Associations between energy intake and physical activity in a sample of adolescent females in New Zealand

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Abstract

Background: Physical activity and energy intake are the two most variable components of energy balance and their association with obesity has been studied separately throughout literature. Despite their important role in energy balance, there is limited evidence describing the direct association between physical activity and energy intake.

Objective: The purpose of this study was to investigate associations between energy intake and physical activity levels across categories of BMI in adolescent females from the SuNDiAL project.

Design: Adolescent females aged 15-18 y were recruited from eight locations around New Zealand to participate in the SuNDiAL project. Physical activity was measured using ActiGraph GT3X+ accelerometers worn on the right hip 24 hours a day for seven days. Energy intake was measured via two 24-hour dietary recalls and adjusted to represent usual intake using MSM. Height and weight were used to calculate BMI, and WHO growth standards were used to calculate z-scores to categorise participants as normal weight, overweight or obese.

Results: 34.5% of the sample were classed as overweight or obese with zero participants in the underweight category. Less than 25% of the sample met the physical activity guideline. 26.9% of participants in the healthy weight category met the physical activity guidelines, while only 11.1% of participants in the obese category met the guideline. Energy intake for healthy weight and obese individuals was similar across BMI categories, however the lowest energy intake was observed in those classified as overweight, but who were meeting the

physical activity guidelines. There was no evidence of meaningful association between energy intake and physical activity (R^2=0.015).

Conclusion: No overall association was found between energy intake and physical activity. Small but insignificant associations were found within BMI categories. Some participants in the overweight category were found to be conducting more physical activity and eating less, likely with intentions to lose weight. Given the sample size is not representative of the New Zealand population further research is required to draw stronger conclusions. Regardless, the findings of this study highlight the need for extensive improvements to be made to help increase physical activity in adolescent girls.

Keywords: obesity, physical activity, energy intake, BMI female, adolescent.

Preface

This Masters of Dietetics thesis is based on data collected as part of the Survey of Nutrition, Dietary Assessment and Lifestyles (SuNDiAL) Project. The study aimed to compare the nutritional intakes, dietary habits, health status and attitudes and motivations for food choices between vegetarian and non-vegetarian New Zealand adolescent females. The SuNDiAL project ran from February to September 2019. The project was funded by the Department of Human Nutrition and a Lottery Health Research Grant. In 2020 the SuNDiAL project was extended to include a sample of adolescent boys to facilitate comparisons between females and males, and to provide an overall estimate of nutritional intakes, dietary habits, health status and attitudes and motivations for food choices in New Zealand adolescents. Data collection was planned to take place between February and September 2020. However, data collection was halted in March 2020 due to the global pandemic of COVID-19.

Initially, my thesis was supposed to focus on describing the physical activity patterns of male adolescents using data collected in 2020. However, upon the commencement of Level 4 lockdown due to COVID-19, limited accelerometers had been returned to researchers. In addition, physical activity that was being recorded at this point was unlikely to be representative of regular physical activity due to all organised sport being cancelled and national requirements to stay at home. Subsequently, relevant data on adolescent males could not be obtained and I was required to change my thesis topic and use data from the February and September 2019 phases of this project on adolescent females.

The primary investigators, Dr Meredith Peddie, Dr Jill Hazsard and Tessa Scott were responsible for both the 2019 and 2020 phases of the SuNDiAL project including the study design, gaining ethical approval, initial contact with schools and oversight of the study. The

candidate conducted the thesis under the supervision of Dr Meredith Peddie as a requirement of the Masters of Dietetics programme at the University of Otago.

As the candidate in 2020 I was responsible for:

- Completing training for data collection including anthropometric measurements and 24-hour recall training.
- Liaising with school staff to co-ordinate school visits.
- Preparing and delivering school presentation to Macleans College house assembly and gaining participant sign-ups for recruitment.
- Developing a booking system to organise appointments with participants and reminding them of their appointment through text and email reminders.
- Obtaining data from participants including anthropometric measurements.
- Fitting accelerometers and providing participants with wear time diaries.
- Entering anthropometric data into REDCap.
- Organising zoom sessions for 24-hour dietary and activity recalls.
- Conducting a second 24-hour dietary and activity recall via zoom.
- Data entry of 24-hour recalls into FoodWorks.
- Data entry of 24-hour activity recalls into REDCap
- Conducting literature searches, reviewing the literature, and developing a literature review on physical activity, energy intake, BMI category and patterns between each.
- Statistical analysis of data related to the thesis topic from accelerometers, 24-hour dietary recall and BMI z-scores.
- Interpretation and discussion of results.
- Write up of thesis components.

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To my family who supported me, particularly through having to change thesis topics in the middle of lockdown, you always encouraged me to keep working hard and constantly offered a helping hand. Finally, to my friends who motivated me and provided well-needed breaks and distractions with way more fun things than writing and reading literature.

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List of Abbreviations

ANS08/09	Adult Nutrition Survey 2008/2009
BMI	Body mass index
CI	Confidence interval
CPM	Counts per minute
CVD	Cardiovascular disease
h	Hour
kg	Kilograms
kJ	Kilojoules
m	Metres
min	Minutes
MSM	Multiple source method
MVPA	Moderate-to-Vigorous Physical Activity
n	Number of participants
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
PA	Physical Activity
SD	Standard Deviation
SuNDiAL	Survey of Nutrition, Dietary Assessment and Lifestyles
T2DM	Type 2 diabetes mellitus
WHO	World Health Organisation

1 Introduction

Inadequate physical activity (as energy expenditure) and high energy intake contribute to the development of obesity (Romieu et al., 2017). However, the results of numerous studies indicate that physical activity levels are below recommendations particularly in adolescent girls with the World Health Organization reporting only 15% of school-going females are meeting the guideline globally (World Health Organisation, 2019). The results of a recent study conducted in New Zealand found that ~36% of the participants aged 13-18 y are meeting the guideline (Kek, García Bengoechea, Spence, & Mandic, 2019). Whilst some may anticipate that those in the normal weight body mass index (BMI) category would be more likely to meet the physical activity guideline than those in the overweight or obese categories, no obvious trend to support this appears in the literature (Janssen, Katzmarzyk, Boyce, King, & Pickett, 2004; Laguna et al., 2013; Song, Carroll, & Fulton, 2013). Additionally, one might expect those in the highest BMI categories to report the highest energy intake, however, this is also not often the case. These results may be reflective of underreporting, social desirability bias, and/or the limitations associated with the cross-sectional nature of much of this research. However, given the obvious role of both energy intake and physical activity in energy balance and the development of obesity, there is a surprising lack of evidence investigating the association between these areas across different BMI categories. Given that obese adolescents are more likely to develop metabolic syndrome as adults (Sun et al., 2008), it is of high importance that we set up healthy eating and activity habits in adolescence. Investigation of potential associations between energy intake and physical activity will provide fundamental evidence to enhance our understanding for further interventions. Subsequently it will help us gain a better understanding of whether we should emphasize increases in physical activity and/or reduction of energy intake when helping to prevent

obesity in youth. Therefore, this thesis aims to investigate the associations between physical activity and energy intake a sample of adolescent girls in New Zealand.

2 Literature Review

2.1 Literature review methodology

Relevant journal articles were found using electronic databases such as Medline, Scopus PubMed, Ovid and Science Direct. Additional papers were extracted from reference lists of other published papers.

Key search terms used to identify literature for this review:

1. Physical Activity
2. Energy intake
3. Caloric intake
4. Diet
5. Obesity
6. BMI
7. Body Mass Index
8. Energy balance
9. Accelerometer
10. ActiGraph
11. ActiGraph GT3x+
12. Youth
13. Adolescence
14. Adolescent
15. Girls
16. Females
17. Aged 15-18

This literature review summaries the key literature about physical activity and energy intake in adolescents and is presented in five main sections:

- Section 2.3 explores the role of physical activity and energy intake in energy balance and how they may contribute to obesity.
- Section 2.4 investigates physical activity rates in adolescents around the world and how they are associated with weight/BMI.
- Section 2.5 investigates energy intakes in adolescents around the world and how they are associated with weight/BMI.
- Section 2.6 summarises the methodological considerations when measuring physical activity and energy intake (respectively) in the free-living population.
- Section 2.7 examines how energy intake and physical activity are associated with each other in adolescents.

2.2 Obesity in Adolescents

In New Zealand, the rate of obesity, cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) are rapidly increasing. The country has the fourth-highest rates of obesity in the Organisation for Economic Co-operation and Development (OECD) (OECD, 2017). Whilst CVD and T2DM appear more frequently in adulthood, child and adolescent obesity rates are rapidly emerging with 1 in 9 children between the age of 2-14 y, and almost 20% of those aged 15-24 y being classified as obese in New Zealand (Ministry of Health, 2019a). Obesity at a young age is related to a number cardiometabolic issues such as dyslipidaemia, high blood pressure and impaired glucose tolerance, leading to metabolic syndrome later on in life (Ministry of Health, 2019b; World Health Organisation, 2020). A longitudinal study conducted by Shumei Sun and colleagues found that those who were obese at age 13 were 2.8 times more likely to have metabolic syndrome as an adult (Sun et al., 2008). As it is well acknowledged that obese children are likely to become obese adults (Deshmukh-Taskar et al., 2006; Todd, Street, Ziviani, Byrne, & Hills, 2015; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997) the resulting risk factors can lead onto not only early mortality and morbidity for several health outcomes (Must, Jacques, Dallal, Bajema, & Dietz, 1992), but also impaired quality of life and financial stress on health systems (Lobstein, Baur, & Uauy, 2004). In 1997 the cost of healthcare in New Zealand concerning obesity was $135 million (Swinburn et al., 1997) and since then obesity rates have risen from 17.0% to 30.9% only increasing the financial burden (Ministry of Social Development, 2004). In both longitudinal and retrospective studies, it was found that if obesity is established during adolescence, later reversal in adulthood is unlikely (McTigue, Garrett, & Popkin, 2002; Patton et al., 2011). It has been suggested that obesity arising in adolescence is related to the increased energy intake and decreases in physical activity. During adolescence, there is less parental influence on food choice and a movement towards consuming more meals away from home (Todd et

al., 2015), particularly from fast food or takeaway shops which are energy dense foods (Ambrosini et al., 2012). Physical activity often becomes less of a priority for girls as pressure from their peers to seek activities associated with perceptions of femininity is introduced (Bailey R, Wellard, & Dismore, 2005). Physical activity may also be displaced by more sedentary activities such as homework and exciting electronic media. These changes, combined with reduced sleep are likely to be contributing to obesity in youth (Robinson et al., 2017). As adolescents move through puberty the changes in growth and body composition result in traditional BMI calculations (weight in kilograms (kg)/ height in metres (m) squared) not being accurate for this age group (Centre for Disease Control and Prevention, 2018). Body Mass Index z-scores from growth curves were refined by the WHO in 2007 to accurately calculate obesity in those under the age of 19. If BMI for age and sex is one standard deviation above the relative weight for age and sex they are classed as overweight while two standard deviations above will result in an obese categorisation. While body mass index is strongly associated with adiposity and increased cardio-metabolic disease at a population level, it performs less well at individual level, and in certain ethnicities where higher muscle mass is prevalent (Buksh et al., 2019).

2.3 Role of Energy Balance in Obesity

A fundamental aspect of maintaining, gaining or losing weight is energy balance (Gordon-Larsen, 2001). Energy balance is achieved when energy intake is the same as energy expenditure (National Research Council (US) Committee on Diet and Health, 1989). If energy intake is greater than expenditure we tend to put on weight, while if energy intake is less than expenditure, we tend to lose weight. Obesity often stems from a prolonged excessive energy intake or insufficient energy expenditure resulting in weight gain (National Research Council (US) Committee on Diet and Health, 1989). While the aetiology of obesity

is multifactorial, the role of physical activity and dietary energy intake cannot be overlooked as the major contributors.

2.3.1 Energy Expenditure

Total energy expenditure is subdivided into three components; basal metabolic rate, thermic effect of food and physical activity. Total energy expenditure differs from person to person due to age, sex, growth, body composition, pregnancy and hormonal status, with females tending to have lower energy expenditure per kilogram than males (National Institutes of Health (US), 2007; National Research Council (US) Committee on Diet and Health, 1989). Basal metabolic rate is the energy the body needs to carry out regular metabolic functions such as maintaining homeostatic body temperature, repair of internal organs and supporting respiration and cardiac function (National Research Council (US) Committee on Diet and Health, 1989). Thermic effect of food is the heat that is produced from the ingestion of food to absorb, digest, metabolise and store consumed nutrients (Ravn et al., 2013). Physical activity refers to any bodily movement of skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985) and is the most vital component of energy expenditure in relation to obesity. Individuals can modify their physical activity levels to increase total energy expenditure and promote a negative energy balance for weight loss or maintenance (Hills, Andersen, & Byrne, 2011). In a cross-sectional study conducted on school-aged children in twelve sites globally, in females, BMI z-scores decreased across tertials of increasing moderate-to-vigorous physical activity (MVPA) ($P < 0.001$) (Katzmarzyk et al., 2015). The odds of being obese were found to be (0.49; 95% CI, 0.44–0.55) for every 25-minute increase in MVPA and (0.41; 95% 0.37–0.46) for every 10-minute increase in vigorous physical activity (Katzmarzyk et al., 2015).

