Dietary Fibre Intake: Validity of a Short-Term Food Frequency Questionnaire; Association with Gastrointestinal Health and Public Perceptions

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Science

In

Nutrition and Dietetics

Massey University, Albany,

New Zealand

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2018

Abstract

Introduction: Dietary fibre is an important constituent of the diet as it plays a key role in reducing the risk of certain diseases. There are several validated dietary assessment tools that measure current fibre intakes; however these are lengthy, cannot be self-administered or classify dietary fibre intakes. The beneficial effects of fibre consumption have led to dietary recommendations that encourage adequate intake, yet there are a limited number of studies that have investigated the effect fibre has on gut symptoms or examined the perceived benefits *versus* barriers to eating fibre containing foods.

Objectives: This study aimed to validate a tool that measures short term dietary fibre intake against a 4-day food record, and compare dietary fibre intake to gastrointestinal symptoms. The study also aimed to survey perceived benefits and barriers to dietary fibre intake.

Methods: One hundred and five healthy male and female participants aged 19-65 years completed the study. All eligible participants completed a 4-day diet record, a food frequency questionnaire based 9-item dietary fibre intake tool (DFiT), a daily gastrointestinal symptom diary and a 15-item dietary fibre perceptions survey. Agreement between the 4-day diet record and DFiT was analysed using a paired t-test, correlation coefficient, cross-classification, weighted k statistic and Bland Altman analysis.

Results: The DFiT was accurate in classifying but not estimating total dietary fibre intakes. When different levels of dietary fibre intakes were compared to markers of gastrointestinal health, there were no associations found for occurrence or severity for gastrointestinal symptoms. However, high fibre consumers pass one additional bowel motion per day and had softer stool than low fibre consumers. The survey of perceptions showed that the majority of participants agreed with the health benefits, however just over half of participants identified with barriers. There were some differences in responses between genders, levels of dietary fibre intake and socioeconomic status.

Conclusion: The DFiT is a valid, simple, short and easy to use questionnaire for classifying but not estimating total short term dietary fibre intakes. In the context of sustainability and shift towards a higher consumption of dietary fibre, it is important to further investigate the effect of dietary fibre on gastrointestinal symptoms and perceptions of barriers.

Acknowledgements

I would have never been able to complete my thesis without the guidance of my supervisors and support from family and friends.

I would first like to thank my supervisors Dr Jane Coad and Dr Genelle Healey who have guided me throughout this project from start to finish, thank you both for sharing your knowledge with me, I am grateful for your valuable feedback. I would also like to thank Dr Barry McDonald for his support with the data analysis; this thesis would not have been possible without your input.

I must express my very profound gratitude to my parents Grace and Richard and to my sister Jessie for your unfailing support and continuous encouragement throughout my years of study. Without you all, I am nothing.

Finally I would like to thank Massey University Institute of Food Science & Technology for funding this project.

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Abbreviations list

CHD	Coronary heart disease
CRC	Colorectal cancer
CVD	Cardiovascular disease
DFI-FFQ	Dietary fibre intake food frequency questionnaire
DFiT	Dietary fibre intake tool
FFQ	Food frequency questionnaire
GSRS	Gastrointestinal symptom rating scale
HbA1c	Glycosylated haemoglobin
LoA	Limits of agreement

Chapter 1: Introduction

Dietary fibre is defined as an indigestible carbohydrate and is comprised of two main types; soluble and insoluble fibre. Dietary fibre is resistant to digestion and absorption in the small intestine and usually undergoes complete or partial fermentation in the large intestine (2). The significance of dietary fibre is marked by its association with various pathologies such as cardiovascular disease (3), type 2 diabetes (4), metabolic syndrome (5) and gastrointestinal cancers (6). Furthermore, it is associated with a myriad of physiological outcomes such as: lowering cholesterol and blood pressure (7) and modulating gut bacteria (8). Evidence of the beneficial role fibre plays in human health, therefore, is strong, which in turn increases the demand for suitable dietary assessment methods for assessing fibre intake.

A small number of tools that measure current fibre intakes have been developed over time. The dietary intervention in primary care (DINE) tool is a brief assessment of an individual's fat and fibre intake (9). It is designed to be used in a clinical setting and categorizes different levels of fibre intake: low, medium, or high. It has been previously validated with a 4 (9) and 7 day semi-weighed food diary (10). It is designed to be administered by a nurse and is estimated to take 20 minutes to complete. Therefore, it does not encompass the efficiency and cost-effectiveness features that a web based self-administration method would provide.

In the same vein, the fat and fibre related behaviour (11) and the fat and fibre barometer questionnaires (12) were also developed to provide an insight into the process of adopting healthy behaviours. They are considered to be a valid and a reliable measure of dietary intake. However, these tools also lack the features mentioned previously.

Currently, there are no tools that can rapidly assess an individual's short-term dietary fibre intake and provide a valid and relevant clinical assessment for healthy New Zealand adults. Recently, a dietary fibre intake tool (DFI-FFQ) was developed to measure habitual dietary fibre consumption and classify the level of fibre intake (13). As a response to a lack of tools with the aforementioned features, the DFI-FFQ was

designed to be self-administered, easy and quick to complete and can be web-based. The results of its initial validation revealed that additional food groups and a supplemental question to include prebiotic supplements could be incorporated to improve total fibre intake estimation. The tool's inherent features make it an ideal candidate for further development and subsequent validation of a short-term food frequency fibre intake questionnaire in healthy New Zealand adults.

The beneficial effects of dietary fibre consumption on health have led to dietary recommendations that are predominantly plant based in the treatment of high blood pressure and cardiovascular disease (14), metabolic syndrome (15) and type 2 diabetes (16). In light of this, only a few studies have examined barriers specific to dietary fibre intake. A qualitative study with closed-ended questionnaire items identified that the majority are aware of the health benefits, yet barriers for fibre consumption include a lack of information about plant based diets and an unwillingness to modify dietary behaviours (17).

Additionally, it has been hypothesized that dietary fibre, especially that which is fermented, produces intestinal gas (1).Given this, barriers to dietary fibre consumption may include perceptions of gastrointestinal symptoms; a qualitative survey of dietitians identified that patients avoid certain fibre containing food groups such as legumes, due to fear of gastrointestinal symptoms like flatulence, abdominal discomfort and bowel movements (18).

Currently, the literature presents a limited number of studies examining these perceptions about specific fibre containing foods. Clinical studies examining the effect of bean consumption on gastrointestinal health have failed to find a negative association (19). The same result was demonstrated in another study investigating consumption of pulses specifically (20). The evidence base is, therefore, weak owing to the limited number of studies; which warrants further research.

To our knowledge, firstly, there is no rapid short-term dietary fibre intake assessment tool that is validated for use in healthy adults. Secondly, there are only a limited number of studies that have been carried out to examine dietary fibre intake and its apparent physiological relation to markers of gastrointestinal health, and

finally, there are no New Zealand specific surveys of public perceptions on the health benefits and barriers to dietary fibre intake.

1.1 Aims

To modify the DFI-FFQ and validate it against a 4-day food diary in healthy adults aged 19-65 years in New Zealand, compare dietary fibre intake to markers of gastrointestinal health and survey perceptions of health benefits and barriers to fibre intake.

1.2 Objectives

Primary

1. The primary objective of the study will be to validate the modified DFI-FFQ (DFiT) against a 4-day food diary to determine whether the DFiT can accurately measure short-term total dietary fibre intake and classify individuals as low, moderate or high dietary fibre consumers.

Secondary

2. To compare intakes of dietary fibre with markers of gastrointestinal function such as flatulence, abdominal discomfort and frequency of bowel movements.
3. To qualitatively assess perceptions of health benefits and barriers to dietary fibre intake and examine the association between different levels of dietary fibre intake.

1.3 Hypothesis

1. The DFiT can accurately predict short-term total dietary fibre intakes and classify healthy individuals based on their dietary fibre intakes.

2. Different levels of dietary fibre intake (low *versus* moderate *versus* high) will be associated with differing perceptions of health benefits and barriers to dietary fibre intake.

3. Different levels of dietary fibre intake (low *versus* moderate *versus* high) will be associated with markers of gastrointestinal function: flatulence frequency, abdominal discomfort and bowel movements.

1.4 Thesis structure

Chapter one presents the scope of the study and justifies the research carried out, this includes the aims, objectives and the hypothesis of the study. Chapter two is the literature review, in which the role of dietary fibre in the aetiology of diseases and its association with symptoms is reviewed. Dietary assessment validation epistemology and existing tools are also reviewed in this chapter. Chapter 3 presents the study as a manuscript; this includes the results, discussion and conclusion of the study. The final chapter includes a brief overview and achievement of the aims and objectives of the study, as well as the new knowledge generated and its contribution to research, followed by strengths and limitations of the study and final recommendations.

1.5 Contribution of researchers

John Micah MSc Nutrition and Dietetics Candidate	Responsible for writing the research proposal, modification of the questionnaires, study design, ethics application, recruitment of participants, data collection and data analysis, and editing and preparation of the manuscript.
Dr Jane Coad Primary Supervisor	Responsible for supervising and assisting with the research proposal, modification of the questionnaires, study design, ethics application, and editing and preparation of the manuscript.
Dr Genelle Healey Co-supervisor	Responsible for supervising and assisting with the research proposal, modification of the questionnaires, study design, ethics application, and editing and preparation of the manuscript.
Dr Barry McDonald Co-supervisor	Responsible for supervising and assisting with data analysis and presentation of the results.
Owen Mugridge Research Assistant	Responsible for advertising the study on the web and assisting with recruitment.

Chapter 2: Literature review

2.1 Introduction

A literature search was conducted between July 2016 to November 2017 to review the role of dietary fibre in the diet, definition, health benefits, fibre assessment tools, effects on gastrointestinal health and consumer perceptions, by searching in databases: Google Scholar and PubMed. A combination of keywords was used for searching, “health benefits”, “cardiovascular disease”, “diabetes”, “cancer”, “fibre/fiber”, “soluble”, “insoluble”, “dietary”, “validity”, “questionnaire”, “assessment”, “evaluation” “tool”, “Gastrointestinal markers/symptoms”, “flatulence”, “abdominal discomfort”, “bowel motion/frequency”, “stools”, “perceptions” and “benefits and barriers”.

2.2 Definition

Historically, dietary fibre was thought to be a component of food that had negligible nutritional value (21). Intake of fibre was suggested to be important when fibre was linked to pregnancy toxaemia (22). Subsequently, the increased prevalence of colonic disorders in westernized countries was linked to a deficiency of dietary fibre (23, 24). Early population studies examining diet-disease relationships in different countries theorized high dietary fibre consumption was a protective factor against ischemic heart disease, diabetes mellitus and obesity (25).

Dietary fibre was defined initially as components of a plant cell wall that are resistant to enzymatic digestion in humans; this included cellulose, hemicellulose and lignin (26). This definition was later expanded to include, not only the constituents of the cell wall but also other components of a plant cell that are indigestible such as gums, modified celluloses, mucilages, oligosaccharides and pectins (27). Over time, methods for quantifying dietary fibre in foods were developed and standardized, in response to the evolving definition. (28).

More recently, the American Association of Cereal Chemists proposed a more specific definition for dietary fibre. “Dietary fibre is the remnants of the edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in

the human small intestine with complete or partial fermentation in the human large intestine. It includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibre exhibits one or more of either laxation (faecal bulking and softening; increased frequency; and/or regularity), blood cholesterol attenuation, and/or blood glucose attenuation" (AAOC 2001). This definition is consistent with the one provided by Food Standards Australia and New Zealand (29). The above criteria recognize three characteristics that a compound must have inherently to be termed as dietary fibre: indigestibility, specificity and physiological activity.

2.3 Diet-disease relationship

2.3.1 Cardiovascular disease

Cardiovascular disease (CVD) is the leading cause of death, both globally (30) and in New Zealand; 33% of all deaths are attributed to CVD (31). CVD refers to a group of heart and blood vessel disorders that includes hypertension, coronary heart disease, cerebrovascular disease, peripheral vascular disease and heart failure (30). A common factor in the pathogenesis of many of these conditions is atherosclerosis, it is structurally described as hardened plaque composed of fat, cholesterol and other substances that obstruct blood flow in arteries (32).The Eating and Activity Guidelines for Adults developed by the Ministry of Health (33) recommends eating fibre containing foods to protect against CVD related conditions.

Keys and co-authors were the first to investigate dietary fibre and cholesterol absorption in humans (Keys et al., 1961). A study was conducted using middle aged men who were reported to have normal cholesterol levels. Subjects were fed a 15g fibre supplement consisting of pectin in addition to their normal diet. Results showed that in 3 weeks participants' cholesterol levels dropped by 5% on average. Prior to this study, the same effect of pectin was first evidenced in rats (34) and later in cockerels (35). The methodology of these studies is questionable due to firstly, the small sample size and secondly, the type and amount of fibre isolated is not representative of a standard diet that the majority consume and, therefore, is not practical to adopt. Never the less, these studies were pivotal in identifying a link between dietary fibre and cholesterol absorption.

Subsequently, in the same decade, numerous studies described similar effects in human and animal models (36-41). This effect was then associated with a clinical endpoint in a later study by Trowell; it was found that serum cholesterol levels and ischaemic heart disease incidence was lower in groups that naturally consumed a higher fibre diet (26). These findings, in turn, led to the development of the dietary fibre hypothesis (42), which describes the link between dietary fibre and protection against a range of conditions including coronary heart disease.

Up to the present time, there have been numerous large scale observational epidemiological studies in different populations. The Zutphen study involved 871 middle aged men in the Netherlands who were followed for 10 years, and during these years, 37 died from coronary heart disease (CHD). The authors reported an inverse relationship between dietary fibre intake and CHD (43). Similarly, another study in England which consisted of 337 middle aged men who were followed for 10 years evidenced the same finding (44). Also, in the diet-heart study, 1001 men's diets were surveyed for 20 years and it was found that, fibre intake was lower among those who died from CHD (45). These well powered prospective studies have consistently shown dietary fibre to be protective against heart disease, lending support to Trowel's earlier observation (25). However, it is unclear which fractions of dietary fibre mediate this effect, soluble *versus* insoluble fibre. The Zutphen study measured total dietary fibre intakes and did not analyse by different fibre containing food groups. Similarly, the diet-heart study measured crude fibre intakes and did not differentiate between food groups. In the English study, analysis by food groups revealed an effect for cereals only and not fruits and vegetables. This finding is inconsistent in comparison to a more recent study, in this larger prospective cohort study that involved both men and women, it was found that fibre fruit and vegetable intake was independently protective after controlling for the effect of fibre from cereals (46). The results of a systematic review of the association between fruits and vegetables and CHD and stroke may, in part, explain this inconsistency. Ness and Powles concluded that, while fruit and vegetable consumption confers protection, the effect may be weaker for CHD and stronger for stroke (47).

There may be a negligible difference in the protective effect of fibre between men and women. In a systematic review (48), 10 prospective cohort studies totalling 91,058 men and 245,186 women from the United States and Europe were included in a pooled analysis of dietary fibre, its subtypes and the risk of CHD. Inclusion criteria allowed for only studies with a minimum of 150 incident coronary cases and studies that employed a validated dietary instrument. The median total fibre intake ranged from 17 to 30g per day, after adjustment for demographics, body mass index and lifestyle factors it was found that, a 10g per day increment of total dietary fibre is associated with a 14% and 27% decrease in risk for coronary events and death, respectively. These findings were similar for both sexes. It is also interesting to note that, fibre from cereals and not fruits and vegetables was independently responsible for the risk reduction.

2.3.2 Diabetes Mellitus

Diabetes is defined as a progressive chronic disease characterized by a high level of blood glucose. The most common form is type 2 diabetes, initially the beta cells in pancreatic islets compensate for insulin resistance by producing a higher level of insulin to maintain a normal level of blood glucose (in between 3.9 and 5.5 mmol/L in a fasted state), but over time the pancreas becomes ineffective (49). Diabetes is related to kidney failure, heart attack, stroke, lower limb amputation and blindness (49). The prevalence of diabetes is increasing, the World Health Organization predicts that diabetes will be the seventh leading cause of death in 2030 (50). In New Zealand, it is estimated that more than 200,000 people are living with diabetes (predominantly type 2 diabetes) (51). Diet may be a major risk factor associated with developing diabetes.

