Dietary Fibre Intakes and the Main Food Sources of Fibre in New Zealand Adolescents

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Abstract

Background: The mean fibre intakes for 15-18-year old females from the last national nutrition survey (2008/09 New Zealand Adult Nutrition Survey) was 16.0 grams/day, well below the Adequate Intake (AI) for this age group of 22.0 grams/day. Adolescent male's fibre was at 21.9 g/day, which was also below the AI for their age group of 28 g/day. Given the role of dietary fibre in optimal health promotion, an update on the dietary fibre intakes of New Zealand adolescents is justified as it is unknown how intakes may have changed over time.

Objective: To assess the dietary fibre intakes and identify the main food groups contributing to fibre intake with secondary aims of examining the association between fibre and bodyweight and correlation with bowel habits.

Methods: The Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) study is two-year multi-centre, cross-sectional survey in New Zealand that was conducted in 2019 and 2020. Data were collected across three points; February-April 2019, July- August 2019 and February-April 2020 throughout New Zealand. Nationwide, adolescents aged 15-18 were recruited from high schools from eight locations nationwide in Dunedin, Wellington, Christchurch, Rotorua, Tauranga, New Plymouth, Wanaka and Auckland. Anthropometric measures were measured using standard protocols and used to calculate body mass index z-scores. Sociodemographic and bowel habits were self-reported with an online semi-quantitative questionnaire through REDCap. Dietary data were obtained via two interviewer-led 24-hour multi-pass dietary recalls on non-consecutive days, with a second recall via phone or video call. The dietary data were entered into FoodWorks 9 (Xyris Software, Australia) for each participant and analysed for nutrient content to estimate mean fibre intakes.

Results: Two hundred and sixty six female and 135 male participants were enrolled. Of the sample, 344 participants completed one 24-hr recall with 281 of those completing a second recall. The mean dietary fibre intake of adolescent females was 24.1 g/day (95% CI: 22.2, 25.9), which was higher than the AI for their age group (22g /day). Mean dietary fibre intake in adolescent males was 24.0 g/day (95% CI: 22.1, 25.8), which was lower than their AI (28 g/day). The top five food sources contributing to fibre intake were bread; grains and pasta; fruits; vegetables and breakfast cereals in both males and females. Bread made the greatest contribution to fibre in males, and fruits and vegetables and bread contributed in equal amounts in females. Dietary fibre intake was positively associated with energy intake, however, a higher fibre intake was associated with a lower bodyweight in females and in males after energy adjustment. A bowel habits questionnaire was completed by 129 males and 124 females. Overall, males and females both tended to have frequent and regular bowel motions regardless of fibre intake ($R^2 = 0.0099$).

Conclusion: Adolescent females had higher mean fibre intakes their AI whilst adolescent male's dietary fibre intake was lower than their AI. Given the influence of dietary fibre on chronic disease prevention, encouraging adolescents, males in particular, to increase fibre-dense foods may help in achieving their AI for dietary fibre.

Preface

The present thesis is part of the "Survey of Nutrition, Dietary Assessment and Lifestyles" (SuNDiAL study), a multi-centre, observational, cross-sectional survey in New Zealand. SuNDiAL is designed to measure dietary intakes, nutritional status, health status, motivations, and attitudes around food choices and lifestyles of adolescents in New Zealand. The SuNDiAL study was funded by the Department of Human Nutrition at the University of Otago, and a Lottery Health Research Grant.

I would like to gratefully acknowledge the work of the following who were responsible for the study design and development, ethical approval, protocol manual and methods paper, training MDiet data collectors, and collating the data in FoodWorks 9.

Drs Meredith Peddie (Principal Investigator), and Jill Haszard (Principal Investigator/Study Biostatistician), were the primary study investigators who designed the study and obtained funding and ethical approval. Dr Haszard was also responsible for overseeing all data management and statistical analysis of the study. Tessa Scott (Study Coordinator) liaised with schools and organised the provision of study equipment. Liz Fleming and Kirsten Webster managed the dietary data collection input and analysis.

Bernard Venn was responsible for supervision of thesis write-up.

The candidate was responsible for the following:

- Conducting a literature review
- Undertaking inferential and descriptive statistics using Microsoft Excel 2016
- Food group coding
- Writing up the statistical analysis based on data
- Preparation, writing and compiling this thesis.

*Due to the COVID-19 outbreak the candidate was unable to undertake 24-hr recalls and anthropometric measurements as part of data collection.

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List of Abbreviations

95% CI	95 percent Confidence Interval
AACC	American Association of Cereal Chemists
AI	Adequate Intake
ANS08/09	Adult Nutrition Survey 2008/2009
ANSES	Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail
AOAC	Association of Analytical Chemists
ABS	Australian Bureau of Statistics
BMI	Body Mass Index
Cm	Centimetres
COVID-19	Coronavirus Disease 2019
CVD	Cardiovascular Disease
EAR	Estimated Average Requirement
FAO	Food and Agriculture organisation.
FFQ	Food Frequency Questionnaire
FSANZ	Food Standards Australia and New Zealand
g	Grams
g/day	Grams per day
Kcal	Kilocalorie
kg	Kilogram
kJ	Kilojoule
IOM	Institute of Medicine
MDiet	Master of Dietetics
MJ	Megajoule
MoH	Ministry of Health
MSM	Multiple Source Method

n	Number
NHANES	National Health and Nutrition Examination Survey
NSP	Non-Starch Polysaccharides
NRV	Nutrient Reference Value
NZ	New Zealand
NCD	Non-Communicable Disease
RDI	Recommended Daily Intake
REDCap	Research Electronic Data Capture
SD	Standard Deviation
SDT	Suggested Dietary Target
SFAs	Short chain fatty acids
SuNDiAL	Survey of Nutrition Dietary Assessment and Lifestyles
US	United States of America
USFDA	United States Food and Drug Administration
UK	United Kingdom
WHO	World Health Organisation
yr	years old

1 Introduction

Dietary fibre is a heterogeneous group of compounds originating from a variety of plant food sources and is an essential component of a healthy diet. Food Standards Australia New Zealand (FSANZ) defines dietary fibre as the non-digestible edible components of plants and their extracts or synthetic equivalents including lignin and resistant starch, which must promote one or more of: laxation, blood cholesterol reduction, or modulation of blood glucose (FSANZ, 2018).

Having a generous amount of fibre in the diet supports normal bowel function and regular laxation (Cummings, 1984). Additionally, fibre is associated with reduced risk of obesity, type 2 diabetes, cardiovascular diseases and both colorectal and breast cancers (Reynolds et al., 2019). Adequate nutrition is essential during periods of growth within the human body, including of adolescence, a time at which the body undergoes maturation into adulthood. Furthermore, adolescence is also a time to form life-long dietary habits which set adolescents up for achieving an optimal dietary patterns during adulthood (Lake et al., 2004).

The recommended of fibre are set as an AI (Adequate Intake), based on promoting adequate laxation. The AI is set at 22 g/day for females and 28 g/day males aged 15-18 years-old, while, for adults, it is 25 g/day for women and 30 g/day for men (ABS 1998, MoH, 2003). The last time adolescent fibre intake was assessed in New Zealand was the 2008/09 Adult Nutrition Survey (ANS08/09). The mean fibre intakes for 15-18 year old adolescent females from the last ANS08/09 New Zealand were 16.0 g/day and males; 21.0 g/day, lower than the recommended AI for their respective age groups (University of Otago & MoH, 2011).Worldwide, there is a similar prevalence of both male and female adolescents not meeting their respective AIs.

As adolescence is a time in which life-long dietary habits may form, an adequate fibre intake during this period may set adolescents up for achieving an optimal intake during adulthood, to reduce risk factors associated with developing chronic disease.

The Survey of Nutrition Dietary Assessment and Lifestyle (SuNDiAL) 2019/2020 is a two-year study that began in 2019 with the focus on adolescent males and females aged 15-18 years. In semester one and semester two of 2019, analysis of adolescent females occurred. In 2020 semester one, an investigation of adolescent males aged 15-18 years old took place. The SuNDiAL study provides an opportunity to investigate fibre intakes whilst assessing the proportion of adolescents meeting the AI, and the subsequent associations between fibre intake and demographic, socioeconomic, and anthropometric indices in a sample of New Zealand adolescents. In addition, the common food sources which contribute to fibre intake will be identified, as well as dietary fibre's association with bowel habits and bodyweight. To this end, the intent is to be able to generate detailed guidance for NZ about not only the quantity of fibre which is being consumed, but specifically, how this might be achieved in terms of foods and the intakes to reach desirable health outcomes.

2 Literature Review

2.1 Methods of Literature Review

The objective of this literature review is to determine the intakes and sources of dietary fibre in both male and female adolescents aged 15-18-year-old. Medline via Ovid and Scopus were the main databases used to obtain literature. Literature was reviewed up until October 2020. Keywords used were ‘dietary fibre’ OR ‘dietary fiber’, ‘males AND females’ or ‘girls’ AND boys’ and ‘adolescent’ OR ‘teen’.

2.2 History of Dietary Fibre and its Definitions

Dietary fibre has long history, dating back to ancient Greece where it was known that bran cereals helped to prevent constipation. In the 1930s, J.H. Kellogg (1931) confirmed the positive effects of wheat bran on patients suffering with colitis and constipation, however it was not until 1953 that the term dietary fibre was officially coined by Hipsley (1953) as non-digestible constituents making up the plant cell wall. This definition has seen several revisions over time, and nearly 20 years later in 1970’s definitions started to incorporate the beneficial relationship between dietary fibre and human health (Trowell, 1972). This definition continued to expand to include polysaccharides, such as gums and mucilage (Trowell, 1974). Present day, there is a wide variety of definitions regarding what constitutes dietary fibre, its associated substances, and how they benefit human health.

2.2.1 Defining fibre

Table 2.2.1 Definitions of dietary fibre according to different issuing bodies

Issuing Body	Definition
Food Standards Australia New Zealand (FSANZ, 2001)[a]	"Dietary fibre means that fraction of the edible parts of plants or their extracts, or synthetic analogues, that are resistant to the digestion and absorption in the small intestine, usually with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides (degree of polymerisation >2) and lignins, and promotes one or more of the following beneficial physiological effects: (i) laxation (ii) reduction in blood cholesterol (iii) modulation of blood glucose"
Codex Alimentarius Commission (FAO/WHO, 2009)[b]	"Dietary fibre means carbohydrate polymers with which are neither digested nor absorbed in the small intestine. Dietary fibre consists of one or more of: • Edible carbohydrate polymers naturally occurring in the food as consumed, •Carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic, or chemical means, •Synthetic carbohydrate polymers. ***Properties*:** Dietary fibre generally has properties such as: •Decreases intestinal transit time and increases stools bulk, •Fermentable by colonic microflora, •Reduces blood total and/or LDL cholesterol levels, •Reduces postprandial blood glucose and/or insulin levels"

Food and Nutrition Board (FNB, 2001)[c]	• *"Dietary Fiber* consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. • *Functional Fiber* consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans. * *Total Fiber* is the sum of *Dietary Fiber* and Functional *Fiber*."
American Association of Cereal Chemists (AACC, 2001)[d]	"Dietary fiber is the remnants of the edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine, with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibers promote beneficial physiological effects, including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation."

[a] Food Standards Australia New Zealand (FSANZ, 2001).
[b]World Health Organisation and Food and Agriculture Organisation of the United Nations (WHO/FAO,2009).
[c] Dietary Fiber Definition Committee, 2001.(FNB, 2001).
[d]American Association of Cereal Chemists (AACC, 2001).

There is currently no single universally accepted definition of dietary fibre, and no global agreement as to what constitutes dietary fibre (Augustin et al., 2020). Most definitions commonly report dietary fibre as a type of carbohydrate resistant to digestion by dietary enzymes, with some type of benefit to health e.g. laxation or cholesterol reduction. ***Table 2.2.1*** depicts common definitions of dietary fibre from issuing bodies around the world. The above definitions all define fibre as edible components of plants or carbohydrates that are resistant to digestion and absorption. Furthermore, all four definitions denote fibre as imparting some kind of beneficial effect to human health and digestion. However, where the definitions differ is in defining which part of fibre and its associated compounds are included. Unlike the other definitions, the AACC includes associated plant substances in their definition. This is because in recent times definitions have expanded due to recognition of the fact that non-digestible oligosaccharides and resistant starch also behave physiologically as dietary fibre.

2.2.2 Classification

Dietary fibre falls into two main categories: soluble and insoluble. Types of soluble fibre include pectin, mucilage, beta-glucans and guar gum, which are found in varying quantities in all plant foods (Lo, Gordon, & Moore, 1991). Soluble fibre dissolves in water and is readily fermented in the colon into gases and physiologically active by-products. These by products include, short-chain fatty acids (SFAs) produced in the colon by gut bacteria. Some types of soluble fibre absorb water to become a gelatinous, viscous substance which delays gastric emptying which or may not be fermented by bacteria in the digestive tract (Champ et al., 2003; Asp, 1994).

Insoluble fibre does not dissolve in water, is resistant to digestive enzymes in the upper gastrointestinal tract and provides bulking. It is predominately found in wholegrain foods. Some types of insoluble fibre have bulking action and are not fermented. Bulking fibres absorb water as they move through the digestive system, easing defecation. Examples are wheat bran, lignin, cellulose and hemicelluloses. Lignin is a major dietary insoluble fibre source and may alter the rate and metabolism of soluble fibres (Champ et al., 2003; Asp 1994). Additionally, some other forms of fibre, such as resistant starch and inulin can be fermented in the colon by the gut bacteria where they produce SFAs and gases such as hydrogen, carbon dioxide and methane (Cummings, 1984; Champ et al., 2003).

2.3 Methods of fibre analysis

The two main approaches for the determination of dietary fibre include the Englyst method (enzymatic) (Englyst, 1989) and the AOAC (non-enzymatic-gravimetric) method (Association of Official Analytical Chemists) (AOAC, 1990).

The enzymatic-chemical method, otherwise known as the Englyst method, is used to measure non-starch polysaccharides (NSP) or the cell wall of a plant (Englyst, 1989). This method enzymatically removes sugar and starch, leaving behind a NSP residue, thus measuring dietary fibre as a chemically defined portion of the food (Champ, Langkilde, Brouns, Kettlitz, & Collet, 2003). After further enzymatic treatment of this residue, the fraction of soluble NSP and insoluble NSP can be determined. The enzymes used mimic the action of those in the gastrointestinal tract, with the resulting residue representing the fraction of insoluble dietary fibre (Elleuch, et al. 2011). Thus, the difference between total NSP and insoluble NSP represents the fraction of soluble NSP (Westenbrink, 2013; Elleuch, 2011).

The enzymatic-gravimetric method, otherwise known as the AOAC method (AOAC, 1990) is used to measure total fibre, as well as fractions of soluble and insoluble fibre. Non-fibre components are extracted from a food then protein and ash residue are corrected for. The remaining sample is then weighed, with the weight representing the total fibre value, (McCleary, Sloane, & Draga, 2015). From further filtration, the determinants of soluble and insoluble fractions of fibre are established (Westenbrink 2013; Elleuch, 2011

Both the AOAC and Englyst methods produce different proportions of insoluble, soluble fibre and resistant starch (Marlett, & Vollendorf, 1994). The AOAC method in general, produces a higher fibre content than the Englyst method (Marlett, & Vollendorf, 1994). New Zealand Plant and Food Research use the AOAC method for the New Zealand Food Composition Database.

2.4 Assessing adequacy of dietary fibre in individuals and groups

Apart from small amounts of short-chain fatty acids (SFAs) fermented in the gut, dietary fibre provides little to no energy or nutritional value to the body thus is technically not a nutrient. However, as fibre can provide functional and therapeutic benefits to the body it therefore has its own set of prescribed nutrient reference values (NRVs). Unlike most other nutrients, there is no biochemical marker that can be used to determine a person's dietary fibre needs. Accordingly no estimated average requirement (EAR) can be determined. Consequently, Adequate Intake is used when an RDI (Recommended Daily Intake) cannot be determined, in this case, fibre. According to the Institute of Medicine (IOM) this is based on the average daily nutrient intake of observed or experimentally determined estimates of intake by a group or groups of healthy people that are assumed to be adequate (IOM, 2002). As a result, estimated requirements are based on adequate gastrointestinal function and adequate laxation in New Zealand rather than reduction of risk for chronic disease (ABS 1998, MOH 2003). While the AI for fibre in NZ is not based on reducing chronic disease in the NZ NRVs include a Suggested Dietary Target (SDT) which is based on chronic disease risk reduction. These are set at 38 g/day for men and 28 g/day for women (ABS 1998, MOH 2003).

Table 2.5 Fibre Recommendations and Issuing Bodies Worldwide

Country	Fibre Recommendation		Issuing body
	Male	**Female**	
New Zealand	**28 g/day** (15-18yr olds)	**22 g/day** (15-18yr olds)	[a]MoH
Australia	**28 g/day** (15-18yr olds)	**22 g/day** (15-18yr olds)	[b]National health and medical research council
Europe	**40 g/day**	**30 g/day**	[c]European food safety authority
United Kingdom	**30 g/day** (16 to 18 years)	**30g /day** (16 to 18 years)	[d] Public Health England and Food Standards Agency, 2015, Scientific Advisory Committee on Nutrition
Netherlands	**30 g/day** 15-18yr olds	**25 g/day** 15-18yr olds	[e]Health Council of Netherlands
Canada	**38g /day** 15-18yr olds	**26g /day** 15-18yr olds	[f]Institute of Medicine
Ireland	**Age +5 g** (20-38g/day) 15-18yr olds	**Age+5 g** (20-38g/day) 15-18yr olds	[g]Food safety Authority of Ireland
USA	**38 g/day** 15-18	**25g /day** 15-18	[h]American Health Foundation, Academy Nutrition and Dietetics
France	**Age +5 g (20-38 g/day)** 15-18yr olds	**Age+5 g (20-38 g/day)** 15-18yr olds	[i]French Food Safety Authority

[a] & [b] NZ MoH and Australian National research council. [c] European Commission, 2020. [d] Scientific Advisory Committee on Nutrition, 2015. [e]Brink et al.,2019. Trumbo, Schlicker, Yates, & Poos, 2002. [g]Food Safety Authority Ireland, 2011. [h] Dahl & Stewart, 2015. [I] Agence nationale de sécurité sanitaire de l'alimentation de l'environnement et du travail, 2017 (ANSAS).

2.5 Fibre intake recommendations

The current AI for fibre intake in adolescents in New Zealand aged 14-18 years old is set at 28 g/day for boys and 22 g/day for girls. This is set at the median for dietary fibre intake in New Zealand and Australia and are based on the National Dietary Surveys of Australia undertaken in 1995 and New Zealand Children's Survey undertaken in 2002 (ABS 1998, MOH 2003). This also includes an allowance of 2–4 g/day to account for soluble fibre (ABS 1998, MOH 2003).

There is large variation in recommendations between countries and can vary slightly dependent on which age range the issuing body is targeting, as well as the basis or evidence supporting these recommendations. ***Table 2.5*** displays the fibre recommendations worldwide. Countries including Australia, Europe United Kingdom, Netherlands and Canada base their recommendations from their own specific national surveys. Conversely, Ireland and France set their adolescent fibre recommendations by age, thus the two have their recommendations set at Age in g + 5 g/day. The United Kingdom recommendations do not differentiate their fibre recommendations between males and females, thus their AI is set at 30 g/day for both sexes, the same as their adult recommendations. The range of daily dietary fibre recommendations from the different countries ranges between 20 g and 40 g for adolescents with Europe having the highest AI at 40 g for males.

Dietary fibre intake is commonly measured in grams per day. However, this can become problematic when comparing the fibre intakes of males and females, especially in regards to energy association and bodyweight. This is because males in general have higher energy intakes so representing fibre intake in grams/1000 kcal (kilocalories) or per MJ (Megajoule) provides standardisation and demonstrates fibre density in the diet rather than absolute fibre

intake. Countries such as the USA base their recommendations in energy; 14 g/1000 kcal/ day (Dahl & Stewart, 2015). They portray this as 38 g for males and 25 g for females to make them easier to follow for the general public. These figures are derived from the median energy intakes of the population in national nutrition surveys (Dahl & Stewart, 2015).

