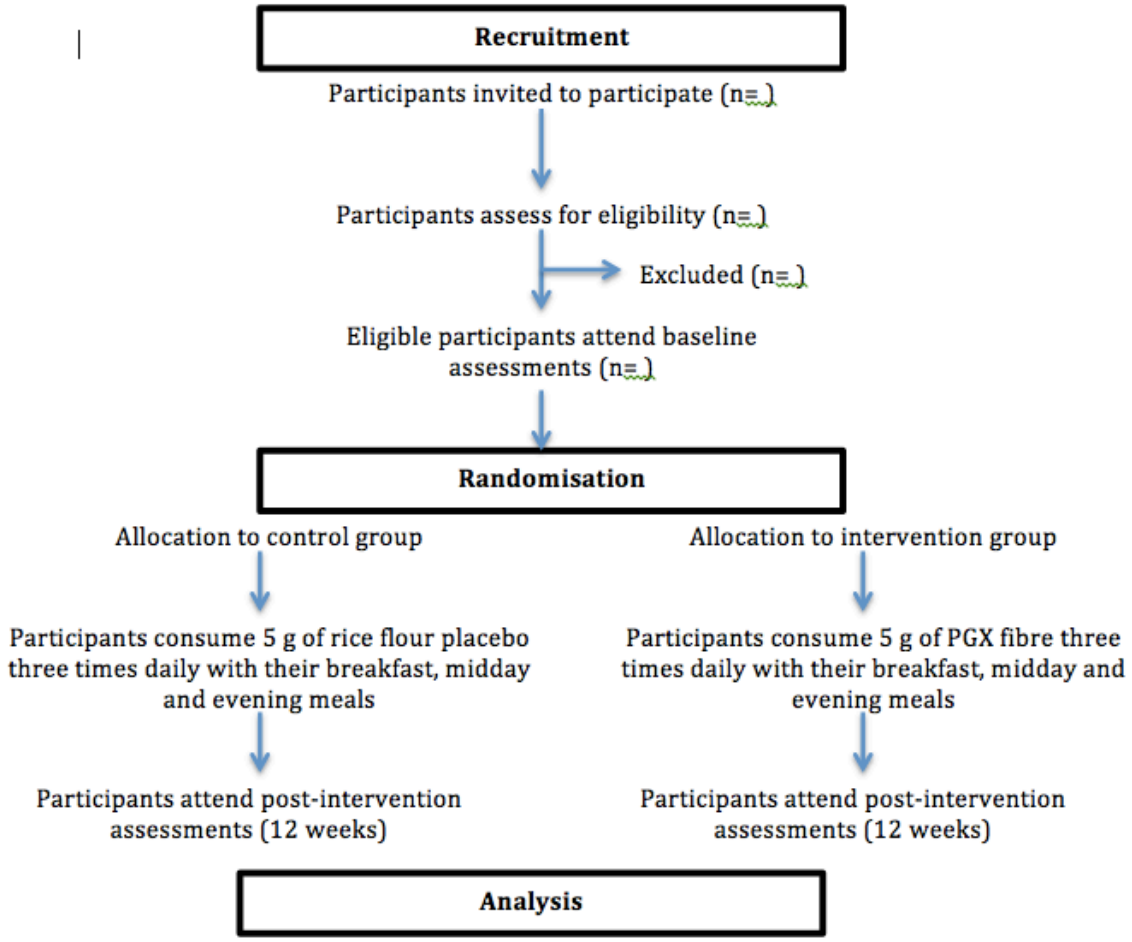
APPENDICES

Appendix A: Study design template



Appendix B: System architecture for CHAT app mobile device food record

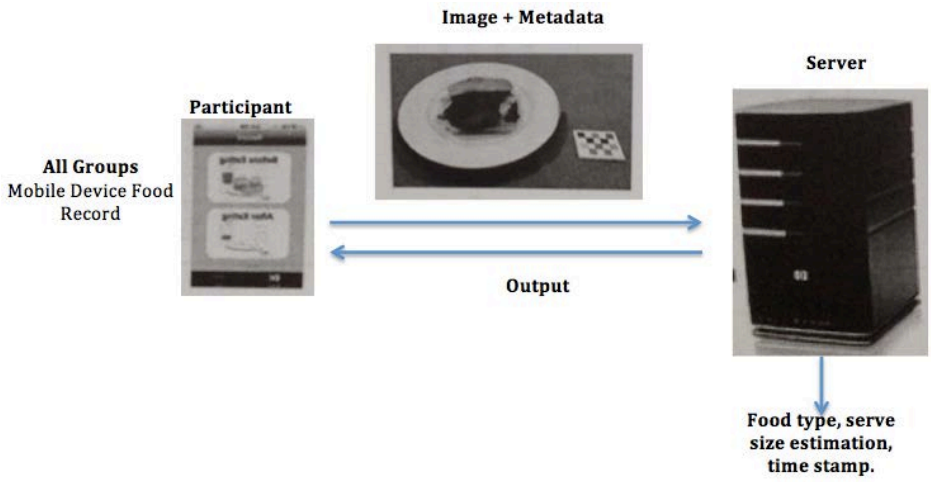


Image + Metadata
Server
Participant
All Groups
Mobile Device Food Record
Output
Food type, serve size estimation, time stamp.