Dietary fibre may play a role in the prevention of diabetes. The European Prospective Investigation into Cancer and Nutrition (EPIC) was established to determine the relationship between nutrition and cancer and other chronic diseases. Recently, a prospective cohort study (52) in the Netherlands as part of EPIC, was conducted to investigate associations between dietary fibre, glycaemic load and glycaemic index, and the risk for type 2 diabetes. A total of 37, 846 persons aged between 21 to 70 years who were free from diabetes were followed for an average of

10 years. Participants' dietary intake was assessed using a validated food frequency questionnaire and incident cases were self-reported and verified with medical records. The results showed that dietary fibre was inversely associated with diabetes risk; diets that were high in glycaemic load, index and starch and low in fibre were associated with an increased risk. By the same token, in the EPIC Germany study, which consisted of 9702 men and 15,3605 women who were followed for 11 years, a higher dietary fibre intake was found to be protective (53).

In a bid to understand which fibre subtypes are involved in risk reduction, specific sources were investigated. The previously mentioned study also carried out a meta-analysis of prospective cohorts from different countries, it was found that a higher intake of cereal *versus* fruit and vegetable fibre was associated with a lower risk of diabetes (53). It is not clear what mechanisms are involved however it is proposed that insoluble fibre reduces diabetes risk via production of short chain fatty acids in the colon that affect hepatic insulin insensitivity (53). A later study demonstrated the same finding and supports this conclusion as researchers failed to find beneficial effects of fruit and vegetable consumption on diabetes risk (54). Despite these findings, however, increasing consumption of fruit and vegetable may indirectly confer protective effects through reducing the risk for developing obesity (55), as a high body mass index is associated with higher levels of insulin resistance, which is characteristic of diabetes (56).

In addition to having a preventative role, increasing dietary fibre intake may form part of treatment. Post and co-authors (16) performed a meta-analysis of randomized controlled trials investigating the effect of increasing dietary fibre on glycosylated haemoglobin (HbA1c) and fasting blood glucose. It was found that dietary fibre as an intervention *versus* placebo, resulted in a mean decrease of 26% (95% CI; 0.02 – 0.51) in HbA1c. However, the type of fibre used varied widely and in some studies, it was unknown. Additionally, the increase in fibre consumption varied widely, from 4g/d to 40g/d. Furthermore, the small decrease in HbA1c may in part, be explained by the inclusion of studies that lasted less than 12 weeks, glycosylated haemoglobin (HbA1c) turns over every 12 weeks and hence it should be measured within an appropriate time frame. In light of such evidence, the American Dietetic

Association recommends increasing fibre intake up to 50g/d in those with diabetes (57)

2.3.3 Cancer

The link between dietary fibre and cancer was first investigated nearly 50 years ago. It was speculated that dietary intake differences between developed and developing countries may explain the significant difference in bowel cancer incidence rates (24). Investigations into the relationship between dietary fibre and cancer have focused on cancers of the colon and rectum as these are the main sites involved in interactions with dietary fibre. Colorectal cancers (CRC) first begin as a growth (polyp) on the inner lining of the colon or rectum. Over time, some types of polyps can change into cancer (58). CRC development is associated with environmental risk factors such as physical activity and dietary intake (59).

Case control studies show dietary fibre intake is inversely related to colorectal cancers. In a combined analysis of 13 studies, Howe and co-authors examined the effects of fibre, vitamin C and beta carotene intakes on CRC risk (60). The sample group consisted of 5,287 CRC diagnosed and 10,470 control subjects from different countries. Results showed 12 of the 13 studies reported an inverse association, and furthermore the relative risks (RR) were 0.79, 0.69, 0.63, and 0.53 for the four highest quintiles of intake compared with lowest quintile ($p < 0.0001$) after adjusting for total energy intake, age and sex. However, case control studies are retrospective and rely on individuals to recall dietary intake information over a long period of time, therefore, increasing the potential of an inaccurate dietary fibre intake estimate.

Evidence from prospective observational cohort studies is unclear. Bingham and co-authors investigated dietary fibre in food and CRC incidence, as part of EPIC (61). The study included 519,978 individuals aged 25-70 years who were recruited from 10 European countries, including the United Kingdom. Participants were followed from 1992 to 1998; with an average of 4.5 years follow up being reported. Dietary intake was assessed through a food frequency questionnaire that was country specific. Results showed that dietary fibre was inversely associated with CRC incidence. Overall, the RR was 0.70 [95% CI, 0.58-0.85] ($p = 0.005$) for the highest *versus* lowest quintile of

intake after adjusting for age, gender, BMI, energy from fat, non-fat energy and centre. The same conclusion was formed in another study of the United States and Hawaiian populations (62), in which authors reported a lower RR of 0.49 [95% CI, 0.41-0.60] ($p < 0.001$) for the highest *versus* lowest quintiles of intake. The average total fibre intake per day in both studies was similar in the highest and lowest quintiles.

The same association was not evidenced in a pooled analysis of prospective cohort studies. Park and co-authors analysed 13 prospective cohorts that had at least 50 incidents of CRC. Habitual dietary fibre intake was assessed using a validated dietary instrument. Pooled data consisted of 725,628 participants who were followed for 6 to 20 years. While the age adjusted model showed an inverse association that was significant (pooled RR was 0.84 [95%CI, 0.77-0.92] [$p = 0.002$] for highest *versus* lowest quintiles), the significant association disappeared after further adjusting for age, BMI, physical activity, family history of CRC, hormone therapy and drug use, smoking, multivitamin use, folate and red meat intake, total meat and alcohol intake (pooled RR was 0.94 [95%CI, 0.86-1.03] [$p = 0.75$]) (63). These results are not in support of the previously mentioned studies (61, 62) and may be attributed to the difference in risk factors adjusted for in models. However, a later EPIC study, explored whether the association remained after a longer follow up and found a statistically significant association despite adjusting for risk factors similar to the pooled analysis (64).

In a large scale randomized controlled trial, that investigated the effect of a low fat and high fibre diet on CRC adenoma recurrence (65), the treatment group (n= 958) was instructed to consume 20% of total energy intake from fat and 18g of dietary fibre per 1000kcal and the control group (n = 947) were instructed to follow their usual diets. After 4 years the assigned diets showed no differences in recurrence rates between groups. Specifically, 39.7% (intervention) and 39.5% (control) had at least one recurrence. The risk ratio was 1 (95% CI; 0.90-1.12) suggesting that there was no observed effect of a low fat and high fibre diet on CRC recurrence. A potential explanation for the lack of an effect is that the dietary intervention period may have been too short (4 years), a longer period could have allowed for the development of a sufficient number of adenomas, thereby allowing for an effect to be identified.

2.3.4 Mechanisms

The mechanisms involved vary and are associated with the physiochemical properties of dietary fibre: viscosity, water holding capacity, bile acid binding, and fermentation.

Viscosity of dietary fibre can be defined as the ability of fibre to thicken fluids. The viscosity of soluble (gums, pectins, psyllium and beta glucans) versus insoluble fibre is higher. Viscous fibres have been shown to decrease the glycaemic response via delaying gastric emptying by forming a gel matrix owing to its water holding capacity (66). Also, the absorption of nutrients is modulated via reducing contact with digestive enzymes and the intestinal transit time is reduced (66). As a result, post prandial glucose levels are decreased thereby decreasing diabetes risk (66-67).

Soluble dietary fibre (SDF) has an effect on bile acid metabolism. Bile acids are synthesized from cholesterol in the liver, stored in the gall bladder and secreted to the intestine to aid in the absorption of lipids, they are also involved in regulating hepatic lipid metabolism via cell signalling pathways (68). Consumption of SDF has been shown to significantly reduce total plasma cholesterol and low-density lipoprotein cholesterol (67), this effect is thought to be mediated by binding of the bile salts by SDF in the intestine and excretion in the faeces thereby preventing re-absorption (68). Consequently, depletion in the bile acid pool stimulates cholesterol catabolism in the liver leading to lower plasma TC and LDL-C (69).

In addition, SDF can undergo anaerobic bacterial fermentation in the caecum and colon, metabolites are produced as a result, and these include short chain fatty acids (SCFAs): butyrate, propionate and acetate (66-68). There are numerous health benefits associated with SCFAs, the associated mechanisms are complex. SCFAs are thought to play an important role in cancer of the colon as they are an energy substrate for the colonocytes, modulate colonic, intracellular pH and cell volume, and are involved in the regulation of cell proliferation, differentiation and gene expression (69).

2.4 Gastrointestinal function markers

2.4.1 Excessive flatulence, abdominal discomfort and bowel movements

Excessive flatulence has been described as an excessive amount of air or gas accumulating in the stomach or intestines, symptoms can be varied and include, stomach discomfort, cramps and diarrhoea. Intestinal gas is composed of oxygen, carbon dioxide, methane, nitrogen and hydrogen, and its production is dependent upon age, ethnicity, and extent of air swallowing, colonic fermentation and more importantly; the diet. Particular fibre containing foods such as legumes have been linked to causing excessive flatulence (1).

The indigestibility of some oligosaccharides gives rise to the potential for excessive flatulence. This may be attributed to the lack of alpha galactosidase in humans, this enzyme is required to digest specific oligosaccharides such as raffinose, stachyose and verbascose. If consumed, they are subject to fermentation by colonic bacteria (70) resulting in gas production that can lead to abdominal discomfort and increased flatulence (1).

Given this, barriers to increased dietary fibre consumption may include perceptions of gastrointestinal symptoms due to their indigestibility. A qualitative survey of dietitians revealed that patients avoid certain fibre containing food groups such as legumes, due to fear of gastrointestinal symptoms like excessive flatulence, abdominal discomfort and bowel movements (18). These reports are supported by food composition data. **Figure 1** shows varying amounts of the indigestible fibre fractions (raffinose, stachyose and verbascose) found in legumes.

Veenestra and co-authors carried out a randomized double-blind placebo-controlled cross-over study (20), in which they assessed the effect of pulse consumption (chickpeas, lentils and peas) on gastrointestinal function and perceived flatulence in healthy males. Participants received 100 g/d of the three different pulses as treatment. The study design consisted of four 28-day treatment periods separated by 28-day washout periods. Participants completed a questionnaire before (pre-phase) and during the study (early and late phases) that assessed flatulence, abdominal

comfort and bowel habits. Results showed minor significant changes in occurrence and/or severity of flatulence and abdominal comfort.

This study showed that while flatulence occurrence was similar before and during the study, severity was significantly higher during the study for chickpeas and lentils. This is expected, given that legumes have been shown to have an indigestible component. Previously, it has been shown that 200 g of lentils (containing 16 grams of fibre) produced 34-41 mL flatus per hour (1), and another study showed a quantitative increase in intestinal gas production following consumption of 100 g of kidney beans (71). Despite these findings, the authors concluded that, the perceived changes in flatulence and gastrointestinal function were negligible.

Winham and Hutchins conducted a parallel trial (19) in which the relationship between bean consumption and perception of increased flatulence and gastrointestinal discomfort in 80 subjects was investigated. The treatment group received half a cup of pinto beans (7 grams of fibre) and the control group received soup (2 grams of fibre) for 12 weeks. At the end of each week participants completed a gastrointestinal questionnaire that assessed changes in flatus, bloating and stools. An ordinal scale was used to indicate the magnitude of change. Results showed that 45% of participants in the treatment group reported increased flatulence in week one, however, this figure reduced to 15-23% in weeks 6 to 12. By contrast, only 3-8% consistently reported an increase in the control group. Interestingly, women were more likely to report bloating and stool changes more often than men in the treatment group.

An adaptation of the gastrointestinal (GI) system may explain the decreasing trend in perceived flatulence. Winham and Hutchins concluded that any initial increase in perception of this symptom will decrease over time if bean consumption is consistent (19). However, this idea is not supported by physiological evidence, Donnell and co-authors investigated the effect of frequent legume consumption on excretion of fermentation gases (71). Flatus gases were measured both quantitatively and qualitatively. Results failed to identify a decrease in the volume of intestinal gas or excretion of fermentation gases. Despite this result, researchers did note that

participants reported lesser physical discomfort and a greater tolerance during the study. While these results are not in support of a GI adaptation directly, it does suggest that an individual's perceptions may be desensitized. Therefore, any presenting barriers to legume consumption may change over time if bean consumption is consistent.

Oligosaccharides of leguminous beans [mg g^{-1}]

Ref. Species	Sucrose	Raffinose	Stachyose	Verbascose
[36] Chickpea	20—23	8—9	15—19	tr
[37] Fieldpea	19	6	17	23
[36] Green pea	35	10	27	
[36] Horsebean	23	7	24	
[36] P. vulgaris	22 24	9—11	35 56	
[38] Mung bean	8—9	4 -5	17—20	
[38] Adzuki bean	6 7	3	28 41	
[38] White bean	26	4—7	34—39	
[36] Lentil	13	5	22	tr
[39] Cowpea	22	12	34	9
[40] Black gram	15	tr	9	34
[36] Soybean	40 -70	11—18	38—48	
[41] Red gram	8—15	3—18	* 12—16	
[42] Peanut	59	3	9	tr
[42] Broad bean	25	7	20	23
[42] Asparagus bean	10	5	35	5
[42] Sword bean	25	13	13	2
[43] Kidney bean	16	4	4	
[43] Pink bean	15	4	4	
[43] Blackeye bean	26	4	4	

* combined figure for stachyose and verbascose

Figure taken from (1)

Figure 1: Oligosaccharide content of leguminous beans

2.5 Perceptions of Dietary Fibre

The Ministry of Health in New Zealand provides dietary guidelines on the consumption of fibre containing foods. The Eating and Activity guidelines for New Zealand Adults published by the Ministry, recommend consumption of 25-30g of dietary fibre every day, whereas to reduce chronic disease risk, it is recommended that women should consume 28g and men 38g daily (2). The New Zealand Adult Nutrition Survey conducted in 2008/09 showed that the median daily intake was 19.6g which is less than the recommended amount for men and women (72). This finding suggests that other barriers may be present, which in part may be explained by differing perceptions.

In recent years, social psychologists have attempted to conceptualize theory based models in a bid to understand the decision making process of an individual. For example, there are the trans theoretical model, the theory of planned behaviour model and the health belief model (73). The latter is based on two key behavioural theories, the motivation to avoid illness and the belief that undertaking particular actions will prevent illness. In this model, the likelihood of action is determined in part, on the perceived benefits versus the barriers to behavioural change and this is affected by age, sex, ethnicity, socioeconomics and knowledge (74). This model suggests that, for an individual to frequently consume fibre containing foods, the perceived benefits versus barriers must be greater.

In an investigation of perceptions that individuals may have, Lea and co-authors studied the perceived benefits and barriers to consuming a plant based diet by administering a closed-ended survey (17). The barriers section included 27 items that related to socio-cultural and socio-economic aspects. The benefits section included 24 items that related to awareness of health benefits, taste, sustainability and practical aspects. Results showed that, although the majority of participants were aware of the health benefits, common barriers were a lack of dietary information and an unwillingness of the individual or family to alter their current diets, however, most participants did not identify these or other barriers. Despite these findings, it was found that only a minority (7.4%) were consuming the recommended amount of high fibre foods, a finding that is not explained by the health belief model. Thus, suggesting that knowledge does not necessarily translate into behaviour, a conclusion that is unclear in the literature (75, 76). And furthermore, other barriers may be present that the survey did not address.

Perceived barriers may differ between sub groups within a population. For example, in families with children, meals are likely to be influenced by the child's acceptance. In a study that investigated the perceived benefits and barriers of lentil consumption in families with young children, the most common barrier identified related to the child's food preference (77). This suggest that, a family's acceptance for a food is a culmination of the members' preferences, meaning that an individual's

perceived barrier is influenced by the food preferences of others. This in turn is a determinant of choosing to eat fibre containing foods.

2.6 Dietary assessment methods

Over the past few decades, dietary assessment has become the cornerstone of epidemiological research in the field of nutrition and health. Over time, different methods for collecting dietary information have been developed: such as the food record, 24-hour recall and food frequency questionnaire. These methods are subjective and rely on the individual to provide dietary information. There has been considerable debate regarding the significance of such methods in epidemiological research. The merits and drawbacks will be reviewed, with respect to dietary fibre.

2.6.2 Food record

The food record relies on the subject to record their food and/or fluid intake over the course of one or more days. The portion sizes are either estimated, weighed or both. The former typically requires the individual to make estimated guesses using household measures or a to-scale pictorial representation of foods, whereas weighed food records require portions to be weighed and are more accurate. Food records contain the date, the time a food is eaten, a description of the food or the brand name of the product and the portion size. Ideally, entries should be made close to the time that a food is eaten and hence should not rely on memory (78). In recent years, food records are used less in epidemiological research due to having a high respondent burden, and also dietary analysis for large cohorts can be expensive, time consuming and, therefore, impractical (79). Food records, however, are used for validating other methods and are thought to be the 'gold standard' reference method (78, 79).