2.5.1 Fibre intakes in New Zealand and worldwide

Overall mean fibre intakes in New Zealand were below the AI according the last national nutrition survey in 2008/09. Mean intake for adolescent males was 22.1 g/day which is 7.9 g below the AI/day for males. Similarly, the mean intake for female adolescents was 17.5 g/day which falls just 5 g below the AI/day for females (University of Otago and MoH, 2011). Worldwide, there is a similar prevalence of fibre intake being lower than recommended for their countries respective NRV. In the United Kingdom (UK), Belgium, Italy and the United States (US), dietary fibre intakes were well below the recommended levels for adolescents **(Table 2.9),** ranging from 10.7g- 18.1g (United States Food and Drug Administration, 2012; Scientific Advisory Committee on Nutrition, 2015; Lin et al., 2011; Sette, et al., 2011). Similarly, national nutrition surveys carried out in France, Denmark, Ireland and Australia, mean intakes of dietary fibre were lower than the AI (10.1 to 19.3g) (Agence nationale de sécurité sanitaire de l'alimentation de l'environnement et du travail (ANSAS), 2017; Fayet-Moore, Cassettari, Pedersen et al., 2015; Food Safety Authority of Ireland, 2011). In summary, worldwide there is a common trend of fibre intakes being low, however as mean intakes of a group are below the AI, it is not possible to make assumptions about the prevalence of inadequacy. Furthermore, there is substantial variation in survey types, dietary collection methods and age ranges which makes comparisons between studies difficult.

2.5.2 Interpretation of Adequate Intake

Caution should be used when assessing adequacy of intakes of populations using the AI (Barr, Murphy & Poos, 2002). When the AI represents the mean intake of an apparently healthy group or groups of people, a group with mean intakes at or above the AI can be assumed to have a low prevalence of inadequate intakes (Murphy & Poos, 2002). However, when mean intakes of a group are below the AI, it is not possible to make assumptions about the prevalence of inadequacy. This is because it assumes that variance (distribution) of requirements are similar to the distribution of intake in a healthy population (IOM, 2002). Consequently, it is not possible to determine the proportion of group with intakes below requirements (Murphy & Poos, 2002). Furthermore, The Institute of Medicine (IOM, 2006) states that AIs are likely to overestimate any true requirement for the majority of individuals.

2.5.3 Foods contributing most to adolescent fibre intakes

According to the 2008/09 adults nutrition survey in New Zealand, the top five contributors to adolescent's fibre intake were breads, vegetables, kumara potatoes and vegetables, fruit and bread based dishes. Bread made the greatest contribution to dietary fibre for both males and females (University of Otago and MoH, 2011). In Australia, bread, breakfast cereals, cereal dishes, fruit and potatoes are the first five main contributors to dietary fibre intakes in both male and female adolescents (Fayet- Moore et al., 2018). Similarly, grain based cereals, fruits, vegetables and bread top the list as the five main contributors to dietary fibre intakes in French, German, Irish and Italian adolescent males and females (Alliance, 2011; ANSES, 2017; Stahl et al., 2009; Sette,et al, 2013). Overall, the main contributors of fibre in adolescent diets are similar in New Zealand, and internationally, generally constituting grains, fruits, vegetables and breads or cereals/cereal foods. Although, some international studies do not always separate their fibre contributors between males and females when

reporting sources, with additional studies reporting fibre intake but not always the food sources.

2.6 Dietary Fibre, Health and disease

The health benefits of dietary fibre in adults have been well documented in the literature and diets deficient in dietary fibre contribute to a number of chronic diseases such as cardiovascular disease, type 2 diabetes (T2DM), obesity, and some cancers (Hajishafiee, Saneei, Bensi-Kohansal & Esmaillzadeh 2016; Reynolds et al., 2019., López-Suárez, 2019). In more recent studies it has also been noted that dietary fibre has a dose dependent relationship with health benefits and amounts greater than 30 g/day confer even greater health benefits in adults (Reynolds et al., 2019).

2.6.1 Gastrointestinal health

Fibre is well known for its positive effects on laxation, digestion and gastrointestinal health (Anderson et al., 2009). Fibre works by both bulking the stools and retaining water, keeping bowel movements soft and regular (Cummings, 1984). Consequently, a high fibre diet can result in lower rates of constipation (Bosaeus, 2004) as well as aid in the prevention and management of diverticular disease, appendicitis, hiatus hernia and gallbladder disease (Burkitt et al, 1974). Some evidence also suggests that fibre quality and quantity may improve immune function through gut health and fibre-microbiota interactions (Watzl et al., 2005; Simpson & Campbell 2015).

2.6.2 Cardiovascular disease

An inverse relationship exists between dietary fibre intake and cardiovascular disease; (Ning et al., 2012; Threapleton et al., 2013) and individuals with adequate intake of dietary fibre are at lower risk of developing stroke (Zhang et al., 2013), hypertension and hypercholesterolemia (Brown et al., 1999). Dietary fibre is thought to lower cholesterol due to the unique physico-chemical properties of soluble fibre which can lower cholesterol by binding to it in the small intestine (Gunness & Gidley, 2010). Additionally, higher intakes of fibre during young adulthood also appear to decrease the risk of developing cardiovascular disease later in life (Ludwig et al., 1999).

2.6.3 Cancer

The World Cancer Research Fund reports a strong correlation between consuming foods containing dietary fibre and the reduction in risk of colorectal cancer (World Cancer Research Fund/American Institute for Cancer, 2018). Individuals with high fibre diets are at decreased risk of colorectal cancer (Aune et al., 2011; Bingham et al., 2003). Additionally, in females adequate fibre intake has been associated with significantly lower breast cancer risk (Chen et al., 2016; Dong, 2011), with adolescent consumption appearing to be particularly protective of development of breast cancer (Farvid et al., 2016; Chen et al., 2016; Dong et al., 2011).

2.6.4 Bodyweight

Systematic reviews link the consumption of fibre with both the prevention and management of obesity in adults (Mozaffarian et al., 2011; Wanders et al., 2011; Vitaglione, 2020). This association with bodyweight is proposed to be partly due to the effect that dietary fibre has on

satiety and subsequent energy intake (Shay et al., 2012; Clark & Slavin, 2013; Salleh, 2019). In adolescents, increased fibre intake has been found to be associated with lower risk of being overweight or obese (Choumenkovitch et al 2013; Quick, 2013) and those with low fibre intakes are at a higher risk of obesity (Brauchla, 2012). Furthermore, low intakes of fibre in adolescence are negatively associated with visceral fat, C-reactive protein, (Parikh et al., 2012) body fat percentage and waist to height ratio (Lin et al., 2015; Zhu et al., 2014)

2.6.5 Type 2 Diabetes

Adequate fibre intake, particularly from wholegrains, is associated with a lower risk of T2DM (Reynolds, 2020; Tieri, 2020). Improved glycaemic control, reductions in postprandial glycaemia and enhanced insulin response is associated with consumption of a diet high in fibre in those with existing type 2 diabetes (Ye et al., 2012; Cho et al., 2013; Yao et al., 2014). McRae (2018) observed that a high intake of dietary fibre, especially from cereals resulted in a reduction in the risk of developing T2DM.

In those already diagnosed with T2DM, a reduction in fasting blood glucose concentration, as well as a small reductions in glycated haemoglobin have also been observed (McRae, 2018). As the majority of research on fibre intake and diabetes risk focuses on adults, data in adolescents for comparison is limited. However, given adolescent fibre intake has been inversely associated with the both the risk of developing metabolic syndrome (Carlson, 2011) and obesity (Brauchla, 2012) which are independent risk factors for the development of type 2 diabetes, it is therefore, possible there is an association between the two, as observed in analogous adult studies (Ye et al., 2012; Cho et al., 2013; Yao et al., 2014).

2.6.7 Limitations of studies assessing fibre and health outcomes

To summarise, it is important to note that the studies linking fibre intake and to beneficial health outcomes are not without their limitations. The health benefits of fibre may be reflective of a high-fibre diet with all its accompanying nutrients, than of an independent effect of fibre. Associations with fibre and health found in epidemiological studies may be partially due to associated substances in fibre containing foods and not due to fibre alone. For example, fibre containing foods such as fruits, vegetables, and wholegrains, also contain health promoting nutrients such as amino acids, minerals, vitamins, phytochemicals and unsaturated fats.

2.7 Methods of Measuring Dietary Intake and Fibre

The aim of dietary assessment is to collect an accurate record of the dietary intake of an individual or population group. The common methods of gathering intake include food diaries, 24-hour recall, diet history, weighed diet record and a food frequency questionnaire (FFQ) (Souverein,et al., 2011). Which method is chosen depends on a variety of factors such as cost, participant burden, and the assessors. Dietary intake can be complex as there can be large day-to-day and seasonal variation in the foods and drinks individuals consume (Shim, 2014). In assessing associations between dietary variables, disease risk, and comparison with NRVS, it is important to consider habitual dietary intake. Most methods of assessing diet rely on self-reported intake and are complicated by the socio-cultural relationships individuals may have with food (Shim, 2014).

For obtaining quantitative recall data, 24-hour dietary recall is commonly used in dietary surveys (Rutishauser, 2005). This method requires roughly 30-40 minutes of the participant's time and 24- involves reporting all food and beverages consumed over last 24 hours in an interview. The recall method has a lower participant burden than weighing and recording all foods consumed which is required for the more accurate weighed food record method (see below) (Bingham et al., 1994). As a result, the 24-hour recall method has a higher response rate than other methods such as self-administered FFQs (Rutishauser, 2005; Bingham et al., 1994), which involves reporting frequency of consumption and portion sizes of a range of foods and beverages over a long-term period

Diet records involves recording all food and beverages consumed over 3 days (commonly 2 weekdays and 1 weekend). They can give a good representation of usual intake and can provide data on less frequently consumed foods if enough days are completed (Shim, 2014). Additionally, portion size accuracy is greater than other methods as it does not rely on the memory of the participant (Rutishauser, 2005). However, food records have a high respondent burden, with this increasing as the number of recording days increase, leading to a potential decrease in accuracy (Shim, J S, 2014). They can also be prone to under or over reporting (Johnson, 2002).

Diet histories involve recording intake on a 'usual' or average day and are good at representing usual intakes and are more qualitative than quantitative. However, they rely on the memory of the participants and require a highly trained interviewer to collect data (Shim, 2014; Bingham et al., 1994). Food frequency questionnaires can give a good representation of usual dietary intake and in addition, have a low respondent burden (Rutishauser, 2005). However, many FFQS are semi-quantitative, thus, cannot provide exact portions (Rutishauser,

2005). Over-reporting of high fibre foods is also common in FFQs, where fruits and vegetables have been shown to be eaten in higher rates when compared with 24-hr recalls from the same group of volunteers (Shim, 2014).

In summary, compared to FFQs, estimated weighed diet records have been shown to have a greatest alignment with dietary fibre intake. Although this method is the 'gold standard method', it can have high participant burden and is subject to over and underreporting. Overall, 24-hour recalls are suitable for larger studies as they provide the lowest participant burden and the highest response rate.

2. 8 Measuring stool form

Stool form refers to the shape and texture of the stool which can be assessed visually (Bliss et al., 1999). Measurement of stool consistency or water content requires laboratory analysis or weighing the stools which can be invasive and time consuming. However, stool form scales are a standardised and inexpensive method of classifying stool form. One of the most widely used is the Bristol Stool Form Scale, commonly referred to as the Bristol Stool Chart (BSC) (Blake et al., 2016). The BSC is an ordinal scale of stool types ranging from 1 to 7 with type 1 being the hardest and type 7 the softest. Type 3- 4 are generally considered to be normal stool form (Bliss et al., 1999). The BSC was developed and validated in order to be appropriate for comprehension and use by health professionals, patients and the general public (Blake et al., 2016).

2.9 Conclusion

There are limited up to date survey data on the fibre intakes of the adolescent populations around the world, although older studies indicate intakes are lower than their respective country recommendations, although no assumptions on inadequacy can be made. There is also no recent data for comparison available in New Zealand. Current dietary fibre data are provided from the 2008/09 ANS, which was conducted more than a decade ago which highlights the need for an updated assessment of adolescent fibre intakes. The current literature suggests that both adolescent males and females worldwide could be at risk of not consuming enough dietary fibre, although true requirements are unknown. In general, bread, grain products, cereals, fruits and vegetables appear to be the main contributors to dietary fibre intake in adolescents both in New Zealand and worldwide. The potential health benefits of fibre in adults are well documented however studies on the effect of fibre and health in adolescents are limited; thus, recommendations for adequate intake and disease prevention are based on data from adults which may not be appropriate for adolescents for optimal health promotion as they go into adulthood.

Table 2.9 Dietary Fibre Intakes Worldwide by Country, Age, Study Design and Collection Method.

Author and date	Country	Age range (yr)	n	Study and design	Dietary Collection Method	Male Mean Fibre Intake (g /day)	Female Mean Fibre Intake (g /day)
University of Otago and Ministry of Health (2011)	New Zealand	15-18	699 326 Male 373 Female	Voluntary Cross-sectional survey	24-hour diet recall & FFQ (survey)	21.9	16.0
Fayet-Moore et al., (2018)	Australia	2-18	2812	2011–2012 National Nutrition and Physical Activity Survey	One 24-hour dietary recall	18.4 (14-18yr)	19.3 (14-18yr)
United States Food and Drug Administration (USFDA) , (2012)	USA	12-19	585 Male 567 Female	National Diet and Nutrition (NHANES) Survey 2009-2010	Two 24-her recall	16.4	12.6
Scientific Advisory Committee on Nutrition, (2015)	United Kingdom	11-18	744	National Diet and Nutrition Survey	Four-day food record	12.8	10.7

Agence nationale de sécurité sanitaire de l'alimentation de l'environnement et du travail (2009)	France	11-17	880	Individual and National Study on Food Composition	7-day food record	15.2 (15-17 y)	13.3 (15-17y)
Alliance, (2011)	Ireland	13-17	224 Male 217 Female	National Teens Food Survey	7-day diet record	13.1	10.1
Stahl et al. (2009)	Germany	6-17	1272	Healthy Eating Project (Survey)	3-day food record	27.0	24.0
van Rossum et al. (2011)	Netherlands	7-18	1713	Dutch National Nutrition Survey	Two 24-hr recalls	18.5	16.2
Pedersen et al., (2018)	Denmark	14-17	101 Male 134 Female	National survey of dietary habits and physical activity	3-day food record	19.0	16.0
Sette, et al. (2011)	Italy	10-17	492	National Food consumption Survey	3-day food record	18.1	16.4

3 Objective Statement

The aim of this study was to evaluate and compare dietary fibre intakes of male and female adolescents in New Zealand aged 15-18 yr.

The objectives of this study were:

1) To estimate the dietary fibre intakes of adolescents aged 15-18 yr
2) To determine whether there are any differences in dietary fibre intakes in male and female adolescents
3) To identify the food sources that are the main contributors to dietary fibre intake between males and females
4) To determine whether there is a relationship between dietary fibre and bodyweight
5) To determine whether there is a relationship between dietary fibre intake and bowel habits.

4 Methods

The following chapter describes the methods of the SuNDiAL study. The study protocol for SuNDiAL was developed by Dr Jill Haszard and Dr Meredith Peddie (Department of Human Nutrition, University of Otago) and the following section is based on their previously published methods paper (Peddie et al., 2020).

4.1 Study Design

This study is a two-year, clustered cross-sectional survey (SuNDiAL; Survey of Nutritional, Dietary Assessment and Lifestyle) designed to describe nutritional status and dietary habits, health status, attitudes and motivations for food choice, 24-hour activity patterns of adolescent boys and girls aged 15-18 years of age. Data were expected to be collected across 2019 and 2020 in 4 phases; February-April 2019, July- August 2019 and February-April 2020 and July-August 2020 throughout New Zealand.

In the first phase and second phase, data were collected from females attending thirteen high schools in Christchurch, Dunedin, Nelson, New Plymouth, Tauranga, Wanaka, Wellington, and Whangarei during 2019. In the third phase, data were collected from adolescent boys aged 15-18 years recruited from local high schools in Dunedin, Wellington, Christchurch, Tauranga, and Auckland from the February to the March 2020. Due to the COVID-19 outbreak and Level-4 lockdown, data were not able to be collected during semester two of 2020, thus semester one data were used for the adolescent male comparison.

4.2 Ethical approval

This study was approved by the University of Otago Human Ethics Committee (H19\004) **(Appendix A)** and is registered with the Australian New Zealand Clinical Trials Registry: 2019: ACTRN12619000290190 and 2020: ACTRN1262000018596. Informed consent was obtained from each participant. For those participants aged less than 16 years, parental consent was also obtained. This study has also been acknowledged by Ngāi Tahu Research Consultation Committee Māori in both 2019 and 2020 **(Appendix B).**

4.3 Participant Recruitment and eligibility

4.3.1 Eligibility Criteria

Individuals were eligible to participate if they self-identified as female or male, were between the ages of 15-18 years and were enrolled in one of the recruited schools. Participants had to be able to speak and understand English, and be willing to complete the required online questionnaire. Exclusion criteria were if participants were pregnant or not able speak English. For this thesis, participants who did not complete at least one 24-hr recall were excluded from statistical analyses. All participants gave informed online consent, and from a parent or guardian for those that were under the age of 16.

4.3.2 Recruitment of Schools

School-based recruitment involved two components: the recruitment of secondary schools and the recruitment of student within the schools. Initially, selected high schools were emailed inviting them to participate in the study, including to a link to the study website. Participating schools gave consent in writing to take part in the study and for data collectors to attend their

schools. Invitations were sent until the required number of schools were obtained. Following this, the SuNDiAL data collectors contacted the schools to initiate the collection procedure.

4.3.3 Participant recruitment

MDiet research students visited the schools to initiate recruitment of participants. Initially this involved a PowerPoint presentation and an information session during a school assembly. This gave the potential participants background to the study, what it would require from them, and the reimbursement details. Students were provided information sheets **(Appendix C)** and a link to the SuNDiAL website (https://www.otago.ac.nz/sundial/index.html). Students who were interested in participating in the study could provide their contact details immediately after the presentation on a signup sheet, or alternatively through the website link. In addition, both electronic and print information about the study and its procedures were circulated within school newsletters or posted on school websites.

4.3.4 Enrolment and consent

A Consent and Eligibility questionnaire **(Appendix D)** was sent out to participants to screen potential subject and provide consent before continuing on to the study questionnaire. Interested participants were sent an email link to an online questionnaire which provided online consent and assigned each participant a study ID code. The questionnaire was administered though REDCap, a web-based software package for online surveys and databases. Initially, participants were asked to provide their name, age, date of birth and consent. Participants were also given the option to consent here to additional parts of the study including wearing an accelerometer, urine and blood samples. Participants who were under 16 yr were also directed to provide the email address of a parent or guardian.

4.3.5 Reimbursement

Reimbursement for completion resulted was a $5 supermarket voucher for each stage of the study completed: online questionnaires, 24-hr recall in person, 24-hr recall via a phone or video call, blood sample, urine sample, and wearing an accelerometer for seven days. The maximum value of supermarket vouchers a participant could receive was $30. The vouchers were sent out to the participants via post once data collection had ceased.

4.4 Data Collection

4.4.1 Questionnaire

Following online enrolment and consent, participants were then required to complete the study questionnaire. The questionnaire took approximately 30 minutes in its entirety to complete, and was separated into four sub-questionnaires; Sociodemographic Data; Health and Demographics; Attitudes and Motivations and Dietary Habits. For the purposes of this thesis and relevance to dietary fibre, the Sociodemographic data and the Dietary Habit questionnaires will be outlined below.

4.4.1.1 Sociodemographic data.

Data were collected on sociodemographic characteristics of all participants. Ethnicity was collected using the 2018 New Zealand Census (Atkinson et al., 2019). Participants were asked to select one or more ethnicities from following categories: "*New Zealand European, Māori, Samoan, Cook Island Māori, Tongan, Niuean, Chinese, Indian, and Other (please state).*" Participants who reported two or more ethnic groups were assigned to one group using a prioritization method (Poutasi, 2004) under priority of highest to lowest of the following groups: Māori, Pacific, Asian or NZ European/other. Deprivation index was based on mesh block data determined from participants' home addresses (Stats New Zealand, 2006). The NZ Deprivation Index is an area-based measure of socioeconomic deprivation in New Zealand and

measures the level of deprivation for people in a small area (Stats New Zealand, 2006).

4.4.1.2 Dietary Habits

Participants were asked to complete this questionnaire regarding their dietary habits to collect data on usual eating habits and frequencies. Relevant questions pertaining to dietary fibre are included below.

Participants were asked the frequency of which they consumed the following food groups; bread, fruits, vegetables, legumes, nuts and snack foods. For each food group participants were asked to select one the following answers: *"Never I do not eat ; less than once a week; once a week; 2-4 times a week; 5-6 times a week; once a day; 2 times a day; 3 times a day or more than 3 times a day."*

4.4.1.3 Bowel Habits

In addition, participants were also asked to provide the following information regarding frequency and stool type pertaining to the Bristol Stool Chart **(Appendix F):**

1. ***How many times per week do you usually have a bowel movement (poo)?***

Participants had the option to choose a value between 1 and 70. If participants entered a number above this range they would receive an alert to double check the value.