2.3.2 Energy Intake

Energy input is solely based on the individuals' behaviour through food and beverage consumption (Astrup, 2005). Energy intake comes from proteins, carbohydrates, fats and alcohol and whilst its benefits are to support bodily functions such as maintenance of body temperature, cardiac output, respiration, muscle repair and function and the storage and metabolism of food (National Research Council (US) Committee on Diet and Health, 1989), if consumption exceeds what is necessary for these functions it is stored as fat.

2.4 Physical Activity in Adolescents

2.4.1 Physical Activity Guidelines

"Sit Less, Move More, Sleep Well" are the physical activity guidelines for children and young people (5-17 years old) in New Zealand. The recommendations can be seen in Table 2.1 below.

Table 2.1: 24-hour activity guidelines – Sit Less, Move More, Sleep Well

Description	Definition
Sleep	8 to 10 hours per night for those aged 14 to 17 years with consistent bed and wake-up times.
Activity	Accumulation of at least 1 hour per day of moderate-to-vigorous physical activity (MVPA) (incorporate vigorous physical activities and activities that strengthen muscles and bones at least three days a week.)
Screen time	<2 hours/day of recreational screen time.

(Ministry of Health, 2017)

In 2016 the Canadian Society for Exercise Physiology released new guidelines integrating sleep, sedentary behaviour/screen time and physical activity (Canadian Society for Exercise Physiology, 2016), which New Zealand (Ministry of Health, 2017) which Australia have now adopted too (Australian Government Department of Health, 2019). With the substantial increase in sedentary behaviour, screen time and poor sleep hygiene, and the evidence of their negative implications on health, these additions to New Zealand's guidelines are crucial

in tackling obesity. Traditionally, New Zealand's physical activity guidelines of 60 minutes of MVPA daily closely align with the World Health Organisation (WHO) recommendations (World Health Organisation, 2011). A large proportion of other countries follow the same or similar guidelines as WHO globally.

2.4.2 How much physical activity are adolescents doing?

Despite physical activity guidelines being produced to help tackle the growing obesity pandemic, they are rarely being met. Researchers from WHO found that globally more than 85% of adolescent females attending school did not meet the current recommendations of 60 minutes (min)/day of MVPA (World Health Organisation, 2019). With evidence that 1.9 million deaths per year and the associated burden on the health system could be prevented if everybody met the physical activity guidelines (World Health Organisation, 2005), efforts to achieve this recommendation should be paramount. Table 2.2 reports the results of nine studies measuring physical activity in adolescents around the world. The proportion of those meeting the guidelines ranges from 5% to 36% for girls with six out of nine of the studies reporting the proportion meeting the guidelines was less than 20%. Median MVPA minutes per day ranges from 28.3 to 51.1 minutes but is not reported in all studies shown. The variation between countries may be influenced by the number of different methodologies, (although no clear patterns between self-report and accelerometry are obvious) however, the possibility of true differences existing in the literature cannot be excluded. While it appears New Zealand adolescent females accumulate more physical activity than other countries, they are still doing less than their male counterparts, and both sexes require improvement (Table 2.2). Adolescence is an age where more independence is obtained and after year 10 (~15 years of age) physical education is no longer a compulsory part of the school curriculum (at least in New Zealand) (Ministry of Education, 1999). Consequently, further research on

physical activity in female adolescents aged 15-18 y is required to effectively target interventions.

Table 2.2: MVPA minutes per day and prevalence (%) meeting the physical activity guidelines

Author/date	Study/participants	Measurement of physical activity	Mean amount of MVPA	Prevalence (%) meeting the guideline[1]
(Clinical Trials Research Unit, 2010)	New Zealand's National Survey of Children and Young People's Physical Activity and Dietary Behaviours 2008/09, n=84 males and females, aged 15-19 y.	ActiGraph Accelerometer use over seven days.	36 min/day	33% of females met the guideline using the "any day average method"[2]. More boys meeting guideline than girls but not specified how much in this age group.
(Kek et al., 2019)	Cross-sectional study on transport and physical activity habits in New Zealand adolescents, n=211 females, aged 13-18 y.	GT3X+ ActiGraph accelerometer for seven consecutive days with wear time log	33.4 ± 11.5 min/day	36.0% of girls met the guideline. 45.6% of boys met the guideline. Those who used active forms of transport for school were more likely to meet the guideline than those who did not.
(Cristi-Montero et al., 2019)	HELENA study 2006/08, n=289 females, aged 12.5–17.5 y.	GT1M ActiGraph accelerometer Seven consecutive days	51.1 ± 19.2 min/day	26.3% females met the guideline. 61.8% of boys met the guideline.
(Guthold, Cowan, Autenrieth, Kann, & Riley, 2010)	Cross-sectional survey data from 298 surveys from 146 countries 2001-2006, n=1,600,000 aged 11-17 y.	Validated self-report surveys from WHO or multi-country surveys	N.A.	15.4% of females met the guideline. 23.8% of boys met the guideline. No significant change from 2001 data of 14.9%
(Jekauc, Reimers, Wagner, & Woll, 2012)	Motorik Modul (MoMo-Study), n=474 aged 14-17 y.	Self-reported questionnaire	N.A.	5.0% of girls met the guideline. 8.1% of boys met the guideline.

(Amornsriwatanakul, Lester, Bull, & Rosenberg, 2017)	Cross-sectional with multi-stage stratified cluster sampling in Thailand. N=2237 females, aged 14-17 y.	Self-reported Student Questionnaires	N.A.	12.2% CI (11.0 – 13.5) of girls met the guideline. 28.2% CI (22.6-30.2) of boys met the guideline.
(Australian Bureau of Statistics, 2013)	2011-2013 Australian Health Survey, aged 15-17 y.	Self-reported	Males and females aged 15-17 38min/day.	6.2% of females met the guideline.
(Wang, Chen, & Zhuang, 2013)	National Survey of Chinese city children, n=247 aged 15-17 y.	ActiGraph GT3X+ or GT3X accelerometers for seven consecutive days	Girls aged 9-17 y did 28.26 ± 17.66 min/day	8.5% of females met the guideline. 56.8% of boys met the guideline.
(Song et al., 2013)	NHANES study, n= 3240 females, aged 12-17 y.	Self-reported	N.A.	12.4% CI (10.8, 14.2) of girls met both muscle strengthening and aerobic guideline. 20.1% CI (18.1, 22.2) of boys met both muscle strengthening and aerobic guideline.

Abbreviations: CI = confidence interval

[1]Deemed to be meeting the physical activity guideline if MVPA minutes was ≥60 minutes.

[2]A child or young person aged up to 18 years accumulates at least 60 minutes of MVPA per day on any valid sampled day (at least one) (Any Day Average Method)

2.4.3 How does physical activity relate to BMI?

2.4.3.1 BMI class and guidelines

When investigating the relationship between BMI and meeting the physical activity guidelines, historically physical inactivity (i.e. not meeting the activity guidelines) is thought to be directly related to obesity. However, the cross-sectional association reported in the literature is weak at best as seen in Table 2.3. The results of the majority of cross-sectional studies indicate no significant differences between the proportions meeting the physical activity guidelines across BMI categories. Due to the known vital role of physical activity in preventing obesity (Hills et al., 2011), the lack of a significant association between BMI and rates of physical activity may be the result of over-reporting in overweight or obese individuals (McMurray et al., 2008) or those in overweight or obese BMI ranges completing more physical activity to help assist weight loss. It is important to note that these studies are cross-sectional which do not allow us to detect causality, but allow us to find associations between risk factors (Jacob & Ganguli, 2016).

Table 2.3: Prevalence (%) of those meeting physical activity guideline by BMI categories

Author/date	Study/participants	Physical activity measurement	Results – percentage meeting the guideline[1]
(Laguna et al., 2013)	Physical activity patterns of Spanish adolescents, n=274 age 15y	GT1M accelerometer for 6 consecutive days.	16.4% of NW 27.3% of OB The number of minutes spent in MVPA was not statistically different between NW and OB, 45.3 (SD 19.4) and 49.3 (SD 20.6) respectively.
(Song et al., 2013)	NHANES Representative study U.S. n=6547 age 12-17y	Self-report	16.2% (14.5, 18.2) UW/NW 15.4% (12.5, 18.9) OW 17.4% (14.5, 20.7) OB No significant differences in meeting both the aerobic and muscle-strengthening guidelines in all BMI categories.
(Janssen et al., 2004)	Cross-sectional survey n=3078 11-16y	Self-report	15.1% of NW girls 12.9% of OW girls 12.1% of OB girls No significant differences between BMI levels.

Abbreviations: NW = normal weight, OB = obese, MVPA = moderate-to-vigorous physical activity, SD = standard deviation, UW = underweight, BMI = body mass index

[1] Deemed to be meeting the physical activity guideline if MVPA minutes was ≥60 minutes.

2.5 Energy Intake in Adolescents

2.5.1 Energy intake recommendations

Energy intake recommendations for adolescent girls aged 15-18 y vary due to the rapid growth and changes throughout puberty. In New Zealand, the general recommended energy intake for adolescents is enough to support growth and maintain energy balance which differs for age, sex, BMI and physical activity level (Ministry of Health, 2002).

2.5.2 How much energy are adolescents consuming?

Evidence from the literature displayed in Table 2.4 indicates the average daily energy intake for female adolescent's ranges from 6,700 kJ in Finnish based adolescents (Hoppu, Lehtisalo, Tapanainen, & Pietinen, 2010) to almost double that at 12,000 kJ in Philadelphia living adolescents (Gordon-Larsen, 2001). There does not appear to be any pattern between the studies using 24-hour recalls to measure energy intake, showing both the highest value and second-lowest value reported in Table 2.3. However, it should be noted that the study conducted on Finnish youth has a relatively large standard deviation of 2,0002 kJ (Hoppu et al., 2010), given the difficulty in accurately recalling 24-hour energy intake, understandably the methodology and large variation in results from this study make readers less confident in the estimation. These vast differences between studies could be true differences; however we cannot exclude the possibility that these differences could be explained by varying methodology, and/or varying impacts of recall and social desirability bias which is commonly seen in females and this age group (Vance, Woodruff, McCargar, Husted, & Hanning, 2009). Despite the numbers below, evidence indicates food choices and behaviour in adolescence are predictive of those made in adulthood (Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005), subsequently good habits must be formed for energy intake to remain at recommended levels for weight maintenance both in adolescence and later on in life.

Table 2.3: Energy intake in adolescent females

Author/date	Study Participants	Measurement of intake	Energy Intake (kJ)
(University of Otago, 2011)	New Zealand Adult Nutrition Survey 2008/09, females aged 15-18 y.	24-hour recall with 25% of sample completing second 24-hour recall.	7,635 kJ for girls, an non-significant decrease of only 400 kJ since 1997.
(Gupta, Noronha, Shobha, & Garg, 2018)	Selected schools in Udupi Talu, n=422 females, aged 15-17 y.	One 24-hour recall was conducted after giving previous instructions to write daily intake in a note-book of three days including intake from two weekdays and one weekend day.	7,079 kJ
(Hoppu et al., 2010)	23 Finnish secondary school students, n=170 females, mean aged 13.8 y.	48-hour recall.	6,696 kJ (SD 2,002 kJ) Below the recommended amount of 9,489 kJ/day.
(Samuelson, Bratteby, Enghardt, & Hedgren, 1996)	Nutritional survey 1993-1994 in Uppsala and Trollhättan, in Sweden, n=218 females aged 15 y.	Combination of food frequency questionnaire and weighed seven-day dietary record.	8,300 kJ, in Uppsala, and 7,400 kJ in Trollhättan.
(Crespo et al., 2001)	NHANES III, US, 1988-1994, n=622 females aged 14-16 y.	24-hour recall.	8,029 kJ (CI 7,489-8,560)
(Garaulet et al., 2000)	Secondary school of Terre Pacheco (Murcia) Spain, n=133 normal weight, n=59 obese females aged 14-18 y.	Seven consecutive day food record.	10,328 kJ (± 317.7) NW 9,225 kJ (± 399.7) OW

(Mohd Shariff, Khor, Kandiah, Norimah, & Ang, 2006)	Cross-sectional study on Malaysian adolescents, n=317, aged 11-15 y.	Three-day food record.	8,009 kJ (CI 308.1), NW 7954 kJ (CI 236.2) OW 8,937 kJ (CI 237.1) OB
(Gordon-Larsen, 2001)	Obesity-Related Knowledge, Attitudes, and Behaviours in Obese and Non-obese Urban Philadelphia Female Adolescents. n=64 aged 11-15 y.	24-hour recall.	11,715 kJ (± 2,658.2) NW 11,979 kJ (± 3,465.2) OB

Abbreviations: SD = standard deviation, NW = normal weight, OW = overweight, CI = confidence interval, OB = obese

2.5.3 How does energy intake relate to BMI?

It is often believed that BMI has a positive correlation with energy intake. Surprisingly, however, there is a large body of evidence showing obese individuals report a lower energy intake than their normal-weight counterparts (Bandini, Schoeller, Cyr, & Dietz, 1990; Garaulet et al., 2000; Kucukkomurler & Istik, 2016). In Garaulet (2000) study overweight individuals reported energy intake of 9,225 ± 389 kJ/day with normal weight girls reporting median energy intake of 10,329 ± 318 (p value for difference $p<0.05$) (Garaulet et al., 2000). Hypotheses behind this vary from underreporting (Mohd Shariff et al., 2006), methodologies being unable to distinguish intake differences, and true results of lower intake in general due to dieting and weight loss intentions (Rodríguez & Moreno, 2006). It is frequently agreed that assessing dietary intake accurately is exceptionally difficult (see section 2.6). Variations in energy intake as little as 500 kilojoules a day (which is equivalent to a can of coke) can eventuate to 50 kg increase in body mass over ten years, elucidating the need for longitudinal studies in this area (Ebbeling, Pawlak, & Ludwig, 2002).