There are several drawbacks to using a food record. Firstly, it requires subjects who are literate and highly motivated (78). Secondly, the quality of the entries decreases over time which can result in under or over reporting (78) and thirdly, recording can cause an individual to alter their diet (78). Individuals' may incorrectly estimate portion sizes of fibre containing foods or submit records with missing entries. Therefore, not being representative of actual fibre intake, which can translate to poor validation of other instruments.

2.6.3 Food frequency questionnaire

The food frequency questionnaire (FFQ) was developed in the mid 1900's to measure habitual dietary intake, since then it has undergone several revisions to become a major dietary assessment tool in epidemiological, interventional and observational studies (80). In comparison to a food record, the FFQ qualitatively assesses dietary intake by asking the respondent to indicate the consumption frequency of a list of foods over a defined time period – per day, week or month etc. And can either be self or interviewer administered (81). The FFQ can be semi quantitative with the inclusion of reference portion sizes for foods which allows for total energy and nutrient analysis (79).

There are several advantages associated with administering a FFQ. Firstly, the participant burden is significantly less when compared to a food record, it can be completed in one sitting and can reflect dietary intake of up to a year if validated, reducing the cost of data collection. Costs can be further reduced if the FFQ is designed to allow for computerised data entry. FFQ's are flexible and can be adapted to studies investigating associations with a particular group of foods or to assess total dietary intake. Lastly, it requires minimal training to complete as opposed to completing to a food record (83, 84).

There are also several limitations that should be considered when employing a FFQ. The design of the questionnaire inherently allows for measurement error. Firstly, the size of the food list must be practical and cannot include a list of all foods, therefore potential fibre containing foods could be missed out. Secondly, the FFQ is less able to quantitatively measure intake in comparison to a food record due to the lesser amount of dietary information collected, such as cooking methods or the form of food consumed which can either lead to over or under estimation of fibre intake. Thirdly, reporting relies on the ability to recall and the reference portion size descriptions are subjective which may further affect the accuracy. Fourthly, a FFQ may be population specific depending on the population it is validated in, therefore they cannot be widely employed in studies including different populations.

2.6.4 24-hour recall

The 24-hour recall is a retrospective method that involves an interview led by a trained interviewer (81, 82). During the open-ended interview, the respondent is asked to recall food and drink consumed in a specified period of time (usually the previous 24 hours). Portion sizes may be estimated with or without the use of food models. Dietary information may then be checked for omission or errors and is then analysed (84).

This method has several advantages and disadvantages. Firstly, when compared to a food record, there is low respondent burden, making it suitable for studies that require a large number of participants (84). Secondly, the method relies on an individual's short term memory to recall dietary information therefore a greater accuracy is expected (82). A major disadvantage though is that a single recall is not representative of an individual's usual intake (82. Also, when compared to a weighed food record, the portion sizes are estimated, thus reducing the reliability (84).

2.6.5 Dietary analysis

Dietary analysis is the derivation and analysis of nutrient values. The most commonly used method is a food composition database where each value is the average of a limited number of samples. The foods in a database can differ by country so as to more accurately reflect the foods available in that country (81). Additionally, food composition data vary between countries. Deharevang and co-authors studied food composition tables from nine European countries and found that nutrients such as carbohydrates, dietary fibre, folate and carotenes were not comparable as there were differences in definitions or modes of expression (84). Subsequently, joint food databases have been developed to allow for between country comparisons (86).

The New Zealand food composition database (NZFCD) contains nutrient data of 2631 foods that are commonly consumed (87). With respect to choosing a database, it is important to select one that is complete, as missing values for nutrients can reduce analysis accuracy. Furthermore, the error associated with using a database for nutrient analysis can be kept constant by using the same database to analyse both the FFQ and the reference method, hence improving the reliability of a validation study. A limitation of this database is that not all values for nutrients are derived using analytical data from New Zealand, some are borrowed in reference to another

country's database, such as the United States (87). As a result, the accuracy of the value for dietary fibre in foods may be lowered.

2.7 Validation Epistemology

A validation study can be defined as one that collects information on measurement error of the exposure by comparing a test method with a reference method that is considered to be 'gold standard' (88). This type of study is important to ensure that a dietary instrument such as a FFQ (test method) is measuring what it is intended to measure. A validation study can focus on objectives such as, measurement of between subject variation, ability of an instrument to detect differences in diet that exist among subjects and an assessment of measurement error (89).

2.7.1 Selection of a population

The selection of a population should be derived from a random sample of the main population on which the study is intending to focus on. However, in large scale studies this is often impractical due to logistical reasons (89). In a study that reviewed the design, validation and utilization of FFQs used in research showed that not all studies obtain a representative sample (80). The impact of not selecting an appropriate sample for validation will affect the quality of the data obtained in the main study.

2.7.2 Reference method

The selection of a reference method provides for a comparison of the measurement error that is relative between the test and reference method. Food records are considered to be the 'gold standard' as their sources of error are largely independent of the errors associated with a dietary questionnaire: reliance on memory, portion size estimates and a limited list of foods (89). Although, the 24 hour recall method and biomarkers are also considered to be suitable (80).

Biomarkers for validation of a FFQ that assesses habitual fibre intake are still being developed. For example, there is emerging research on alkylresorcinols as a biomarker for wholegrain intake (90). However, there is wide inter individual variation and further research is required to improve its accuracy. Additionally, it is difficult to validate with a reference method that involves direct assessment of the gut

microbiota, which means that, in this case; the accuracy of the test method is limited to being reliant on participants' reports of dietary intake.

2.7.3 Time frame

For epidemiological studies, it is important to consider the time frame as dietary intake data collected should ideally reflect a period of time that is considered to be representative of habitual intake. In other words, if the tool to be validated measures habitual intake, a period of one or more years rather than a few days or weeks is considered to be appropriate as it is likely to capture different factors that impact dietary intake such as seasonal variability.

Conversely, to validate short term intake, the test and the reference method should both assess dietary intake over the same period (80). Furthermore, measurements should be repeated over multiple days in the same subject to measure the true between subjection variation in dietary factors and for the tool to discriminate among subjects (91).

2.7.4 Sequence of administration

The sequence of which the test and the reference method are administered should be considered as it may affect validation. If the test method is administered prior to the period measured by the reference method, this would simulate the actual measurement conditions, in which the tool were to be used, i.e. main study, intervention study etc. (80), however this may result in a low correlation (91). On the other hand, if the test method is administered after the reference method, this may artificially improve the accuracy as completing a food record may heighten an individuals' awareness of their intake. Thus, administering the test method both before and after the reference is recommended to derive a truer estimate of agreement (91).

2.7.5 Sample size

In arriving at a sample size that is appropriate, it is important to consider statistical methods being used. For the Bland-Altman method, a sample size of at least 50 to 100 subjects is desirable, although this is dependent on within subject variation, investigation of biases and the precision of the limits of agreement (91). Alternatively,

for the correlation coefficient, the size is dependent on the expected association of the test and reference method. A coefficient of 0.5 to 0.7 with a corresponding sample size of 100 to 200 is considered to be adequate, assuming a sufficient number of days of dietary information are collected (14-28 days). A higher number would provide only a small increase in precision (91).

However, for many studies, it is not feasible to collect 28 days' worth of dietary information. In light of this, previous studies have used smaller number of replicates per subject but have increased the number of the subjects to maintain the same precision of the corrected correlation coefficient (91).

2.7.6 Statistical Analysis

There are several different analyses to assess validity through agreement, each will be reviewed: comparison of group means, cross classification, correlation analysis and Bland-Altman method.

2.7.7 Comparison of group means

If the objective is to investigate differences between subject groups, the means of two groups can be compared (i.e. analysing absolute fibre intake by sex) (91). This can be achieved through employing a paired t-test on parametric data, such as the Wilcoxon signed ranked sum test. Additionally, if the objective of the study does not need to consider the ranking of individuals, a unpaired t-test for parametric data or the Mann-Whitney U test for non-parametric data can be used (91).

2.7.8 Classification into categories of intake

In this analysis, the distributions of dietary intake for both the test and reference method are divided into categories (e.g. tertiles, quartiles or quintiles of intake). The categories for each subject in both methods are then compared to examine whether an individual has been classified correctly or incorrectly. The results can then be analysed by percentage of agreement with, exact agreement indicating that a subject has been classified into the same category by both methods, whereas participants who are classified into opposite categories are said to be grossly misclassified (91).

The kappa statistic method is similar to cross classification, however it accounts for subjects being correctly classified due to chance and, therefore, is a better measure than percent agreement (91). However, interpreting its value poses some difficulty as it depends in part on the number of categories defined and does not take into account subjects that are misclassified by one or two categories, instead it provides for the total agreement only. In light of this, the weighted kappa is a better alternative as it focuses on disagreement and accounts for partial disagreement in comparison to non-weighted kappa. Although, a disadvantage of using this method is that results between studies cannot be compared (92).

2.7.9 Correlation analysis

Correlation indicates the degree of relationship between two variables or in other words, are the test and reference method measures comparable for each subject? A review of validation studies showed that 83% (168 studies) of the studies used this type of analysis (80). Before deriving a coefficient (e.g. Pearson product moment), distributions should be normalized as dietary intake distributions are likely to be skewed. Conversely, if normalization cannot be achieved then a non-parametric coefficient (e.g. Spearman) should be used.

Correlations are affected by variation. A large with-in person variation results in a lower correlation that is less significant. This effect however can be de-attenuated by calculating an attenuation factor. This factor takes into consideration the variance ratio, which is the ratio of with-in to between person variation, and accounts for the number of recording days in the reference method (81). Similarly, covariates that should also be adjusted in validation studies are, age, sex and energy intake (91).

This method has several limitations. Bland and Altman (89) argue that, firstly, correlation is expected when two methods are designed to measure the same thing. Secondly, correlation does not indicate agreement but rather the strength of the relationship. This is evident by the fact that agreement can be low even when there is a high correlation. In addition, it does not account for a test method that consistently produces higher or lower results than the reference.

Finally, a stronger correlation will be observed in a sample that has a higher between subject variation versus a sample with a lower between subject variation. For these reasons, it is suggested that correlation coefficients should not solely be indicative of validity but rather, be used in conjunction with other methods. A perfect agreement can only occur when results are identical in both methods (81, 80, 89, 91).

2.7.10 Bland-Altman analysis

Bland and Altman advocated for and proposed a truer method for assessing validity; the limits of agreement technique (LoA) (94). This method involves plotting for each nutrient, the mean versus difference of each pair of measurements, provided by the test and reference method, and calculating the LoA and the corresponding 95% confidence interval. This allows for a conclusion to be made as to whether there is good agreement between methods. Leading researchers on validation studies have recommended the use of the Bland-Altman method for assessing validity (79, 80, 89, 91).

2.8 Review of fibre assessment tools

A literature search was conducted to identify existing validated tools that assessed short term or current fibre intake in healthy adults. Google Scholar and PubMed online database were searched for validation studies published prior to August 2017. A combination of keywords was used for searching, “fibre/fiber”, “dietary”, “validity”, “questionnaire”, “assessment”, “evaluation” and “tool”. Studies were included if they were designed to be used in clinical studies and in the primary health care setting for educational and counselling purposes. Overall, 7 studies were included in this review, details are shown in **Table 1**. At the time of writing, there are no published studies reporting the validation of a tool that is able to quickly assess short term dietary fibre intakes in healthy New Zealand adults.

2.8.1 Background information of validation studies

Roe and co-authors (9) and Svilaas and co-authors (95) identified the need for a tool that is able to be used by primary health care workers who do not have in-depth nutrition knowledge and developed a tool that could be used to guide a dietary intervention in primary care. Similarly, Rifas-Shiman and co-authors and Hemiö and co-authors identified that physicians are in need of a tool that is easy to use and is able to provide accurate dietary assessment for counselling (96, 97). Similarly, other studies by Shannon and co-authors and Wright and co-authors have developed a tool for evaluating the interventional effect of health promotion programmes (11, 12). Lastly, Apovian and co-authors developed a tool that is able to capture food intake and provide real time feedback to participants undertaking a specific diet (98).

2.8.2 Functional features

All reviewed studies developed tools with functional features: quick and easy to complete, cost-effective, able to guide the interviewer in providing individualized dietary advice and able to be computerized and self-scored (9, 11, 12, 95-98). These features are distinct from those of a food record, albeit a food record provides for a more detailed and quantitative assessment of an individual’s diet, it may be impractical in clinical settings with constraints such as time and budget. Only one study validated a tool that is able to classify an individual’s total dietary fibre intake (9).

2.8.3 Test methods validated

A range of test methods were analysed for validity, 4 of the tools were food frequency questionnaires (9, 12, 95, 96), one was a food intake questionnaire based on a FFQ (97), an online questionnaire based on a 24-hour diet recall method and also a behavioural questionnaire (98). All test methods were semi quantitative except one (96). The number of items in the questionnaires ranged from 16 to 41. The majority of test methods were self-administered, except two studies, in which one was administered by a nurse in person (9) and the other was administered over the telephone (11). Furthermore, the test method in all studies probed for current or short term intakes, which is the period of significance in clinical studies and in the primary health setting.

2.8.4 Reference methods used

Overall, three different types of reference methods were used for validation. Three studies employed the food record, Roe and co-authors used a 4 day diet record, in which 1 was a weekend day, Hemiö and co-authors and Svilaas and co-authors used a 7 day diet record (9, 95, 97). Three studies used a longer food frequency questionnaire; 300, 142 and 110 item questionnaires (11, 12, 98) and Rifas-Shiman and co-authors used both a 131 item FFQ and biomarkers for selected nutrients. Studies using the FFQ reference method reported that, although food records would have been ideal to use, they were not feasible. As a consequence, the results observed may be less valid as there is likely to be a correlation of errors between the reference and test methods, resulting in artificially improved accuracy.

2.8.5 Study design

The sample size varied widely from 77 (97) to 1795 participants (11). In terms of sequence of administration, two studies administered the test method only once (9, 97), and one administered the test method 2 times (95) and another study administered it 4 times (98) before subjects completed the reference method. One study administered it both before and after the reference method (12). In one study, participants were randomized to either receive the test (group A) or reference method (group B) initially. At 2 weeks, group A received another test method and group B received their initial test method and then, at 4 weeks group A received the reference

method and group A received another test method (96). Another study had participants complete both methods in the same day, at two separate times in a year (11).

The sample size should partly be dependent on the statistical methods. For a correlation coefficient, Willet recommends a minimum of 100 subjects (85), all except one study had a size greater than 100 (9, 11, 12, 96, 98) (9, 11, 12, 95, 96, 98). Whereas the study conducted by Hemiö and co-authors had only 77 participants (97). Furthermore, two study designs (9, 97) had participants complete diet records after receiving a health check-up, which introduces the potential for subjects to change their dietary habits, a clearance period between the check-up and initiating the reference method would have negated this effect.

2.8.6 Reported outcomes

The reported outcomes were varied, three studies reported on fat and fibre intakes, in which two looked at total fat and fibre exclusively (9, 12) and one reported on responsiveness to dietary intervention (11) in addition to total fat and fibre. Three studies reported on food groups and a range of nutrients (95-97) and finally one study reported on food groups and dietary compliance (98).

2.8.7 Statistical methods

Overall three different methods were used for assessing validity. Correlation analysis was employed by all studies, five studies used Pearson's correlation (9, 12, 95, 96, 98) and two studies used Spearman's correlation (11, 97). In addition to correlation analysis, three studies classified intakes into categories and reported on percentage exact and opposite classification, these studies also used the weighted kappa statistic (9, 12, 97). Only one study used an adjusted correlation coefficient (98). In this study, the variation was accounted for by using a calculated de attenuated correlation.

Surprisingly, none of the studies reviewed used the Bland-Altman method, instead all studies relied on correlation analysis either in conjunction with cross classification and the weighted kappa statistic or by itself for demonstrating validity. As previously discussed, Bland and Altman argued that when two instruments are

designed to measure the same exposure, correlation is expected and therefore it is not a measure of agreement.