2. ***Please look at the picture below and select the number that corresponds to your usual and most common stool type***

Participants were presented with an in-questionnaire Bristol Stool Chart **(Appendix F)** and prompted to choose one of the following responses: *Type 1, Type 2, Type, 3 Type 4, Type 5, Type 6 or Type 7*. Note- the BSc and Bowel habits questionnaire was only included from the second quarter of the SuNDiAL study onwards hence the smaller response rate.

4.4.2 Anthropometric Measurement

Following the completion of the questionnaires, participants attended a study visit where anthropometric measurements, height and weight were collected by trained MDiet researchers. All MDiet researchers followed the standard study protocols in order to ascertain accurate anthropometric measurements. The extensive anthropometric protocol is included in **(Appendix G).**

Participant's heights were measured with a stadiometer Seca 213 Wedderburn (Wedderburn, Sydney, Australia, 2020). Firstly, participants were asked to remove their shoes, as well as any hair buns on top of the head. Additionally, before weight was taken, participants were asked to remove any heavy clothing and shoes. Participants were then instructed to step onto the scale

(Seca Alpha 770) facing away from the display (to prevent seeing the weight). Values were recorded to the nearest 0.1cm and 0.1kg. Two separate measurements were recorded and averaged to decrease measurement error, if these two measurements were more than 0.5 units apart, a third measurement was recorded **(Appendix G).** Height and weight indices were entered into REDCap, to generate a BMI calculated in kg divided by square of height in metres (WHO, 2006). Z-scores were used to classify BMI using the WHO guidelines. <-2 is classified as underweight; ≥-2 to ≤+1 is classified as a healthy weight; >+1 to ≤+2 is classified as overweight; >+2 is classified as obese (WHO, 2006)

4.4.3 Dietary Assessment

To determine estimates of dietary intake, an initial 24-hour recall was conducted face to face with a participant during school hours and a second 24-hour recall was conducted over the phone after school. The recalls were completed on non-consecutive days of the week and if possible, included one weekday to capture usual variation between different days of the week. For a proportion of adolescent males who were under Level 4 Lockdown, 24-hr recalls via Zoom were used.

The Multiple Pass Method was used to account for individual variation **(**Harttig et al., 2011**).** The method involves four stages; 1) recalling foods and drinks consumed; 2) recalling specific restrictions of food and drinks consumed 3) estimating portion sizes 4) reviewing recall interview (Blanton, 2006).

For each interview, participants were first asked to list all items they ate from midnight to midnight the previous day in a ‘quick list’, they were then probed to recall details such as brands of food items and cooking methods. Lastly, participants would work with the interviewer to estimate quantities using standardized house-hold measures, food models, and

photos of different portion sizes **(Appendix H).** Interviewers were trained to gather 24-hr recall data as per the study protocol to produce the most accurate record **(Appendix I).**

4.5 Dietary Data Analysis

All recalled foods and drinks were then entered into FoodWorks 9 (Xyris software Australia pty Ltd, 2017) by MDiet students to calculate dietary fibre and energy intakes. Supplement data were provided from the online questionnaire. FoodWorks is comprised of the most up-to-date food composition tables for New Zealand (FOODfiles 2014) (The New Zealand Institute for Plant and Food Research Limited, 2019) which was enhanced by the inclusion of ANS08/09 recipe calculated foods. For each recalled item, the data collector entered the exact food or drink within the database. If pre-packaged food items were not already in the database, the ingredients list of the product would be found on the manufacturer website and entered from constituent ingredients available on FoodWorks. Details on the cooking method of homemade recipes were gathered during the diet recall; e.g. boiled, fried, baked, and adjusted for the appropriate retention factors. Data in FoodWorks were monitored by the study biostatistician, extremely low or high values were identified and cross referenced against the original recording sheets and clarified with the original interviewer. Foods entered were coded into the 33 major food group categories based on the groups used for the ANS08/09 **(Appendix J).** For each participant, the proportion of their total nutrient intake from each of the 33 food groups was calculated.

4.6 Statistical Analyses

All statistical analyses were carried out using Stat Statistical Analysis Software 16.0 (StatCorp Texas, 2019). All descriptive and inferential analyses were completed by the candidate; graphs, mean dietary fibre, contribution from each food group, energy adjustment and 95% Confidence Interval (95 CI) were calculated using Microsoft Excel 2016 (Microsoft Excel for PC version 16.35 Microsoft Corporation, 2016). Due to the incomplete sample size in males from COVID-19, descriptive and inferential graphs were presented in separate figures where appropriate.

4.6.1 Sample size calculation

The study biostatistician was responsible for calculating the sample size and statistical power of the SuNDiAL19/20 study. The design effect for school clusters was found to be 1.5 in the 2019 portion of the study. For the adolescent females in 2019 the aim was to recruit at least 300 female participants. In the 2020 section of the study, the design effect was predicted to be 1.5 as well, with 150 males required in order to allow for dropouts, incomplete data and a small design effect from school clusters. The intra-class correlation for nutrient intakes within schools was small (less than 0.04) if at least ten boys from each school participated in the 2020 study.

5 Results

5.1 Participant and school recruitment

A total of 108 eligible schools were invited to participate in 2019, of these 16 of the 108 eligible schools were recruited to participate in the study. In 2020, 140 eligible schools were invited to participate in the study; out of the 140 potential male schools, 8 schools consented to participate. However, 2 of these schools were unable to participate due to COVID-19. Consequently, a total of 13 female schools and 6 male schools consented to participate in the SuNDiAL study. A flow diagram of participant recruitment and selection for the study is shown in **Figure 5.1**. In total, 272 adolescent females and 146 males consented to participate. Of these, 242 females and 102 males completed at least one 24-hour recall, and were therefore included analyses. 209 female participants completed both 24-hour recalls, and 72 males completed a second recall.

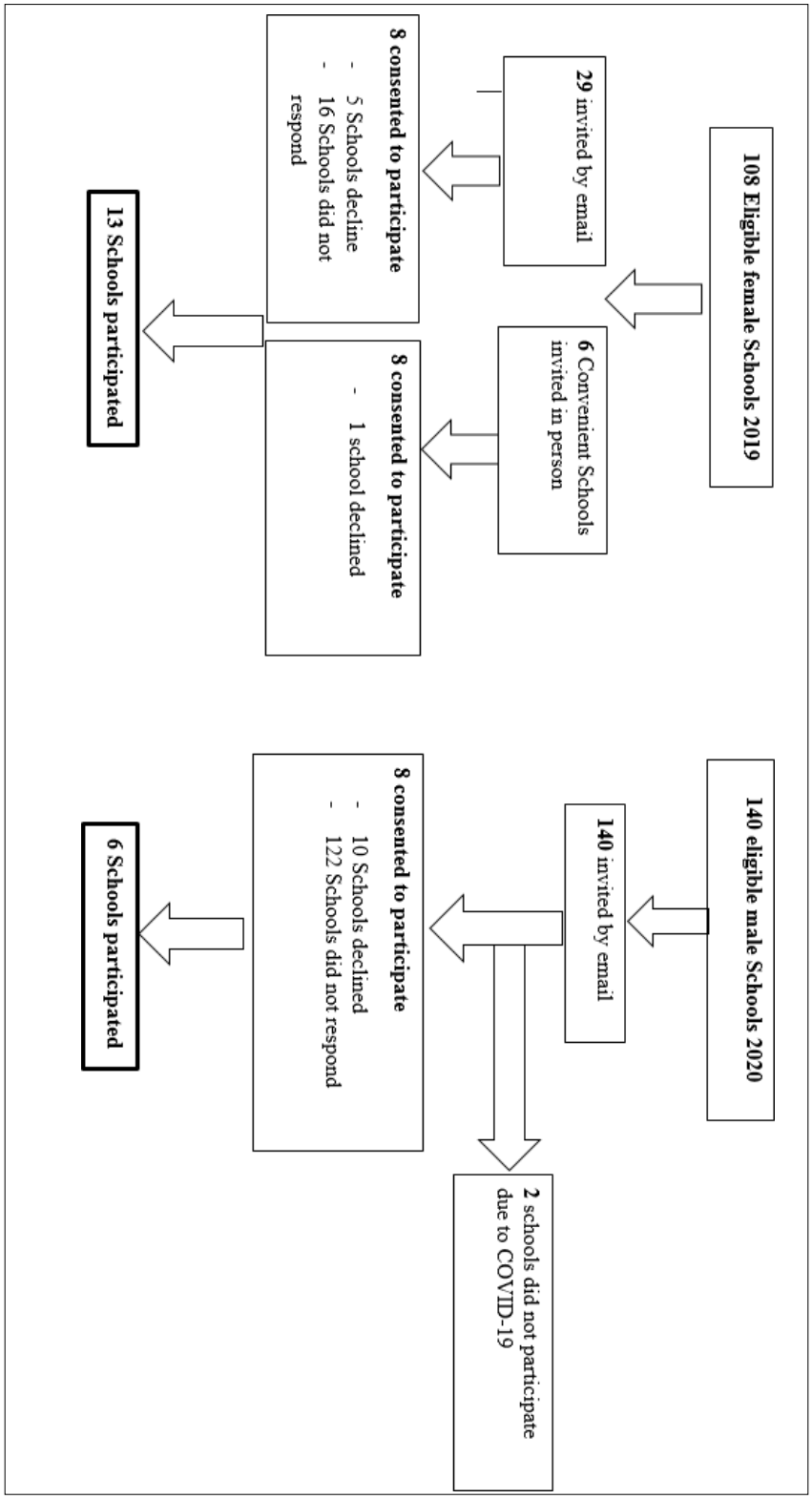


Fig 5.1 School Recruitment Flow Chart

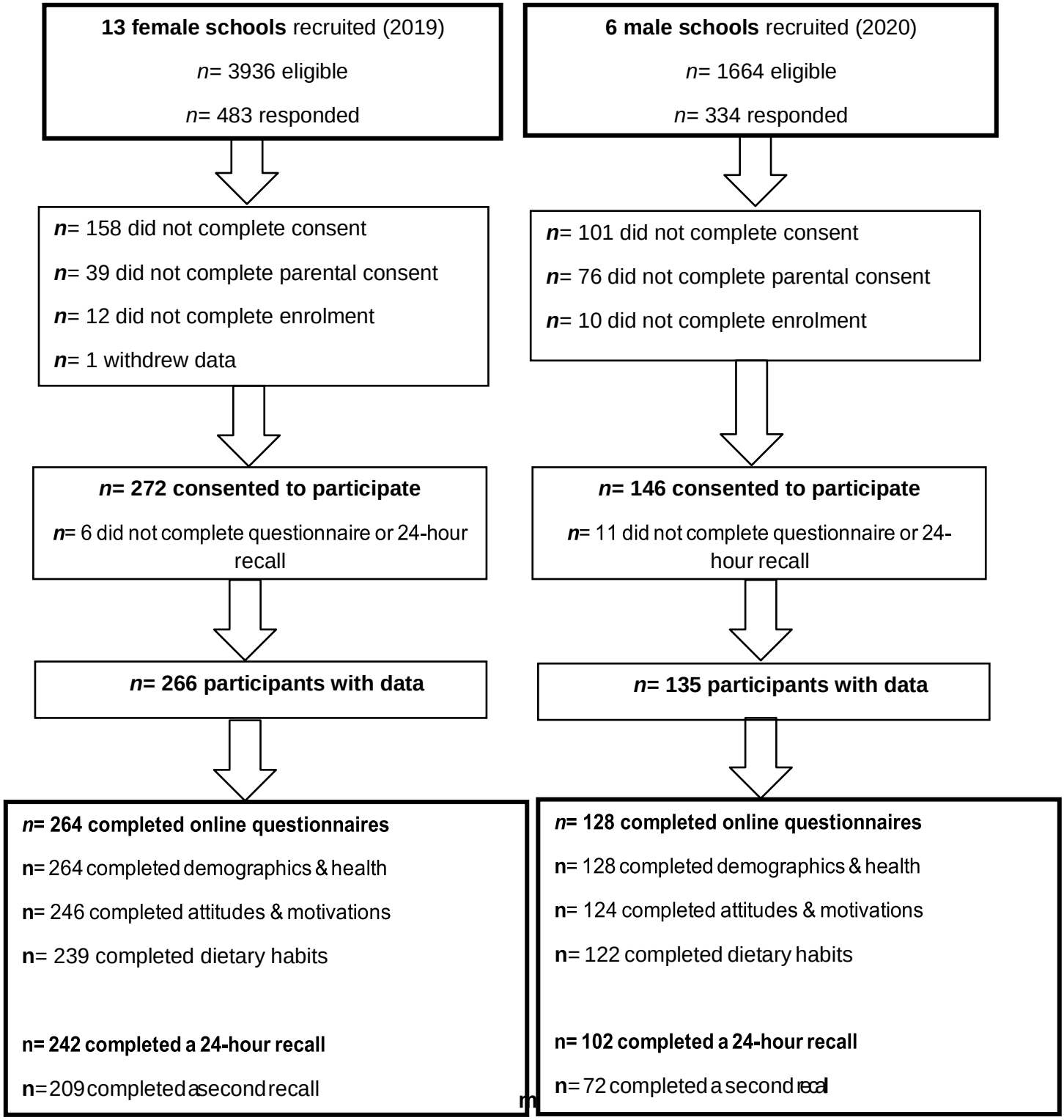


Figure 5.1.2 Participant Flow Chart

TABLE 5.1 displays the demographic characteristics of male and female participants by age, ethnicity, deprivation index and BMI Z-score. The mean age for females was 16.8 yrs whilst the mean age for males 16.6 yrs. There was only one underweight male in our study and no underweight females.

TABLE 5.1 Male and female demographic characteristics based on age, BMI Z-score, ethnicity and deprivation index

Characteristics	**Participants**	
Sex	**Female (%)**	**Male (%)**
Age (years)	**n=266**	**n=135**
15	58 (21.8)	20 (14.7)
16	84 (31.5)	71 (52.6)
17	99 (37.2)	44 (36.3)
18	15 (5.6)	-[1]
BMI[2] Z-score[3]	**n=240**	**n=109**
Underweight(<-2)	-	1 (0.9)
Healthy (≥-2 to 1)	157 (65.4)	73 (67.0)
Overweight (1 to ≤2)	57 (23.8)	29 (26.6)
Obese (>2)	26 (10.8)	6 (5.5)
Ethnicity[4]	**n=263**	**n=129**
NZEO	207 (78.4)	73 (56.6)
Māori	42 (15.9)	12 (9.2)
Pacific Islander	6 (2.3)	3 (2.3)
Asian	9 (3.4)	41 (31.8)
NZDep2018[5]	**n=264**	**n=129**
1-3 (Low)	106 (40.2)	46 (35.7)
4-7 (Moderate)	106 (40.2)	54 (41.9)
8-10 (High)	52 (19.7)	29 (22.5)

[1] There were no participants in this socio-demographic category
[2] Body mass index (BMI) Kg/m2 (WHO, 2006)
3 BMI Z-score is the difference between an observed value and the median value of a reference population divided by the standard deviation value of that population (WHO, 2006)
4 Ethnicity- ethnic groups as of 2018; NZ European and Others (NZEO), Māori, Asian and Pacific Islander (Stats NZ 2018)
4 5 NZ deprivation Index 2018- The New Zealand Deprivation Index is a scale of deprivation from 1-10. 1 represents an area of lowest deprivation and 10 an area with the highest deprivation. (Atkinson et al.,2019)

5.2 Dietary Fibre Intake

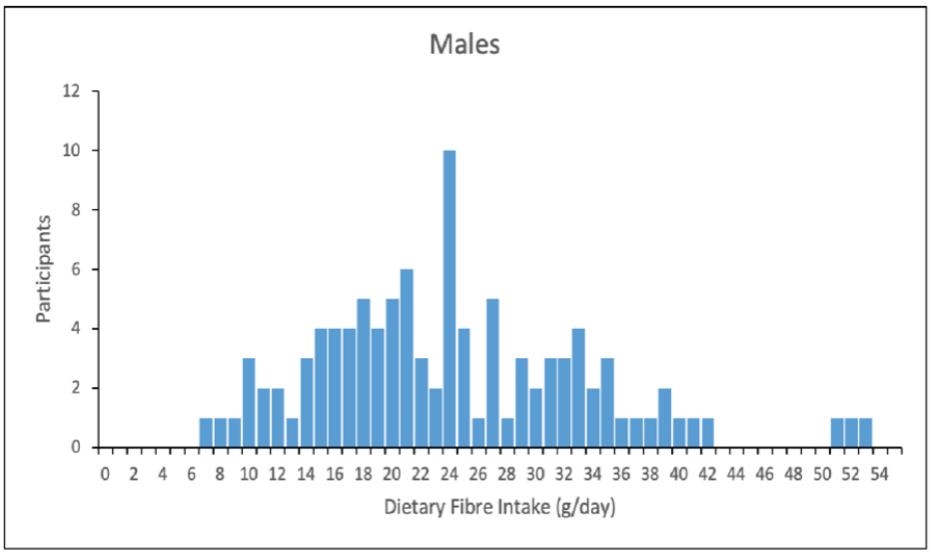
Table 5.2 Mean daily dietary fibre intake of male and female participants based on age, BMI Z-score, ethnicity and deprivation index

Characteristics		**Mean Dietary Fibre Intake (g/day) (95%CI)**		
Sex		**Female**		**Male**
Age (years)	**n=256**		**n=135**	
15	58	23.1 (21.0, 24.7)	11	22.5 (21.3, 23.7)
16	84	23.2 (22.5, 25.0)	55	23.5 (21.9, 25.1)
17	99	25.2 (24.0, 26.0)	49	25.57(24.0, 27.5)
18	15	23.8 (21.0, 24.1)	-	-
BMI Z-score	**n=240**		**n=109**	
Underweight(<-2)	-		1	25.0
Healthy (≥-2 to 1)	157	24.5 (23.7,25.4)	73	24.1 (22.4, 25.8)
Overweight (1 to ≤2)	57	23.0 (22.0,24.7)	29	24.7 (22.8, 26.7)
Obese (>2)	26	22.5 (20.3,23.9)	6	27.1 (24.3, 29.8)
Ethnicity	**n=263**		**n=129**	
NZEO	207	24.3 (23.8, 25.4)	73	25.4 (23.7, 27,1)
Māori	42	23.1 (22.3, 24.6)	12	21.1 (20.2, 22.0)
Pacific Islander	6	30.7 (25.1, 37.6)	3	29.6 (26.1, 33.2)
Asian	9	18.4 (14.3, 22.1)	41	21.8 (20.3, 23.3)
NZDep2018	**n=264**		**n=129**	
1-3 (Low)	106	23.9 (23.1, 24.8)	29	24.4 (22.6, 26.1)
4-7(Moderate)	106	25.9 (24.6, 27.1)	54	24.6 (22.7, 26.4)
8-10 (High)	52	25.9 (24.6, 27.1)	46	23.3 (22.0, 24.6)

The mean daily fibre intakes of males and females are shown in **Table 5.2** Pacific Islanders had the highest mean fibre intake when compared to other ethnicities, but also had the smallest sample size. Asian females and Māori males had the lowest fibre intake in their respective gender-ethnic category. Females in areas of highest deprivation index had lower mean fibre intake, whilst in males those in areas of lowest deprivation had lower mean fibre intakes.

5.2.1 Distribution of dietary fibre intake

A.



B.