2.6 Methodological Considerations in the Measurement of Physical Activity

2.6.1 Physical activity

There are several different methods for measuring physical activity, including self-reported, device measurement or direct observation (although the latter method will not be reviewed in this literature review). Due to physical activity's multidimensional nature, accurate assessment is fraught with difficulties and, therefore, no individual method can capture all subcomponents and domains while avoiding limitations (Monyeki, Moss, Kemper, & Twisk, 2018). Consequently, researchers must evaluate the intended outcomes of their study and find the method to best match their study design.

2.6.1.1 Self-reported measurement

Self-report is the most commonly used methodology for measuring free-living physical activity worldwide (Castillo-Retamal & Hinckson, 2011). Self-reporting often involves self-administered or interviewer-administered diaries or questionnaires. Questionnaires may ask the participant to recall the average amount of physical activity they do in a week or month, while activity logs or diaries requires participants to record physical activity over a given time (Sallis & Saelens, 2000). Self-report is cost-effective, relatively unobtrusive and suitable for large-scale studies as it does not require expensive equipment (Sallis & Saelens, 2000; Warren et al., 2010). This method can provide accurate data on the type, mode, duration and frequency of some activity that device methods cannot (Warren et al., 2010). While this method is less burdensome on both the individual and the research team, it is largely limited by bias (Warren et al., 2010). Social desirability bias commonly arises as a result of pressures from peers, social media, societal pressures to conform to the 'norm' or meet the recommended guideline leading to over reporting (Adams et al., 2005; Warnecke et al., 1997). Recall bias is also particularly prevalent in adolescent studies as short bursts of activity which is common in this age group (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005) can be overlooked, additionally intensity is often overestimated (Robbins, Pender, Ronis, Kazanis, & Pis, 2004). Self-report also requires participants to be numerate and literate if self-administered. While children's cognitive maturity is a limitation in accurately recalling physical activity there is limited evidence to say whether this is the case for those aged 15-18 y and thus further research is required (Sallis, 1991).

2.6.1.2 Device measurements – ActiGraph accelerometer

Device measurements include accelerometers, pedometers, heart rate monitors and arm-band technology (Sylvia, Bernstein, Hubbard, Keating, & Anderson, 2014). Accelerometers have

gained popularity with the ActiGraph commonly used in studies. The ActiGraph accelerometer motion sensor can be worn on the hip, wrist or thigh and measures duration, intensity and frequency of physical activity. The newer models of accelerometers such as the GT3X+ are triaxial measuring acceleration in the vertical, anteroposterior and lateral plane (Corder, Brage, & Ekelund, 2007). The data from accelerometers is expressed as activity 'counts' and summed over a specific time (Ridgers & Fairclough, 2011). Data is recorded into epochs, and cut points determine the time spent in either sedentary, light, moderate or vigorous intensity. Benefits of the newer models include large storage space, their ability to measure in epochs of 1-15 seconds (Logan, Duncan, Harris, Hinckson, & Schofield, 2016) and allowing the user to select epoch lengths retrospectively when analysing data. This is advantageous as an adolescents activity has been described as short bursts (Ward et al., 2005) of intermittent or high intensity (Bailey et al., 1995) lasting in bouts of about three to 30 seconds (Baquet, Stratton, Van Praagh, & Berthoin, 2007). Limitations to accelerometers include the inability to measure type activity and that they are often removed for contact sports or water-based activities to avoid possible damage to the device or the participant. This requires the participant to be diligent in remembering to put the accelerometer on after these activities and results in limited accurate data for an activity such as rugby, cycling, water-based activities and weight/resistance training. Subsequently, due to the accelerometer primarily being placed on the hip or lower back which is closest to the centre of mass providing a more precise physical activity measurement (Trost, McIver, & Pate, 2005; Ward et al., 2005), its ability to accurately measure isolated upper body movement is substandard (Lee & Shiroma, 2014; Warren et al., 2010).

Even so, there is strong evidence showing that ActiGraph accelerometers have good validity, feasibility and reproducibility providing a realistic habitual figure of physical activity in adolescents (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006). Accelerometers provide researchers with the ability to greatly avoid recall and social

desirability bias and although it cannot eliminate the issue that the participant is aware of their physical activity being recorded, it prohibits their ability to gain feedback and modify their behaviour during the course of the study providing more true representative data (Sirard & Pate, 2001). A seven-day wear time provides reliable estimates of usual physical activity behaviour while accounting for variability in activity patterns throughout the week (Trost, Pate, Freedson, Sallis, & Taylor, 2000).

2.6.2 Energy intake

Obtaining data on energy intake provides vital information to monitor trends and produce national recommendations in a population, which is crucial in evaluating the rising obesity pandemic. When choosing a method to analyse energy intake the research team must consider the population being studied with age, sex, numeracy, literacy and time required to complete all being factors that may influence the validity of the data (Cade et al., 2017). Even once a method is determined, being able to accurately measure true energy intake is rife with misreporting difficulties such as food omissions, food additions or inaccurate estimation of portion sizes resulting in over and/or under reporting which is frequently presented throughout the literature (Berdanier, Dwyer, & B., 2007; Frobisher & Maxwell, 2003; Livingstone, Robson, & Wallace, 2004). In addition, due to the vast array of brands and types of food consumed, erroneous data entry from ill-matched food intake to food composition databases can result in analysis errors if not accounted for appropriately (Dodd et al., 2006).

2.6.2.1 Under reporting in adolescents

It is well known that adolescent females often underreport, particularly those who have a higher BMI (Gemming, Jiang, Swinburn, Utter, & Mhurchu, 2014; Klesges, Eck, & Ray, 1995; Kye et al., 2014). This may be due to high social desirability in this group. In a study

conducted by Kersting M, Sichert-Hellert W, and Schöch G, it was found that female adolescents underreported by about 20% and found those with higher BMI resulted in more 'not plausible food records' (Kersting et al., 1998). Very similar results were found in a 2005 study with 50% of female adolescents underestimating their energy intake by at least 21% as well as increased underreporting in overweight individuals (Rennie, Jebb, Wright, & Coward, 2005). Feelings of guilt and frequent omissions in energy-dense snack foods may contribute to the reasoning behind this and consequently, caution must be observed when analysing energy intake in this population.

2.6.2.2 Methodologies

Routinely used methods to calculate usual energy intake include 24-hour recall, food record or food frequency questionnaire each defined in Table 5 below.

2.6.2.2.1 24-h recall

In the 2008/09 ANS (section 4.3), 24-hour food recalls were used to assess dietary intakes (University of Otago, 2011). This method is relatively low burden to the participant, can be done in large scale studies and can produce more accurate responses across study outcomes when conducted by trained interviewers following study protocol procedures (Baranowski, 2013). It is unobtrusive and requires a relatively short time to complete (20-30 minutes) which is beneficial in obtaining participant compliance (Shim, Oh, & Kim, 2014). Tools such as the Automated Multiple Pass Method are used to assist participants in accurately recalling energy and dietary intake and helps to reduce bias (Baranowski, 2013; Moshfegh et al., 2008). In short, this method requires the participant to give a brief list of all foods consumed during the day, followed by a detailed description of brands and cooking methods. It also then questions quantities consumed using household measures such as measuring cups and

food aid images to prompt the participant and finally a review of the recall with the interviewer prompting for frequently forgotten foods (Baranowski, 2013; University of Otago, 2011). Limitations of the 24-hour recall include needing a trained interviewer, the extended time frames for researchers to enter data into a food database and the limited ability to summarize participants typical diet from a single day's consumption. Subsequentially, two or more recalls are usually conducted often including a week and weekend day to account for in-person variability (University of Otago, 2011). Additionally, the multiple source method accounts for day-to-day variation from the participants who completed two dietary recalls and applies this information to the rest of the dataset giving an adjusted estimate of usual intake of all participants (Harttig, Haubrock, Knüppel, & Boeing, 2011).

2.6.2.2.2 Food Records

Opposed to a 24-hour recall where data is retrospective, a food record obtains prospective data by asking the participant to record everything they consume on specified days. Participants can be asked to weigh everything they eat using scales or estimate weights using household measures and food models. Consequently, this method may have low participant compliance and high risk of bias as participants could potentially change their diet to make recording consumption easier or not record everything that they eat in the food diaries (Macdiarmid & Blundell, 1997; Thompson, Subar, Loria, Reedy, & Baranowski, 2010). While this method can provide accurate data for estimating nutrient intake compared to other methods (Tabacchi et al., 2014), it can be hard to diarise foods eaten away from home, be relatively expensive in large scale studies if calibrated scales are provided and cannot be regulated by trained researchers (Magarey et al., 2011). Additionally, similar to 24-hour recall, recorded diaries have to be entered into a food database which is relatively

burdensome for the researcher and as mentioned earlier can be problematic with varying recipes, brands of foods and cooking methods (Spark, Dinour, & Obenchain, 2016).

2.6.2.2.3 Food frequency questionnaires

Food frequency questionnaires are often used for assessing total diet and ranking individuals rather than quantifying actual intakes and often require the research team to develop a questionnaire-based off the intended outcomes of the study (Biró, Hulshof, Ovesen, Amorim Cruz, & for the, 2002; Zheng, Campbell, Scanlan, & McNaughton, 2020). Good recall memory and ability to describe diet is required, resulting in large recall bias and subsequently, they are seldom used for measuring energy intake alone (Magarey et al., 2011; Shim et al., 2014; Spark et al., 2016; Thompson et al., 2010).

Table 2.4: Descriptions of methodology for measuring energy intake

Method	Description
24-hour food recall	A trained interviewer asks the participant to recall all food and drink consumed in the previous 24-hour period (Kroke et al., 1999).
Food record	Prospective data collected through weighing or estimating consumed food to determine usual individual or group intake, usually three to seven days (Yang et al., 2010).
Food frequency questionnaire	Questionnaire on the frequency and consumption of food and beverages usually in a specified period of more than 24 hours and usually up to a year (Magarey et al., 2011).

2.7 Relationships between physical activity and energy intake in adolescents.

Given the knowledge that energy intake and physical activity are key components of obesity, establishing whether a clear relationship lies between the two is important when developing interventions aimed at obesity prevention. It is important to note that some evidence suggests physical activity may have a role in appetite control as well as increasing energy expenditure

(Fogelholm, 2010). However, few studies have directly investigated the association between physical activity and energy intake in the adolescent population. The HELENA study reported only a 117 kJ difference in intake between the first and third physical activity tertial in females with no indication of a trend across the categories (Ottevaere et al., 2011). No significant differences were found between BMI and physical activity tertials for females either (Ottevaere et al., 2011). The Australian cross-sectional LOOK study investigated both energy intake and physical activity in relation to body fat percentage but did not compare the energy intake and physical activity together. The results indicated every additional 10min/day of MVPA decreased body fat percentage by 0.6 ± 0.13% ($p < 0.001$). However, energy intake was not significantly associated with percentage body fat in either the younger (mean age 12.4 (SD 0.4) y) or older (mean age 16.3 (SD 0.4) y) age groups. These results indicate that obesity reduction efforts should possibly focus on elevating physical activity rather than reducing energy intake (Telford, Welvaert, Martin, & Telford, 2019).

2.8 Summary

Appropriate levels of physical activity and energy intake play an important role in treatment and prevention of obesity. Due to the numerous methodologies available to measure energy intake and physical activity, there is no clear association between physical activity or energy intake, either alone, or together, with BMI. Nonetheless, the literature is eye opening to the reality that physical activity levels and prevalence of those meeting the guideline across all BMI categories are extremely low particularly in adolescent girls (Jekauc et al., 2012; Wang et al., 2013). Despite energy intake and physical activity's well-established role in the energy balance equation very little research has been conducted to investigate a relationship between these two factors, which evidently will help to develop more effective interventions in the future.

3 Objective Statement

The aim of the study is to measure associations between energy intake and physical activity levels and patterns in BMI categories in adolescent girls from the SuNDiAL study.

The objectives are:

- To determine the percentage of SuNDiAL participants meeting the physical activity guideline.
- To determine if the percentage of participants who meet the physical activity guideline differs across BMI categories.
- To determine the energy intake of SuNDiAL participants.
- To determine if energy intake differs across BMI categories.
- To determine if there is an association between energy intake and moderate-to-vigorous physical activity.

4 Subjects and methods

4.1 Overall study design

The SuNDiAL project 2019 (Survey of Nutrition, Dietary Assessment and Lifestyles) was a multi-centred cross-sectional survey aimed at comparing dietary intakes and habits, nutritional status, health status, motivations, attitudes, and lifestyles of vegetarian and non-vegetarian adolescent females in New Zealand. The sample size of this study was determined based on the primary outcome of describing differences between vegetarians and non-vegetarians. A sample size of 300 high school students enrolled from 14 high schools gave 80% power to the α=0.05 level to detect a 0.5 standard deviation difference (a "moderate" difference) in any continuous outcome variables between vegetarians and non-vegetarians, assuming a prevalence of vegetarianism of 20% and a design effect (for school clusters) of 1.5. This thesis presents data investigating the association between physical activity and energy intake in the sample as a whole. Online informed consent was obtained from all participants before data collection, with additional parental consent obtained for participants under the age of 16 years.