2.8.7 Results reported

Correlation for fibre varied widely between studies. The weakest correlation evidenced was R = 0.43 (9) and the strongest R = 0.70 (energy adjusted and de attenuated) (98). Other studies reported values of 0.44, 0.53, 0.58 and 0.50 (11, 12, 96, 97). One study reported a marked correlation but did not show the data (95). The observed correlations are inconsistent between studies; it is difficult to attribute these differences to specific factors as there are several differences between studies, such as the design of the test method, type of reference method used, the sample size and the study design. Cross classification of individuals into exact categories ranged from 48% (97) to 52% (9). However, despite these differences, four studies (11, 96-98) reported a coefficient that is in the range of commonly observed values (0.5 to 0.7 for a range of nutrients) in validation studies lasting one to ten years and thus compare well (99).

2.9 Dietary fibre intake food frequency questionnaire (DFI-FFQ)

Recently a 5 item semi-quantitative food frequency questionnaire (DFI-FFQ) was developed and validated for use in healthy New Zealand adults (13). This questionnaire has been shown to accurately classify individuals based on their habitual dietary fibre intakes (low, moderate or high consumer). It includes five major fibre containing food groups, based on a national nutritional survey (72): vegetables, fruits, breads and cereals, nuts and seeds, and legumes. For each food group, examples of foods and serving size estimates are given. The frequency of consumption is indicated as, on average over the past year; Never, <1/month, 1-3/month, 1/week, 2-4/week, 5-6/week, 1/day, 2/day, 3/day, 4/day, 5/day and 6+/day (Appendix A).

The authors also developed a scoring sheet that enables estimation and classification of habitual dietary fibre intakes. An individuals' total dietary fibre intake is derived by calculating the average amount of dietary fibre corresponding to selected frequency of consumption response categories for each food group and categorizes individuals as being either a low, moderate or high fibre consumer (Appendix B).

The study showed that the DFI-FFQ is a valid tool for classifying but not estimating total dietary fibre intakes. The addition of additional fibre containing food groups such as cakes and muffins, pies and pastries and biscuits may improve the accuracy. This tool can be modified to improve the accuracy in estimating total dietary fibre intakes and reflect short-term or current fibre intake.

2.10 Conclusion

In conclusion there are no validated tools that have the ability to quickly and accurately classify and estimate short-term or current total dietary fibre intakes for use in healthy New Zealand adults. The above discussion reviews the current state of evidence of specific benefits, gastrointestinal effects and consumer perceptions of dietary fibre consumption. There is strong evidence to show that there is a significant risk reduction for developing cardiovascular and diabetes diseases with higher dietary fibre intakes. However, it is less clear whether dietary fibre confers a protective effect on colorectal cancer incidence. Additionally, a limited number of studies have investigated the effect of dietary fibre on gastrointestinal function: abdominal discomfort and excessive flatulence, these studies have shown no negative effects despite consumer reports of gastrointestinal disturbances associated with eating fibre containing foods, further research is required to confirm these results. Finally, there are no local surveys of public perceptions on the benefits *versus* barriers to dietary fibre consumption.

Table 1: Validation studies of short term or current fibre intake assessment tools

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Roe et al (UK)	Validation of the Dietary Intervention in Primary Care (DINE) method for diet assessment	FFQ (19 items, semi-quantitative, administered by nurse, intake over a week) Brief assessment of total fat and fibre intake, 20 minutes to complete Guides interviewer in providing dietary advice	4 day diet record (estimated portion sizes, 3 weekdays and 1 weekend day)	n=206, test method administered ↓ Reference method - diet records were collected and checked daily by nurses	Total fat and fibre intakes	1. Cross classification (53% fat and 52% fibre correct categorization, 6% fat and 5% fibre intakes grossly misclassified) 2. Weighted Kappa statistic (0.38 for fat, 0.30 for fibre) 3. Pearson's correlation (0.51 total fat intake, 0.43 total fibre intake)	Demonstrated acceptable validity for categorizing fat and fibre intakes and is a useful diet assessment and counselling method for use in primary health care

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Wright et al (Australia)	Validation of a barometer that assesses fat and fibre related food behaviours	FFQ (20 items, qualitative, self-administered, probed for usual intake) Self scored, easy to complete and an educational tool	FFQ (300 items, meal based quantitative, previously validated with 12 day diet records, usual intake over 3 months)	n=122, test method administered initially ↓ Reference and test method administered after 7-10 weeks	Total fat and fibre intakes	Comparisons were analysed separately by sex 1. Cross classification for fibre, correct (41% males, 62% females) and incorrect (10% males, 6% females) 2. Weighted kappa statistic for fibre (males = moderate agreement and females = fair agreement) 3. Pearson's correlation for fibre (0.44 and 0.76 energy adjusted for all)	The validity is acceptable for educational purposes and has functional features, therefore it can be deployed In the primary health care setting

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Hemiö et al (Finland)	Validation of a food intake questionnaire (FIQ) that aimed to be a practical tool for estimating and monitoring diet quality in primary health care	FIQ (16 items, semi-quantitative, self-administered, probed for intake over the past month) Able to computerized and is quick to complete	7 day diet record (estimated portion sizes)	n=77, test method administered initially ↓ Reference method	Food groups and a range of nutrients	1. Cross classification for fibre (48.1% exact and 7.8% opposite) 2. Weighted kappa statistic for fibre (0.33) 3. Spearman's correlation for fibre (0.53)	A valid tool for estimating nutrient intakes, useful for identifying individuals in need of dietary counselling

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Apovian et al (America)	Validation of a self-monitoring tool designed to monitor dietary changes made	Online questionnaire (8 food groups, based on the 24 hour diet recall, semi quantitative) Quick and easy to use	Block 98.2 FFQ (110 items, semi quantitative, intake over the past year)	n=191, test method administered once a week for 4 weeks ↓ Reference method administered in week 3	Food groups and dietary compliance to intervention	1. Pearson correlation for fibre (0.67 unadjusted and 0.63 energy adjusted and 0.70 energy adjusted and de attenuated) 2. Weighted kappa statistic for agreement level between test and reference by energy level (0.48)	Test method captures food and nutrient intake well in relation to the reference method which is more detailed

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Rifas-Shiman et al (America)	Assess performance of a brief food frequency questionnaire designed to identify those at risk of chronic diseases in primary care setting	FFQ (24 items, self-administered, probed for intake over the past week) Quick and easy to understand and complete	FFQ (131 items, semi quantitative, self-administered, intake over the past year) Biomarkers (vitamin E, beta-carotene and lutein and zexanthin)	n=160, participants randomized to receive either test (group A) or reference method (group B) initially ↓ At 2 weeks, group A received another test method, group B received their initial test method ↓ At 4 weeks, group A received the reference method and group B received another test method	Food groups and a range of nutrients	1. Spearman's correlation for fibre (0.58) and food groups (range = 0.44 to 0.75, mean = 0.61) 2. Pearson correlation (vitamin E = 0.33, beta-carotene = 0.43 and lutein and zexanthin = 0.43)	Test method compares well with a longer food frequency questionnaire and biomarkers. Has potential to be used as an intervention tool in a clinical setting as well as in research

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Shannon et al (America)	Validation of a fat and fibre related behaviour questionnaire (FFB) designed to be used as an evaluation tool in intervention programs	Fat and fibre related behaviour questionnaire (41 items, semi quantitative, telephone administered, intake over the past 3 months)	Block FFQ (142, semi quantitative, telephone administered, intake over the past 3 months)	n=1795 (850 intervention and 945 control), participants randomized to either intervention or control groups ↓ each participant completed the test and reference method in a 45 minute telephone interview ↓ Initially, at 3 months and at 12 months	Fat (%energy) & Fibre (g/1000kcal) and responsiveness to dietary intervention	1. Spearman's correlation for fibre g/1000kcal (~0.50 at all three time points) 2. FFB more responsive to intervention than reference method	FFB is a reasonably valid and reliable measure of dietary intake that is responsive to the effects of a low intensity intervention

Table 1 continued

Reference (Country)	Aim	Test method and functional features	Reference method	Study design	Outcomes	Statistical methods and results	Conclusion
Svilaas et al (Norway)	Validate a short and simple food questionnaire for use in clinical practice	FFQ (15 items, qualitative, emphasis on fat, fibre, fruit and vegetables, self-administered, qualitative)	7-day food record (semi-weighed)	n=101, test method administered twice initially ↓ Reference method administered	A range of food and food groups	Pearson's correlation for fibre (marked correlation with fibre)	Provides a good estimate of dietary fat and fibre in the usual diet

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Chapter 3: Research Manuscript: Dietary Fibre Intake: Validity of a Short-Term Food Frequency Questionnaire; Association with Gastrointestinal Health and Public Perceptions

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3.1 Abstract

Dietary fibre is an important constituent of the diet as it plays a key role in reducing the risk of certain diseases. Several validated dietary assessment tools that measure current fibre intakes exist, however these are lengthy, cannot be self-administered or classify dietary fibre intakes. Furthermore, a limited number of studies have investigated the effect fibre has on gastrointestinal symptoms or examined perceived benefits *versus* barriers to eating fibre containing foods. This study aimed to validate a dietary fibre intake tool (DFiT) that measures short term dietary fibre intake against a 4-day food record, and compare dietary fibre intake to gastrointestinal symptoms. The study also aimed to survey perceived benefits and barriers to dietary fibre intake. 105 healthy adult participants aged between 19 and 65 years completed the DFiT, 4-day food record, gastrointestinal health questionnaire and perceptions survey. The DFiT is a valid, simple, short and easy to use questionnaire for classifying but not estimating total short term dietary fibre intakes. There were no associations found for occurrence or severity for gastrointestinal symptoms between low, moderate and high dietary fibre consumers. There were some important differences in statement responses between genders, dietary fibre intake groups and socioeconomic status.

Keywords: dietary fibre/fiber; assessment; validity; gastrointestinal symptoms; perceptions

3.2 Introduction

Dietary fibre is defined as an indigestible carbohydrate and is comprised of two main types; soluble and insoluble fibre. Dietary fibre is resistant to digestion and absorption in the small intestine and usually undergoes complete or partial fermentation in the large intestine (1). The significance of dietary fibre intake is marked by its implication in various pathologies such as cardiovascular disease (2), type 2 diabetes (3), metabolic syndrome (4), and gastrointestinal cancers (5). Furthermore, it is associated with a myriad of physiological outcomes: lowering cholesterol and blood pressure (6) and modulating gut bacteria (7). Evidence of the beneficial role it plays in human health, therefore, is strong, which in turn increases the demand for suitable dietary assessment methods for assessing fibre intake.

Dietary assessment is paramount for effective nutrition counselling. Methods used in research, such as diet records and lengthy food frequency questionnaires may be impractical due to time constraints and the knowledge required to interpret results (8). A small number of validated tools that measure current fibre intakes have been developed. However, these focus on eating behaviours (9, 10), are lengthy (9-13) and are not designed to be self-administered (9, 13). There are no tools that can rapidly assess an individual's total dietary fibre intake or classify individuals based on their short-term dietary fibre intake, so as to provide a quick, valid and relevant clinical assessment.

Recently, a dietary fibre intake food frequency questionnaire (DFI-FFQ) was developed and validated to categorize an individual's habitual fibre intake as being either low, moderate or high, however, the DFI-FFQ was not able to accurately determine total dietary fibre intakes. The DFI-FFQ can be self-administered and is easy and quick to complete. Initial testing showed that its accuracy can be further improved, making it an ideal candidate for further development and subsequent validation.

It has been proposed that dietary fibre, especially, fermented soluble dietary fibre, produces intestinal gas (14). A qualitative survey of dietitians reported that patients reportedly avoid certain fibre containing foods groups such as legumes, due to fear

of gastrointestinal symptoms like flatulence, abdominal discomfort and bowel movements (15). There have been a limited number of studies examining the effects of dietary fibre on gastrointestinal symptoms. Two clinical studies have investigated the occurrence and severity of these symptoms following bean (16) and pulse consumption (17), both studies failed to find any significant associations. However, the base of evidence is too small, owing to the limited number of studies, to draw conclusions on a null association between gastrointestinal symptoms and dietary fibre intake, thus warranting further research.

Additionally, the beneficial effects of dietary fibre consumption on health have led to dietary recommendations that are predominantly plant based for the treatment of high blood pressure and cardiovascular disease (18). In light of this, there are a limited number of studies that have examined perceived benefits and barriers specific to eating fibre containing foods (19-21).

To the best of our knowledge, there is no tool that can rapidly categorize and quantify an individual's current dietary fibre intake. Secondly, there are only a limited number of studies examining dietary fibre and its apparent physiological relation to gastrointestinal health markers, and finally, there are no local surveys of public perceptions of the benefits and barriers to dietary fibre intake. This study aimed to modify the DFI-FFQ and validate it against a 4-day day diet record, and compare dietary fibre intake to gastrointestinal symptoms. We also aimed to survey local perceptions of the benefits and barriers to dietary fibre intake.

3.3 Materials and Methods

3.3.1 Subjects

The subject group consisted of 105 healthy adult participants living in Auckland, New Zealand. Subjects were recruited via word of mouth in the community and advertisements placed at Massey University and University of Auckland, North Shore hospital, local gyms, AUT Millennium Institute of Sport, and a web page on the Massey University website.

One hundred and twenty-two subjects completed a screening questionnaire (Appendix A) prior to enrolment. Inclusion criteria included: 1) Healthy male and female individuals between the ages of 19 and 65 years; 2) Body mass index ≥18.5 and ≤30 kg/m^2; 3) No acute or chronic diseases; 4) Not currently pregnant or breastfeeding; 5) No food intolerances that cause gastrointestinal symptoms (lactose intolerance etc.); 6) Not currently undertaking a special/restrictive diet; 7) Not currently experiencing severe abdominal pain, excessive flatulence or severe constipation. The questionnaire collected information on major dietary fibre containing food groups, in order to recruit a proportionate number of low, moderate and high dietary fibre consumers.

Participants were offered a dietary analysis of their food record after all data had been collected. The study was approved by the Massey University Human Ethics Committee (Southern A, 16/81), Auckland, New Zealand.

3.3.2 Short-term Food Frequency Questionnaire Development

The original questionnaire (DFI-FFQ) is a 5 item semi-quantitative food frequency questionnaire that has been shown to accurately classify individual's based on their habitual dietary fibre intakes (low, moderate or high consumer). It includes five major fibre containing food groups, based on a national nutritional survey (22): vegetables, fruits, breads and cereals, nuts and seeds, and legumes. For each food group, examples of foods and serving size estimates are given. The frequency of consumption is indicated as, on average over the past year; Never, <1/month, 1-3/month, 1/week, 2-4/week, 5-6/week, 1/day, 2/day, 3/day, 4/day, 5/day and 6+/day (Appendix B).

The authors also developed a scoring sheet that enables estimation and classification of habitual dietary fibre intakes. An individuals' total dietary fibre intake is derived by calculating the average amount of dietary fibre corresponding to selected frequency of

consumption response categories for each food group and categorizes individuals as being either a low, moderate or high fibre consumer (Appendix C). The validity and reproducibility of the DFI-FFQ was tested in a previous study (23). The DFI-FFQ was modified for use in the present study.

The questionnaire was modified to: improve the accuracy in assessing total dietary fibre intakes and reflect short-term or current fibre intake. Results from the original validation study suggested that, although it was accurate in classifying individual's based on their habitual dietary fibre intakes (low, moderate or high dietary fibre consumer), additional fibre containing food groups may have to be added to improve estimation of total fibre intake. Following this, firstly, the breads and cereals food group was divided into refined and wholegrain sources. Secondly, 3 additional food groups were added, these were: baked items, pastries and processed meats and fibre supplements. Thirdly, examples of foods/supplements and serving size estimates were added to the new food groups. Fourthly, to represent current intake, the frequency of consumption was updated to, intake over the past week and the response categories were changed to: never, 1/week, 2-4/week, 5-6/week, 1/day, 2/day, 3/day, 4/day, 5/day and 6+/day. Resulting in a 9-item semi-quantitative FFQ, dietary fibre intake tool (DFiT) (Appendix D).

Finally, the scoring sheet was updated to reflect the modifications made. FoodWorks version 7.0.3016 (Xyris Software Pty Ltd., Brisbane, Queensland, Australia) was used to derive the average amount of dietary fibre per frequency of consumption for each of the additional food groups added to the DFiT (Appendix E).

3.3.3 4-day food diary and gastrointestinal health questionnaire

Subjects were asked to complete a 4-day food diary (Appendix F) and gastrointestinal health questionnaire (Appendix G) on the days the food diary was completed. The 4-day food diary was the reference method used to validate the DFiT. The 4-day food diary asked subjects to record their food and fluid intake on any two weekdays and two weekend days. For portion sizes, subjects were instructed to either weigh or make estimated guesses using household measures. Also, subjects were sent a link to an online video that contained detailed instructions on how to complete the food diary.