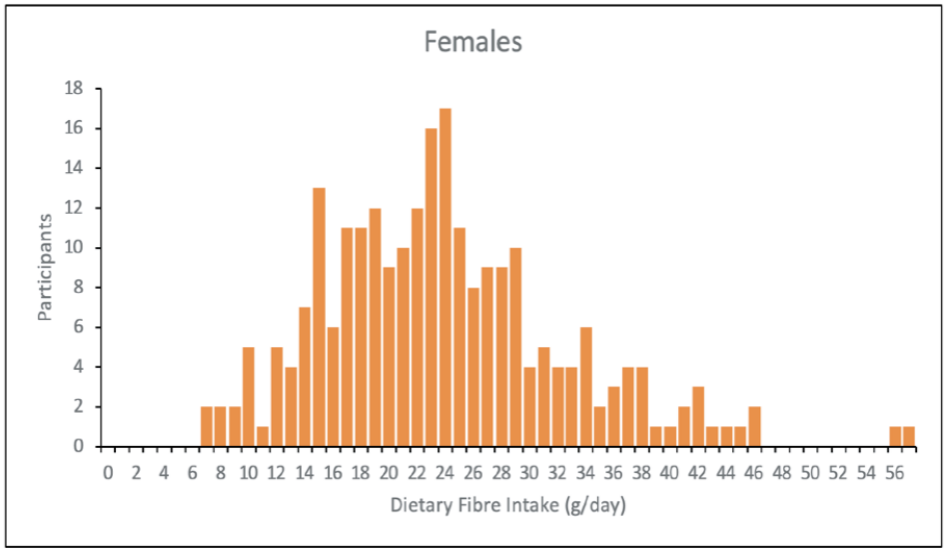


Figure 5. 2.1 Distribution of mean fibre intake of female male adolescents (g/day)

The mean fibre intake of the male population was at 24.1 g/day (95% Confidence Interval (CI): 22.2, 25.9) and median fibre intake was at 23.4 g/day (25th percentile: 17.2, 75th percentile: 29.8). The male's mean fibre intakes were slightly normally distributed, with three participants with an atypically high fibre intake of more than 50 g/day (***Figure 1.2.1 A)***.

The mean fibre intake of the female population was at 24.0 g/day (95% Confidence Interval (CI): 22.2, 25.8); median fibre intake was at 23.3 g/day (25th percentile: 17.1, 75th percentile: 29.7). Female's fibre intake were relatively more normally distributed with a slight skew to the right with two participants having fibre intakes >50g/day (***Figure 1.2.1 B***). An outlier was excluded from ***Figure 1.2.1*** where one participant had a fibre intake of 79.0 g/day and additionally one male in ***Figure 1.2.1 A*** had a fibre intake of 92g /day. These outliers were not excluded from the mean fibre intake value, but distribution only. 59% of females met or exceeded their AI (22 g) compared with 29% of males (28 g). 41% of females were below the AI whereas 71% of adolescent males were below their AI. Only one participant (female) reported taking a fibre supplement, with a mean fibre intake of 24 g/day.

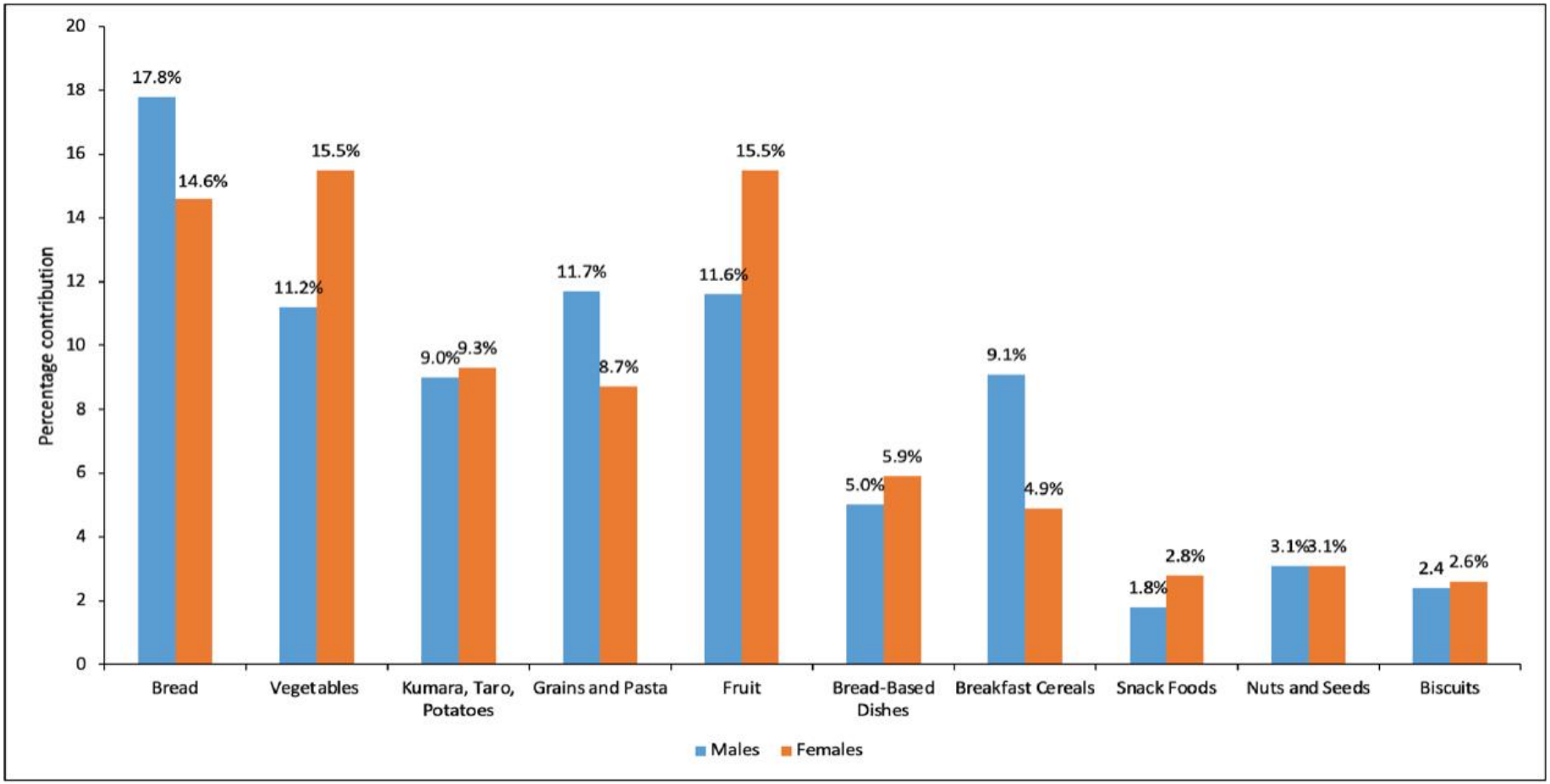


Figure 5.2.2 Bar graph representing the top ten food group contributing to dietary fibre intake of male and female participants

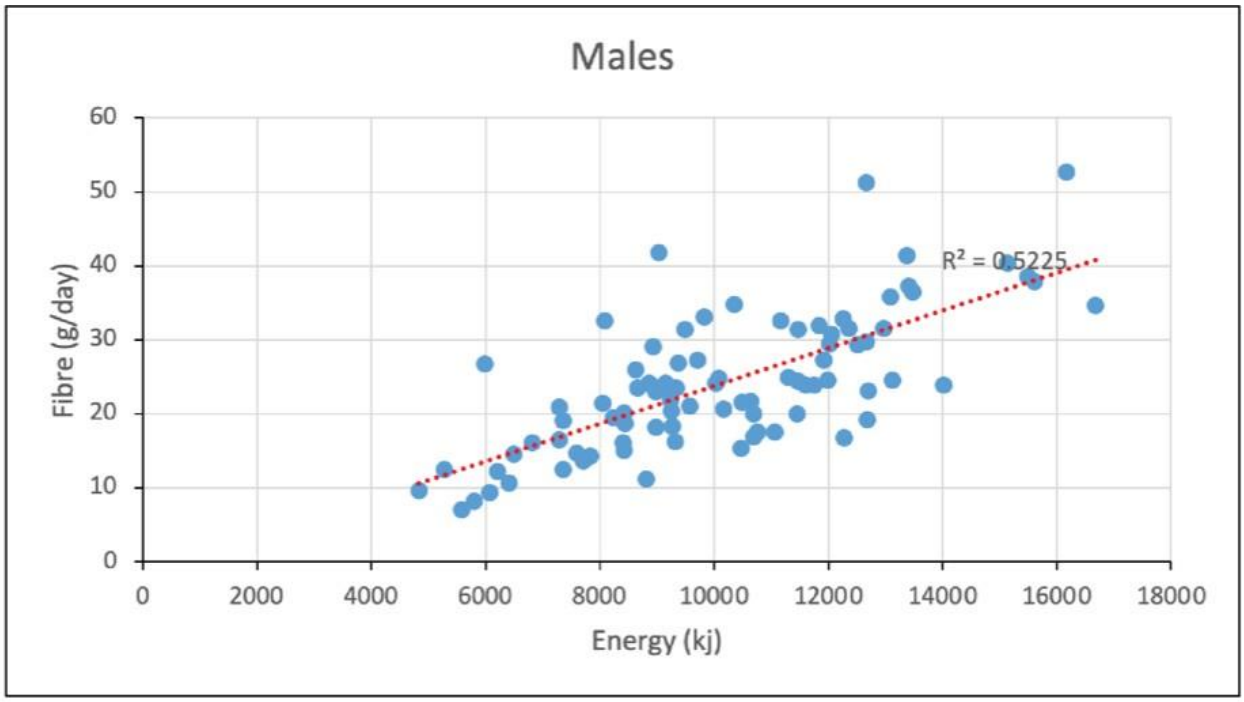
5.2.2 Main food groups contributing to daily fibre intakes of female and male participants

The food groups that were the main contributors to daily fibre intake for male and female adolescents are displayed in ***Figure 5.2.2*** Vegetables; fruits; and bread had the greatest contribution to fibre intake for both males and females. Female adolescents had the highest fibre contribution from fruit and vegetables equally, bread made the highest fibre contribution for adolescent males. Snack foods made the least contribution at 1.8% for boys, whilst, the lowest major contributor for girls was biscuits (2.6%).

5.2.3 Relationship between energy density and dietary fibre intake

Figures 5.2.3 A and B display the correlation between energy and fibre intakes. There was a positive linear association with dietary fibre in both males and females. The mean energy in males was 10007 kJ/day (95% CI, 9452.8, and 10700.6); median energy intake was 9349.6kJ/day (25th percentile: 84037, 75th percentile: 11810.4). The mean energy in females was 7959/day (95% CI 7740, and 8180) median energy intake was 7876.1kJ/day (25th percentile: 6727.1, 75th percentile: 8818.9).

A.



B.

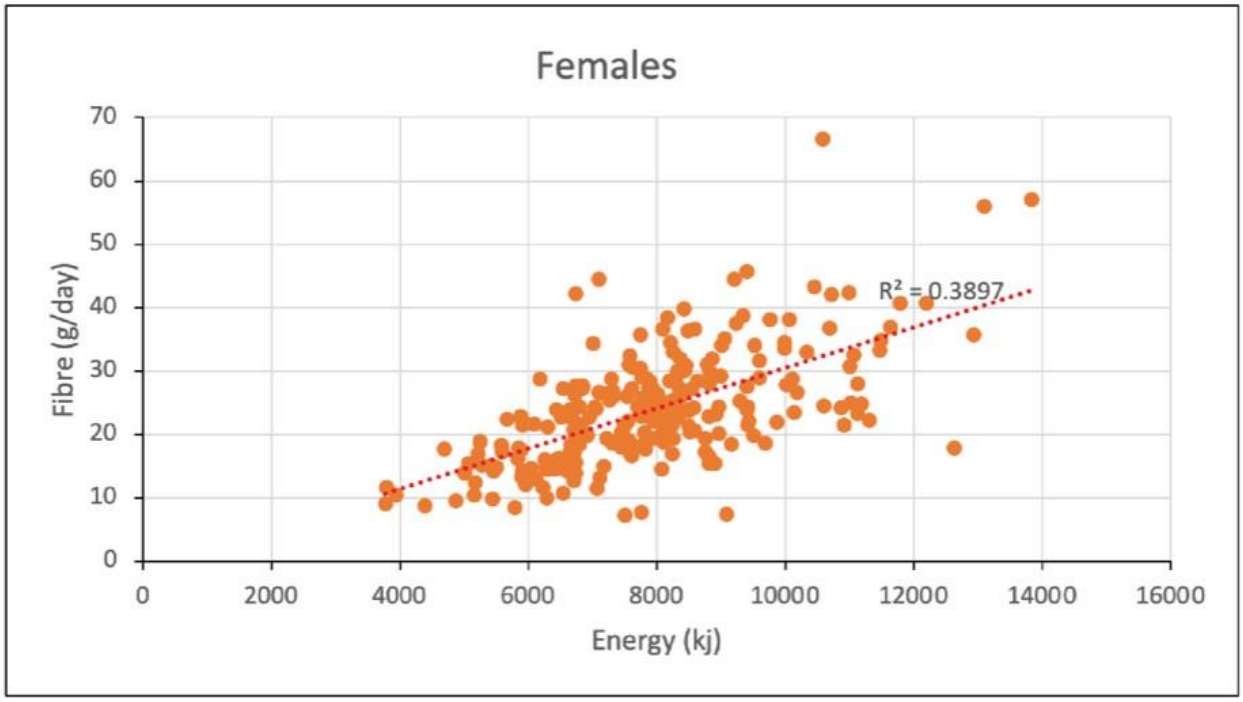


Figure 5.2.3 Scatter plot representing the relationship between fibre intake and Energy in kJ

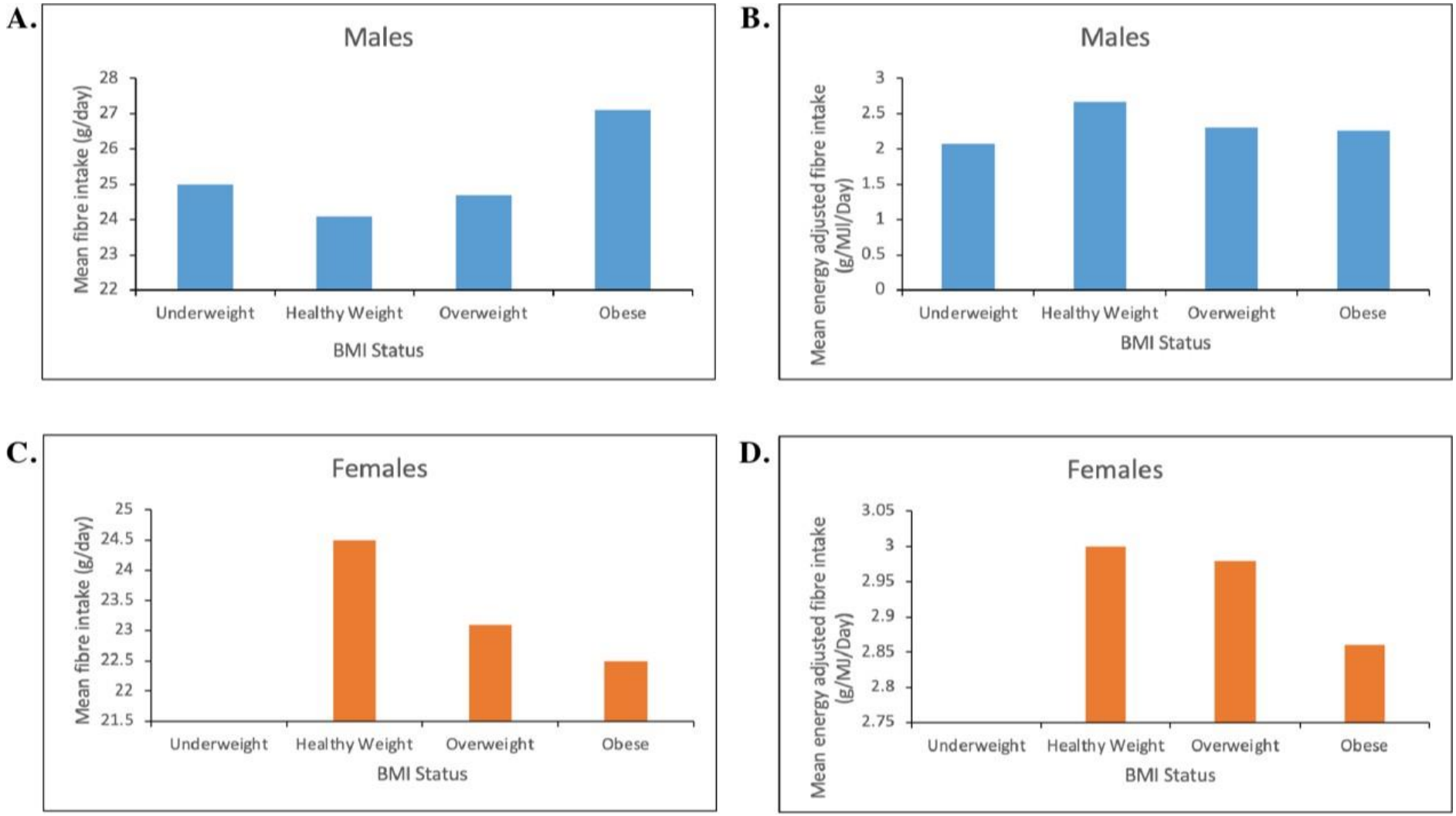


Figure 5.2.4 Mean fibre intake against BMI status with energy adjusted mean fibre intake in adolescent males and females

A. Male dietary fibre intake and BMI status, B. Energy adjusted Male dietary fibre intake and BMI status C. Female dietary fibre intake and BMI status D. Energy adjusted female dietary fibre intake and BMI status.

Z-scores were used to classify BMI using the WHO guidelines.<-2 underweight; ≥-2 to ≤+1 healthy weight; >+1 to ≤+2 is overweight; >+2 obese (WHO, 2006)

5.2.4 Fibre intake and BMI-z score

Figure A and B displays the different fibre intakes of adolescent males and females between BMI z-scores. In females, those who were obese tended to have lower fibre intakes compared with those in the healthy range. Males who were obese tended to have higher fibre intakes than those in a healthy weight range. After energy adjustment (**Fig C and D)**, males with a healthy weight had higher fibre intake compared with overweight and obese boys. Only one male was in the underweight category and no underweight females in the sample were available for comparison. Small numbers of overweight and obese participants, and different sample sizes preclude significant comparisons.

5.3 Bowel habits of adolescents

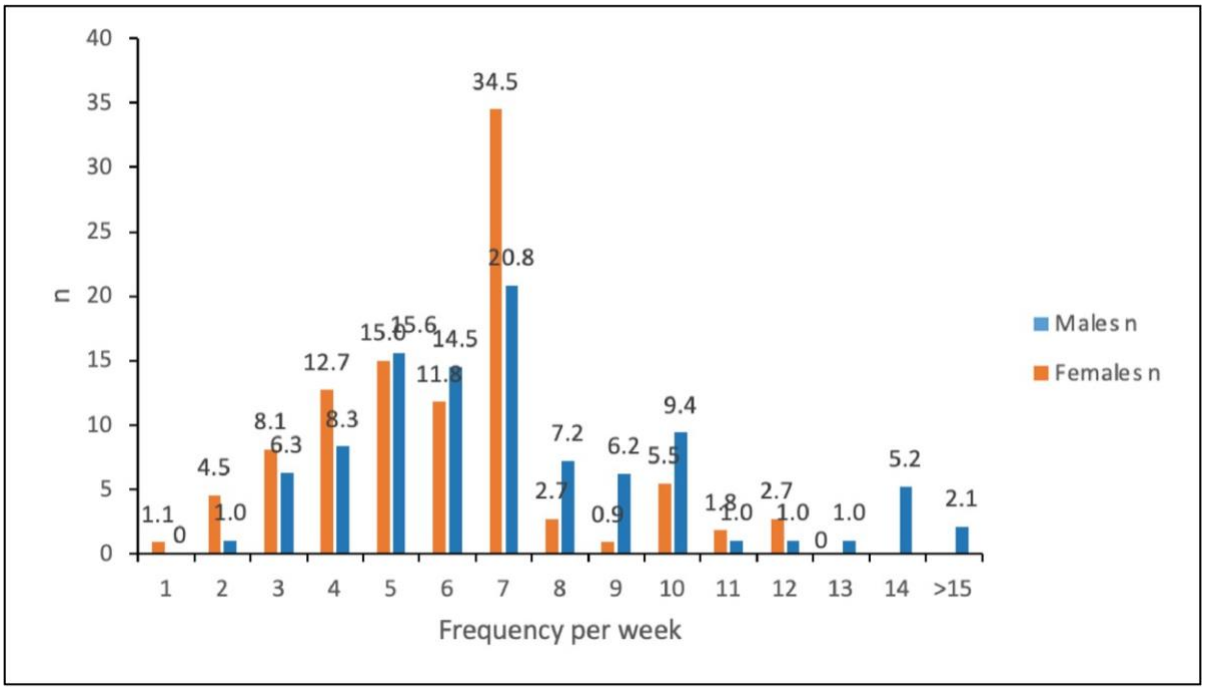


Figure 5.3.1 Frequency (%) of bowel movements per week in adolescent males compared with females

The frequency and consistency of bowel movements in adolescent males compared with females are displayed in **Figures 5.3.1 and 5.3.2**. The majority of adolescent males and females both had a bowel motion between five and seven times a week, with the greatest frequency at more than fifteen times a week in males. Of the analysed data from 129 male and 124 female participants, more than half of the participants had a Type 3 stool consistency on the Bristol Stool Chart **(Appendix F).** 34.5% of females had an average of 1 bowel motion per day compared with 20.8% of males. Two percent of males reported having more than 15 bowel motions a week and 1 participant reported having 1 bowel motion a week.