4.2 Participant recruitment.

Based on the location of data collection, 108 schools were initially eligible to participate in the study, from those schools 29 were selected to be invited to participate based on roll size (only schools with more than 200 girls enrolled were eligible) and decile (schools of lower decile were prioritised). Initially these schools were contacted by email, if no response had been received after two weeks the schools received a follow up email and phone call. In the locations where this method of contact failed to secure a school, a further six other schools who were personal contacts of study investigators, data collectors or University liaison

officers were contacted and invited to participate. In total 13 schools participated, eight schools in the first wave from February to April 2019 and five schools in the second wave from July to September 2019. The schools came from eight locations around New Zealand including Whangarei (two schools), Mount Maunganui, New Plymouth, Wellington (two schools), Nelson, Christchurch, Wanaka, and Dunedin (four schools).

Once schools were recruited data collectors (second-year Masters of Dietetics students) visited the schools and completed an in-school presentation. School pupils who were interested could sign up by providing their name, age, and email address. Those who expressed interest were re-checked for eligibility and sent online consent forms. If the participant was under the age of 16 y they were asked to provide the email address of a parent/guardian who was contacted and asked to provide online consent for their daughter to participate before the link to the study details and questionnaire was sent to the participant. Recruitment occurred at two time points from February to April 2019, and July to September 2019.

4.2.1 Eligibility criteria

Individuals who self-identified as female and were between 15 and 18 years of age, enrolled in one of the recruited high schools, not pregnant, and who spoke and understood English were eligible to participate.

4.2.2 Ethics

This study was approved by the University of Otago Human Ethics Committee (Health):h19/004 (Appendix A). Online informed consent was obtained by all participants

(and parents if under the age of 16) prior to completing the study. The trial was registered with the Australian New Zealand Clinical Trials. Registry: ACTRN12619000290190.

4.3 Measurement procedures

4.3.1 Demographics

Participants were sent an initial questionnaire divided into three sections and administered on REDCap. The first section on demographics and health had questions regarding age, ethnicity, socioeconomic status, menstrual status, food allergies or intolerances and whether they are vegetarian. The second section on attitudes and motivations included four previously validated questionnaires and contained a total of 81 questions. The final section on dietary habits includes questions about dietary habits, and weight loss intentions.

4.3.2 Anthropometry

During the in-school session height and weight was measured using a calibrated stadiometer (either Seca 213 or Wedderburn) and scales (one of Medisana PS 420, Salter 9037 BK3R, Seca Alpha 770 or Soehnle Style Sense Comfort 400) after the participant had removed their shoes and heavy clothing. The weight and height measures were recorded to the nearest 0.1 kg and 0.1 cm by the research team respectively. All anthropometric measurements were performed in duplicate, with a third measurement performed if the difference between the initial two measurements was ≥ 0.5 units, and the mean of the two closest measurements was used as the 'true' value.

Body Mass Index (BMI) was calculated by dividing weight in kilograms by height in metres squared. BMI z-scores for age and sex were calculated using the WHO child growth standards (de Onis et al., 2007).

4.3.3 Usual energy intake – 24-hour diet recall

Energy intake was assessed using two 24-hour recalls, the first diet recall was conducted in the in-school data collection session. The recall was performed using a multiple pass interview technique (Gibson & Ferguson, 2008). In the first pass, a 'quick list' of all foods and beverages consumed starting midnight the day before was obtained. In the second pass, a detailed description of cooking methods, brands, product information and recipes were obtained. In the third pass, the amounts of each food and beverage consumed were obtained. Participants were asked to estimate the amount consumed using standard household measures, food photographs, shape dimensions, food portion assessment aids (dried beans) and information from packaging. Finally, the full food list was reviewed with the participant and any changes and additions were recorded. A second 24-hour diet recall was conducted via phone or video-call on a non-consecutive day, preferably a weekend day where possible to account for between weekdays and weekend variation.

All dietary data which was collected was entered into FoodWorks dietary analysis software (version 9, Xyris Software; Australia) using the New Zealand Food Composition Database, FOODfiles (2016), (The New Zealand Institute for Plant and Food Research Limited and the Ministry of Health (New Zealand)) and nutrient data for commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition Survey (University of Otago and Ministry of Health, 2011).

Estimated energy intake was adjusted to represent 'usual intake' based on the estimated within-person variance of the participants using the Multiple Source Method (Harttig et al., 2011).

4.3.4 Accelerometer - ActiGraph

Average daily moderate-to-vigorous physical was measured via a triaxial ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, Florida, USA) in those who consented to accelerometry.

Accelerometers were worn on an elasticated belt over the top of their right hip 24 hours a day for seven consecutive days. Participants were advised to wear it at all times except for removal for swimming, showering, bathing or during contact sports. The raw accelerometer data was collected at 30 hertz. Over the seven day wear period participants were instructed to complete a sleep and wear time diary, where they recorded the time they got in bed, the time they attempted to sleep, the estimated time it took to fall asleep (minutes), as well as the time they woke up and the time they got out of bed each day. The participants were also required to note the duration and intensity of the activity if the accelerometer was removed to engage in water-based physical activity or full-contact sports.

4.4 Data processing and analysis

4.4.1 Wear time

The time when the participant reported wearing their accelerometer was reported as 'wear-time'. Data was only considered by units of days if wear time during waking hours totalled to ≥10 hours and total wear time plus imputed physical activity totalled to ≥20 hours. Valid days also needed to include 2 hours of sleep. A participant's data was only included in the analysis if there was at least three valid days of data available.

4.4.2 Accelerometer Data Processing

Accelerometers and wear-time diaries were sent back to the research team at the University of Otago. Data was downloaded using Actilife software (ActiGraph, Pensacola, Florida. Version 6) and saved in 15-second epochs to capture short bursts of physical activity, then converted to CSV file and assessed using Stata (Stata Statistical Software: Release 16. College Station, Texas: StataCorp). Customised Stata (StataCorp. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC) code, using both the accelerometer and log data, to differentiate non-wear and wear time. Time spent in MVPA was classified as ≥1952 counts per minute (CPM), using the y-axis thresholds (Freedson, Melanson, & Sirard, 1998). Any physical activity completed not wearing the accelerometer was deemed as 'non-wear time physical activity' and was added to the total wear time MVPA depending on the reported intensity.

4.4.3 Statistical analyses

All analysis was conducted using Excel (version 16.36), participant demographics were derived and tabulated. Participants were defined as meeting the physical activity guidelines if their mean daily MVPA exceeded 60 min. The proportion of participants meeting the guidelines was calculated for the sample as a whole and for each category of BMI (healthy weight, overweight and obese) separately. Similarly, mean daily energy intake was calculated for the sample as a whole and for each category of BMI, with further categorisation as to whether the physical activity guideline was met within each category of BMI. Finally, the association between energy intake and MVPA as continuous variables was assessed by deriving a scatter plot and applying a line of best fit to the data.

5 Results

Figure 5.1 represents the flow of participants from recruitment to analysis. One hundred and nineteen participants were included in the final analysis, all of whom had dietary data based on one (n=1) or two (n=118) 24-hour recalls.

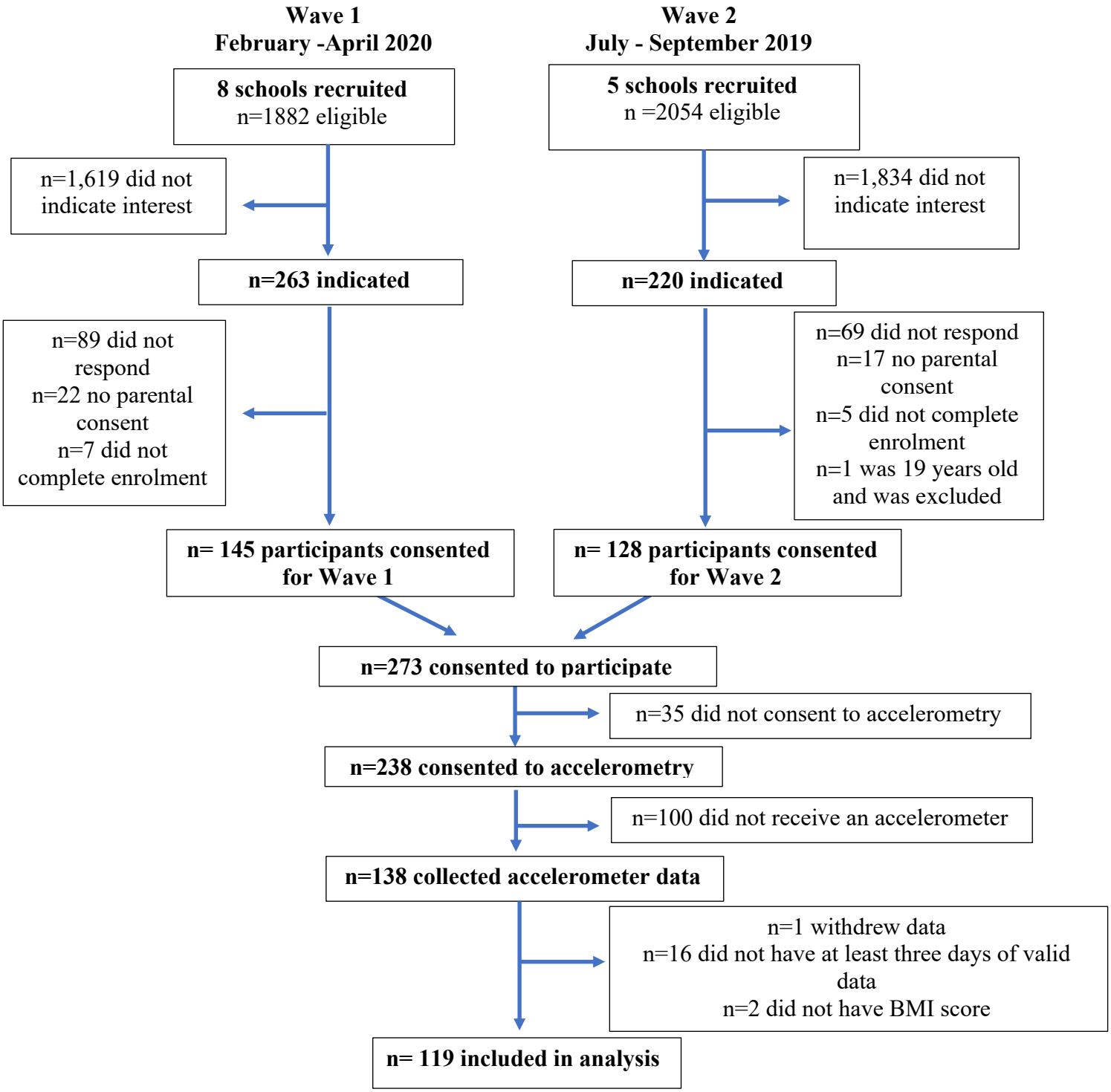

Figure 5.1: Study design and flow chart of participants through the study.

5.1 Demographics

The demographic characteristics of the participants at the time of recruitment are presented in Table 1. The mean age of participants was 17 (0.9) years, and the majority of participants identified as New Zealand (NZ) European or 'other' ethnicity, 34% were overweight or obese. Eighty percent of participants lived in neighbourhoods with low or moderate deprivation, and over 40% of the sample reported that they were trying to lose weight.

Table 5.5 Anthropometric and demographic characteristics of participants (n=119)

Characteristics		n (%)
Age		
	15	12 (10.1)
	16	39 (32.8)
	17	40 (33.6)
	18	28 (23.5)
Ethnicity		
	NZEO	99 (83.2)
	Māori	13 (10.9)
	Pacific	3 (2.5)
	Asian	4 (3.4)
BMI Category[1]		
	Underweight	0 (0)
	Healthy	78 (65.5)
	Overweight	32 (26.9)
	Obese	9 (7.6)
New Zealand Deprivation Score[2]		
	Level 1 (Low)	44 (37.0)
	Level 2 (Moderate)	51 (42.9)
	Level 3 (High)	24 (20.2)
Weight loss intentions		
	Lose weight	50 (42.0)

Stay the same weight	28 (23.5)
Gain weight	1 (0.8)
No, not trying to do anything about my weight	35 (29.4)
No response	5 (4.2)

Abbreviations: n=number of participants, NZEO = New Zealand European, BMI = body mass index

[1] Categorisation calculated using age-appropriate z-scores (de Onis et al., 2007).

[2] Derived from NZ Deprivation of Index score. (level 1 being least deprived and level 3 being most deprived) (Atkinson J, Salmond C, & P, 2019).

5.2 Time spent in moderate-to-vigorous physical activity (MVPA) per day and prevalence meeting the physical activity guideline

Both time spent in MVPA and the proportion of those meeting the physical activity guideline decreased across BMI categories (Table 5.2/Figure 5.2). Only one out of the nine individuals classed as obese in the current study met the MVPA guideline with four times as many people of healthy weight meeting the physical activity guideline than people classed as overweight. Participants in the overweight category did, on average, five minutes more MVPA than those in the obese weight category per day; 38 and 33 minutes per day respectively, while people of healthy weight did 12 minutes more MVPA per day than those classed as obese.

Table 5.2: Proportion of students meeting the physical activity guideline of 60 min MVPA/day by BMI category

	Healthy n=78	**Overweight n=32**	**Obese n=9**	**Overall n=119**
Proportion meeting the guideline[1] n (%)	21 (26.9)	5 (15.6)	1 (11.1)	27 (22.7)

[1]Deemed to be meeting the physical activity guideline if MVPA minutes was ≥60 minutes.