The gastrointestinal health diary contained questions on gastrointestinal symptoms: abdominal discomfort and excessive flatulence, as well as stool frequency and type. Subjects were asked to complete the questionnaire at the end of each food diary entry day. For each of the two gastrointestinal symptoms, subjects were asked to indicate severity using the gastrointestinal symptom rating scale (GSRS) which was shown to be an effective measure of symptoms in patients with irritable bowel syndrome and peptic ulcer diseases (24). As per the GSRS, definitions were provided for each level of severity. For stool type, subjects were asked to indicate using a Bristol stool chart which was attached for reference (Appendix H).

3.3.4 Perceptions of dietary fibre survey

In order to assess public perceptions of dietary fibre, subjects were asked to complete a dietary fibre survey (Appendix I). The questionnaire contained a total of 15 items that investigated the level of knowledge of the health benefits as well as the perceived barriers to eating dietary fibre containing foods. The definition "Dietary fibre is a nutrient that naturally occurs in varying amounts in Breads, Cereals, Nuts, Seeds, Legumes, Vegetables and Fruits" was provided to participants before they undertook the survey. The survey was pilot tested and refined using a convenience sampling method. Thirty-nine subjects were surveyed for item wording, structure and understanding. The items were based on a questionnaire used to survey public views of the benefits and barriers to consuming a plant based diet in Australian adults. Full details of the original surveys' development can be found within this study (19).

3.3.5 Data collection

The subjects first completed an online screening questionnaire that included socio-demographic questions such as, age, gender, weight, height, ethnicity, education level, employment status and job title and duties (Appendix A). This questionnaire also asked subjects to indicate how often they consumed fruits and vegetables, legumes and wholemeal/wholegrain breads and cereals in order to recruit 35 low, medium and high fibre consumers. Participants initially completed a 4-day food diary and gastrointestinal health questionnaire which was posted to them. The completed 4-day food diary and gastrointestinal questionnaire was then emailed or posted back to the primary researcher. Following this, online links to the DFiT questionnaire and perceptions of dietary fibre survey were sent via email. Participants were instructed to complete the DFiT questionnaire one

week after completing the 4-day food diary and gastrointestinal health questionnaire. Returned food diaries were checked for completeness and subjects were contacted when possible for queries or clarification. The screening questionnaire, DFiT and perceptions of dietary fibre survey were self-administered.

3.3.6 Data Analysis

All statistical analyses were carried out using Minitab® statistical software version 17.3.1 (Minitab Pty Ltd, Sydney, Australia) with a significance level of $p < 0.05$.

Dietary analysis

Food records were analysed using FoodWorks version 8.0.3553 (Xyris Software Pty Ltd., Brisbane, Queensland, Australia) based on the New Zealand food composition database FOODfiles 2014 version 1. Thirty-five of the food records were cross checked by an independent nutritionist using the same software and database. The DFiT responses to each food group were scored using the accompanying DFiT scoring sheet and the average amount of dietary fibre per day was compared between the food records and DFiT.

Classification

Participants average dietary fibre intakes were classified into low, moderate and high groups using cut off points. The cut off points for the high group were based on the Ministry of Health guidelines for recommended dietary fibre intakes; > 25 g/day for females and > 30 g/day for males (25). Whereas for the low group, the cut off points were based on the median dietary fibre intake in New Zealand; 17.5 g/day for females and 22.1 g/day for males, which are below the recommended amounts (22).

Misreporting

To adjust for misreporting of energy intakes, the Goldberg formula was used to evaluate misreporting at the individual level (n=105). Basal metabolic rate (BMR) was calculated using Schofield equations with self-reported height and weight. The self-reported energy intake (using data from the 4-day diet records) to BMR ratio (EI rep: BMR est) was calculated and compared with cut off points derived using the Goldberg formula (26). Subjects below 0.93 and above 2.12 were considered to be under (n=18) and over reporters (n=1), respectively, and were excluded from the validity analysis. We also reported energy adjusted values by calculating the total dietary fibre intake density (grams per 1000 kcal).

Validity analysis

Validity was assessed using a paired t-test, Pearson's correlation, and agreement statistics: cross classification by categories of intake (low, moderate, high) and overall, using tertiles, and weighted kappa statistic and Bland-Altman analysis.

Gastrointestinal health questionnaire

Gastrointestinal symptoms were analysed by different levels of dietary fibre intake (low, moderate and high intake groups) to examine associations between groups. Dietary fibre intake data from the 4-day food diary was used. Occurrence of abdominal discomfort and excessive flatulence symptoms over the four study days were each summarized into a summary variable. Occurrence was assumed if subjected indicated '1' or greater on any of the 4 days and a chi-squared analysis was performed. For severity, data from subjects were included if they experienced an occurrence of the symptom on any of the 4 days, the ranking was averaged and a Kruskal Wallis test was used to compare the average severity between groups. The number of bowel motions over the study days were averaged and a one-way ANOVA was performed to compare differences between groups, significant differences were followed up by Tukey's multiple comparisons post hoc test. Stool form was also averaged and compared using a chi-squared analysis.

Perceptions of dietary fibre survey

Frequencies of participants' responses to items and cross tabulations by gender, age and fibre classification (low, moderate and high fibre consumer) were carried out and compared by a chi-squared analysis. For analysis by age, subjects were split into three groups: 19-24, 25-44, 45-65 years. To assess socioeconomic status (SES), participants were first assigned an occupational class using the Australian and New Zealand Standard Classification of Occupations 2013 version 1.2 (ANZSCO) and then each individual was assigned the corresponding New Zealand Socioeconomic Index-06 score; these ranged from 10 (low SES) to 90 (high SES). For each item, subjects who indicated 'Agree' and 'Strongly agree' were combined into one response group and those who indicated 'Disagree', 'Strongly Disagree' and 'Don't Know' were combined into another, and a binary logistic regression analysis was conducted to predict response to items using SES.

3.4 Results

The results presented here are separated into three sections: 1) Validity analysis of the DFiT, 2) Analysis of the association between dietary fibre intake and gastrointestinal symptoms and 3) Analysis of the perceptions of dietary fibre.

3.4.1 Validity Analysis

Participant characteristics

One hundred and five participants completed the 4-day diet record and DFiT, 19 people were excluded from analysis secondary to misreporting. A summary of the participant characteristics is presented in Table 1. The majority of the participants were aged between 25-40, and were New Zealand European or Asian. The mean body mass index differed significantly between men and women ($p < 0.01$). Table 2 shows data on dietary fibre intake classification, and nutrient intakes calculated from the 4-day diet records for men and women. There was a significant difference in energy intake between men and women ($p < 0.01$). The median total dietary fibre intake in New Zealand adults (19.6 g/day) (22) was similar to the cohorts' average dietary fibre intake.

Table 1 Characteristics of the participants who completed the 4-day diet record and DFiT

Participant Characteristics		Female (n=43)	Male (n=43)	Total (n=86)
		Frequency (%)		
Age				
	19-24 years	23	26	24
	25-44 years	47	51	49
	45-65 years	30	23	27
Ethnicity				
	New Zealand European	35	28	31
	Asian	47	58	52
	Other	19	14	16
		Mean (SD)		
BMI (kg/m²)*		23.8 (2.9)	25.6 (1.9)	24.7 (2.6)

* p =<0.05, significant difference as determined by two-sample t-test

Table 2 Nutritional intake and dietary fibre intake classification of participants by the two methods

Nutritional Intakes and classification		Mean (SD)		
		Female (n=43)	Male (n=43)	Total (n=86)
Energy Intake (kcal/day)*		1915 (456)	2312 (650)	2113 (433)
4-Day Diet records				
Dietary fibre intake (g/day)		24.2 (9.1)	25.2 (8.6)	24.7 (8.7)
Classification (count)				
	Low	13	16	29
	Moderate	11	13	24
	High	19	14	33
DFiT				
Dietary fibre intake (g/day)		17.88 (10.2)	15.18(12.2)	16.5 (11.3)
Classification (count)				
	Low	25	17	42
	Moderate	9	13	22
	High	9	13	22

* p=<0.05, significant difference as determined by two-sample t test

Classification of intakes

Table 3 shows the classification of total dietary fibre intake into low, moderate and high by the DFiT method in comparison with the reference method (4-day diet record). A chi-squared test showed an association between the two methods for classifying individuals ($p < 0.01$). For level of agreement, exact agreement for categorization occurred 70% of the time and gross misclassification occurred 12% of the time. In addition, the linear weighted kappa statistic showed good agreement ($k = 0.55$).

Table 3 Cross tabulation of classification by the 4-day Diet Record and DFiT methods[a]

		4-Day Diet Record			
		Low	**Moderate**	**High**	**Total**
DFiT	**Low**	27 (31.40%)	6 (6.98%)	9 (10.47%)	42 (48.84%)
	Moderate	1 (1.16%)	15 (17.44%)	6 (6.98%)	22 (25.58%)
	High	1 (1.16%)	3 (3.49%)	18 (20.93%)	22 (25.58%)
	Total	29 (33.72%)	24 (27.91%)	33 (38.37%)	86 (100%)

[a] Categories are defined by cut off points for total dietary fibre intake (g/day).

Estimation of total fibre intake

There was a significant difference in the estimation of total fibre intake between the two methods ($p < 0.01$); the DFiT was on average 7 g/d lower than the reference method. The DFiT however was correlated to the reference method; unadjusted r = 0.47, ($p < 0.01$; 95% confidence interval (CI) 0.29 to 0.62) and adjusted (fibre g/d per 1000kcal) r = 0.43 ($p < 0.01$; 95% CI 0.24 to 0.60). Cross classification by tertiles showed exact agreement occurred 42% of the time and gross misclassification occurred 10% of the time. Linear weighted kappa showed fair agreement $k = 0.25$.

Bland-Altman analysis

Figure 1 shows the mean versus the difference of each pair of measurements, provided by the DFiT and reference method (4-day diet record). The mean difference is indicated by the solid line, and the lower and upper limits of agreement are indicated by the dashes lines (-12.46 and 28.71).

Figure 1 Bland-Altman plot showing the mean versus the difference of each pair of measurements

3.4.2 Gastrointestinal symptoms

Participant characteristics

One hundred and one out of the 105 participants completed the gastrointestinal health questionnaire. The misreporters were not excluded from this analysis. Table 4 shows the characteristics of these subjects, grouped according to level of dietary fibre intake. The body mass index (BMI) did not differ significantly between groups, as determined by one-way ANOVA (p = 0.16).

Table 4 Participant characteristics

Participant Characteristics	Mean (SD)			P-value
	Dietary fibre intake groups			
	Low (n=39)	Moderate (n=26)	High (n=36)	
Body mass index (kg/m^2)[a]	25.2 (2.2)	24.6 (2.4)	24.1 (2 .7)	0.16
Fibre intake (grams)[a]	15.9 (3.6)	23.9 (3.6)	32.8 (6.0)	0.00*
Abdominal discomfort severity[b]	0.38 (0.18)	0.86 (0.58)	0.63 (0.27)	0.07
Excessive flatulence severity[b]	0.16 (0.22)	0.56 (0.27)	0.45 (0.27)	0.24
Stool frequency[a]	1.1 (0.2)	1.1 (0.4)	1.4 (0.5)	0.026*
Stool consistency[c]	4.7 (0.8)	3.8 (1.0)	4.0 (0.7)	0.01*

* p=<0.05, significant difference

[a] One-Way ANOVA, [b] Kruskal-Wallis, [c] Chi-squared analysis

Stool frequency and consistency

There was a significant effect of dietary fibre on stool frequency, as determined by one-way ANOVA (p = 0.026). Post-hoc testing revealed that high fibre consumers are likely to pass one additional bowel motion per day as compared to low fibre consumers. Additionally, stool consistency was associated with dietary fibre intake (p < 0.01), with high dietary fibre consumers are more likely to pass a Type 3 or 4 stool.

Abdominal discomfort and excessive flatulence

Occurrence of abdominal discomfort and excessive flatulence did not differ between the three groups (p = 0.73 and p = 0.24, respectively). Similarly, there was no statistically significant difference between the median average severity of abdominal discomfort and excessive flatulence between groups (p = 0.07 and p = 0.18, respectively), as determined by the Kruskal Wallis test.

3.4.3 Perceptions of dietary fibre

Participant characteristics

Out of the 105 participants who completed the 4-day food and gastrointestinal health diary, 94 participants also completed the perceptions of dietary fibre survey. Participants who were excluded for misreporting in the validity analysis were not excluded in this analysis. Table 5 shows the demographic characteristics of the participants and the general New Zealand population. In comparison to the census, the gender was similar, however, the 19-24 and 25-44 year age groups, Asian ethnicity group and the higher qualification group were over-represented. The response rate of the survey was 89.5%. The average intake of dietary fibre (g/day) for women was 25.3, for men 24.5 and for both 24.9.

Table 5 Demographic characteristics of the survey respondents as compared with the 2013 census

		Survey respondents (n=94) (%)	2013 census [a] (%)
Gender			
	Female	52	51
	Male	48	49
Age			
	19-24 years	22	8
	25-44 years	53	26
	45-65 years	24	27
Ethnicity			
	New Zealand European	31	61
	Asian	52	18
	Other	17	21
Education status			
	Higher qualification [b]	95	46
	< Year 13 school education	5	54
Work status			
	Employed	62	59
	Unemployed	11	5

[a] Data was included from the 2013 Census (New Zealand)

[b] Higher qualification includes: Diploma, Bachelors, Masters and Doctorate degrees. Level 1, 2, 3 or 4 certificates have been grouped into < year 13 school education

Perceived dietary fibre benefits

Table 6 shows responses to survey statements. The majority of participants agreed with the health benefits of consuming dietary fibre such as, helping keep bowel motions regular (96%), improving a person's overall health and wellbeing (88%), appetite control (86%), lowering risk of disease (83%), fibre containing foods being high in vitamins and minerals (81%), weight control (76%), cholesterol reduction (76%) and blood pressure control (62%). There were significant differences found between genders; women were more likely than men to agree that, consuming fibre containing foods helps with appetite control ($p < 0.01$), lowers cholesterol ($p < 0.01$) and that, fibre containing foods are high in vitamins and minerals ($p < 0.01$). For responses to benefits statements, there were no associations between 19-24, 25-44, and 45-65 age groups and between fibre consumer groups (low, moderate and high consumers).

Perceived dietary fibre barriers

Over half of the participants disagreed with the statement that, eating a high fibre diet would be or is difficult due to abdominal discomfort, bloating or flatulence (62%), however, a small proportion of participants agreed (29%). Other barriers that participants agreed with were, time to prepare high fibre foods (55%), lack of information (55%) and cost (54%). There were significant gender differences for two barriers; more men than women identified time to prepare high fibre foods ($p < 0.01$) and cooking skills ($p < 0.001$) as barriers. There were no associations between 19-24, 25-44, and 45-65 age groups and responses to barriers. Interestingly, differences between fibre consumer groups (low, moderate, high consumers) were present. Low versus moderate and high fibre consumers were more likely to identify time to prepare high fibre foods ($p < 0.05$), taste ($p < 0.05$) and cost ($p < 0.05$) as barriers.

Socioeconomic status

SES was predictive of responses to the statements. In these models, a higher SES was predictive of agreeing to: time to prepare ($p = 0.03$) and needing more information ($p = 0.04$) about high fibre foods but disagreeing to taste ($p < 0.01$) as being barriers (data not presented in table).

Table 6 Percentages of total participants who agree and disagree with benefits and barriers statements

Item	%Agree (%Disagree)											
		Gender			Age Groups				Dietary fibre Groups			
	All n=94	Women n=49	Men n=45	P-value	19-24 n=21	25-44 n=50	45-65 n=23	P-value	Low n=38	Moderate n=23	High n=33	P-value
Could help with appetite control by keeping me fuller for longer after eating	86 (2)	96 (2)	76 (2)	**	100 (0)	80(2)	87 (2)	NS	84 (3)	91 (0)	84 (3)	NS
Would be or is difficult for me because I get abdominal discomfort, bloating or flatulence after eating high fibre foods	29 (62)	27 (71)	31 (51)	NS	38 (48)	26 (62)	26 (74)	NS	29 (61)	43 (48)	18 (72)	NS
Would be or is difficult for me because I don't have the time to prepare high fibre foods	55 (43)	45 (53)	67 (31)	**	52 (48)	60 (36)	48 (52)	NS	68 (32)	57 (35)	39 (61)	*
Could improve a person's overall health and well being	88 (2)	88 (4)	88 (2)	NS	86 (0)	90 (2)	87 (4)	NS	92 (0)	87 (4)	85 (3)	NS
Can help with weight control	76 (2)	82 (0)	69 (4)	NS	71 (5)	70 (2)	91 (0)	NS	74 (3)	74 (0)	79 (3)	NS

The full question asked was "Some people believe eating fibre containing foods have specific benefits and some believe eating these foods presents specific difficulties. How much, if at all, do these statements apply to you?"