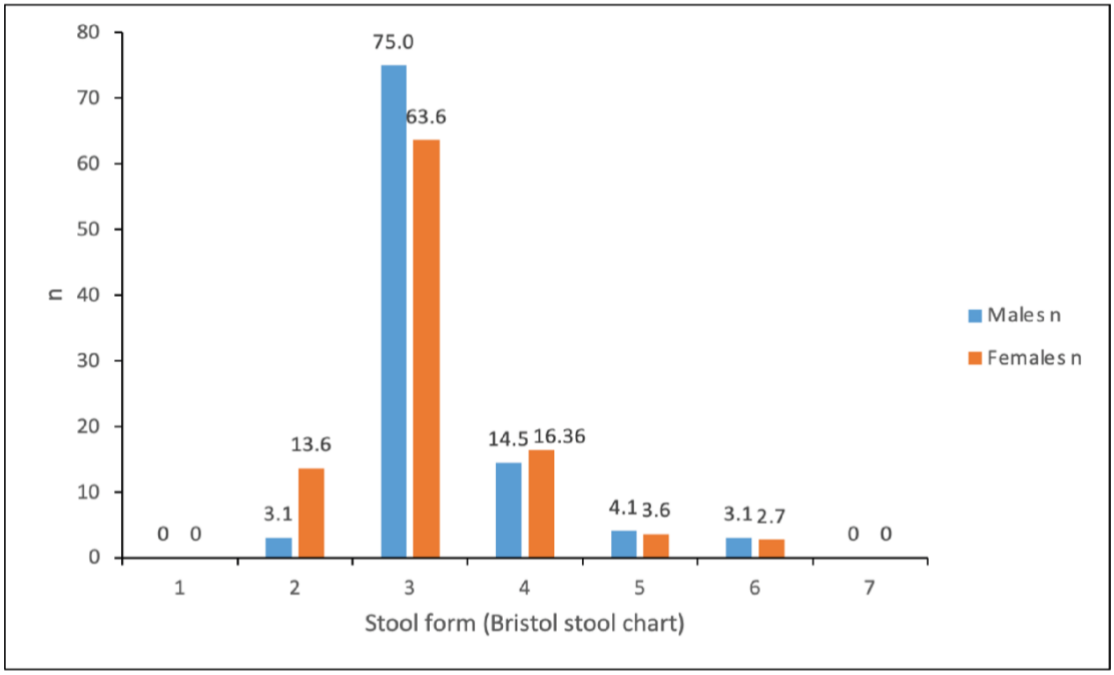


Figure 5.3.2 Consistency (%) of bowel movements per week in adolescent males compared with females

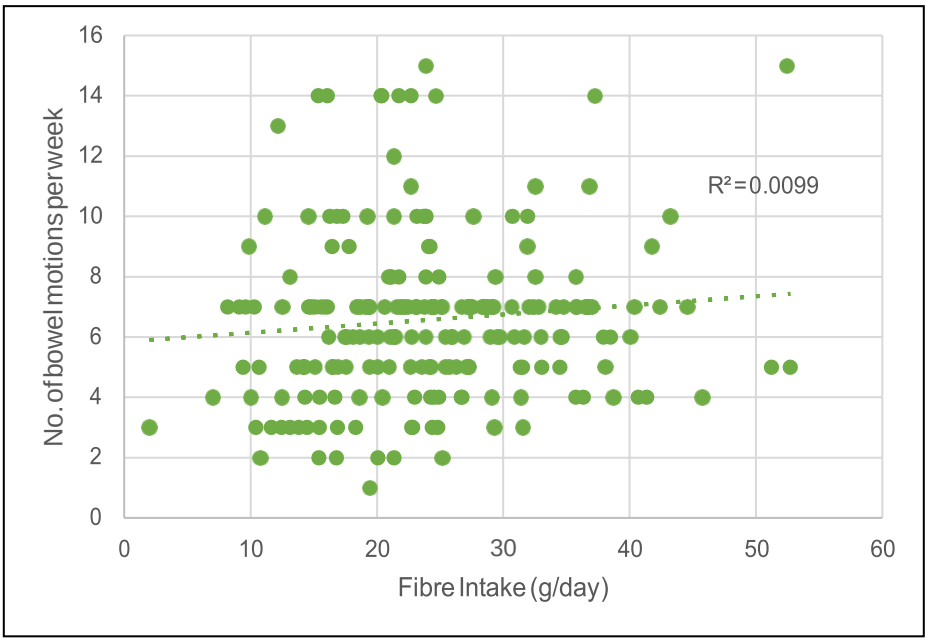


Figure 5.3.3 Relationship between fibre and number of bowel motions males and female.

Figure 5.3.3 displays linear regression analysis of fibre and number of bowel motions. Although appears to be a slight positive trend, there was no association between fibre intake and number of bowel motions per week (R^2=0.0099).

6 Discussion

The mean dietary fibre intake of adolescent females in this study was 24.1 g/day (95% CI: 22.2, 25.9), which was higher than the AI for their age group (22 g/day). Mean dietary fibre intake in adolescent males was at 24.0 g/day (95% CI: 22.1, 25.8), which was lower than the AI (28 g/day) for their age group. The top five food sources contributing to fibre intake were bread; grains and pasta; fruits; vegetables and breakfast cereals. Higher fibre intake was associated with a lower bodyweight in females and in males after energy adjustment. Overall, males and females both tended to have frequent and regularly formed bowel motions regardless of fibre intake (R^2=0.0099)

There is no biochemical marker or test that can be used to determine a group's dietary fibre needs. As a result, AI is used when an EAR cannot be determined, this is based on the average of observed or experimentally determined estimated of intakes by a group of healthy people that are assumed to be adequate (Murphy & Poos, 2002). As there was insufficient evidence to establish the distribution of requirements and thereby determine an EAR, AI cannot be used to determine inadequacy. Accordingly, only limited inferences can be made about the adequacy of our group intakes, this occurs because the true requirement distribution is unknown (IOM, 2006).

In New Zealand, AI is based on adequate gastrointestinal function and laxation (ABS 1998, MoH, 2003). This AI is set at the median for dietary fibre intake in Australia and New Zealand based on the 1995 National Nutrition Survey of Australia (ABS, 1998) and the 1997 National Nutrition Survey of New Zealand (MoH, 1999) where laxation problems are not common, so it is therefore assumed that this was a population with adequate bowel habits.

In our study, 59% of adolescent females met or exceeded their AI and only 29% of males met or exceeded their AI, however for those who were below the AI (41% female, 71% male) no conclusion on adequacy or inadequacy can be made (IOM, 2002). Consequently, it is not

possible to determine the proportion our group with intakes below requirements (Barr & Poos, 2002).

Like New Zealand, Ireland and Costa Rica base their recommendations on amounts assumed to be adequate for normal laxation (Williams, Bollella, & Wynder, 1995). Using a different approach, the UK and US consider the health benefits of fibre, with the US making recommendations observed to protect against coronary heart disease; 25 g for females and 38 g for males, the same as their adult recommendations. This is due to evidence suggesting CVD risk factors start early during adolescence and persist into adulthood (Dahl & Stewart, 2015). Further, development of fatty streaks, cholesterol and fibrous plaques begin to accumulate in the artery walls from a young age (10 yr) (Raitakari et al., 2003). It is possible that adolescents in NZ may be missing some of the potential benefits from higher intakes and consequently, consuming higher amounts which set them up for their AIs as they go into adulthood.

Our finding of a relatively low intake of dietary fibre in New Zealand adolescent males is consistent with nutrition surveys in Australia, Belgium and Italy in which dietary fibre intakes of adolescent males were found to be almost half of the AI for their age group. (Lin et al., 2011; Scientific Advisory Committee on Nutrition, 2015; Sette, et al., 2011). In comparison to NZ, the UK sets their fibre recommendations at 30 g/day for boys and girls, with adolescent males consuming just 18 g of fibre per day. Similarly in the US, adolescent males were consuming 13 g fibre per day, 20 g less than their respective AI. Conversely, in Germany, adolescent males were consuming 27 g of fibre and meeting their AI. This could be attributed to the shift in German adolescent eating habits over time, with a shift from fat to carbohydrates. (Stahl et al., 2009). In the ANS08/09, male adolescents were consuming 21 g/day of fibre, with an inadequate dietary fibre intake at this age of concern going forward into adulthood, the AI increases to 30 g/day when they reach the age of 19, many falling below their adequate intake in our study. This highlights the need to encourage adolescents to

consume fibre-rich foods to aid in meeting these higher recommendations once they reach adulthood.

In contrast, our female adolescents were not only meeting, but exceeding, their AI. This is unusual compared with existing international literature in which dietary fibre intakes of many female adolescents worldwide were below their respective AIs. The lowest fibre intake was in the US, with a mean intake of 12.6 g/day from a national nutrition survey, 12.4 g below their AI (25 g). This could be attributed to the highly processed nature of common American foods which tend to be energy-dense and low in fibre (Steele et al., 2017). Conversely, fibre intake in German girls with 24 g was equal with our girls and above the German recommendation (24 g), however it was below UK recommendations of 30 g. Although our females met their AI, there is also further increase in AI to 25 g/day when females reach the age of 19, therefore encouraging fibre consumption into adulthood is important.

In NZ females were consuming 16.0 g/day in the 08/09ANS, lower than in our study (University of Otago and MoH, 2011). This could possibly be attributed to the shift in major fibre contributors in females from bread to fruit and vegetables over time, although direct comparisons between studies are limited as our study is not representative. Fruit and vegetables equally made the most significant contribution to fibre intake in our adolescent girls. When compared with international surveys, vegetables or fruits make up the second major contribution in the studies carried out in Belgium, Germany, Ireland, Italy, Denmark, Australia and France (Lin et al., 2011; Pedersen et al., 2015; Sette, et al., 2011; Stahl et al., 2009; Fayet-Moore et al., 2018) however, there was considerable variation between these surveys and age ranges.

In contrast bread, followed by fruits and vegetables, grains and pasta were the most significant contributors to male fibre intake. In the last NZ Adult Nutrition Survey, along with males, females obtained most of their fibre from bread (University of Otago and MoH, 2011). In the current study, bread was the single largest food group contributor to daily fibre intake

in our adolescent male population only. Bread and cereals or cereal being a major contributor is consistent with the national nutrition surveys carried out in, Denmark, Germany, Ireland, and Australia (Pedersen et al., 2015., 2007; Stahl et al., 2009; 2014; Fayet-Moore et al., 2018).

Our findings in females might be explained by results from the NZ Health Survey 16/17; where women in general were more likely to eat the recommended servings of fruit and vegetables per day than men (MoH, 2017). However, the survey also reported only 50% of those aged 15–24 years ate at least three servings of vegetables per day. Therefore, enhancing the daily amount of vegetables, fruits and substituting foods such as white bread with wholegrain bread could contribute considerably to higher fibre intakes in both our male and female populations and as they go into adulthood.

While a higher fibre intake was associated with a higher energy intake in our participants, a higher fibre diet is generally associated with lower energy-density (Burton-Freeman, 2000), and numerous fibre types have been shown to reduce subsequent food or energy intake (Wanders et al., 2011). Furthermore, high-fibre foods tend to be low energy-dense (Rolls, 2009) and lower energy intakes from high fibre foods can result in a lower BMI, which is demonstrated in studies with participants consuming fibre-rich foods (Vitaglione, 2020; Wanders et al., 2011 Shay et al., 2012). Reflected in our study, females who were obese tended to have lower fibre intakes compared with those in the healthy range. However, males who were obese tended to have higher fibre intakes than those in a healthy weight range. This is likely due to males tending to have high energy intakes, thus consume more total energy and therefore on average, more of all nutrients, including fibre (Stockman, 2005). Adjusting fibre intake for energy removes possible confounders when comparing to females and bodyweight which can misrepresent true fibre intake. Consequently, after energy adjustment, males along with females with a healthy weight also had higher fibre intake compared with overweight and obese boys.

In addition, according to the 18/19 NZ National Health survey, approximately 26% of 15-24-year-olds are overweight, and 30% of 15-24-year-olds are obese (MoH, 2019). In our sample, 23.8% of females were overweight and 26.6% of males were classified as overweight, hence are fairly representative of NZ rates. However, only 10.8% of females and 5.5% of males were classified as obese in our study. As a result, due to low numbers of obese males, our study may represent an underestimate of mean fibre intake if the higher fibre intakes observed in this study remain true to the obese male adolescent population in general.

An energy-dense and low-fibre diet has been associated with obesity in childhood and increased adiposity in adolescence (Parikh et al., 2012). Moreover, being overweight and obese are associated with an increased risk of T2DM, coronary heart disease and cancer (López-Suárez, 2019). There is also evidence that the precursors of these NCDs commence during adolescence (Ludwig et al., 1999) and will ultimately track into adulthood (Zhang et al., 2013). Dietary fibre has been shown to protect against cardiovascular diseases, T2DM and colorectal and breast cancers in adults (Hajishafiee, 2016; Reynolds et al., 2019). Risk reduction has been associated with a range of critical outcomes which were greatest when daily intake of fibre was between 25 g and 29 g/day, which represents our adolescent and adult AI range. Additionally, dose-response curves suggest that higher intakes of fibre greater than 30 g/day could confer even greater benefits to the aforementioned NCDs (Reynolds et al., 2019).

One of these NCDs, colorectal cancer is of particular note in New Zealand as colorectal cancer has been rated as the second highest cause of cancer deaths, particularly in males (World Cancer Research Fund, 2018). The possible role dietary fibre has in colorectal cancer risk reduction include increased stool bulk, dilution of carcinogens in the colonic lumen, reduced transit time, and production of SFAs. Additionally, New Zealand females have higher rates of colorectal cancer than females worldwide (World Cancer Research Fund, 2018) thus it is important to encourage fibre consumption for all adolescents as they enter adulthood.

However, potential inadequacy and risk of ill-health are not the same, nutrient intake is only one of many factors that may affect disease state, particularly for fibre and health.

Although there can be large variation and frequency, normal laxation is typically considered to be about once per day in western diets (Haack et al., 1998; Burkitt, 1994). In our data there was not a strong relationship between fibre intake and frequency of bowel motions (R^2 = 0.0099). This could possibly be attributed to the qualitative nature of our bowel habit data collection, which may misrepresent the positive relationship commonly associated with fibre and stool frequency. Further, underestimation of mean fibre intake in males may skew its subsequent association with bowel habits. However, these data are also indicative that intakes of 10-20 g/day are compatible with good bowel function in our participants. This is consistent with literature in older children (8-14 years) where intakes of 10-15 g/day contribute to the amelioration of constipation (Chao et al., 2008).

However, the amount of fibre required to maintain good bowel habits increases as we age, with adult studies suggesting that intakes of 25 g/day are compatible with a frequency of 1 motion/day (EFSA Panel on Dietetic Products, Nutrition, and Allergies, 2010). Further, amounts of 25 g or greater are used for the treatment of constipation in adults (Johanson, 2007). Intakes of fibre at or above these amounts are also consistent with protection against CVD, T2DM and colorectal cancer (Reynolds et al., 2019).

In summary, our male participants are generally reporting acceptable laxation even at an intake lower than the AI. Nevertheless, it is still important to encourage boys and girls to consume at least the AI to ensure optimal laxation and chronic disease prevention are maintained as they transition into adulthood.

This study was not without limitations. The SuNDiAL 2019/2020 study was conducted only in certain parts of the country, thus sampling of our study might not be representative of New Zealand. Additionally, the majority of our participants were New Zealand European (71%) with Asian (12%), Māori (13%) and Pacific Islanders (2%) being underrepresented in the total

sample. Furthermore, the 2020 component of our study was conducted during the COVID-19 when many of the adolescent males were in Level 4 lockdown whereby they were confined to their homes, unless they were essential workers or for essential services. Supermarkets were the only available source of food at this time, and so in these participants, the true intake of convenience foods may be under-represented. Consequently, our dietary data might not reflect the usual intake of adolescent males.

A considerable strength of this study was the multi-centric setting that included adolescents from 10 geographical locations around New Zealand. Furthermore, dietary fibre data were obtained from repeated diet recalls, which has a lower participant burden as compared to other methods (Shim, 2014). Another strength of the SuNDiAL project has been the use of MSM which allows for the adjustment and estimation of usual intakes. This assessment method reduces the chance of generating an inflated fibre estimate compared to other dietary assessment methods (Shim, 2014) and the lowest incidence of under-and over-reporting in adolescents (Souverein et al., 2011).

Further research should focus on routine and comprehensive monitoring of dietary fibre intake data which allows more detailed tracking on the association between dietary fibre and its subsequent benefits in this population such as NCD prevention and laxation.

To conclude, the current study sought to explore the dietary fibre intakes of New Zealand adolescent males and females aged 15-18 years. Findings indicate that adolescent females were consuming dietary fibre that met their AI, whilst adolescent males did not meet the AI for their age group, although no definitive conclusion on adequacy can be inferred. The current findings suggest that New Zealand adolescent males may have a potential intake that is insufficient to meet their AI but is adequate for laxation at this life stage. Given the benefits of dietary fibre demonstrated at the levels recommended to this age group and beyond, it would be sensible to encourage adolescents to consume lots of fibre-rich foods for optimal health promotion and chronic disease prevention.

7 Application to dietetic practice

The current study provides valuable information on the dietary fibre intakes of adolescents in New Zealand. Results suggest that while females met their AI, New Zealand adolescent boys have an intake that is that is not sufficient to meet their AI, a consideration that is useful for dietitians to keep in mind when coming in contact with adolescent males.

Several dietary interventions may be recommended to achieve daily dietary intake from food, particularly for our adolescent males. With male adolescents failing to achieve their AI (28 g/day) there is concern whether they could realistically achieve their AI into adulthood (30 g). However, it has been suggested it is possible to consume 30 g of fibre with a daily diet that includes a high-fibre breakfast cereal, two slices of wholemeal bread, a baked potato, a serving of wholegrain pasta with 2 serves of fruits and 3 of vegetables (Hooper, Spiro, & Stanner 2015).

Additionally, the results of this survey indicate that breads, fruits and vegetables contribute by far the most dietary fibre to individual's diets. As dietitians, encouraging daily consumption of whole grains, vegetables, fruits, legumes comply with the MoH guidelines, whilst reducing consumption of low-fibre processed foods and encouraging optimal intake. Moreover, our findings show that overweight and obese participants had the lowest fibre intakes after energy adjustment. Many unprocessed or lightly processed plant foods are low energy-dense while providing dietary fibre which are also in line with the MoH guidelines (McIntyre & Dutton, 2015).

Therefore, it is important to take into consideration any options that may impact client's subsequent energy intake and finding appropriate alternatives to ensure they are meeting their requirements to achieve adequate intake without additional energy.

It is also appropriate that a practitioner is aware of their patients' social history, so as to not recommend changes that would not realistically fit within their budget. Some affordable sources of dietary fibre include tinned legumes such as chickpeas, lentils and beans; and other

sources such as in-season fruits and fresh and frozen vegetables. Consequently, providing affordable recommendations to include fibre-rich foods into an individual's diet, tailored to socioeconomic status would be beneficial. Overall, findings from this current study emphasise to dietitians to be aware of the potential for low fibre intake and should encourage dietitians to instil good habits into adolescents to set them up for continuing healthful eating patterns into adulthood. The results from this study confirm that current recommendations are achievable as evidenced by the girls in our study. Finally, this study provides information to inform policy makers, specifically targeting New Zealanders to improve fibre intake, to reduce the burden of NCDs that track into adulthood.

7.1 Individual reflection

An aspect of my research journey that I have found particularly important for my personal development as a dietitian was being resilient to changes. I found the research process challenging due to the nature of the study during the COVID19 pandemic. Initially, working in a lockdown environment was not something that worked well for me. Throughout this experience, I struggled knowing that my deadline was moved forward and my placement was out of my control. Secondly as a result of this, I really struggled to write my methods, section due to not having done the proper data collection. I found it very challenging to know which parts applied to my results and how my study and methods made up the "bigger picture" as part of the SuNDiAL. Furthermore, I found it harder to critically think about the limitations/strengths of our data collection methods and study has a whole. However, I understand that a global pandemic is out of everyone's hands and I am grateful that I managed to be finished on time. Overall, this experience has challenged me and has taught me a lot, I now understand that everything doesn't always go to plan and there will always challenges along the way. It has also taught me that you have to be a more adaptable and flexible practitioner, resistant to change and adapt when things don't always go as planned. This is already a skill have started to use while being back on placement. These skills will be invaluable for my career as a dietitian and I feel confident for my future career in the field.