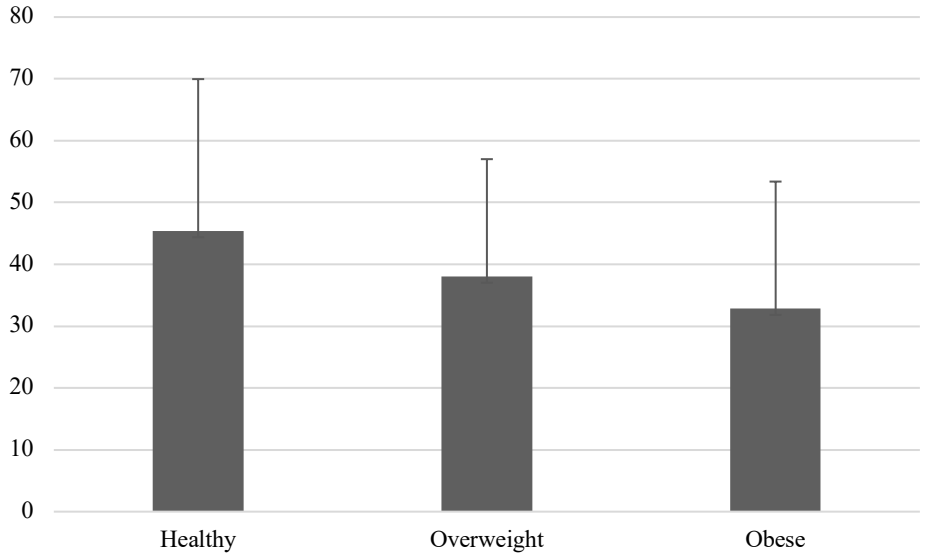

Figure 5.2 Time spent in MVPA (min) by BMI category.

5.3 Comparisons of body mass index and daily energy intake (in kilojoules).

Energy intake was relatively similar across BMI categories. Similar results were found for energy intake in participants who were not meeting the physical activity guidelines. However, those in the overweight category who were meeting the guideline reported consuming ~780 kJ less energy than those in the healthy or overweight categories that were also meeting the physical activity guidelines.

Table 5.6 Proportion of students meeting the physical activity guideline of 60 min MVPA/day by BMI category

	Healthy	Overweight	Obese	Overall
Average daily energy intake of those not meeting the PA guideline (kJ)[1]	7838 (1583)	7903 (2147)	7908 (939)	7863 (1712)
Average daily energy intake per day of those meeting the PA guideline (kJ)[1]	8437 (1626)	7662 (380)	8100*	8280 (1467)
Energy intake per day of the total sample (kJ)[1]	7999 (1608)	7865 (1972)	7929 (880)	7958 (1663)

Abbreviations: PA = physical activity, kJ = kilojoules

[1] Average intake (SD)

*Only one participant classed in the obese weight range met the physical activity guideline, therefore, there is no standard deviation.

5.4 Energy intake and time spent in moderate-to-vigorous physical activity.

Average MVPA ranged from zero to 111 minutes per day with 27 people meeting the physical activity guideline reporting ≥60 minutes of MVPA daily, with 92 participants who did not meet the guideline. The highest energy intake of 13,098 kJ is over three times the amount of the lowest reported energy intake of 3,790 kJ. The R-squared value of < 0.3 seen in Figure 5.3 classifies the relationship as weak to none.

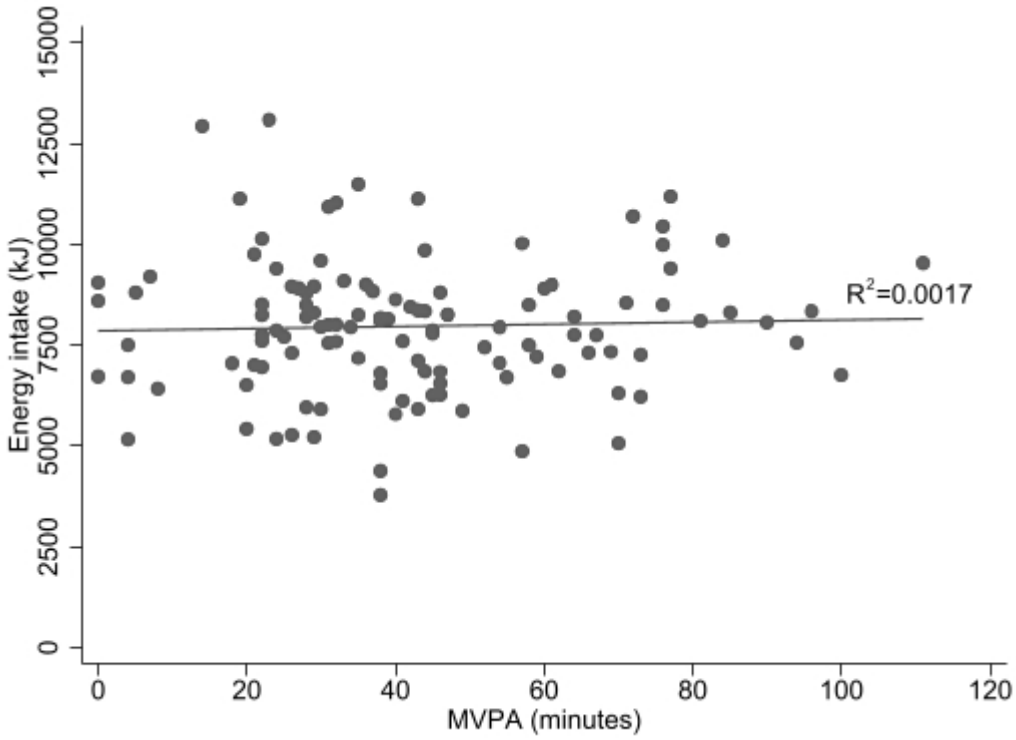

Figure 5.3 Association between energy intake (kJ) and MVPA (min)

6 Discussion

Investigations in female adolescents about the associations between physical activity and energy intake are sparse. Given the influence physical activity and energy intake have on energy balance and the consequential weight gain that can arise from inappropriate amounts of both factors, this study aimed to investigate energy intake and physical activity levels of a sample of female adolescents and associations between BMI categories. While no meaningful relationship was found between physical activity and energy intake, intriguing results indicate that, participants in the normal weight and obese weight categories, had higher energy intakes when they were also physically active, however those in the overweight category who met the physical activity guidelines had the lowest energy intakes.

6.1 Rates of overweight and obesity

None of the participants were recorded as being classed in the underweight category in this sample which is similar to the 3.9% of 15-24 year old's that are underweight according to New Zealand statistics (Ministry of Health, 2019a). Less than 10% of participants were classed as obese which is 10% less than what New Zealand statistics report for adolescents classed as obese aged 15-24 years old (Ministry of Health, 2019a), highlighting that the current sample is not representative of the New Zealand population. Interestingly, 40% of the sample indicated that they were trying to lose weight while only one participant indicated they were trying to gain weight.

6.2 Physical activity

While it is evident that physical activity helps to increase energy expenditure to maintain a healthy weight (Chaput et al., 2011), evidence shows that youth are still not doing enough physical activity globally (World Health Organisation, 2019). The results of the current study

only add to these statistics with just over one-fifth of the sample meeting the physical activity guideline of ≥60 minutes of MVPA daily. The results of this study report a higher prevalence of participants meeting the guideline than all studies that measure physical activity by self-report, which indicate that 5.0 - 15.4% of participants meet the guidelines (Amornsriwatanakul et al., 2017; Australian Bureau of Statistics, 2013; Guthold et al., 2010; Jekauc et al., 2012; Song et al., 2013). However, the percentage of participants meeting the guideline in the current study is lower than the percentage reported by the two other studies that have used accelerometers to measure physical activity in New Zealand populations. Both of these studies reported around a third of the females in the sample met the guideline (Clinical Trials Research Unit, 2010; Kek et al., 2019). Potential differences may have occurred as Kek et al., (2019) participants were aged 13.3-16 years meaning the majority of that sample would have been required to take physical education class (PE is compulsory to up until year 10 in NZ) (Kek et al., 2019; Ministry of Education, 1999). Additionally, the sample from Kek et al., (2019) study was all from Otago based schools rather than from numerous places around the country used in the current study. Dissimilarities from the Clinical Trials Research Unit study could be because meeting the guideline was deemed by whether the participant accumulated at least 60 minutes of MVPA per day on any valid sample day (at least one) compared to the current study which required the average over seven days to be 60 minutes or more.

The average MVPA for the current sample of 42.4 minutes per day, was higher than both New Zealand studies (Clinical Trials Research Unit, 2010; Kek et al., 2019). Unexpectedly this means that the percentage meeting the guideline was lower in this study compared to the other New Zealand studies, but the average MVPA per day was higher. Disparities between meeting the guideline and average MVPA time per day may be due to 6.7% of the current

study completing an average between 80 to 111 minutes of MVPA per day. Ultimately this would bring up the average for the sample which may not be the case in the other studies.

6.3 Time spent in MVPA (min) and BMI category

Individuals in the obese category did on average >5 minutes less MVPA per day than those in the overweight and healthy weight range, this result is similar to that of Elmesmari et al (2018) (Elmesmari, Martin, Reilly, & Paton, 2018). The results from this study exploring BMI category and meeting the guideline align with the results of (Janssen et al., 2004) study that indicate that physical activity decreases across the increasing categories of BMI. However, dissimilarities are shown between these results and those displayed in Song et al (2013) and Laguna et al (2013). These two studies report a higher percentage of obese classed individuals meeting the guideline than normal-weight individuals. With 42% of the sample trying to maintain or lose weight this would indicate that participants could be trying to increase their energy expenditure which may not be the case in the other studies. The cross-sectional nature of this study means that higher physical activity amounts may be the result of trying to lose weight, rather than the cause of obesity (i.e. those in the obese category are deliberately doing more MVPA in an attempt to control their weight).

6.4 Energy intake

The mean energy intake reported in this study (7,958 kJ) falls within the energy intakes for this age group, reported by others (Crespo et al., 2001; Hoppu et al., 2010; Mohd Shariff et al., 2006; Samuelson et al., 1996), and is only slightly (323 kJ) higher than the energy intake reported of this age group in the last Adult Nutrition Survey (7,635 kJ) (University of Otago, 2011). Although when compared to the 1997 intakes (University of Otago, 2011) it does

appear to indicate that the energy intakes of adolescent girls may be slowly increasing over time.

6.5 Comparing energy intake by BMI category

There is no clear association between energy intake and BMI in the previous literature. Some studies report individuals of healthy weight consume more energy than their obese weight counterparts (Garaulet et al., 2000) and vice versa (Gordon-Larsen, 2001; Mohd Shariff et al., 2006). Interestingly, the results of this study indicate a very slight U shape relationship between energy intake and BMI, with those in the overweight category reporting slightly lower energy intakes than those in either the normal weight or obese weight category and is more pronounced when comparing BMI categories for those meeting the physical activity guidelines. It seems likely that those in the overweight category are actively trying to lose weight by lowering their energy intake and increasing their physical activity.

6.6 Association between energy intake and time spent in moderate-to-vigorous physical activity.

The results of this study do not indicate the presence of a meaningful relationship between energy intake and MVPA. This result is similar to that of the HELENA study which had more than double the participants of the current study and found less than 200 kJ difference in energy intake between the first and third physical activity tertial (Ottevaere et al., 2011). If all participants in the current study were in energy balance at the time of data collection, we would expect that energy intake would be closely correlated with energy expenditure. Due to the high percentage of participants who report trying to lose weight, this suggests that at least some of the sample were deliberately in an energy deficit, which might have affected our ability to detect a clearer association between energy intake and physical activity. It is

also possible that MVPA is not a good proxy for total energy expenditure, perhaps a combination of MVPA and light physical activity, or a measure of total activity would result in a stronger association with energy intake. Additionally, we cannot exclude the possibility that social desirability bias and other recall biases have limited the accuracy of our measurement of energy intake, however, if this is the case, it seems that this limitation could be applied to much of the available research in the area.

6.7 Strengths and limitations

This study has a few limitations, which need to be considered when interpreting the results. The methodology for measuring physical activity and energy intake in this study is prone to bias. For example, from the time wearing the accelerometer and between the first and second food recalls participants are more conscious that their actions are being recorded and therefore, may have changed both their activity and eating behaviour. Those who volunteered to wear an ActiGraph may be more health-conscious, do more physical activity or may find interest in obtaining data on their physical activity levels. Therefore, the data may sway towards more physically active individuals than the general population. Due to the study being cross-sectional this limits the ability to determine direct cause and effect relationships and provides data on a snapshot of time which may not be representative of usual behaviour either.

This study had multiple strengths. Using accelerometers as a proxy to measure physical activity rather than self-reporting reduces bias and does not require participants to gauge the intensity of the activity they are doing. Recording seven consecutive days of accelerometer data allowed the study to account for day-to-day variation, this is important for school-aged females as planned sport and training sessions are usually the same day each week, therefore,

some days will have higher physical activity levels than others. Dietary intake was collected by trained interviewers through two 24-hour recalls including weekday and weekend variation. Lastly, the multiple source method was used to give an adjusted estimate of usual intake for each participant.