Response options were: 'Strongly Agree', 'Agree', 'Disagree', 'Strongly disagree' and 'Don't know'. '%Agree' percentages here combine 'Strongly Agree' and 'Agree' and '%Disagree' combines 'Strongly Disagree' and 'Disagree'.

Dietary fibre groups were determined using cut off points for total dietary fibre intake (g/day) for men and women

*** P<0.001, ** P<0.01, *P<0.05, NS=not significant

Table 6 Continued

Item	%Agree (%Disagree)											
	All n=94	Gender		P-value	Age Groups			P-value	Dietary fibre Groups			P-value
		Women n=49	Men n=45		19-24 n=21	25-44 n=50	45-65 n=23		Low n=38	Moderate n=23	High n=33	
Would be or is difficult for me because I need more information about fibre containing foods	55 (40)	51 (47)	60 (33)	NS	57 (43)	56 (36)	52 (48)	NS	45 (52)	61 (37)	55 (40)	NS
Could help lower cholesterol	76 (2)	84 (0)	67 (4)	**	67 (5)	76 (2)	83 (0)	NS	79 (3)	71 (3)	78 (0)	NS
Would be or is difficult for me because my cooking skills are limited	38 (59)	24 (73)	53 (42)	***	48 (52)	38 (58)	30 (65)	NS	24 (73)	42 (55)	52 (44)	NS
Can help to control blood pressure	62 (1)	67 (2)	56 (0)	NS	57 (0)	56 (0)	78 (4)	NS	64 (3)	61 (0)	61 (0)	NS
Would be or is difficult for me because a high fibre diet does not taste good	28 (65)	27 (65)	29 (64)	NS	29 (67)	24 (66)	35 (61)	NS	42 (50)	26 (65)	12 (82)	*

The full question asked was "Some people believe eating fibre containing foods have specific benefits and some believe eating these foods presents specific difficulties. How much, if at all, do these statements apply to you?"

Response options were: 'Strongly Agree', 'Agree', 'Disagree', 'Strongly disagree' and 'Don't know'. '%Agree' percentages here combine 'Strongly Agree' and 'Agree' and '%Disagree' combines 'Strongly Disagree' and 'Disagree'.

Dietary fibre groups were determined using cut off points for total dietary fibre intake (g/day) for men and women

*** P<0.001, ** P<0.01, *P<0.05, NS=not significant

Table 6 Continued

Item	%Agree (%Disagree)											
	All n=94	Gender		P-value	Age Groups			P-value	Dietary fibre Groups			P-value
		Women n=49	Men n=45		19-24 n=21	25-44 n=50	45-65 n=23		Low n=38	Moderate n=23	High n=33	
I believe choosing wholemeal or wholegrain bread over white bread provides health benefits	99 (0)	98 (0)	100 (0)	NS	100 (0)	98 (0)	100 (0)	NS	97 (0)	100 (0)	100 (0)	NS
I believe fibre containing foods are high in vitamins and minerals	81 (4)	90 (6)	71 (2)	**	81 (5)	82 (0)	78 (13)	NS	76 (3)	78 (4)	88 (6)	NS
Would be or is difficult for me because a high fibre diet is expensive	51 (39)	57 (39)	51 (40)	NS	57 (43)	54 (36)	52 (43)	NS	63 (29)	62 (26)	36 (61)	*
Could lower my risk for certain diseases	83 (1)	90 (2)	76 (0)	NS	90 (0)	76 (2)	91 (0)	NS	87 (0)	70 (4)	88 (0)	NS
Helps keep bowel motions regular	96 (0)	98 (0)	93 (0)	NS	100 (0)	92 (0)	100 (0)	NS	98 (0)	91 (0)	97 (0)	NS

The full question asked was "Some people believe eating fibre containing foods have specific benefits and some believe eating these foods presents specific difficulties. How much, if at all, do these statements apply to you?"

Response options were: 'Strongly Agree', 'Agree', 'Disagree', 'Strongly disagree' and 'Don't know'. '%Agree' percentages here combine 'Strongly Agree' and 'Agree' and '%Disagree' combines 'Strongly Disagree' and 'Disagree'.

Dietary fibre groups were determined using cut off points for total dietary fibre intake (g/day) for men and women

*** P<0.001, ** P<0.01, *P<0.05, NS=not significant

3.5 Discussion

The dietary fibre intake tool (DFiT) was tested for relative validity against a 4-day diet record. The DFiT was accurate in classifying but not estimating total dietary fibre intakes. When different levels of dietary fibre intakes were compared to markers of gastrointestinal health, there were differences in the stool frequency and consistency. No differences were observed for either occurrence or severity for abdominal discomfort and excessive flatulence. A survey of perceptions of dietary fibre showed that, the majority were aware and agreed with the health benefits of consuming dietary fibre, however, just over half of participants identified that they agreed with the dietary fibre barriers statements. There were gender differences for some items and a higher socioeconomic status was predictive of responses.

The DFiT demonstrated a good ability to classify individual dietary fibre intakes (low, moderate and high). Cross classification by intake categories showed that exact agreement occurred 70% of the time and gross misclassification 12% of the time. Only one other study that aimed to validate a tool for assessing short term fibre intake has stratified dietary fibre intake into categories (low, moderate and high), and when compared to the present study, exact agreement occurred more frequently in this study (13).

For estimation of total dietary fibre intake (g/d), the DFiT may not be able to accurately quantify total short term dietary fibre intake as there was a significant difference between the two methods. The same result was evidenced in the original validation study, of which the DFiT was based on (23). Therefore, the DFiT was modified to include other dietary fibre containing food groups (baked items, pastries and processed meats and fibre supplements) to help improve the estimation of total dietary fibre intake (g/d). A possible reason for this difference may be related to the foods and serving size examples provided. It was not practical to include a list of all possible foods and serving size examples for each food group and therefore participants had to use their judgement to include and indicate a serving size for foods that were not listed. In light of this, the difference may be improved with the addition of other examples of foods and serving sizes in each of the food groups.

Despite the significant difference observed, the correlation (unadjusted r = 0.47) compares well with previous studies, in these studies, correlations ranged from 0.43 to 0.67 (9-13, 27). Higher values evidenced in other studies may in part, be explained by the correlation of error when both the test and reference methods are the same, i.e. food frequency questionnaires, as was the case in three studies, Apovian and co-authors (27), Rifas-Shiman and co-authors (12) and Shannon and co-authors (9). In the three studies that measured fat and fibre intake only, correlations were similar to this study; 0.43 (13), 0.44 (10) and 0.50 (9). Additionally, agreement between the two methods as assessed by the weighted kappa statistic, showed fair agreement.

The Bland-Altman plot showed that the difference between the DFiT and the 4-day diet record increased as the average amount of fibre increased. The significance of the average discrepancy is left for the reader to interpret if it is large enough to be of clinical significance, as this will be dependent on the application of the DFiT. Overall, there is good agreement between both methods as more than 95% of the points fell within the lower and upper limits of agreement.

The DFiT is a simple, short and easy to use questionnaire that has the ability to quickly classify an individual based on their total dietary fibre intake, making it in an ideal tool for use in the clinical setting and in research.

A strength of this validity analysis was the reference method used. We used a 4-day diet record to assess relative validity, therefore our coefficient is free of the error associated with correlation between two similar methods, thus making our coefficient more reliable. A limitation, however, is that a large proportion of subjects who completed the validity analysis identified themselves as being Asian (52%), therefore, caution must be exercised when applying the DFiT for dietary fibre assessment in different ethnicities. Future research should further validate the DFiT in different ethnicities.

The role of plant based diets is becoming increasingly important given that meat and meat based products are less sustainable in the long term (28). Since plant

based foods are high in dietary fibre, it is important to further investigate the effect of high fibre diets on gastrointestinal symptoms. Between low, moderate and high fibre consumers, we failed to find any significant association for occurrence or severity of abdominal discomfort and excessive flatulence. To the best of our knowledge, this was the first observational study to investigate the association between gastrointestinal symptoms and dietary fibre intake groupings; therefore, our results could not be directly compared to other studies. However, two randomized control trials that assessed the effect of specific fibre containing foods on the same gastrointestinal symptoms found no significant overall change (16, 17). Our results further add to the evidence that consumer concerns of excessive flatulence and abdominal discomfort resulting from eating fibre containing foods may be exaggerated.

It could be possible that the high fibre consumers in our sample may be desensitized to perceptions of abdominal discomfort and excessive flatulence. A previous study has investigated the adaptability of the gastrointestinal system to frequent dietary fibre consumption and excretion of gases. While quantitative results failed to identify a decreasing trend in the volume of intestinal gas or excretion of gases, researchers did note that participants reported lesser physical discomfort and a greater tolerance during the study (29). This may explain why we failed to observe any differences between groups.

On average, the high dietary fibre intake group consumed 16.9 g/d more dietary fibre than the low dietary fibre intake group. We did observe evidence that high fibre consumers pass one additional bowel motion per day and have a softer stool consistency than low fibre consumers. These results are not surprising as dietary fibre consumption increases laxation (30).

Our analysis has several potential limitations, the sample size within each of the low, moderate and high fibre groups was small and therefore future studies should be conducted with larger sample sizes to confirm our findings. Additionally, our study relied on subjective reports of flatulence as we did not quantitatively measure gas produced, thus limiting the significance of our findings.

Our study was unique as we were able to analyse perceived dietary fibre intake barriers and benefits by dietary fibre intake groups (low, moderate and high). Overall, the majority of participants had a high awareness of the health benefits, particularly in relation to the role of dietary fibre in laxation and lowering risk of disease. Only a small proportion of participants identified that eating a high fibre diet would be or is difficult due to abdominal discomfort, bloating or flatulence. This finding is consistent with that evidenced from the quantitative analysis of gastrointestinal symptoms in this study.

Compared with the proportion of respondents who agreed with the dietary fibre health benefits statement, fewer people identified barriers. Our analyses revealed that low dietary fibre consumers were more likely to identify time to prepare high dietary fibre foods as a barrier. Interestingly, these individuals are likely to have a higher socioeconomic status and are more likely to be men than women. Another barrier identified was lack of information; interestingly these individuals were more likely to have a higher socioeconomic status. To address these barriers, public health campaigns should consider targeting these individuals and providing education on preparation of high dietary fibre meals that take minimal time, and also provide nutrition education.

Additionally, those who perceived cost to be a barrier were more likely to be a low dietary fibre consumer. Surprisingly, our results showed that cost is perceived as a barrier regardless of SES. Previously, the national nutrition survey has shown that cost was a frequently cited barrier to increasing fruit and vegetable intake (31). This finding varies in other populations, Australian consumers are less likely (32) and UK consumers are more likely to perceive cost as being a barrier (33). The difference in this finding may be attributed to food prices between countries, albeit there is no data available that allows for direct price comparison of fruit and vegetable, and other high dietary fibre containing foods. To address this barrier, further research is required to consolidate the effect of price on consumer perceptions. A recent study has identified a low cost dietary pattern that is high in dietary fibre and meets the nutritional requirements of New Zealand Adults (34). Government authorities should consider using these results and findings from this study to guide decisions around food policies that will increase the average dietary fibre intake.

It is important to note, however, that the perceived benefits outweighed the perceived barriers, however, the mean dietary fibre intake (24.9 g/d) was below the dietary recommendations for males and females (25). Suggesting that other barriers may be present that the survey did not address or the perceived level of benefits need to be even greater to improve dietary fibre consumption. In the context of sustainability, it may be important to increase the awareness of health benefits and address barriers to increase dietary fibre consumption.

There are several limitations to this analysis that should be considered. Firstly, the sample size and sampling methodology was primarily based for validating the DFiT, thus when compared to the census, although the genders were representative, those in the 19-44 age group, those who identified themselves as being Asian, and those who were employed and unemployed were over-represented in our cohort. Further to this, the misreporters were not excluded in the analysis of gastrointestinal symptoms and perceptions by dietary fibre intake for statistical power, therefore limiting the reliability, future studies should be conducted using a larger representative sample size. However, this study is novel as it was the first study to examine perceived benefits *versus* barriers to dietary fibre consumption in a New Zealand population.

3.6 Conclusion

The DFiT is a valid, simple, short and easy to use questionnaire for accurately classifying individuals based on their short term dietary fibre intakes. The DFiT however is unable to accurately estimate total dietary fibre intake. There were no associations found for occurrence or severity for abdominal discomfort or excessive flatulence between low, moderate and high dietary fibre consumers. High dietary fibre consumers were likely to pass one additional bowel motion per day and softer stools than low dietary fibre consumers. There were some important differences in statement responses between genders, dietary fibre intake groups and socioeconomic status. Future research should further validate the DFiT in different populations, and further investigate the association between dietary fibre intake and gastrointestinal symptoms, and administer the perceptions of dietary fibre survey to a larger population.

3.7 Acknowledgements

The authors would like to thank all the participants who took part in this study.

3.8 Author contributions

John Micah wrote the research proposal, modified the DFI-FFQ questionnaire and scoring sheet, filed the ethics application, was responsible for recruitment, data collection and analysis and editing and drafting of the manuscript. Dr Jane Coad and Dr Genelle Healey supervised and assisted with all aspects of this study. Dr Barry McDonald supervised and assisted with data analysis and presentation of results. Owen Mudridge assisted with recruitment of participants.

3.9 Conflicts of Interest

The authors have no conflict of interest to declare.

Chapter 4: Conclusions and Recommendations

4.1 Overview of study findings

The primary objective of this study was to validate the DFiT tool to determine whether it can accurately classify individuals based on their short-term dietary fibre intake and estimate total dietary fibre intakes. The secondary objectives were to: 1) Compare different levels of dietary fibre intakes with gastrointestinal symptoms: flatulence, abdominal discomfort and bowel consistency and movements and, 2) Assess perceived benefits and barriers to dietary fibre intake.

The results of this study show that the DFiT is a valid tool for classifying (low, moderate or high) but not estimating total dietary fibre intakes. There was no association in occurrence or severity of gastrointestinal symptoms between low, medium and high fibre consumers, however, there were differences in the number of stools passed per day and stool form. Furthermore, the majority were aware and agreed with the health benefits of consuming dietary fibre, however just over half of participants identified with barriers such as time to prepare high fibre foods, lack of information and cost. There were gender differences in responses; more men than women identified time and cooking skills as barriers. Furthermore, socioeconomic status (SES) was predictive of responses; a higher SES was predictive of agreeing to: time to prepare and needing more information about high fibre foods but disagreeing to taste as being barriers

4.2 Significance of findings

Given the importance of the role of dietary fibre in health, the DFiT is a simple, short and easy to use questionnaire, it has the ability to quickly classify an individuals' total dietary fibre intake, making it an ideal tool for use in clinical settings as well as in research. The tool may prove to be useful, particularly for primary health care providers and dietitians operating in clinical settings and in the community, enabling them to quickly and accurately assess dietary fibre intakes.

We failed to observe any differences in occurrence or severity of any of the gastrointestinal symptoms analysed between low, medium and high dietary fibre consumers. These findings are consistent with and add to the existing evidence. The role of plant based diets is becoming increasingly important given that meat and meat

based products are less sustainable in the long term. Since these foods are high in fibre, it is important to further investigate the effect of high dietary fibre diets on gastrointestinal symptoms.

For perceived benefits and barriers to dietary fibre consumption, we observed important differences in responses. Public health campaigns could use these findings to target interventions. We have also shown that the price of dietary fibre containing foods is a barrier regardless of socioeconomic status. If the objective is to increase the national dietary fibre intake, government authorities should use these findings to further consolidate the effect of price and consider creating policies that will help achieve this objective.

4.3 Strengths and Limitations

Validity analysis

A strength of this study was the reference method used; a 4-day diet record. In validation studies, it is well known that there is a correlation error when the reference and test methods are similar (i.e. both food frequency questionnaires), thus artificially improving the accuracy of the test method (35). Therefore, to avoid this error a 4-day diet record was used as the reference method.