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9 Appendices

9.1 APPENDIX A Ethical Approval

H20/004

Academic Services
Manager, Academic Committees, Mr Gary Witte

10 February 2020

Dr M Peddie
Department of Human Nutrition
Division of Sciences

Dear Dr Peddie,

I am again writing to you concerning your proposal entitled "**SuNDiAL Project: Survey of Nutrition Dietary Assessment and Lifestyle 2020: Adolescent males.**", Ethics Committee reference number **H20/004**.

Thank you for your email of 5th February 2020 with response attached addressing the issues raised by the Committee.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

The standard conditions of approval for all human research projects reviewed and approved by the Committee are the following:

Conduct the research project strictly in accordance with the research proposal submitted and granted ethics approval, including any amendments required to be made to the proposal by the Human Research Ethics Committee.

Final report: A Final Report is required by the Committee upon completion of the study. The Final Report template can be found on the Human Ethics Web Page

https://www.otago.ac.nz/council/committees/committees/HumanEthicsCommittees.html

Adverse or unforeseen events: Inform the Human Research Ethics Committee immediately of anything which may warrant review of ethics approval of the research project, including: serious or unexpected adverse effects on participants; unforeseen events that might affect continued ethical acceptability of the project; and a written report about these matters must be submitted to the Academic Committees Office by no later than the next working day after recognition of an adverse occurrence/event. Please note that in cases of adverse events an incident report should also be made to the Health and Safety Office:

http://www.otago.ac.nz/healthandsafety/index.html

Discontinuation: Advise the Committee in writing as soon as practicable if the research project is discontinued.

Amendments: Make no change to the project as approved in its entirety by the Committee, including any wording in any document approved as part of the project, without prior written approval of the Committee for any change. If you are applying for an amendment to your approved research, please email your request to the Academic Committees Office:

gary.witte@otago.ac.nz

jo.farrondediaz@otago.ac.nz

Locality authorisation: Studies requiring locality authorisation, i.e. permission from the organisations at which the study is taking place or from which participants are being accessed, must be confirmed before the study commences.

Approval period: Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval or an extension of approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

Yours sincerely,

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8256
Email: gary.witte@otago.ac.nz

c.c. Assoc. Prof. L Houghton Department of Human Nutrition

9.2 APPENDIX B. Maori Consultation Committee letter 2019 and 2020

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KAI TAHU

Wednesday, 12 February 2020

Dr Meredith Peddie
Department of Human Nutrition

Tēnā Koe Dr Meredith Peddie,

SuNDiAL Project: Survey of Nutrition Dietary Assessment and Lifestyle 2020: Adolescent males

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 11 February 2020 to discuss your research proposition.

By way of introduction, this response from the Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee is aware of the researcher's experience in similar studies that have been referred to this Committee. As in the past, the Committee encourages the collection of ethnicity data as part of the research project as a right of participants to express self-identity. The Committee also supports the analysis of cultural perspectives on diet, nutrition and social activities such as screen time which may have an impact on the research findings.

The Committee acknowledges the aims and outcomes of this research project, and wishes to advise that further consultation is not required.

This letter of suggestion, recommendation and advice is current for an 18-month period from Tuesday, 11 February 2020 to 11 August 2021. The Committee would

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki

appreciate receiving a copy of the research findings.

The recommendations and suggestions above are provided on your proposal submitted through the consultation website process. These recommendations and suggestions do not necessarily relate to ethical issues with the research, including methodology. Other committees may also provide feedback in these areas.

Nāhaku noa, nā

Claire Porima
Manager, Māori Research Consultation; Senior Project Manager
Office of Māori Development
Te Whare Wānanga o Otākou
Ph: +64 3 4798081
Email: claire.porima@otago.ac.nz
Web: www.otago.ac.nz

Ngāi Tahu Research Consultation Committee
Te Komiti Rakahau ki Kai Tahu

Monday, 17 December 2018

Dr Meredith Peddie
Department of Human Nutrition

Tēnā Koe Dr Meredith Peddie

The SuNDiAL Project 2019: Survey of Nutrition, Dietary Assessment and Lifestyle.

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 11 December 2018 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed Committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other Committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."

The Committee considers the research to be of importance to Māori health.

As this study involves human participants, the Committee strongly encourages that ethnicity data be collected as part of the research project as a right to express their self-identity.

The Committee suggests researchers consider the Southern District Health Board's Tikaka Best Practice document, in particular patient engagement. The document also covers the collection, storage and disposal of blood and tissue samples. This document is available on the Southern District Health Board website. The Committee also refers researchers to Te Mana Raraunga Māori Data Audit Tool, which gives an overview of key Māori Data Sovereignty terms and principles.

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki

We wish you every success in your research and the Committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18-month period from Tuesday, 11 December 2018 to 3 June 2020.

The recommendations and suggestions above are provided on your proposal submitted through the consultation website process. These recommendations and suggestions do not necessarily relate to ethical issues with the research, including methodology. Other Committees may also provide feedback in these areas.

Nāhaku noa, nā

Claire Porima
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9.3 APPENDIX C Participant Information Sheets 2019 & 2020

UNIVERSITY OF OTAGO
NEW ZEALAND

Participant Information Sheet

Study title:	The SuNDiAL Project 2020: A survey of nutrition, dietary assessment and lifestyle	
Principal investigators:	**Names** Dr Jill Haszard & Dr Meredith Peddie **Department:** Human Nutrition **Position:** Research Fellows	Contact phone number: 03 479 5683 03 479 8157

Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to think about it and talk with family or friends before you decide whether to take part or not.

If you decide to take part we thank you. If you decide not to take part that won't disadvantage you and we thank you for considering our request.

What is the aim of this research project?

The food and activity patterns of teenage boys probably influence their health and wellbeing. However, we don't know much about teenage boys' food intakes and physical activity patterns in New Zealand. Teenagers often make their own decisions about what foods to eat, but *why* they choose the foods they do is not well known. Last year we conducted a similar study in teenage girls. To get a more complete picture of what the teenagers of New Zealand eat and how they spend their time the SuNDiAL project is now going to investigate the food intakes and physical activity of adolescent males (aged 15-18 years), and why they choose to eat the way they do.

Who is funding this project?

This project is funded by the Department of Human Nutrition, University of Otago

Who are we seeking to participate in the project?

We are looking for at least 150 male high school students who are between 15 and 18 years old. To be eligible to take part, your high school must have agreed to take part in the study, you must speak and understand English, and be able to complete the questionnaires.

If you participate, what will you be asked to do?

If you agree to take part in this study you will be asked to do three things:

1) **Complete an online questionnaire**
   After you have completed the consent process you will be asked to complete an online questionnaire that asks questions about your health and some general questions such as what ethnicity you identify with. This online questionnaire also asks you about your overall eating habits, and why you choose to eat the foods that you do. It should take about 30 minutes to complete all the online questionnaires.

2) **Attend a session at your school with our research team**
   This visit will take about 60 minutes during the school day and you will be asked to:
   - Complete a face to face interview with one of our research team where you will be asked to recall everything you ate and drank the day before. They will also ask you to recall how you spent your time during that day.
   - At this session one of our research team will also measure your blood pressure, height, weight, and the length of your lower arm. Blood pressure will be measured three times, and the other measurements will be taken twice to make sure they are as accurate as possible. This will be done in a private space and you won't be told these measurements unless you ask for them.

3) **Complete a second interview about the food you have eaten and your physical activity on another day**
   Sometime in the 2 weeks after you have finished the session at school you will be contacted by the research team and asked to complete a second interview where you will be asked to recall everything you ate and drank and how you spent your time on a different day of the week than the first interview. This is important because sometimes you can eat quite differently or do different activities from one day to the next. **This interview will be performed over Facetime or Zoom, at a time that is convenient for you.**

There are three other parts to the SuNDiAL project that are entirely optional.
Please read the following information carefully before you decide whether to take part in these optional bits of the study. If you agree to do these, but change your mind later, that's OK - there is no disadvantage to you if you decide not to do these. You will be asked again on the day if you still want to do them.

1) **Provide a blood sample**
   We would like you to provide a blood sample (which would be collected by someone with extensive training in how to take a blood sample), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. However, if you do provide a blood sample, we can tell you the cholesterol and HBA1c concentrations in your blood.

Cholesterol in a type of fat, and HbA1c is a measure of how much sugar you have had in your blood over the last few weeks. You can still take part in the rest of the study even if you don't do this bit. If you do agree to give a blood sample, an appointment will be made to get this done at school, and collection of the sample should only take about 10 minutes.

2) **Provide a urine sample**
We would like you to give a urine ("pee") sample (which is easy for you collect yourself in the bathroom with the equipment we give you). You can still take part in the rest of the study even if you don't do this bit. If you do agree to give a urine sample, we will tell you a day that you can drop in and do this at school.

3) **Wear an accelerometer for a week**
We would like you to wear a small red box called an accelerometer on an elastic belt 24 hours a day for the seven days following the session at your school. This will tell us how much time you spend sitting down, moving around, and sleeping. If you choose to wear the accelerometer you will be asked to complete a little diary about the times you took the device off, and what time you went to bed each night on the days that you wear it. One of our research team will return to your school the week after this visit to collect the accelerometer. You can still take part in the rest of the study even if you don't do this bit.

After the completion of the study you will receive a $5 supermarket voucher for each component of the study that you complete . That is $5 for completing the online questionnaire, $5 for completing the face to face interview about what you ate in the last 24 hours and what activity you did, $5 for completing the second interview about what you ate and what activity you did; $5 for providing a blood sample; $5 for providing a urine sample or $5 for wearing the accelerometer for a week. Adding to a possible total of $30 in supermarket vouchers.

Is there any risk of discomfort or harm from participation?

If you choose to provide a blood sample, you should know that there is a risk of a little pain or discomfort, and possibly a small bruise from the blood test. Any bruising should only last a few days and an experienced nurse or phlebotomist (someone with training to take blood samples) will collect the blood to minimise any discomfort to you.

What specimens, data or information will be collected, and how will they be used?

The answers you provide to the questionnaires and the food and activity questionnaire will be entered into a database with every other participants' answers. All your answers will be kept confidential and stored using an ID number, not your name. This information will provide valuable and unique information about the food intakes and activity levels of male high school students in New Zealand. Information about why people eat the way they do will also be very helpful as some eating patterns provide health benefits. Ultimately, the results of this study will support the development of up-to-date government and health agency guidelines for young men in New Zealand.

If you provide a blood sample it will be taken to a local laboratory where it will be analysed for cholesterol and HbA1c concentrations.

If you provide a urine sample it will be transported to the Department of Human Nutrition at the University of Otago where it will be stored in a freezer until it is analysed for iodine concentrations.

Once all of the analysis on your blood and urine samples has been completed they will be disposed of using standard biohazard protocols. **We will only test your samples for the things listed here, and won't test them for anything else.**

What about anonymity and confidentiality?

Once your information has been collected and entered into our database your information will be identified with an ID number only. This database will be stored on the researchers' computers which are password protected. A backup copy may also be stored on the University's shared server space, but only Jill Haszard and Meredith Peddie will have the password so no one else can access the information .

The information linking you to your ID number will be stored in a separate password protected file that only Jill Haszard and Meredith Peddie will have access to. The only reason they would access this information once you have completed the study would be if you requested your individual results. This file will be destroyed once all participants have been given the opportunity to request individual information. The de-identified information collected as part of this research will be kept in secure storage for at least 10 years.

If you agree to participate, can you withdraw later?

You may pull out of the project before the study has been completed (anticipated to be October 2020) without any disadvantage to yourself of any kind. Once data collection is completed and your information is integrated into the study it will no longer be possible to withdraw your information from the study.

Any questions?

If you have any questions now or in the future, please feel free to contact either:

Name: Dr Jill Haszard **Position: Senior Research Fellow** **Department of Human Nutrition**	Contact phone number: 03 479 5683
Name: Dr Meredith Peddie **Position: Research Fellow** **Department of Human Nutrition**	Contact phone number: 03 479 8157

This study has been approved by the University of Otago Human Ethics Committee (Health). If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email

+64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

UNIVERSITY of OTAGO
NEW ZEALAND

Participant Information Sheet

Study title:	The SuNDiAL Project 2020: A survey of nutrition, dietary assessment and lifestyle	
Principal investigators:	**Names** Dr Jill Haszard & Dr Meredith Peddie **Department:** Human Nutrition **Position:** Research Fellows	Contact phone number: 03 479 5683 03 479 8157

Introduction

Thank you for showing an interest in this project. Please read this information sheet carefully. Take time to think about it and talk with family or friends before you decide whether to take part or not.

If you decide to take part we thank you. If you decide not to take part that won't disadvantage you and we thank you for considering our request.

What is the aim of this research project?

The food and activity patterns of teenage boys probably influence their health and wellbeing. However, we don't know much about teenage boys' food intakes and physical activity patterns in New Zealand. Teenagers often make their own decisions about what foods to eat, but *why* they choose the foods they do is not well known. Last year we conducted a similar study in teenage girls. To get a more complete picture of what the teenagers of New Zealand eat and how they spend their time the SuNDiAL project is now going to investigate the food intakes and physical activity of adolescent males (aged 15-18 years), and why they choose to eat the way they do.

Who is funding this project?

This project is funded by the Department of Human Nutrition, University of Otago

Who are we seeking to participate in the project?

We are looking for at least 150 male high school students who are between 15 and 18 years old. To be eligible to take part, your high school must have agreed to take part in the study, you must speak and understand English, and be able to complete the questionnaires.

If you participate, what will you be asked to do?

If you agree to take part in this study you will be asked to do three things:

1) **Complete an online questionnaire**
   After you have completed the consent process you will be asked to complete an online questionnaire that asks questions about your health and some general questions such as what ethnicity you identify with. This online questionnaire also asks you about your overall eating habits, and why you choose to eat the foods that you do. It should take about 30 minutes to complete all the online questionnaires.

2) **Attend a session at your school with our research team**
   This visit will take about 60 minutes during the school day and you will be asked to:
   - Complete a face to face interview with one of our research team where you will be asked to recall everything you ate and drank the day before. They will also ask you to recall how you spent your time during that day.
   - At this session one of our research team will also measure your blood pressure, height, weight, and the length of your lower arm. Blood pressure will be measured three times, and the other measurements will be taken twice to make sure they are as accurate as possible. This will be done in a private space and you won't be told these measurements unless you ask for them.

3) **Complete a second interview about the food you have eaten and your physical activity on another day**
   Sometime in the 2 weeks after you have finished the session at school you will be contacted by the research team and asked to complete a second interview where you will be asked to recall everything you ate and drank and how you spent your time on a different day of the week than the first interview. This is important because sometimes you can eat quite differently or do different activities from one day to the next. **This interview will be performed over Facetime or Zoom, at a time that is convenient for you.**

There are three other parts to the SuNDiAL project that are entirely optional.
Please read the following information carefully before you decide whether to take part in these optional bits of the study. If you agree to do these, but change your mind later, that's OK - there is no disadvantage to you if you decide not to do these. You will be asked again on the day if you still want to do them.

1) **Provide a blood sample**
   We would like you to provide a blood sample (which would be collected by someone with extensive training in how to take a blood sample), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. However, if you do provide a blood sample, we can tell you the cholesterol and HBA1c concentrations in your blood.

+64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

9.4 Appendix D Consent and Eligibility Questionnaire

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Page 1

Study Consent & Eligibility

Thank you for showing an interest in this project. Please read the information about the SuNDiAL project carefully. This can be found on our website www.otago.ac.nz/sundial. Take time to think about it and talk with family or friends before you decide whether to take part or not. If you decide to take part we thank you. If you decide not to take part that won't disadvantage you and we thank you for considering our request.

What is the aim of this research project?

The food and activity patterns of teenage boys probably influence their health and wellbeing. However, we don't know much about teenage boys' food intakes and physical activity patterns in New Zealand. Teenagers often make their own decisions about what foods to eat, but why they choose the foods they do is not well known. Last year we conducted a similar study in teenage girls. To get a more complete picture of what the teenagers of New Zealand eat and how they spend their time the SuNDiAL project is now going to investigate the food intakes and physical activity of adolescent males (aged 15-18 years), and why they choose to eat the way they do.

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If you take part, what will you be asked to do?
If you agree to take part in this study you will be asked to do three things:

1) Complete an online questionnaire

After you have completed the consent process you will be asked to complete an online questionnaire that asks questions about your health and some general questions such as what ethnicity you identify with. This online questionnaire also asks you about your overall eating habits, and why you choose to eat the foods that you do. It should take about 30 minutes to complete.

2) Attend a session at your school with our research team

This visit will take about 60 minutes during the school day and you will be asked to:

Complete a face to face interview with one of our research team where you will be asked to recall everything you ate and drank the day before. They will also ask you to recall how you spent your time during that day.

At this session one of our research team will also measure your blood pressure, height, weight and the length of your lower arm. Blood pressure will be measured three times, and the other measurements will be taken twice to make sure they are as accurate as possible. This will be done in a private space and you won't be told these measurements unless you ask for them.

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3) Complete a second interview about the food you have eaten and your physical activity on another day

Sometime in the 2 weeks after you have finished the session at school you will be contacted by the research team and asked to complete a second interview where you will be asked to recall everything you ate and drank and how you spent your time on a different day of the week than the first interview. This is important because sometimes you can eat quite differently or do different activities from one day to the next. This interview will be performed over Facetime or Zoom, at a time that is convenient for you.

Any questions?

Contact Meredith or Tessa (ph 03 479 8157) or Jill (ph 03 479 5683) or email us on: sundial@otago.ac.nz

This study has been approved by the University of Otago Human Ethics Committee (Health) reference number H20/004. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (phone +64 3 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

Electronic consent
Click on the "agree" button below if:

You have read the information about the study and understand the aims of the study

You have had all your questions answered about the study and understand that you can ask for more information at any stage

You are a young male who is 15 to 18 years old

You have chosen to take part, but you know you can pull out of the study anytime before it finishes in October 2020

You know that as a participant you will be asked to complete questionnaires about why you choose to eat the foods that you do, and have your blood pressure, height, weight and the length of your forearm measured, and complete interviews about the food that you eat and how you spend your time over two different 24 h periods

You know that the responses you provide to the questionnaires in this study will be recorded aginst an ID number, not your name. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years

You understand the results of the project may be published and be available from the University of Otago

You know that no commercial use will be made of this data

You know that for each component of the study you complete you will receive a $5 voucher (up to a possible total of $30)

Agreeing to this part of the study does not mean that you have agreed to give a blood sample, a urine sample or to wear an accelerometer (you will be asked about those bits separately)

If you don't want to take part in the SuNDiAL project, please click on the "DISAGREE" button.

○ AGREE
○ DISAGREE

Thank you for agreeing to taking part in the SuNDiAL project! If you are male and aged 15-18 years of age, please answer the following questions:

What age are you as of today?

- ○ 15
- ○ 16
- ○ 17
- ○ 18
- ○ None of the above

What high school do you attend?

- ○ Macleans College
- ○ John Paul College
- ○ Papamoa College
- ○ Catholic Cathedral College
- ○ South Otago High School
- ○ St Patrick's College Silverstream
- ○ Wesley College

Thank you! You are eligible to take part in the SuNDiAL project!

There are three other parts to the SuNDiAL project that are optional. Please read the following information carefully before you decide whether to take part in these optional bits of the study. For each one of these that you do, you will receive a $5 gift voucher from New World or PaknSave.

If you agree to do these, but change your mind later, that's OK - there is no disadvantage to you if you decide not to do these.

Once all of the analysis has been completed the samples will be disposed of using standard biohazard protocols.

Electronic consent

Click on the "AGREE" button below if:
- You have read the information on the website
- You want to take part in these parts of the study

If you don't want to take part in these parts of the study, please click on the "DISAGREE" buttons.

BLOOD SAMPLE:

We would like you to provide a blood sample (which would be collected by someone with extensive training in how to take a blood sample), but we understand that not everyone feels comfortable about this so it is entirely up to you if you do this. You can still take part in the rest of the study even if you don't do this bit.