6.8 Recommendations for future research

This study accentuates the requirement for action on healthy eating and increasing physical activity with more than a third of the sample being overweight or obese and less than 25% meeting the physical activity guideline. It also highlights the inconsequential association between energy intake and physical activity; however, it is known that individually these factors can help aid weight loss, therefore the first recommendation for future research is:

To investigate whether interventions on physical activity and healthy eating are more beneficial for weight loss individually or in conjunction.

A weak association between MVPA and energy intake was found in this sample, however, it is understood that surplus energy expenditure over energy intake aids weight loss. Light physical activity, when preformed in large amounts can meaningfully contribute to total energy expenditure. Therefore, including light, as well as MVPA to give total physical activity might show a stronger association with energy intake and BMI categories therefore my second recommendation is to:

Investigate the association between *total* physical activity and energy intake.

Additionally, the small sample size including one obese participant meeting the guideline representing 0.8% of the sample is not indicative of the New Zealand female adolescent population as a whole (Ministry of Health, 2019c). This made finding correlations between variables difficult. Consequently, a follow-on recommendation is:

Increase the sample size and ensure it is representative of the New Zealand population.

Cross-sectional studies give results from a snapshot of time, as mentioned previously overweight/obese weight individuals may decide to lower their energy intake or increase their physical activity to obtain an energy deficit to help lose weight. It is also well known that day-to-day variations in both physical activity and energy intake arise. Weight loss occurs over a gradual period of time hence investigating a samples physical activity, energy intake and weight over an extended period will provide information on patterns in these areas. **Recommendation: Conduct longitudinal studies on energy intake, physical activity levels and weight loss/gain outcomes**.

6.9 Conclusion

This is the first study conducted in New Zealand investigating the association between energy intake and physical activity in adolescent girls. The study highlights the poor prevalence (22.7%) of adherence to the physical activity guideline, with participants on average doing 42.4 minutes of MVPA per day. Energy intake was highest for healthy weight individuals but only slightly higher than the energy intake of those classified as obese. Those in the overweight category had energy intakes that were ~135 and 64 kJ lower than those in the healthy weight and obese categories, respectively. Although those who met the physical activity guideline in the healthy weight category had a higher energy intake than those who did not, the reverse was true for those classified as overweight and overall no significant association was found between energy intake and physical activity. Further investigation into this relationship on a larger sample size is needed in the future. For now, obesity interventions need to be tailored to include both sufficient physical activity to meet the guideline, which has proven to have numerous benefits as well as educating individuals on appropriate energy intake.

7 Application to dietetic research

7.1 The relevance of research to dietetic practice

As a future dietitian, my role is to guide and educate my patients in the science around food and nutrition in a clear and concise manner. Outpatient consultations would usually involve discussing the patients food intake, however, after conducting this research I have developed an understanding of the importance of discussing their physical activity as well. Additionally, through taking multiple 24-hour recalls, this has highlighted the importance of building rapport with my patients and investigating other areas of the patient's life, including habits around physical activity and energy intake as well as weight loss intentions. This is explained through the results seen in Figure 5.3 which display energy intake and physical activity level varying widely between individuals. For example, one participant's energy intake is 12,941 kJ, their MVPA per day is 14 minutes and they are in the healthy weight range, while another individual consumes on average 8,100 kJ per day, does 81 minutes MVPA per day and is classed as obese. Each individuals body composition, eating habits and physical activity regimes are unique and many factors such as puberty and genetics may influence this. Accordingly, future interventions and dietetic consults in this age group require educating these individuals on energy balance and the importance of maintaining a healthy body weight through finding the right energy intake and physical activity level to meet the requirements and acquire the associated health benefits.

7.2 What this research experience has taught me

This research experience has taught me the importance of critically reviewing literature. Before this project if I was unsure of how to answer a nutrition related question I was aware that I should look at scientific papers for evidence-based guidance. However, since reviewing

numerous research papers for this thesis topic I have come to understand the importance of critically analyzing multiple papers ensuring I assess all the information, but also to look for potential bias such as study type, methods, sample size, sample distribution and other factors that may influence the results. Simply looking at the abstract or results section may be misleading. For example, the results of the current paper indicate that obese weight individuals meeting the guideline consume more energy than overweight individuals meeting the guideline, however, there is only one participant classed as obese meeting the guideline and therefore further investigation would be required before claiming this association.

The learning I have taken away from completing my thesis is the ability to adapt to changes or issues that may arise. Due to the COVID-19 lockdown ceasing in-person data collection this resulted in a lot of changes. From having to redistribute jobs, organize zoom meetings and conduct 24-hour recalls online without the assistance of my classmates with me to help, to having to change my thesis topic and start my literature review again, these all taught me valuable lessons in being adaptable. When I found out I had to change my thesis topic after spending months reading literature and writing my review, I was frustrated that I had spent so much time and effort into something that now couldn't be used. I quickly learnt that the situation was out of control and I now had to work out how best to overcome this frustrating situation in a short period of time. Consequentially this helped me develop good time management skills and made me more productive with the shorter period I had left to complete my thesis. I believe this will be useful to carry over into other situations of my life especially for my hospital placement, for example a patient I was meant to see may get rushed off to get a scan done or new information may come to light that wasn't in their patient notes and I will need to adapt and think on my toes of how best to respond to make the best use of my time.

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9 Appendices

A. Ethics Approval Letter

B. Maori Consultation 2019

C. Study Protocol

D. 24-hour recall recording sheet

E. Sleep and wear time diary

Appendix A: Ethics Approval Letter

H20/004

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

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

Appendix B: Maori Consultation 2019

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.

Appendix C: Study Protocol

SuNDiAL Project: Survey of Nutrition Dietary

Assessment and Lifestyle 2020: Adolescent Males

PROTOCOL MANUAL

Funding Agencies:Department of Human Nutrition

Study Investigators

Principal Investigator: Dr Jill Haszard[1]

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1. Project Summary

The aim of the SuNDiAL 2020 project is to describe the nutritional status, dietary habits, health status, attitudes and motivations for food choice, 24 h activity patterns and screen time of adolescent boys. There is very limited data about dietary intake and lifestyles of this age group. At least 150 males aged between 15 and 18 years will be recruited to participate from secondary schools throughout New Zealand between February 2020 and November 2020. Participants will complete two 24-hour diet recalls to provide an estimate of usual dietary intake, provide a blood sample for the analysis of biochemical status of cholesterol concentrations and HbA1c, have their blood pressure measured, have their height, weight, and ulna length measured, provide a urine sample to allow assessment of iodine intake, perform two previous day activity recalls and wear an accelerometer for 7 days to

provide an estimate of 24-hour activity (sleep, sedentary behavior, screen time and physical activity), and answer questions about their attitudes and beliefs about the foods they choose to eat (or not eat) their dietary habits and screen time. Results will be used to inform public health policy about appropriate ways to encourage healthy lifestyles in this age group.

2. Background

There is a very limited up-to-date data on the dietary intakes and physical activity patterns of adolescent boys in New Zealand. The last Adult Nutrition Survey (which included adolescents 15 years and over) was conducted over 10 years ago, and it is likely that food patterns have changed dramatically over this time. Physical activity was last assessed using accelerometers (as opposed to self-report) in 2010 as part of the Health Survey. However, the physical activity guidelines were updated in 2017 to include recommendations for the entire 24 h period, and since then no-one has assessed the 24 h activity patterns of a nationwide sample of New Zealand adolescent males. In 2019 the Department of Human Nutrition at the University of Otago conducted a survey of the nutritional status, dietary habits, health status, and attitudes and motivations for food choice and 24 h activity patterns of nearly 300 female adolescents from eight centers throughout New Zealand. The SuNDiAL 2020 project will collect comparable data from a sample of adolescent boys, facilitating comparisons between females and males, and the creation of an overall dataset that describes the diets and lifestyle habits of New Zealand adolescents.

3. Aim of Study

To describe the dietary intakes and habits, nutritional status, health status, motivations, attitudes, 24 h activity patterns, and screen time habits of adolescent males in New Zealand.

4. Objectives

To describe the dietary intake of macronutrients, sugars, fibre, and key micronutrients (iron, zinc, B12, folate, iodine, fluoride, magnesium, riboflavin, and calcium) in a sample of adolescent males in New Zealand.

To describe the cholesterol and HbA1c concentrations, and blood pressure in a sample of adolescent males in New Zealand.

To describe the 24-hour activity patterns (sleep, sedentary behavior and physical activity) in a sample of adolescent males in New Zealand.

To describe the screen time habits of a sample of adolescent males in New Zealand.

To describe the attitudes and motivations towards food choice/dietary patterns (e.g., the environment, animal welfare, health) in a sample of adolescent males in New Zealand.

To describe dietary habits in a sample of adolescent males in New Zealand.

To describe the weight gain or loss intentions and methods of adolescent males in New Zealand.

To assess whether an estimate of height calculated from ulna length is feasible in this population.

5. Study Design

Cross-sectional survey

6. Study Setting/ Location

A multi-centered study including at least 14 high schools across New Zealand. The localities in which data will be collected are determined by where data collectors (MDiet students) will be based in 2020. Data will be collected in either Term One (February to April) or Term Three (July to September) of the school year based on when the data collectors are in their locations. These locations and times for data collection are:

- Dunedin, Term One and Term Three
- Wellington, Term One and Term Three

- Christchurch, Term One and Term Three
- Hawkes Bay, Term Three
- Tauranga, Term One
- Auckland, Term One

7. Study Population

At least 150 male high school students between the ages of 15 to 18 years from across New Zealand.

8. Eligibility Criteria

9. Inclusion criteria

Individuals who self-identify as male and are between 15 and 18 years of age, who are enrolled in one of the recruited high schools, and who speak and understand English and are able to complete the required online questionnaires are eligible to participate.

9b. Exclusion criteria

None

10. Study Outcomes

10a. Primary Outcomes

Nutrient intakes

10b. Secondary Outcome(s)

HbA1c concentrations

Cholesterol concentrations (total cholesterol, HDL)

Blood pressure

Urinary iodine concentrations

Attitudes and motivations for food choice

Dietary habits

BMI z-score

24-hour activity patterns (time spent in sedentary behavior, physical activity and sleep)

Screen time

Weight gain or loss intentions & methods

11. Study Procedures

11a. Recruitment of participants

School-based recruitment

High schools in the areas in which data collectors are based will be invited to participate. Initially an email invitation will be sent to all schools who have males enrolled and have a total roll of greater than 400. The PIs (JH and MP) and/or the SuNDiAL coordinator (Tessa Scott) will initiate contact via email from October 2019. If email contact does not result in the targeted number of schools enrolling in the study (at least one school per pair of data collectors), schools in the data collection area may be recruited via word of mouth. Schools who are interested will provide written consent to participate (signed by an appropriate representative from the school), after which, dates and times for the research teams to visit will be arranged.

Master of Dietetic students (the data collectors) will visit participating schools early in the term to initiate recruitment of students within the school. This visit may include a presentation to school or year group assemblies, showing a recruitment video that explains what is involved in the study and providing the school with electronic and/or print information that can be circulated with the school newsletters and posted on school related social media sites etc. Facebook/Instagram ads featuring part or all of the recruitment video may also be run in data collection locations targeting males aged 15-18 y.

School students who are interested in participating will be given the opportunity to provide their name, age, and email address after the in-school presentation, where information sheets will be available. Alternatively, school students will also be able to visit the study website (www.otago.ac.nz/sundial) where they will be able to read more information about the study, watch the recruitment video about what is involved in participating, and read the information sheet. Individuals interested in participating can then provide their name, age, email address, and high school to the website.

The SuNDiAL coordinator will email potential participants a link to a REDCap questionnaire, at this point they will be assigned a study id code and complete online consent. Following consent, they will answer a series of questions about demographics and health. Potential participants are free at any time to contact investigators via phone or email to ask questions about participating in the study. Once the potential participant clicks the link which takes them to the REDCap questionnaire, a unique ID number will be assigned to the participant. Where a participant is under 16 years of age, they will be asked to provide the email address of a parent/guardian, who will then be contacted and asked to provide online consent for their son to participate before the link to the study is sent to the participant.

11b. Study procedure

Once participants have completed online consent, and answered the initial demographic and health questions, they can continue on to complete the rest of the online questionnaires or return to complete them later. These additional questionnaires assess dietary habits, and attitudes and motivations to food choice, as well as weight-loss intentions and methods. These are administered on the web application REDCap and are completed in their own time.

Participants will be contacted by data collectors (either by phone or email) to be scheduled to attend a visit with study investigators at school, during school time. During this visit participants will carry out a 24-hour dietary recall and a previous day activity recall with one of the Master of Dietetics students. Height, weight and ulna length will be measured in duplicate and blood pressure measured in triplicate. It is expected that this part of the data collection visit will take approximately 60 minutes to complete.

Individuals who consent to wear an accelerometer will be fitted with an Actigraph GT3x+ accelerometer to be worn on an elasticated belt over their right hip continuously for 24 hours a day for seven days. Participants wearing an accelerometer will also be asked to complete a sleep and wear time diary over the time which the accelerometer is worn, which will involve recording the times they

went to bed and to sleep each night, and to record any time for which the accelerometer was removed for more than five minutes. Actigraphs and sleep & wear time diaries will be collected eight days after the initial visit by a data collector.

A second 24-hour dietary recall and previous day physical activity recall will be undertaken over the phone or by video-call. This will take place the following weekend to capture the variation in dietary intake and activity between different days of the week, including weekend days. Completion of these second recalls will take participants approximately 45 min.