Also, a variety of statistical methods were used for assessing validity: cross classification, weighted kappa statistic, correlation coefficient and the Bland-Altman analysis. Cade and co-authors (36) and Willet (35) both recommend using more than one statistical method for analysis of validity, thereby increasing the robustness of the analysis.

A limitation, however, is that a large proportion of subjects who completed the validity analysis identified themselves as being Asian (52%), therefore caution must be exercised when applying the DFiT for dietary fibre assessment in different ethnicities.

Another limitation of this study was the inability of the DFiT to accurately estimate an individual's total dietary fibre intake. Thus limiting the tools features. However, this may be improved with the addition of more foods and serving size examples.

Gastrointestinal symptoms

For recording the severity of gastrointestinal symptoms: abdominal discomfort and excessive flatulence, we used the GSRS. The GSRS has previously been shown to be an effective measure of symptoms in patients with irritable bowel syndrome and peptic ulcer diseases (24), making our results more reliable.

Our analysis has potential limitations such as the small sample size within each of the low, moderate and high dietary fibre groups. As the analysis of gastrointestinal symptoms were the secondary objective, we based the sample size for the study primarily on the primary objective (validity analysis). Therefore, future studies should be conducted with larger sample sizes to confirm our findings. In addition, our study relied on subjective reports of flatulence as we did not quantitatively measure gas produced, potentially limiting the significance of our findings.

Perceptions of dietary fibre survey

The perceptions of dietary fibre survey was novel in that it was the first to examine perceived benefits *versus* barriers to dietary fibre consumption in a New Zealand population. The survey was pilot tested prior to being administered which is a strength of this study.

One of the limitations of this analysis is that, when compared to the census, although the genders were representative, those in the 19-44 age group and those who identified themselves as being Asian were over-represented in our cohort.

4.4 Recommendations for future research

- Further modify the DFiT to improve the estimation of total fibre intake and assess the validity of the DFiT in other populations and ethnicities
- Further investigate the effect of dietary fibre intake on gastrointestinal symptoms (quantitative measures if possible) using a randomized controlled trial study design with a larger sample size to confirm our findings
- Examine perceived benefits and barriers to consuming dietary fibre containing foods with an appropriate sampling technique and size

Appendices

Appendix A: Screening questionnaire

Screening Questionnaire

Thank you for your interest in this study. This study aims to understand different attitudes and the level of knowledge about dietary fibre intake. You have been given this questionnaire to assess your suitability to participate in the Dietary Fibre Study.

Please fill in the following information to the best of your knowledge and a member of the research team will contact you shortly after.

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 16/81*).* If you have any concerns about the conduct of this research, please contact Mr Jeremy Hubbard, Chair, Massey University Human Ethics Committee: Southern A, telephone 04 801 5799 x 63487, email humanethicsoutha@massey.ac.nz

Background Questions

1. **What is your Gender?**

   Female ☐
   Male ☐

2. **What is your current weight in kilograms (kg)? _____**
   (If you do not have a scale, roughly estimate your weight)

3. **What is your current height? _____**

4. **Do you have any acute and/or chronic diseases? (I.e. Diabetes, Asthma etc.) If so, please state them**

   _____
   _

5. **What is your ethnicity?**

   New Zealand European ☐
   Maori ☐
   Asian ☐
   Other (please state) _____

6. **What is the highest degree or level of school you have completed?**

   No schooling completed ☐
   Some high school ☐
   Diploma ☐
   Trade/technical/vocational training ☐
   Bachelor's degree ☐
   Master's degree ☐
   Doctorate degree ☐

7. **What is your Age?**

   19-24 years old ☐
   25-34 years old ☐
   35-44 years old ☐
   45-54 years old ☐
   55-65 years old ☐

8. **Are you a vegetarian or vegan or do you avoid meat?**

   Yes ☐
   No ☐

If you are a student or are currently unemployed, please skip questions 8 and 9 and go straight to question 11.

9. **What is your occupation _____**

10. **Please describe your responsibilities in your job briefly**
    _____
    _____
    _____
    _____
    _____

11. **In any <u>WEEK</u>, how often do you eat the following food groups in the table below, please answer by ticking the box which best represents your intake.**

12. **Please complete the following table**

	Everyday	On most days	Some days	Rarely
How often do you eat wholemeal/wholegrain breads and cereals such as: brown bread, Weet-bix and brown rice	☐	☐	☐	☐
How often do you eat legumes such as beans, peas and lentils	☐	☐	☐	☐
How often do you eat fruit	☐	☐	☐	☐
How often do you eat vegetables	☐	☐	☐	☐

Appendix A continued

	Yes	No
Are you currently pregnant or breastfeeding?	☐	☐
Do you have any food intolerances that can cause gastrointestinal symptoms (lactose intolerance etc.)?	☐	☐
Are you currently on a restrictive diet? (i.e. weight loss diets such as: Weight watchers, Jenny Craig, Atkins etc.)	☐	☐
Are you currently experiencing any of the following symptoms: severe abdominal pain, excessive flatulence or severe constipation?	☐	☐

Thank you for taking the time to complete this form. We really appreciate your commitment and effort. Please fill in the following contact information and we will be in touch with you shortly after.

Contact Details

Name _____

Email Address _____

Postal Address

_____

_____

_____

Phone number _____

Please save and return this form via email to dietaryfibrestudy@gmail.

Appendix B: DFI-FFQ

Introduction

* Welcome to the Dietary Fibre Intake Short Food Frequency Questionnaire (DFI-FFQ).

The questionnaire contains 5 questions about your FOOD INTAKE and is estimated to take you around 5-10 MINUTES to complete.

Please enter your FULL NAME in the box below.

* Please also enter the DATE and MONTH of your birthday in the BOX BELOW, e.g. 2nd July

Appendix B continued

Fruit intake

On average, over the PAST YEAR, how many serves of FRUIT have you consumed?

The following are examples of 1 SERVE of FRUIT

1 medium piece of fruit- i.e. apple, banana, orange, tomato or pear OR
2 small pieces of fruit- i.e. apricot, kiwifruit or plum OR
1/2 cup fresh, frozen, tinned or stewed fruit- i.e. berries or tinned peaches OR
1 small handful of dried fruit- i.e. sultanas

	Never	Less than 1 serve per MONTH	1-3 serves per MONTH	1 serve per WEEK	2-4 serves per WEEK	5-6 serves per WEEK	1 serve per DAY	2 serves per DAY	3 serves per DAY	4 serves per DAY	5 serves per DAY	6 or more serves per DAY
Fruit	○	○	○	○	○	○	○	○	○	○	○	○

Vegetable intake

On average, over the PAST YEAR, how many serves of VEGETABLES have you consumed?

The following are examples of 1 SERVE of VEGETABLES

1 medium potato, kumara, yam, taro or carrot OR
1/2 cup cooked broccoli, green peas, corn, pumpkin or spinach OR
1 cup salad

	Never	Less than 1 serve per MONTH	1-3 serves per MONTH	1 serve per WEEK	2-4 serves per WEEK	5-6 serves per WEEK	1 serve per DAY	2 serves per DAY	3 serves per DAY	4 serves per DAY	5 serves per DAY	6 or more serves per DAY
Vegetables	○	○	○	○	○	○	○	○	○	○	○	○

Appendix B continued

Bread and Cereal intake

On average, over the PAST YEAR, how many serves of BREADS AND CEREALS have you consumed?

The following are examples of 1 SERVE of BREADS AND CEREALS

Wholegrain/wholemeal- 1 slice of bread, 1 small roll or 1 wrap OR
White- 2 slices of bread, 2 small rolls or 2 wraps OR
Rice/pasta- 1/2 cup cooked brown rice or wholemeal pasta or 1 cup cooked white rice or white pasta OR
Cereals- 1/2 cup cooked porridge or muesli, 1/3 cup All/Sultana/San Bran or 2 Weetbix

	Never	Less than 1 serve per MONTH	1-3 serves per MONTH	1 serve per WEEK	2-4 serves per WEEK	5-6 serves per WEEK	1 serve per DAY	2 serves per DAY	3 serves per DAY	4 serves per DAY	5 serves per DAY	6 or more serves per DAY
Breads and Cereals	○	○	○	○	○	○	○	○	○	○	○	○

Nut and Seed intake

On average, over the PAST YEAR, how many serves of NUTS AND SEEDS have you consumed?

The following are examples of 1 SERVE of NUTS AND SEEDS

2 tablespoons of peanut butter OR
1/3 cup (or a small handful) of nuts or seeds (e.g. cashew nuts, almonds, pistachio nuts, brazil nuts, macadamia nuts, hazel nuts, chia seeds, sunflower seeds, pumpkin seeds, sesame seeds)

	Never	Less than 1 serve per MONTH	1-3 serves per MONTH	1 serve per WEEK	2-4 serves per WEEK	5-6 serves per WEEK	1 serve per DAY	2 serves per DAY	3 serves per DAY	4 serves per DAY	5 serves per DAY	6 or more serves per DAY
Nuts and Seeds	○	○	○	○	○	○	○	○	○	○	○	○

Appendix B continued

Legume intake (e.g. beans, peas and lentils)

On average, over the PAST YEAR, how many serves of LEGUMES (e.g. BEANS, PEAS and LENTILS) have you consumed?

The following are examples of 1 SERVE of LEGUMES (e.g. BEANS, PEAS and LENTILS)

3/4 cup tofu OR
3/4 cup cooked legumes (e.g. kidney beans, chickpeas, green/brown/red lentils, hummus, baked beans, split peas, canned bean mix, broad beans, white/black beans)

	Never	Less than 1 serve per MONTH	1-3 serves per MONTH	1 serve per WEEK	2-4 serves per WEEK	5-6 serves per WEEK	1 serve per DAY	2 serves per DAY	3 serves per DAY	4 serves per DAY	5 serves per DAY	6 or more serves per DAY
Legumes-Beans, peas and lentils	○	○	○	○	○	○	○	○	○	○	○	○

Appendix C: DFI-FFQ scoring sheet

Food group	**1 serve equals...** (these are examples only)	**Frequency of consumption (serves)-** tick the box which applies for each food group										
		Never	<1/ month	1-3/ month	1/ week	2-4/ week	5-6/ week	1/ day	2/ day	3/ day	4/ day	5/ day	6+/ day
Fruit	1 medium piece of fruit- i.e. apple, banana, orange, tomato or pear OR 2 small pieces of fruit- i.e. apricot, kiwifruit or plum OR ½ cup fresh, frozen, tinned or stewed fruit- i.e. berries, tinned peaches OR 1 small handful dried fruit- i.e. sultanas				0.31g fibre	0.92g fibre	1.7g fibre	2.14g fibre	4.28g fibre	6.42g fibre	8.56g fibre	10.7g fibre	12.8g fibre
Vegetables	1 medium potato, kumara, yam, taro or carrot OR ½ cup cooked broccoli, peas, corn, pumpkin, spinach OR 1 cup salad				0.42g fibre	1.25g fibre	2.3g fibre	2.91g fibre	5.8g fibre	8.73g fibre	11.6g fibre	14.6g fibre	17.5g fibre
Breads and cereals	Wholemeal/wholegrain- 1 slice of bread, 1 small roll or 1 wrap OR White- 2 slices of bread, 2 small rolls or 2 wraps OR Rice/Pasta- ½ cup cooked brown rice or wholemeal pasta or 1 cup white rice or white pasta OR Cereals- ½ cup porridge or muesli, ⅓ cup All/Sultana/San Bran, 2 Weet-Bix				0.4g fibre	1.2g fibre	2.19g fibre	2.79g fibre	5.6g fibre	8.4g fibre	11.2g fibre	14.0g fibre	16.7g fibre
Nuts and seeds	2 Tb peanut butter OR ⅓ cup nuts or seeds (e.g. cashews, almonds, pistachio, brazil nuts, macadamia nuts, hazel nuts, chia seeds, sunflower seeds, pumpkin seeds, sesame seeds)				0.54g fibre	1.63g fibre	3.0g fibre	3.8g fibre	7.6g fibre	11.4g fibre	15.2g fibre	19.0g fibre	22.8g fibre
Legumes- beans, peas and lentils	¾ cup tofu OR ¾ cup cooked legumes (e.g. kidney beans, chickpeas, green/brown/ red lentils, hummus, baked beans, split peas, canned bean mix, broad beans, white or black beans)				1.2g fibre	3.6g fibre	6.6g fibre	8.43g fibre	16.9g fibre	25.3g fibre	33.7g fibre	42.2g fibre	50.6g fibre

Appendix C continued

Low dietary fibre consumer= **<18g/day (Female) or <22g/day (Male)**

Moderate dietary fibre consumer= **18-24.9g/day (Female) or 22-29.9g/day (Male)**

High dietary fibre consumer= **≥25g/day (Female) or ≥30g/day (Male)**

Appendix D: DFiT questionnaire

Food group	**1 serve equals...** (these are examples only)	Never	1/ week	2-4/ week	5-6/ week	1/ day	2/ day	3/ day	4/ day	5/ day	6+/ day
Fruit	1 medium piece of fruit- i.e. apple, banana, orange, tomato or pear OR 2 small pieces of fruit- i.e. apricot, kiwifruit or plum OR ½ cup fresh, frozen, tinned or stewed fruit- i.e. berries, tinned peaches OR 1 small handful dried fruit- i.e. sultanas										
Vegetables	1 medium potato, kumara, yam, taro or carrot OR ½ cup cooked broccoli, peas, corn, pumpkin, spinach OR 1 cup salad										
Refined breads and cereals	Breads- 1 slices of bread, 1 small roll Rice/Pasta- ½ cup white rice or white pasta Cereals- 1 cup Rice bubbles or ½ cup cornflakes										
Wholegrain breads and cereals	Breads- 1 slices wholemeal bread or 1 small mixed grain roll Rice/Pasta- ½ cup brown rice or wholemeal pasta Cereals- ½ cup porridge or 1 Weet-Bix										
Nuts and seeds	2 Tb peanut butter OR ½ cup nuts or seeds (e.g. cashews, almonds, pistachio, brazil nuts, macadamia nuts, hazel nuts, chia seeds, sunflower seeds, pumpkin seeds, sesame seeds)										
Legumes- beans, peas and lentils	¾ cup tofu OR ¾ cup cooked legumes (e.g. kidney beans, chickpeas, green/brown/red lentils, hummus, baked beans, split peas, canned bean mix, broad beans, white or black beans)										
Baked items	1 slice of cake (100g) OR 1 medium sized Muffin (50g) OR 4 plain biscuits										
Pastries and processed meats	1 individual meat pie OR 1 medium sized sausage roll OR 1 large sausage										
Fibre supplements	2 tsp Metamucil OR 2 tsp Benefiber OR 7 Metamucil fibre capsules										

Appendix E: DFiT scoring sheet

Food group	**1 serve equals...** (these are examples only)	Never	1/ week	2-4/ week	5-6/ week	1/ day	2/ day	3/ day	4/ day	5/ day	6+/ day
Fruit	1 medium piece of fruit- i.e. apple, banana, orange, tomato or pear OR 2 small pieces of fruit- i.e. apricot, kiwifruit or plum OR ½ cup fresh, frozen, tinned or stewed fruit- i.e. berries, tinned peaches OR 1 small handful dried fruit- i.e. sultanas		0.31 g fibre	0.92 g fibre	1.7 g fibre	2.14 g fibre	4.28 g fibre	6.42 g fibre	8.56 g fibre	10.7 g fibre	+12.8 g fibre
Vegetables	1 medium potato, kumara, yam, taro or carrot OR ½ cup cooked broccoli, peas, corn, pumpkin, spinach OR 1 cup salad		0.42g fibre	1.25g fibre	2.3g fibre	2.91g fibre	5.8g fibre	8.73g fibre	11.64 g fibre	14.6g fibre	+17.5g fibre
Refined Breads and cereals	Breads- 1 slices of bread, 1 small roll Rice/Pasta- ½ cup white rice or white pasta Cereals- 1 cup Rice bubbles or ½ cup cornflakes		0.1 g fibre	0.3 g fibre	0.55 g fibre	0.7 g fibre	1.4 g fibre	2.1 g fibre	2.8 g fibre	3.5 g fibre	+4.2 g fibre
Wholegrain breads and cereals	Breads- 1 slices wholemeal bread or 1 small mixed grain roll Rice/Pasta- ½ cup brown rice or wholemeal pasta Cereals- ⅓ cup porridge or 1 Weet-Bix		0.26 g fibre	0.78 g fibre	1.43 g fibre	1.8 g fibre	3.6 g fibre	5.4 g fibre	7.2 g fibre	9 g fibre	+10.8 g fibre
Nuts and seeds	2 Tb peanut butter OR ⅓ cup nuts or seeds (e.g. cashews, almonds, pistachio, brazil nuts, macadamia nuts, hazel nuts, chia seeds, sunflower seeds, pumpkin seeds, sesame seeds)		0.54 g fibre	1.63 g fibre	3g fibre	3.8 g fibre	7.6 g fibre	11.4 g fibre	15.2 g fibre	19 g fibre	+22.8 g fibre
Legumes- beans, peas and lentils	¾ cup tofu OR ¾ cup cooked legumes (e.g. kidney beans, chickpeas, green/brown/ red lentils, hummus, baked beans, split peas, canned bean mix, broad beans, white or black beans)		1.2 g fibre	3.6 g fibre	6.6 g fibre	8.43 g fibre	16.9 g fibre	25.3 g fibre	33.7 g fibre	42.15 g fibre	+50.6 g fibre
Baked items	1 slice of cake (100g) OR 1 medium sized Muffin (50g) OR 4 plain biscuits		0.2 g fibre	0.6 g fibre	1.1 g fibre	1.45 g fibre	2.9 g fibre	4.35 g fibre	5.8 g fibre	7.25 g fibre	+8.7g fibre
Pastries and processed meats	1 meat pie OR 1 medium sized sausage roll OR 1 large sausage		0.17 g fibre	0.51 g fibre	0.94 g fibre	1.2 g fibre	2.4 g fibre	3.6 g fibre	4.8 g fibre	7.2 g fibre	+8.4g fibre
Supplements	2 tsp Metamucil OR 2 tsp Benefiber OR 7 Benefiber fibre capsules		0.4g fibre	1g fibre	2.2g fibre	2.7g fibre	5.4g fibre	8.1g fibre	10.8g fibre	13.5g fibre	+16.2g fibre

Appendix E continued

Low dietary fibre consumer= **<18g/day (Female) or <22g/day (Male)**

Moderate dietary fibre consumer= **18-24.9g/day (Female) or 22-29.9g/day (Male)**

High dietary fibre consumer= **≥25g/day (Female) or ≥30g/day (Male)**

Appendix F: 4-day food diary

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

The dietary fibre study

4-Day food record & gut health diary

Thank you very much for taking part in the Dietary Fibre study. We are extremely grateful for your time, effort and commitment!