Click on the 'AGREE' button below if:
You agree to have a blood sample collected by a phlebotomist (someone with special training in how to take a blood sample) You understand the possible risk and discomfort involved in providing a blood sample You understand that your blood sample will be analysed locally for concentrations of cholesterol and HbA1c You know that the concentrations of things measured in your blood will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in any way, will be placed in secure storage and kept for at least ten years You will receive an additional $5 voucher if you provide a blood sample If you do not wish to provide a blood sample, please click the 'DISAGREE' button

○ AGREE
○ DISAGREE

URINE SAMPLE:

We would also like you to give a urine sample ("pee or wee") - which is easy for you collect yourself with the equipment we give you. You can still take part in the rest of the study even if you don't do this bit.

Click on the 'AGREE' button below if you are ok with providing a urine sample:
You agree to provide a urine sample You understand that your urine sample will be frozen and transported to the University of Otago where it will be stored until it is analysed for iodine concentrations You understand that your urine sample will only be analysed for iodine concentrations You know that the concentrations of iodine measured in your urine will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in any way, will be placed in secure storage and kept for at least ten years You will receive an additional $5 voucher if you provide a urine sample If you do not wish to provide a urine sample, please click the 'DISAGREE' button

○ AGREE
○ DISAGREE

ACCELEROMETER:

We would also like you to wear a small red box called an accelerometer on an elastic belt 24 hours a day for seven days. This will tell us how much time you spend sitting down, moving around, and sleeping. If you choose to wear the accelerometer you will be asked to complete a little diary about the times your took the device off, and what time you went to bed each night on the days that you wear it.

One of our research team will return to your school the week after this visit to collect the accelerometer. You can still take part in the rest of the study even if you don't do this bit.

Please click the 'AGREE' button below if:
You agree to wear an accelerometer for 24 hours a day for seven days You understand the during this time you will asked to record in a diary provided to you when you take the accelerometer on and off, and when you go to bed each night You know that amount of time you spend sleeping and moving will be recorded against an ID number. The information linking you to this ID number will be destroyed once all the data has been collected and you have been given the opportunity to request your individual information. The remaining data, which will not be able to be linked back to you in anyway, will be placed in secure storage and kept for at least ten years You will receive an additional $5 voucher if you wear the accelerometer for seven days and return it to the research team when they visit your school If you do not wish to wear an accelerometer, please click the 'DISAGREE' button

- ○ AGREE
- ○ DISAGREE

Please let us know which type of gift card you would prefer:

- ○ New World
- ○ PaknSave

Please answer the following questions:	
What is your first name?	_____
What is your last name?	_____
What is your date of birth?	_____
Today's date for age calculation	_____
Age	_____
What is your phone number (mobile would be best - so we can text you reminders)?	_____
What is your email address?	_____

Thank you for enrolling in the SuNDiAL project!

What happens next?

We are now going to ask you to complete a health and demographic questionnaire. If you want to complete it at a later time, please click the "Save and Return" button at the bottom of this page (if you click this button you will be given a code which you will need to write down and which you will need to use to return to and continue this survey). Or, click the "Submit" button to continue.

You will also get an email and/or text to tell you when you can visit the SuNDiAL clinic at your school to complete the other measurements, a food recall and an activity recall.

9.5 APPENDIX E Supplement Use Questions

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Supplement Use

Did you take any supplements during the last year?
- ○ Yes
- ○ No

What type of supplement was it? (Select as many as apply)

- ☐ Multivitamin and/or multimineral
- ☐ Single vitamin or mineral
- ☐ Sports supplement (including protein powders or shakes)
- ☐ Other (please specify)

Multivitamin and/or multimineral:
How often did you take the supplement in the last 12 months?
- ○ Daily
- ○ More than once a week
- ○ Once per week
- ○ Monthly
- ○ Regularly but for a limited time
- ○ Not very often

Multivitamin and/or multimineral:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Multivitamin and/or multimineral:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

Single vitamin or mineral: Please tell us what vitamin or mineral it was:

_____

Single vitamin or mineral:
How often did you take the supplement in the last 12 months?
- ○ Daily
- ○ More than once a week
- ○ Once per week
- ○ Monthly
- ○ Regularly but for a limited time
- ○ Not very often

Single vitamin or mineral:

If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.

_____

Single vitamin or mineral:

If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time).

When taking a photo (or two), please make visible the brand and the list of contents.

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Sports supplement (including protein powders or shakes): How often did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Sports supplement: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Sports supplement: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	
If Other, please specify:	_____
Other: How often did you take the supplement in the last 12 months?	◯ Daily ◯ More than once a week ◯ Once per week ◯ Monthly ◯ Regularly but for a limited time ◯ Not very often
Other: If you know the brand name and/or the product name please write them here. Please provide as much information about the product as possible.	_____
Other: If you are able to take a photo of your supplement packaging, please do so and upload here (you can complete the questionnaire and come back to upload a photo at a later time). When taking a photo (or two), please make visible the brand and the list of contents.	

9.6 APPENDIX F Bowel habits section of questionnaire

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How many times per week do you usually have a bowel movement (poo)?	_____
Please look at the picture below and select the number that corresponds to your usual and most common bowel movement (poo) type:	○ Type 1 ○ Type 2 ○ Type 3 ○ Type 4 ○ Type 5 ○ Type 6 ○ Type 7

Bristol Stool Chart

Type 1		Separate hard lumps, like nuts (hard to pass)
Type 2		Sausage-shaped but lumpy
Type 3		Like a sausage but with cracks on its surface
Type 4		Like a sausage or snake, smooth and soft
Type 5		Soft blobs with clear-cut edges (passed easily)
Type 6		Fluffy pieces with ragged edges, a mushy stool
Type 7		Watery, no solid pieces. **Entirely Liquid**

20-04-2020 11:05am projectredcap.org REDCap

9.7 APPENDIX G Anthropometry Protocol

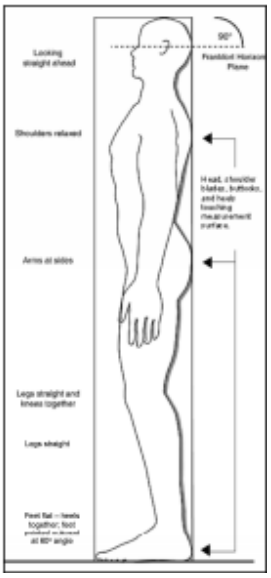
Anthropometric Measurements

To complete anthropometric measurements you will need:

- This protocol
- A stadiometer that has been assembled correctly, and positioned appropriately against a straight wall
- A set of body weight scales
- A steel anthropometric measuring tape
- The blood pressure and anthropometry recording sheet

Make sure you have taken the ID number from the **name & ID spreadsheet** and written it correctly on the blood pressure and anthropometry recording sheet.

Gain verbal consent from the participant for each measurement and explain fully what you will do to obtain them, specifically asking them if it is ok to touch the top of their head with the stadiometer when doing the height measurement. Before beginning, gain consent from the participant to use non-permanent pen for marking anatomical land marks.



HEIGHT

1. Ask the participant to remove their shoes, as well as any hair ornaments or buns/braids on the top of the head.
2. If the participant is taller than the investigator, use a step tool to take the measurements. Errors can be minimised by the investigator being parallel to the participant and the headpiece.
3. Tell the participant to stand with their heels together and toes apart pointing outward at approximately a 60-degree angle.

4. Make sure the back of the head, shoulder blades, buttocks, and heels of the participant are touching the backboard/stadiometer.
5. Make sure the participant's head is aligned in the Frankfort horizontal plane, where a horizontal line connects from the ear canal to the lower border of the orbit of the eye.
6. Lower the headpiece to rest firmly on the top of the participant's head and ask the participant to stand as tall as possible and take a deep breath.
7. Record the result to the nearest 0.1 cm in the HEIGHT 1 box on the recording sheet without informing the participants.

WEIGHT

1. Ask the participant to remove any heavy clothing (such as jackets, heavy tops, boots etc). As the participant would have just had their height measurement done, they should not be wearing shoes.
2. Turn on the scales, ensure they are switched on to metric (kg).
3. Ask the participant to step on to the scales so that they are facing away from the display (to prevent seeing the weight) cautioning them that they need to step up onto the scales.
4. Wait for the scales to read or come to a stable number.
5. Record the participant's weight to the nearest 0.1 kg in the WEIGHT 1 box on the recording sheet without informing the participant.

ULNA LENGTH:

Ulna length is measured between the point of the elbow and the midpoint of the prominent bone of the wrist using an anthropometric steel tape. This value is then compared with a standardized height conversion chart. Participants should be dressed in light clothing with no wrist watch or other jewellery on the arm that is to be measured.

Fig 2: ulna length measurement

1. Measure between the point of the elbow and the midpoint of the prominent bone of the wrist (non-dominant side).
2. Read and accurately record the measurement to the nearest 0.1 cm in the UNLA LENGTH 1 box on the recording sheet without informing the participants.

NB: anthropometry tapes have a blank lead before measurement markings start - consider this when reading a measurement.

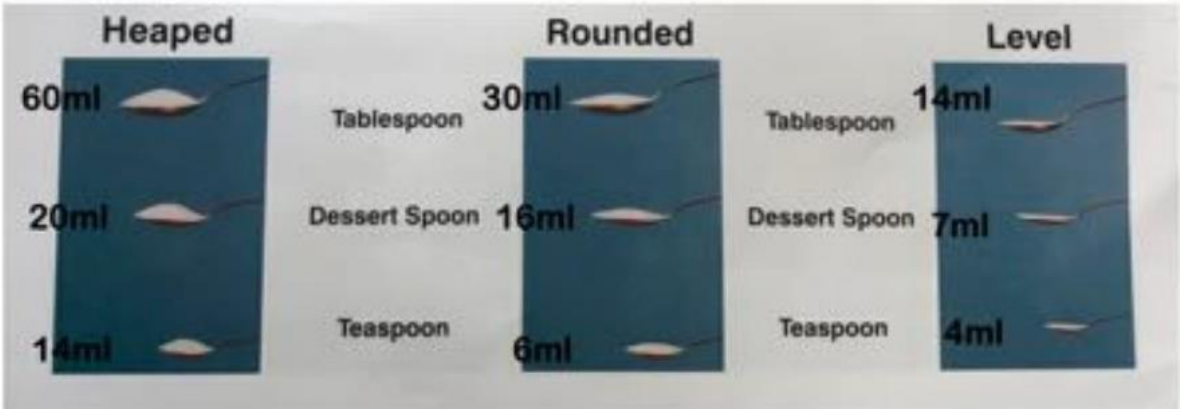
REPEAT ALL MEAUREMENTS

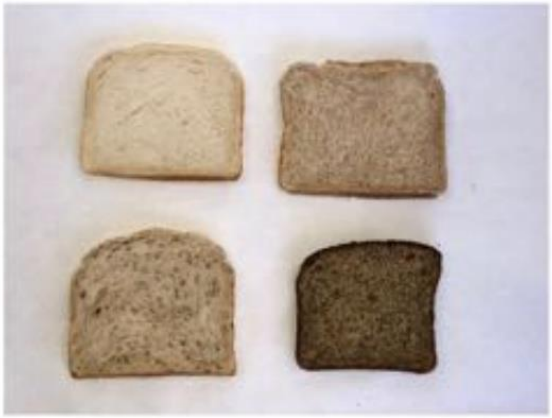
Repeat all three measurements again, in the same order, entering the measurements in the HEIGHT 2, WEIGHT 2 and ULNA LENGTH 2 box as appropriate (do no tell participant measurements).

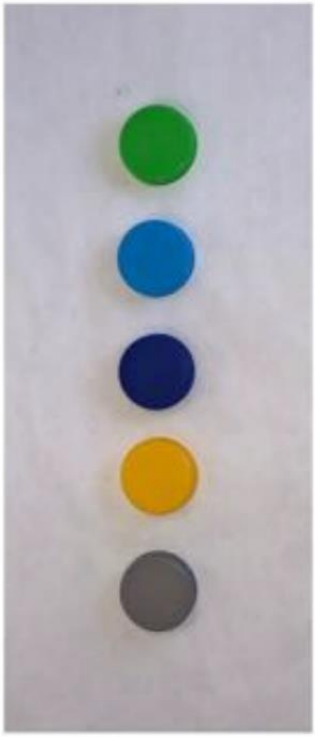
CHECK: are any of the 1st and 2nd measurements are more than 0.5 units apart? If so take a third measurement where required.

Anthropometric measurements will need to be entered into REDCap (see REDCap data entry protocol)