Participants who consent to providing a blood sample will have one collected by the trained phlebotomist/research nurse at an appointed time. Participants may also provide a urine sample (collection of biochemical samples may occur on a separate day to the 24 h recall depending on the availability of the phlebotomist).

11c. Measurement tools used

Demographics and health status

After the participant has given consent (and a parent or guardian has given consent if they are 15 years of age) then they will continue on to an online questionnaire assessing demographics and health status, such as whether they are diabetic or have any food allergies. This is administered in REDCap. Ethnicity will be assessed using the 2006 New Zealand census question. Home address will be used to determine New Zealand Deprivation Index.

Dietary habits, weight gain or loss intentions & methods, attitudes and motivations for food choice

Dietary habits, and attitudes and motivations for food choice will be assessed via questionnaires administered in REDCap. These online questionnaires will be available for the participant to complete in their own time after they have consented. The majority of these questionnaires are based on previously validated questionnaires [16] where, if necessary, modifications (such as changing of country specific jargon) have been made to make them suitable for New Zealand male adolescents.

Dietary intake

Estimates of dietary intake will be calculated for each participant through the completion of two 24 h recalls. During each 24 h recall participants will be asked to recall everything they ate from midnight to midnight the previous day (see 24 h recall protocol in appendix). Participants will be probed to recall details such as brands of food items and cooking methods. Participants will be asked to estimate quantities using household measures, food models, and photographs of different portion sizes.

The recalled foods and portion sizes will then be entered into FoodWorks 9 (Xyris Software Australia Pty Ltd) by the MDiet students to calculate the energy, macronutrients and micronutrients contained in the recalled diet. FoodWorks uses the most up-to-date and comprehensive food composition tables for New Zealand (FOODfiles 2018 (The New Zealand Institute for Plant & Food Research Limited)) which was enhanced by the inclusion of Adult Nutrition Survey 2008/2009 (ANS08/09) recipe calculated foods. The administration of a second 24 h diet recall will allow for an estimation of 'usual intake', by using the MSM programme to adjust for the within-person variation in intakes [7].

Physical Activity and Screen time

Estimates of physical activity and screen time will be calculated through the completion of two previous day physical activity and screen time recalls. During each recall participants will be asked to identify the main activities they did outside of school time for each 30 min block of time from midnight to midnight the previous day. Participants will also be asked to identify the physical intensity (from very light to hard) for each activity that was performed, the posture (sitting, standing, or stepping) it was performed in, and whether they were interacting with a screen (phone, tablet, computer or TV) while they performed that activity. The information reported in each recall will be entered by the MDiet students into REDCap, and activities will be summed based on intensity and posture to provide an estimate of physical activity and sedentary time, as well as to provide an estimate of total screen time. The administration of the second physical activity and screen time recall will

allow for estimation of 'usual time' spend in each activity using the MSM programme to adjust for the within-person variation in intakes [7].

Blood pressure

Blood pressure will be measured via a digital blood pressure monitor (OMRON HEM907; Omron Healthcare, Japan) using the right arm and an appropriately sized cuff. Participants will rest in a seated position for 15 minutes prior to having three measurements taken at one-minute intervals. The mean of the three measurements will be recorded.

Anthropometry

All data collectors will be trained to measure height, weight, and ulna length (see anthropometry protocol in appendix) according to study protocols, which are based on published protocols [8, 9]. Height will be measured in duplicate using stadiometers (Seca 213; and Wedderburn), weight will be measured in duplicate using scales (one of Medisana PS420; Salter 9037 BK3R; Seca Alpha 770; or Soehnle Style Sense Comfort 400) that have been calibrated by the research team. Ulna length will be measured in duplicate using a flexible steel measuring tape on the non-dominant side.

Biological specimens

A total of 12 ml of blood will be collected into two tubes by a trained phlebotomist (see blood and urine protocol in appendix). This blood will be transported to a local laboratory affiliated with Southern Community Laboratories by the phlebotomist where measurements of cholesterol and HbA1c will take place.

The urine sample will be collected by the participant, using equipment provided, and will be transferred into a storage container and then transported on ice to the Department of Human Nutrition at the University of Otago in Dunedin by the local laboratory who is performing the processing of blood samples. Samples will be stored at -20°C until analysis of iodine concentrations are done.

24-hour activity

24-hour activity patterns will be assessed using data collected using the Actigraph

GT3x+ (see accelerometer protocol in appendix). Data from each accelerometer will be downloaded using Actilife software and deposited electronically onto the password protected SuNDiAL folder on the University's shared server. Accelerometer data will then be transferred into Stata (StataCorp. 2017.Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC) where it will be cleaned, wear time and sleep time will be entered, and age appropriate cutoffs used to identify time spent in sleep, sedentary behavior, as well as light, moderate and vigorous physical activity for each 24-hour period. The use of both the physical activity and screen time recall and accelerometer to identify physical activity allow for both accurate, more objective assessment of physical activity (via accelerometer) and contextual information about the specific modes of activity being performed (via the recall).

11d. Data monitoring and quality control

No formal data monitoring will take place.

Data collection will be the responsibility of investigators under the supervision and direction of the PIs. The use of REDCap will minimize the need for extensive data entry and cleaning, although checks of each variable will be undertaken before statistical analysis takes place.

Quality control will be ensured by developing standard operating procedures for all data collection, including:

- 24-hour dietary recall;
- Previous day activity recall
- Anthropometry (height, weight, ulna length);
- Blood pressure;
- Fitting the accelerometers;
- Collection of blood sample and urine samples;
- Data entry into FoodWorks
- Data entry into REDCap

To further ensure the quality of the data collected, all data collectors (MDiet students) will have completed a six-week research methods paper in the previous year, led by the PIs. This focuses on preparing them for this research project. A further two weeks of intensive training in data collection procedures will occur prior to data collection.

The intensive training will be led by the PIs (Drs Jill Haszard and Meredith Peddie) with expertise brought in as needed (e.g., to teach about FoodWorks and food composition tables). This will cover obtaining informed consent, conducting research studies, dietary data collection and anthropometric measurements, handling biological samples, and fitting accelerometers.

During data collection, the students will receive ongoing support and supervision from the study investigators.

12.Statistical Considerations and Data Analysis

12a. Sample size and statistical power

To estimate mean nutrient intakes with a 95% precision interval, 100 participants will be required to give a precision level of +/-0.2 SD (standard deviations). To allow for drop-outs, incomplete data and a small design effect from school clusters, we aim to recruit at least 150 boys. In a similar study of adolescent girls (SuNDiAL Project 2019) the intra-class correlation for nutrient intakes within schools was small (less than 0.04), meaning that the design effect from school clusters is likely to be less than 1.5 (if at least 10 boys from each school participate).

12b. Statistical methods

Statistical analyses will be carried out using Stata (StataCorp. 2017.Stata Statistical Software: Release 16 College Station, TX: StataCorp LLC). School clusters will be accounted for in all analyses using appropriate methodology (for example, with the survey command, a sandwich estimator, or as a random effect). Dietary intake estimates will be adjusted for 'usual intake' using the Multiple Source Method (MSM) [7]. Estimates of prevalence and means will be reported with 95%

confidence intervals. All data management and statistical analysis will be overseen by the study biostatistician, Dr Jill Haszard (PI).

13. Ethical Considerations

13a. Ethical Standards

This study is conducted in full conformity with the current revision of the Declaration of Helsinki, or with the International Conference for Harmonization Good Clinical Practice (ICH-GCP) regulations and guidelines, whichever affords the greater protection to the participant, as well as the laws and regulations of New Zealand. All dietetic students are trained under the Code of Health and Disability Services Consumers' Rights 1996. They adhere to the New Zealand Dietitians' Board Code of Ethics.

13b. Quality Assurance

This research will be conducted by researchers who are highly skilled in the technical aspects of this research study, in particular dietary and nutritional assessment.

13c. Risks/safety considerations

All data collectors (dietetic students) have been vetted by the New Zealand Police under Vunerable Children Act (2014).

Participant Burden: To reduce the respondent burden for the participant, questionnaires will be completed online in their own time. For those recruited through schools, completing the second dietary assessment recall and previous day activity recall outside of school time will also minimize any further disruption to the participant's school day.

Blood sampling: There is a risk of discomfort, pain and bruising from the blood test. Participants will be informed of these risks, and an experienced nurse or phlebotomist will collect the blood samples and ensure strict aseptic technique is followed during blood collection to minimize any risk of infection.

The data collectors will be briefed on health and safety policies and procedures at their respective schools and will comply with these for the duration of the study. Examples of such policy and procedure will include, but not be limited to:

Emergency procedures
Biological sample handling

MDiet students have been vaccinated for Hepatitis B as a requirement for admission into the Dietetics program.

Informed Consent Process

Information about the study will be provided to potential participants at either an inschool presentation; and/or through the website, where an informative video about the study can be viewed and a detailed information sheet will be available. The information sheet will also be provided at the school presentation. Participants will be encouraged to discuss this with their family/whānau. Participants can enter their name, age, email address, and school on the website (or on a sign-up sheet at the school presentation) if they are interested in participating. At this point an ID number will be assigned to them and an email sent with a link to the consent form. If at any time potential participants have questions about the study they can contact the investigators via email or phone. Once participants have had all their questions answered they can provide consent by completing the consent form electronically. The participant (or their legally authorised representative) can withdraw consent at any time throughout the course of the study. Consent information will be stored electronically in REDCap.

Participant Confidentiality

Participant confidentiality is strictly held in trust by the investigators. This confidentiality is extended to cover testing of biological samples and to the clinical information relating to participants.

Upon enrolment, participants will be assigned a unique identifying code, this is done automatically by REDCap. To preserve confidentiality, during data collection all data will be recorded against this ID number. The information linking the code to

the participant's identity will be stored in a separate password protected file that only the PIs (MP and JH) and the SuNDiAL coordinator will have access to.

Responses to online questionnaires will be electronically linked to study ID numbers, as will accelerometer data. Study ID number will also be written on all biological sample tubes and the recording sheets for anthropometry measurements and 24 h recalls.

Follow-up

Once the data from the study has been analyzed, the participants will be provided with an overall summary of the results. Participants are also free to request a copy of their individual data. All participants who provide a blood sample will also be emailed their cholesterol and HbA1c concentrations, with a note about how to interpret these values. If concentrations are outside the normal range (>4 mmol/L for total cholesterol, or >41 mmol/mol for HbA1c) they will be encouraged to tell their parents and discuss these results with their doctor. Participants whose blood pressure is measured to be above 130/90 will be sent an email encouraging them to tell their parents and make an appointment to see their doctor (GP).

Participating schools will also be provided with a summary of both the overall results as well as a summary of selected results obtained from their school (e.g. percentage of boys consuming breakfast, average number of servings of fruits and vegetables etc.)

If student investigators are concerned about an aspect of the nutritional or mental health of a study participant, they may suggest that the participant contact their school counsellor and/or nurse.

Data Management

Data will be collected as per Standard Operating Procedures and cleaned as per standard data entry procedures. Data quality checks will be run on all entered data to check for accuracy, consistency and completeness. The results database will be stored on the investigators' computers, all of which are password protected. A

backup copy may also be stored on the University's shared server space, but only the PIs (JH and
MP) will have the password that will enable access to the data stored on the server.

Information linking participant identity to their ID number will be stored in a separate password protected file that only the PIs (JH and MP) will have access to. The only reason this information will be accessed once the study is completed is if the participant requests their 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 retained for at least 10 years in secure storage.

14. Outcomes and Significance

There is currently no up-to-date data available on the dietary intakes and physical activity patterns of adolescent boys in New Zealand. This study will provide a meaningful investigation into the nutritional intakes, physical activity and health status of New Zealand adolescent males. This study, combined with the female data collected in 2019 will provide an up to date picture of what adolescents in New Zealand are eating and how much sleep, physical activity and sedentary time they are accumulating. The collection of information about beliefs and motivations for food choice strengthens outputs and aids in the identification of appropriate guidelines and/or further interventions that may target this age group.

15.References

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Appendix
Standard Operating Procedures

Daily data collection procedure

1. The day before starting data collection, send text and/or email reminders to participants who have been sceduled for appointments the following day.

2. Report to the school office and sign in (if required).

3. Set up data collection space. Put up SuNDiAL project signs where appropriate.
   Ensure you have your name badge on.

4. Put anthropometric equipment in a private space.

5. Set up clipboards with a diet recall recording sheet, a previous day activity recall and a blood pressure and anthropometric recording sheet (at the back).

6. Set up the sphygmomanometer so that it will reach the table at which you are completing the 24 h recalls

7. When a participant arrives greet them and take their name.

8. Check on the Name & ID spreadsheet that they have enrolled in the study.

   a. If they have not then ask them to complete online enrolment by going to the SuNDiAL website, or checking their email for a link to enrol.

   b. If they are not on your latest Name & ID spreadsheet but claim to have recently enrolled, give Tessa, Jill, or Meredith a quick call.

   c. DO NOT collect any data from participants if we don't have a record of their consent to participate.

9. If they are on the spreadsheet take the ID number next to their name and write it on the diet recall recording sheet, the previous day activity recall and the blood pressure and anthropometric recording sheet.
    a. The ID number is the most important variable in this study. If the ID number is recorded incorrecty then any data collected cannot be matched to the right person and that data may not be included in the data set.
    b. EVERY TIME you record an ID number double check that you have written the number EXACTLY as it is on the Name & ID Spreadsheet.
    This is very important.