If you have any questions, please contact John.
dietaryfibrestudy@gmail.com

All information in this diary will be treated with the strictest confidence. No one outside the study will have access to this.

Please post this form using the pre-paid envelope supplied or alternatively scan & email it to dietaryfibrestudy@gmail.com

Appendix F continued

4 Day food & gut health diary - what to do?

- Instructions for completing this diary are below.

- Record all that you eat and drink for any 2 weekdays and 2 weekend days. For a total of 4 days. After completing each day please complete the gut health diary for that day

- Please complete each day of the gut health diary at the end of the day

  For example: You could choose to do Tuesday, Thursday and Saturday, Sunday.

- If possible record food at the time of eating or just after – try to avoid doing it from memory at the end of the day.

- Include all meals, snacks, and drinks, even tap water.

- Include anything you have added to foods such as sauces, gravies, spreads, dressings, etc.

- Write down any information that might indicate size or weight of the food to identify the portion size eaten.

- Use a new line for each food and drink. You can use more than one line for a food or drink. See the examples given.

- Use as many pages of the booklet as you need.

- For full instructions please visit this link to watch an instructional video: www.massey.ac.nz/foodrecordinstructions

Appendix F continued

Describing Food and Drink

- Provide as much detail as possible about the type of food eaten. For example **brand names and varieties / types** of food.

General description	Food record description
Breakfast example – cereal, milk, sugar	1 cup Sanitarium Natural Muesli 1 cup Pam's whole milk 1 tsp Chelsea white sugar
Coffee	1 tsp Gregg's instant coffee 1 x 200ml cup of water 2 Tbsp Meadow fresh light green milk
Pasta	1 cup San Remo whole grain pasta spirals (boiled)
Pie	Big Ben Classic Mince and Cheese Pie (170g)

Appendix F continued

- Give details of all the **cooking methods** used. For example, fried, grilled, baked, poached, boiled…

General description	Food record description
2 eggs	2 size 7 eggs fried in 2tsp canola oil 2 size 6 eggs (soft boiled)
Fish	100g salmon (no skin) poached in 1 cup of water for 10 minutes

- When using foods that are cooked (eg. pasta, rice, meat, vegetables, etc), please record the **cooked portion** of food.

General description	Food record description
Rice	1 cup cooked Jasmine rice (cooked on stove top)
Meat	90g lean T-bone steak (fat and bone removed)
Vegetables	½ cup cooked mixed vegetables (Wattie's peas, corn, carrots)

Appendix F continued

- Please specify the **actual amount of food eaten** (eg. for leftovers, foods where there is waste)

General description	Food record description
Apple	1 x 120g Granny Smith Apple (peeled, core not eaten – core equated to ¼ of the apple)
Fried chicken drumstick	100g chicken drumstick (100g includes skin and bone); fried in 3 Tbsp Fern leaf semi-soft butter

General description	Food record description
Hot chocolate	I x cup hot chocolate made with Cadbury's powder and 150 mls Calcitrim milk, 100 ml hot water. No sugar

Appendix F continued

Record recipes

Record recipes of home prepared dishes where possible and the proportion of the dish you ate. There are blank pages for you to add recipes or additional information at the end of this booklet.

The following is an example of a recipe.

Recipe Example

Black bean dip

Ingredient	Amount
Watties tinned black beans	400g
Salt	1 teaspoon
Garlic	3 cloves
Salsa	1 cup
Olive oil	1 tbsp
Serves 6	

Recording supplements

Record any fibre supplements being taken. For example: Breakfast – Benefibre capsule x 1

Appendix F continued

Recording the amounts of food you eat

It is important to also record the quantity of each food and drink consumed. This can be done in several ways.

- By using household measures – for example, cups, teaspoons and tablespoons. E.g. 1 cup frozen peas, 1 heaped teaspoon of sugar.

- By weight marked on the packages – e.g. a 425g tin of baked beans, a 32g cereal bar, 600ml Coke

- Weighing the food – this is an ideal way to get an accurate idea of the quantity of food eaten, in particular for foods such as meat, fruits, vegetables and cheese.

- For bread – describe the size of the slices of bread (e.g. sandwich, medium, toast) – also include brand and variety.

- Using comparisons – e.g. Meat equal to the size of a pack of cards, a scoop of ice cream equal to the size of a hen's egg.

- Use the food record instructions provided to help describe portion sizes.

General description	**Food record description**
Cheese	1 heaped tablespoon of grated cheese 1 slice cheese (8.5 x 2.5 x 2mm) 1 cube cheese, match box size Grated cheese, size 10B

- If you go out for meals, describe the food eaten in as much detail as possible.

- ***Please eat as normally as possible - don't adjust what you would normally eat just because you are keeping a diet record and be honest! Your food record will be identified with a number rather than your name.***

Appendix F continued

Example

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)
7:55am	Sanitarium weetbix	2 weetbix
" "	Anchor Blue Top milk	150ml
" "	Chelsea white sugar	2 heaped teaspoons
" "	Orange juice (Citrus Tree with added calcium – nutrition label attached)	1 glass (275 ml)
10.00am	Raw Apple (gala)	Ate all of apple except the core, whole apple was 125g (core was ¼ of whole apple)
12.00pm	Homemade pizza	1 slice (similar size to 1 slice of sandwich bread, 2 Tbsp tomato paste, 4 olives, 2 rashers bacon (fat removed), 1 Tbsp chopped spring onion, 3 Tbsp mozzarella cheese)
1.00pm	Water	500ml plain tap water
3.00pm	Plain rice crackers	10
	Black bean dip	1 serving (4 tablespoons)- refer to recipe
6.00pm	Lasagne	½ cup cooked mince, 1 cup cooked Budget lasagne shaped pasta , ½ cup Wattie's creamy mushroom and herb pasta sauce, ½ cup mixed vegetables (Pam's carrots, peas and corn), 4 Tbsp grated Edam cheese
6.30pm	Banana cake with chocolate icing (homemade)	1/8 of a cake (22cm diameter, 8 cm high), 2 Tbsp chocolate icing
" "	Tip Top Cookies and Cream ice cream	1 cup (250g)
7.30pm	Coffee	1 tsp Gregg's instant coffee 1 x 300ml cup of water 2 Tbsp Meadow fresh blue top milk 2 tsp sugar

Appendix F continued

Date_____ DAY 1 (Weekday)

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

Date_____ DAY 1 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

(Please complete day 1 of the gut health diary [pg 12] at the end of the day)

Recipes (Day 1)

Number of serves recipe makes =	

Appendix F continued

Date_____ DAY 2 (Weekday)

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

Date_____ DAY 2 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

(Please complete day 1 of the gut health diary [pg 17] at the end of the day)

Recipes (Day 2)

Number of serves recipe makes =	

Appendix F continued

Date_____ DAY 3 (Saturday)

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

Date_____ DAY 3 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

(Please complete day 1 of the gut health diary [pg 22] at the end of the day)

Recipes (Day 3)

Number of serves recipe makes =	

Appendix F continued

Date_____ DAY 4 (Sunday)

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

Date_____ DAY 4 Sunday

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Appendix F continued

(Please complete day 1 of the gut health diary [pg 27] at the end of the day)

Recipes (Day 4)

Number of serves recipe makes =	

Appendix F continued

Thank you for completing this diary. Please return this diary to the postal address below with the pre-paid envelope supplied or alternatively you can email it to dietaryfibrestudy@gmail.com

Postal address

John Micah

School of Food and Nutrition
Massey University
Private Bag 102904
North Shore
Auckland 0745
New Zealand

Appendix G: Gastrointestinal health questionnaire

1. Have you experienced any of the following <u>today</u>? (please tick the symptoms that apply if any and tick the severity of the symptoms as being either 1, 2 or 3. See below table for definitions)

Symptoms	**Severity**			
	0	**1**	**2**	**3**
Abdominal discomfort				
Excessive flatulence				

<u>Definitions:</u>

Abdominal discomfort

0 – No discomfort

1 - Occasional discomfort in the abdomen

2 – Frequent episodes of prolonged discomfort

3 – Severe pain that impairs daily activities

Excessive Flatulence

0- No increased flatulence

1 **–** Occasional discomfort of short duration

2 – Frequent and prolonged episodes

3 – Frequent episodes that interfere with social activities

2. How many stools have you passed today? (please tick the box that applies)

None	☐
1	☐
2	☐
3 or more	☐

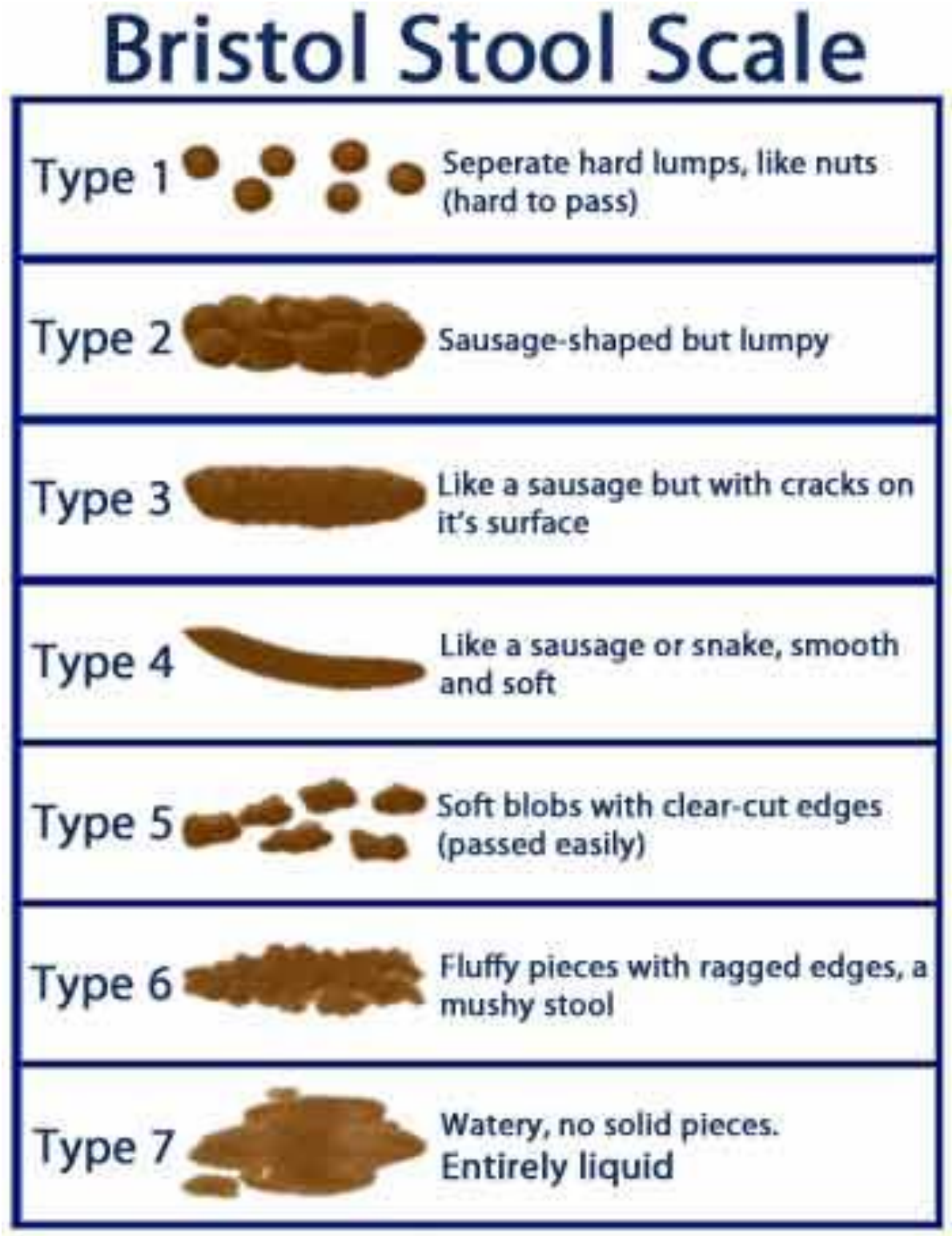
3. What is the consistency of your stool? Please use the Bristol stool chart (attached at the end of this document) please indicate the type (e.g. type 3)

Type_____

Appendix H: Bristol stool chart

Bristol stool scale

Please use the Bristol Stool Scale below to answer question 3 for each of the days in this diary



Appendix I: Perceptions of dietary fibre survey

Some people believe eating fibre containing foods have specific benefits and some believe eating these foods presents specific difficulties. How much, if at all, do these statements apply to you? (Please select one answer for each statement)

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
1. I believe eating a high fibre containing diet could help with appetite control by keeping me fuller for longer after eating	☐	☐	☐	☐	☐
2. I believe eating a high fibre diet would be or is difficult for me because I get abdominal discomfort, bloating or flatulence after eating high fibre foods	☐	☐	☐	☐	☐
3. I believe eating a high fibre diet would be or is difficult for me because I don't have the time to prepare high fibre foods	☐	☐	☐	☐	☐
4. I believe eating a high fibre diet could improve a person's overall health and well being	☐	☐	☐	☐	☐
5. I believe eating a high fibre containing diet can help with weight control	☐	☐	☐	☐	☐
6. I believe eating a high fibre diet would be or is difficult for me because I need more information about fibre containing foods	☐	☐	☐	☐	☐
7. I believe eating a high fibre containing diet could help lower cholesterol	☐	☐	☐	☐	☐
8. I believe eating a high fibre diet would be or is difficult for me because my cooking skills are limited	☐	☐	☐	☐	☐
9. I believe eating a high fibre diet can help to control blood pressure	☐	☐	☐	☐	☐
10. I believe eating a high fibre diet would be or is difficult for me because a high fibre diet does not taste good	☐	☐	☐	☐	☐
11. I believe choosing wholemeal or wholegrain bread over white bread provides health benefits	☐	☐	☐	☐	☐
12. I believe fibre containing foods are high in vitamins and minerals	☐	☐	☐	☐	☐
13. I believe eating a high fibre diet would be or is difficult for me because a high fibre diet is expensive	☐	☐	☐	☐	☐
14. I believe eating a high fibre containing diet could lower my risk for certain diseases	☐	☐	☐	☐	☐
15. I believe eating a high fibre diet helps keep bowel motions regular	☐	☐	☐	☐	☐

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