9.8 APPENDIX H 24 hour recall guide photos







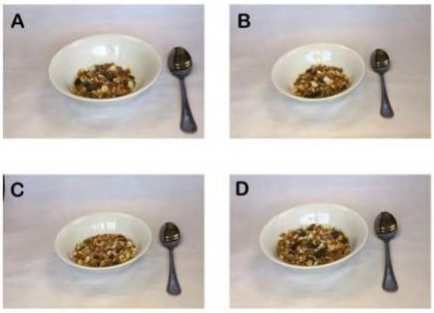

Block 250g
Row 22g
Square 4g
CREAMY MILK
Dairy Milk
Block 200g
Row 25g
Square 5g


50g
130g
146g

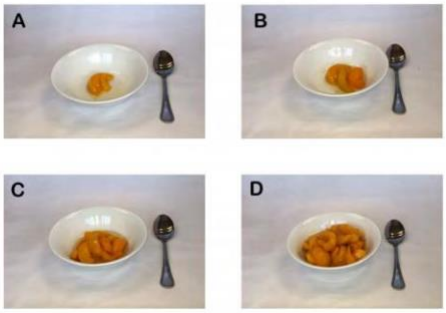

Block 100g
Row 20g
Square 10g
Milky bar
Block 200g
Row 25g
Square 5g


19g 22g 50g 35g 40g

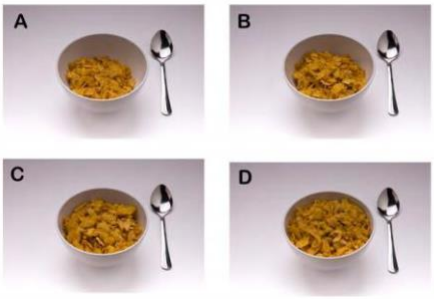
Muesli



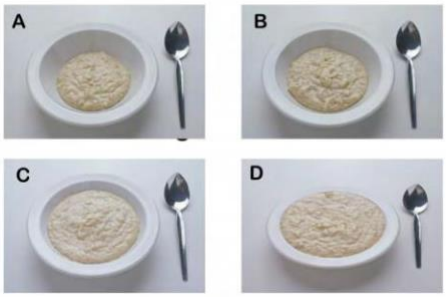
Peaches



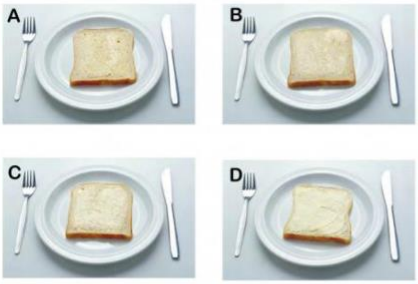
Cornflakes



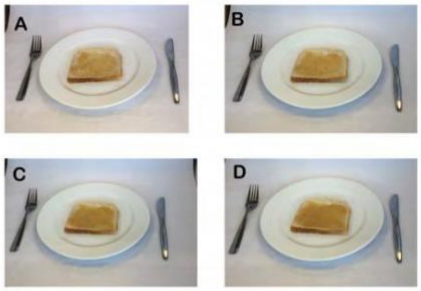
Porridge



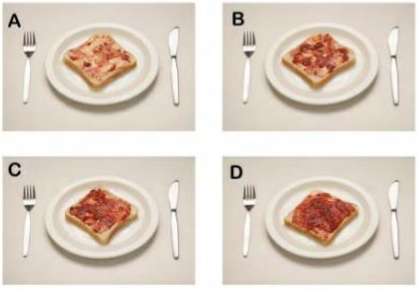
Margarine/butter



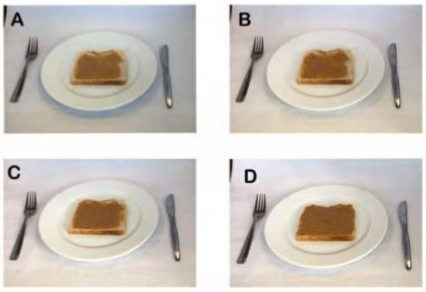
Honey

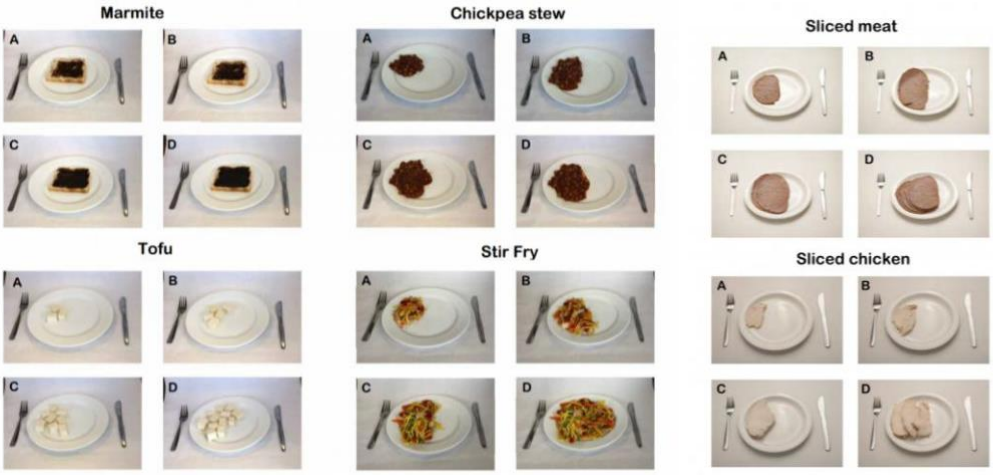


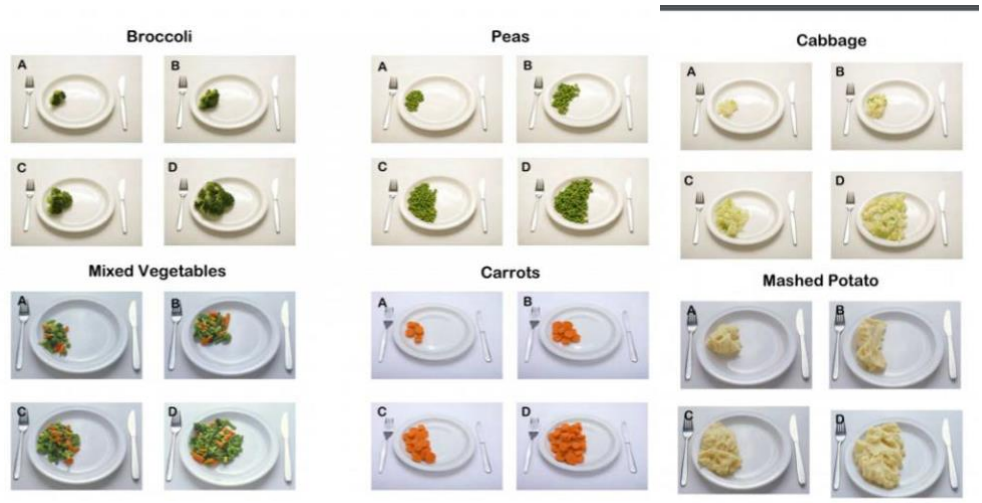
Jam

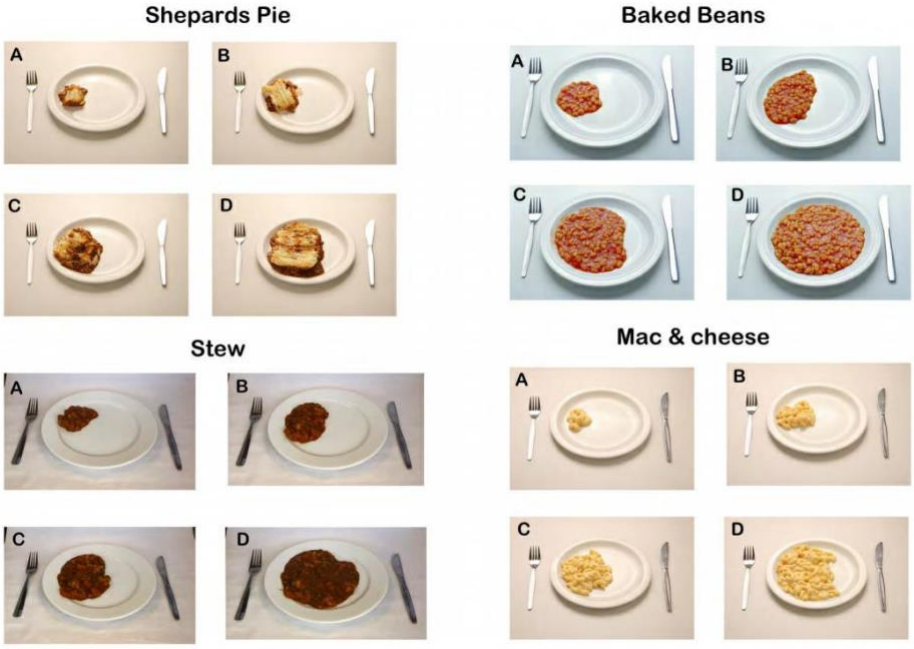


Peanut butter

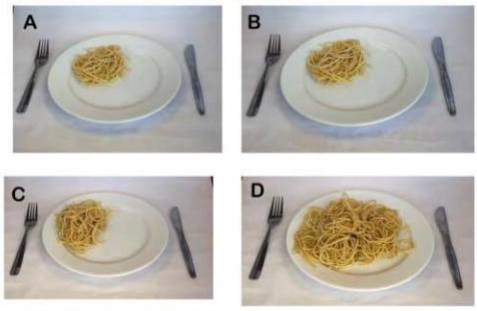



Marmite
Chickpea stew
Sliced meat
Tofu
Stir Fry
Sliced chicken

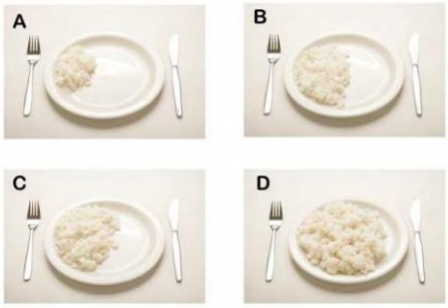

Broccoli
Peas
Cabbage
Mixed Vegetables
Carrots
Mashed Potato


Shepards Pie
Baked Beans
Stew
Mac & cheese

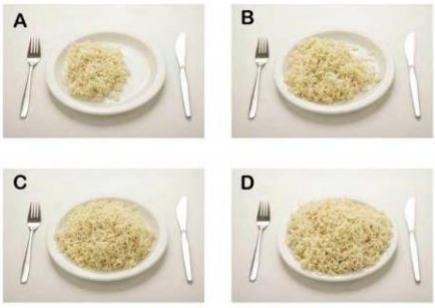
Spaghetti



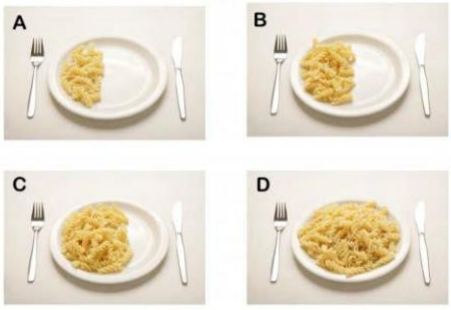
Rice



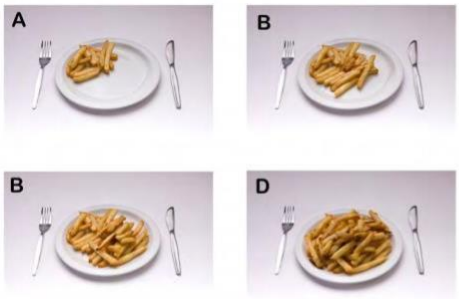
Noodles



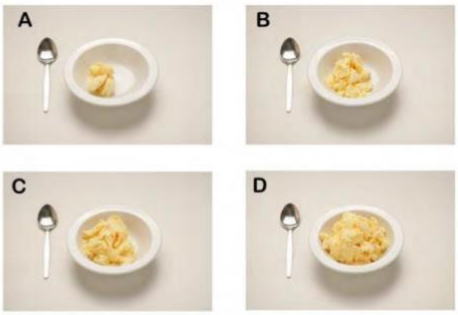
Spiral Pasta



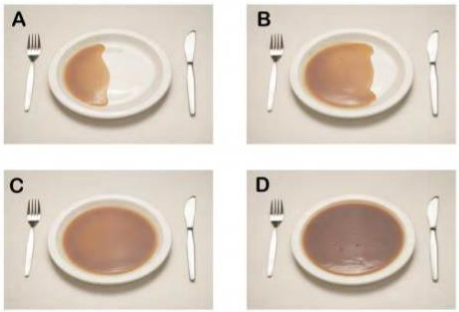
Chips



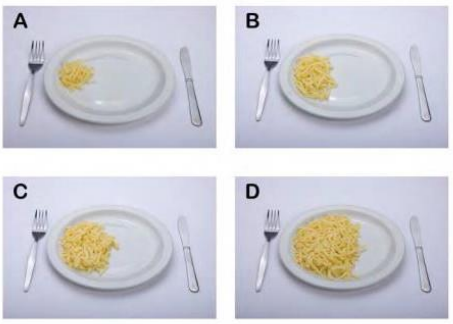
Ice cream



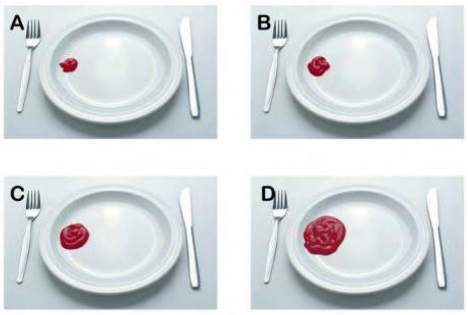
Gravy



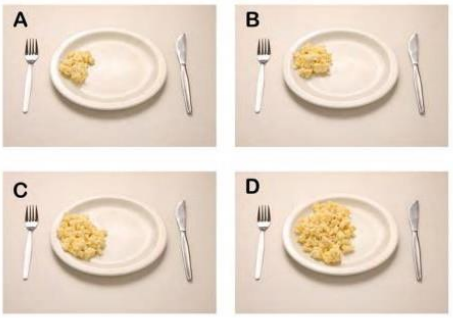
Grated cheese



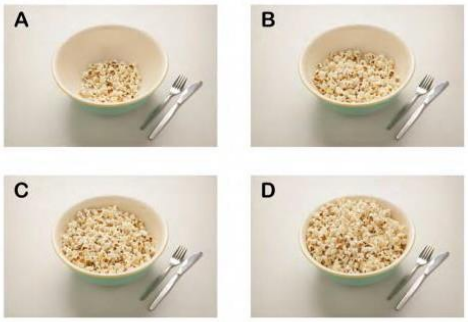
Tomato sauce

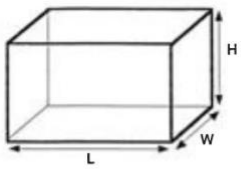


Scrambled egg

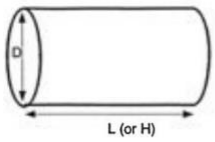


Popcorn

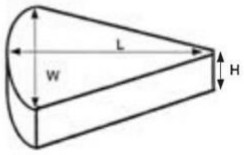




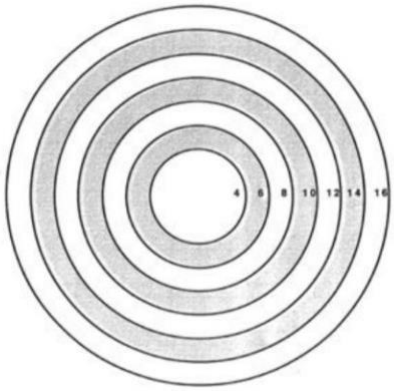
SQUARE OR RECTANGLE
(3 Dimensions required)
L=length
W=width
H=height



CYLINDER
(2 Dimensions required)
D=diameter
L=length



WEDGE
(3 Dimensions required)
L=length
W=width
H=height/thickness



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University of Otago
PO BOX 56 Dunedin
New Zealand

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Baked beans	Grated cheese	Noodles	Shepard's pie
Broccoli	Gravy	Peas	Sliced chicken
Cabbage	Ice cream	Popcorn	Sliced meat
Carrots	Mac and cheese	Porridge	Spiral pasta
Chips	Mashed potato	Rice	Tomato sauce
Cornflakes	Mixed vegetables	Scrambled egg	

9.9 APPENDIX I 24 hour recall Protocol

24 Hour Dietary Recall

To complete the 24 h dietary recall you will need:

- This protocol, including the tips sheet and useful prompts.
- The 24 h dietary recall recording sheet.
- Portion size box, including measurement aids and food photographs.

Make sure you have taken the ID number from the **name & ID spreadsheet** and written it on every page of the 24 h diet recall recording sheet.

Explain the 24 h recall to the participant

"I am going to ask you about everything that you ate and drank yesterday. Please try to recall, and tell me about everything that you had to eat at drink, whether it be at home, or away from home, including snacks, drinks and water. We are not here to decide if what your eating is healthy or not – we just want to understand what boys around New Zealand are eating, so we would like you to be really honest with us"

Stage One – Quicklist

"First, we will make a quick list of all the things you ate and drank, and then we will go back over this list and I will ask you more details about the specific foods and drinks, and the amounts."

"It might help you remember what you ate by thinking about where you were, who you were with, or what you were doing yesterday; like going to school, eating out, or watching TV. Feel free to keep these activities in mind and say them aloud if that helps."

"So starting from midnight the day before yesterday, what was the first thing you remember eating?"

Start recording quick list – keep prompting until finished

"That's great. Sometimes people forget to tell us about drinks, particularly water when we do this list."

"How much water do you remember drinking yesterday?" *(record)*

"Did you have any other drinks you might have forgotten about?" *(record)*

Stage two – Collect more information

"I am now going to ask you some more specific questions about each food. We also need to work out how much of each food that you ate or drank"

"Let's start at the beginning – the first thing you remember eating was xxxx" *(record)*

What time did you eat/drink that? *(record)*

Go on to collect specific information that is relevant to each food based on the tips provided on the tip sheet. Record as much specific information as you can. Record each food item in a different row.

Use the photos and measurement aids to help the participant estimate the portion size. Remember that brand and package size will always give you the most accurate information.

Before you go onto the next food on the quick list be sure to ask if they added anything to the food they have just described.

Stage 3 – check for any further additions

"Ok, thanks for working with me to provide all of that detail. We are now going to do one more check to make sure there isn't anything else that should be on this list. I am going to read this list back to you. If you remember anything else that you ate while I am reading it back to you please interrupt me and we will record it"

Read through with the participant all the food and drink they have listed

"Is there anything you can think of that we need to add in?" (record as necessary)

"Last Question: Do you know if the salt you use at home contains iodine?" (tick appropriate box)

"Great thank you again. If it is ok with you one day in the next week I would like to ring you and go through this process again on a different day, so that we can get an idea of how the foods you eat change from day to day. What time of the day (outside of school time) would suit you for me to ring you?"

Record preferred times - remember, ideally this second 24 h recall will occur on a randomly selected day, but that might not always be possible (at the very least it should be a different day of the week than today)

The 24 h diet recalls will need to be entered into FoodWorks following the FoodWorks Protocol.

Tips Sheet

Remember that the more information you can obtain about each food the more accurate the data is going to be. Please keep in mind that some of your fellow MDiet students are writing their thesis on nutrients (like Folate) that will vary from brand to brand depending on fortification so please be as careful and accurate as possible.

You need to gather more information about each food identified on the Quicklist. Below are some prompts that might help you do this.

Where possible for packaged foods collect the brand name.

Potential questions to consider asking (depending on the food reported):

- What is the brand name?
- Was it fresh, canned, frozen or rehydrated?
- Was it home made? Do they know the recipe? If they do record on the recipe sheet) – this is more important for savory foods than baking (as the basic composition of a biscuit or a cake varies much less than the composition of, for example, a stir fry)
- How was it cooked? Was it baked, fried, or boiled?
- Was the item coated before cooking, if so what it with flour, batter, eggs, or breadcrumbs etc?
- Was it standard, low fat, low sugar caffeine free?

Do not

- x Collect information about herbs and spices that are used in very small quantities
- x Ask leading questions
- x Ask for recipes for traditional home baking, but do note if it is gluten free.

- x Make assumptions
- x Respond in a judgmental way (positive or negative) to the foods or drinks consumed

Do

- ✓ Keep your prompts neutral
- ✓ Ask about cooking method and the type of fat used in cooking e.g. if they say baked, ask what with?
- ✓ Collect brand names for margarine, butter, juices/fruit drinks, breakfast cereals, energy drinks, breads, dairy alternatives (e.g. almond milk) as the micronutrient content of these products can vary considerably from brand to brand
- ✓ Ask for the recipe for less traditional home baking (e.g. brownies made with black beans, raw caramel slice etc)

Useful Probes for Specific Food Groups

FRUIT

- Peeled or unpeeled
- Colour? – e.g. red/green apple
- Tinned? – if so was it tinned in syrup or juice, how much of the syrup/juice did they have
- Use photos of tinned peaches, wooden balls, cups or beans to help estimate portion sizes

VEGETABLES

- Fresh, frozen or tinned (if tinned were they tinned with flavoured sauce/syrup/juice)
- Cooking method – boiled, baked (with fat/oil – what type and how much?), microwaved, steamed etc
- Colour – e.g. red/green capsicums
- Potatoes – with or without skin, if mashed what was added and how much?
- Quantities could be recorded in cups (sliced/whole/mashed/diced) or how much of a whole vegetable (e.g. ½ a medium capsicum)
- Use photos to help estimate portion size for similar vegetables not shown in pictures (e.g. broccoli can be used to estimate cauliflower, peas can be used for corn or bean etc). Use thickness guides and rulers to help estimate sliced vegetables (e.g. cucumber)

DAIRY

- Milk – brand name and fat content (show picture of bottle tops)
- Yoghurt – brand and with fruit or plain/natural or vanilla, reduced fat, low fat
- Ice cream – brand, any additions? If in a bowl use pictures to help estimate amounts

- Cheese - type (e.g. Edam, Colby, Feta), brand, grated (in cups or use pictures) or sliced (thickness guides)

NUTS

- Roasted, raw, salted, other favouring, blanched
- Whole, chopped, slivered
- Mixed – with or without peanuts
- How many cups or how many whole nuts? or can use beans to estimate handful size

BREAD

- White, wholemeal, wholegrain, light or dark rye (use photos to help with identification)
- Brand name (important for fortification)
- Toast or sandwich slice (thick or thin)
- For buns – any toppings (don't worry about small amounts of seeds, but do record cheese, bacon etc)

MARGARINE/BUTTER/TABLE SPREAD

- People often use the term butter and margarine interchangeably so collect the brand name (do not comment on the fact they might not have used the correct description)
- Low fat or standard
- Phytosterols (cholesterol reducing)
- Use pictures to help indication of thickness of spread

DRINKS

- Juices/Fruit Drinks
  - Terms used interchangeably so always collect brand information if possible

- 100% juice or fruit drink
- No sugar added or sweetened?
- Added vitamins
- Commercial or freshly squeezed
- Did they dilute with water, is so how much?
- Use cups or pictures of cans and bottles to help estimate portion size

- Fizzy drinks
  - Brand
  - Flavour
  - Diet, standard, zero sugar, type of sweetener
  - Caffeinated
  - Use cups or pictures of cans and bottles to help estimate portion size

- Made from liquid (cordial) or powdered concentrate (Raro)
  - Brand and flavour details of concentrate
  - Standard or low energy/ low sugar version
  - How much concentrate?
  - Did they make it with water or something else?
  - How much water or other substance was added?

PACKAGED FOODS

- Brand and package size most important
- Did they consume everything in the packet?

MIXED DISHES

- Try and record recipe if possible
- If recipe unavailable try and get as much detail as possible
- Check any protein ingredients, starchy ingredients, vegetables, sauces

9.10 APPENDIX K ANS 33 Major Food Group Categories and Descriptions

Major food group number	Major food group description
1	Grains and pasta
2	Bread (incl rolls and specialty breads)
3	Breakfast cereals
4	Biscuits
5	Cakes and muffins
6	Bread based dishes
7	Puddings/desserts
8	Milk
9	Dairy products
10	Cheese
11	Butter and Margarine
12	Fats and oils
13	Eggs and egg dishes
14	Beef and veal
15	Lamb/Mutton
16	Pork
17	Poultry
18	Other meat
19	Sausages and processed meats
20	Pies and pasties
21	Fish/Seafood
22	Vegetables
23	Potatoes, kumara and taro
24	Snack foods
25	Fruit
26	Nuts and Seeds
27	Sugar/sweets
28	Soups and stocks
29	Savoury sauces and condiments
30	Non-alcoholic beverages
31	Alcoholic beverages
32	Supplements providing energy
33	Snacks sweet

Food group	Examples of food items included
Grains and pasta	Rice (boiled, fried, risotto, sushi, salad), flour, pasta/noodles, bran, cereal-based products and dishes (pasta and sauce, lasagne, pasta salad, noodle soup, chow mein)
Bread	All types of bread (rolls, pita, foccacia, garlic), bagels, crumpets, sweet buns
Breakfast cereals	All types (muesli, wheat biscuits, porridge, puffed/flaked/extruded cereals)
Biscuits*	Sweet biscuits (plain, chocolate coated, fruit filled, cream filled), crackers
Cakes and muffins*	All cakes and muffins, slices, scones, pancakes, doughnuts, pastry
Bread-based dishes	Sandwiches, filled rolls, hamburgers, hotdogs, pizza, nachos, doner kebabs, wontons, spring rolls, stuffings
Puddings and desserts	Milk puddings, cheesecake, fruit crumbles, mousse, steamed sponges, sweet pies, pavlova, meringues
Milk	All milk (cow, soy, rice, goat and flavoured milk), milkshakes, milk powder
Dairy products	Cream, sour cream, yoghurt, dairy food, ice-cream, dairy-based dips
Cheese	Cheddar, edam, specialty (blue, brie, feta, etc), ricotta, cream cheese, cottage cheese, processed cheese
Butter and margarine	Butter, margarine, butter/margarine blends, reduced-fat spreads
Fats and oils	Canola, olive, sunflower and vegetable oils, dripping, lard
Eggs and egg dishes	Poached, boiled, scrambled and fried eggs, omelettes, self-crusting quiches, egg stir-fries
Beef and veal	All muscle meats (steak, mince, corned beef, roast, schnitzel, etc), stews, stir-fries
Lamb and mutton	All muscle meats (chops, roast, mince, etc), stews, stir-fries, curries
Pork	All muscle meats (roast, chop, steak, schnitzel, etc), bacon, ham, stews, stir-fries
Poultry	All chicken, duck, turkey and muttonbird muscle meats and processed meat, stews and stir-fries
Other meat	Venison, rabbit, goat, liver (lambs fry), pâté (liver), haggis
Sausages and processed meats	Sausages, luncheon, frankfurters, saveloys/cheerios, salami, meatloaf and patties
Pies and pasties	All pies including potato top, pasties, savouries, sausage rolls, quiche with pastry
Fish and seafood	All fish (fresh, frozen, smoked, canned, battered, fingers, etc), shellfish, squid, crab, fish/seafood dishes (pies, casseroles and fritters), fish/seafood products
Vegetables	All vegetables (fresh, frozen, canned) including mixes, coleslaw, tomatoes, green salads, legumes and pulses, legume products and dishes (baked beans, hummus, tofu), vegetable dishes
Potatoes, kumara and taro	Mashed, boiled, baked potatoes and kumara, hot chips, crisps, hash browns, wedges, potato dishes (stuffed, scalloped potatoes), taro roots and stalks
Snack foods	Corn chips, popcorn, extruded snacks (burger rings etc), grain crisps
Fruit	All fruit, fresh, canned, cooked and dried
Nuts and seeds	Peanuts, almonds, sesame seeds, peanut butter, chocolate/nut spreads, coconut (including milk and cream), nut-based dips (pestos)
Sugar and sweets	Sugars, syrups, confectionery, chocolate, jam, honey, jelly, sweet toppings and icing, ice-blocks, artificial sweeteners
Soups and stocks	All instant and homemade soups (excluding noodle soups), stocks and stock powder
Savoury sauces and condiments	Gravy, tomato and cream-based sauces, soy, tomato and other sauces, cheese sauces, mayonnaise, oil & vinegar dressings, chutney, marmite

Non-alcoholic beverages	All teas, coffee and substitutes, hot chocolate drinks, juices, cordial, soft drinks, water, powdered drinks, sports and energy drinks
Alcoholic beverages	Wine, beer, spirits, liqueurs and cocktails, ready-to-drink alcoholic sodas (RTDs)
Supplements providing energy*	Meal replacements, protein supplements (powders and bars)
Snack bars*	Muesli bars, wholemeal fruit bars, puffed cereal bars, nut and seed bars