10. Take time to introduce yourself, tell the participant where you are from and why you are here. Ask the participant to take a seat, ensure bags and hats are NOT placed on tables. Take time to develop rapport with the participant.

11. Carry out the diet recall as per the protocol.

12. Conduct the previous day activity recall as per the protocol.

13. Measure blood pressure as per the protocol.

14. Undertake the anthropometric measures as per the protcol

Please do not hesitate to contact us is you have any questions during data collection

Tessa Scott phone: 021 231 6263

Jill Haszard phone: 021 0244 8990

Meredith Peddie phone: 021 152 2274

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 o Terms used interchangeably so always collect brand information if possible
  - 100% juice or fruit drink o No sugar added or sweetened? o Added vitamins o Commercial or freshly squeezed o Did they dilute with water, is so how much?
  - Use cups or pictures of cans and bottles to help estimate portion size

- Fizzy drinks

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

- Made from liquid (cordial) or powdered concentrate (Raro) o Brand and flavour details of concentrate o Standard or low energy/ low sugar version
  - o How much concentrate? o Did they make it with water or something else? o 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
- Use photos, cups, plates and bowls to estimate portion size

Previous Day Activity Recall

To complete the previous day activity recall you will need:

- This protocol
- The previous day activity recall recording sheet
- The Activity, Intensity, Posture and Screen use key

Make sure you have taken the ID number from the name & ID spreadsheet and written it on every page of the previous day activity recall recording sheet.

Start by explaining the procedure to the participant
"Now I am going to ask you about what activities you did yesterday. We are going to work together to complete this table, which will help us understand how you spend your time".

"We will start at midnight yesterday, and assign activities to each 30 min block of the day". "What were you doing at midnight on (insert appropriate day here)?"

Step though each block, recording the number of each identified activity in the appropriate column using the activity key sheet. If, for example, they were asleep at midnight and woke up at 7:30 am record a '1' in the 00:00 box and then run a line down to the 07:00 box.

e.g.

Time	Activity	Intensity	Posture	Screen use
00:00	1			
00:03				
01:00				
01:30				
02:00				
02:30				
03:00				
03:30				
04:00				

04:30					
05:00					
05:30					
06:00					
06:30					
07:00					
07:30					

If they report an activity that is not on the list, record 13 for other AND record the name of the reported activity.

You can only record one activity in each 30 min block so if the participant reported doing several things ask them to identify the one that took most of the time. If they say they spent 15 min exactly on each activity report the activity that is associated with the most energy expenditure.

If a participant is having trouble remembering how they spent their day ask them questions such as "Did you go to school yesterday?". If they answer in the affirmative follow with "What time did you leave for school?". Other questions that might be helpful include "What subject did you have first/after lunch?" and "How do you get to school?". Avoid suggesting activities, but try and help them recall by guiding them through known events of the day. It might help to fill in the known activities first and then go back and work through the bits they have had trouble remembering.

You can block out the time at school in a similar manner to that described above for sleep, however, please ask them to identify any physical activity that was incorporated into their day at school. "While you were at school yesterday did you have a PE class in which you were active, have a lunch time sports practice or game (etc)"

e.g.

Time	Activity	Intensity	Posture	Screen use

09:00	5			
09:30				
10:00				
10:30				
11:00	6			
11:30	6			
12:00	12			
12:30	12			
13:00	5			
13:30				
14:00				
14:30				
15:00				

Once you have completed the activities column, go back and ask about the intensity of each activity (see intensity key sheet). Again, when they are doing the same activity across several 30 min blocks you can draw a line through those boxes. You do not need to assign an intensity to sleep. Every activity, other than sleep, should be assigned one of the 4 listed intensities. If they report multiple intensities across the 30 min block take the average (or middle) intensity.

Once you complete the intensity columns go back and ask about posture (see posture key sheet). However, you don't need to assign a posture to sleep. Do not make assumptions. You don't need to go through every 30 min of the school day, but do ask them if they have any classes where they have access to standing desks or do a subject that naturally involves standing (e.g. Technology based classes). Every activity that is not sleep should be assigned one of the 4 listed postures.

Finally, go back and ask about which activities (other than sleep) that involved screen use, and identify the type of screen used (see screen key sheet). Do not make assumptions. Ask about background screens (e.g was the TV on while eating). You can only record one number in a box – if they report using multiple

devices ask them to prioritise the one they were interacting with the most during that time. If the activity did not involve a screen then make sure you record a '1' for 'none'.

Before you finish ask the participant if going through the activity recall has meant that they remember eating anything else that they forgot to report earlier..

The completed Previous Day Activity Recall will need to be entered into REDCap (see

REDCap data entry protocol)

Blood pressure

To complete measurement of blood pressure you will need:

- This protocol
- The OMRON-HEM907 automated sphygmomanometer
- 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.

Blood pressure should only be measured after a participant has been seated quietly for at least 15 min (i.e after you have completed the 24 h diet and previous day activity recalls but before you do the anthropometry measurements).

Explain the procedure to the participant, ensuring to explain to them that measurement will involve touching their upper arm while applying the cuff. Explain that the cuff will inflate and that it may feel uncomfortable when it is fully inflated, but this should only last for a few seconds. Mention that three measurements will be taken with a minute between each measurement. It is important that the participant remains still and quiet while the cuff is inflating and deflating during each measurement, but they can move their arm in-between measurements if they need to. Ask if they are ok with having their blood pressure measured.

Blood pressure should be taken using the right arm and an appropriately sized cuff (using the wrong sized cuff will result in an incorrect measurement). Before wrapping the cuff make sure the bladder is securely installed in the cuff; the bladder is not twisted inside the cuff; and the bladder tube is protruding from the spot on the cuff marked “tube”. Ensure the air tube is securely connected to the main unit in the correct place (the connection for the air tube and the power cable look similar).

Wrap the cuff directly on the arm if possible. Avoid rolling up jacket or jersey sleeves above the height of the cuff, as pressure on the arm may affect the blood

pressure reading. If the participant is not comfortable removing clothing from their upper arm the cuff can be applied over a light shirt sleeve.

Place the right had of the patient on the table/desk with the palm of the hand facing upwards.

Align the artery position mark on the cuff with the position of the brachial artery.

Wrap the cuff snugly using both hands and securely fasten with the Velcro tape. The lower edge of the cuff should be placed 1.2 – 2.5 cm above the inner side of the elbow joint.

The INDEX arrow should be positioned inside the RANGE bar on the cuff. If this is not the case select a cuff more suitable to the patient's arm circumference. Disconnect the current cuff by carefully rotating the black connector ensuring you hold the black connectors in each side, and not the grey tubing. Connect the appropriate cuff in the same manner and rewrap the cuff.

The arm should be positioned so that the cuff is at the same level as the heart while the measurement is taken. For taller individual you may need to place a pillow under their arm if it is resting on a desk.

To take the measurement:

- Turn the monitor on (push the on/off button)
- Set the MODE selector to "AVG"
- Set the P-SET knob to "AUTO"
- Push the start button

The device will now automatically take three measurements, with 1 minute between each measurement. If an erroneous measurement occurs once, the machine will retake the measurement, if the error occurs twice the measurement will stop. Most errors occur because the participant is moving

their arm during the measurement or because the cuff has not been positioned properly.

Do not push the START button unless the cuff is wrapped on the arm.

Once all three measurements have been completed the monitor will display the average of the three measurements. Record the average systolic and diastolic blood pressure in the correct space on the recording sheet (make sure you wait for the average to be displayed instead of the final measurement).

What to do if the blood pressure reading is high (above 130/90).

- Ask them if they are feeling stressed or anxious today (if yes record in comments)
- Ask them if they have ever been told that they have high blood pressure (if yes record in comments)
- Tell them that blood pressure is quite variable, but that the pressure you measured today was higher than expected, so we will be sending them an email with this result that will encourage them to tell their parents and to make an appointment to see their GP.

Blood pressure measures will need to be entered into REDCap (see REDCap data entry protocol).

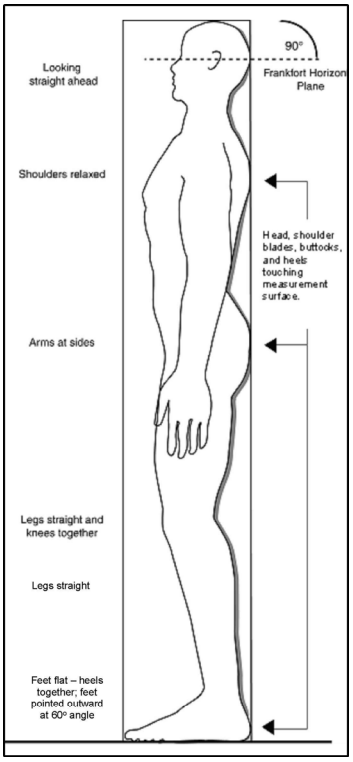
Anthropometric Measurements

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.

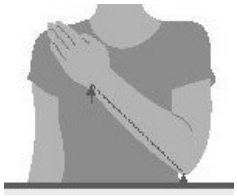


Fig 2: ulna length measurement

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)

Accelerometer protocol

To correctly fit the accelerometer you will need:

- This protocol
- The initialised accelerometers that have been sent to you from Dunedin
- The accelerometer recording sheet
- The wear time diary

Make sure you have taken the ID number from the name & ID spreadsheet and written it correctly on every page of the wear time diary.

Background

The ActiGraph, also known as an activity monitor or an accelerometer, measures activity via internal sensors that detect acceleration on three different axes (up and down, forward and back, and side to side). It is also an accurate sleep assessment tool.

Process

The accelerometers will be sent to you immediately prior to data collection. The accelerometers will have been intialised and will be ready to record. You will also be sent a recording sheet that lists the serial numbers of each of the accelerometers you have been sent next to the ID number of the participant to which the

accelerometer has been assigned. The serial numbers can be found on the back of the accelerometer – they are usually the number beneath the barcode.

Please note, there are limited accelerometers available, so if uptake is high you may not have enough accelerometers for every participant who consents to wear one. If you run out please explain the situation to the participant, thank them for volunteering to wear the accelerometer.

If a participant has consented to wear an accelerometer, this should be fitted at the end of the in-school 24 h recall visit.

Please check the participant list to ensure consent has been obtained. Do not fit an accelerometer if there is no record of the participant consenting to accelerometery.

Find the accelerometer with the serial number that has been assigned to your participant. Double check that the ID number is correct THIS IS VITAL AS IT IS THE ONLY MEANS WE HAVE OF MATCHING THE ACCELEROMETER DATA TO THE CORRECT PARTICIPANT.

Placement of accelerometer

- The monitor weighs approximately 25 g and will be attached by an elastic wrist band and worn on waist so that it sits over the RIGHT hip.

- The black strap that runs across the accelerometer should be securely closed.
  If it isn't use a 10 cent piece to screw the disk closed.

- The participant can put on the accelerometer themselves. Ensure that the strap is snug enough so that the monitor does not move, but loose enough so that it is not causing discomfort. Encourage the participants to wear the accelerometer under clothing as tucking clothing into the strap tends to make it ride up.

- The participant will wear the ActiGraph for the following 7 days.

- Ask the participant to wear this accelerometer at all times (when awake and when asleep), except during showering, bathing, swimming, and other water activities, or during high contact sports for 7 days.

- Provide the participant with a wear time diary and explain how to complete it (make sure to explain that the sleep log should be completed the morning – you may like to write what day this is on the appropriate page). Write the participant's ID number and the time the accelerometer was fitted in the space provided.

- Ask the participant to wear the accelerometer for 7 days and 7 nights. They can remove the accelerometer in the morning after they get up from the 7th night. Please ask them to record the time the accelerometer was removed on the front of the wear time diary. They should drop into the accelerometer in the SuNDiAL collection box (at the office) when they have finished wearing it.

Collecting accelerometers

- Provide the school office with a clearly labelled box ("SuNDiAL project: please drop accelerometers in this box, along with wear time diary")

- Visit the school every day to collect these until they are all collected. Text or email reminders as necessary. It is your responsibility to keep track of what has been returned and what still needs to be chased up.

Return accelerometers to the Department

Once a week, put the returned accelerometers into a courier bag and send them back to the Department (there is no need to download the data from the accelerometers, we will do that and return the accelerometers to you if you require more devices).

Blood and urine collection protocol

During blood collection you will need:

- This protocol
- Urine collection containers and storage tubes
- ID labels
- the blood booking sheet
- the lab booking sheets that have been printed and sent to you from Dunedin

Background

The phlebotomist will be visiting the school on one day only. While they are there you will not collect 24-hour recall data but instead facilitate the collection of blood and urine samples. Bloods will be booked for 15 minute appointments, urine samples will be drop-in.

Preparation

1. Text and/or email reminders to all participants who have consented to blood and/or urine samples. Remind them of their blood sample time, and that they can drop in anytime for a urine sample.

2. Label a urine tube with the ID number only for all participants who have consented to a urine sample. Check the ID numbers are written correctly.

3. Ensure you have the correct number of lab booking sheets for the participants who are booked in.

Process

1. Greet the phlebotomist at the entrance to the school. Report to the school office.

2. Set up in the space assigned for the phlebotomist. Put up SuNDiAL project signs. Check the nearest male toilet – that it is clean and stocked. Set up a biohazard bag for urine tray disposal.

3. When the participant arrives greet the participant and take their name. It is important that you help to make them feel relaxed – they may feel a little anxious.

4. If the participant is there to give a blood sample check that their name and ID number is on the blood booking sheet. If their name is not on the blood booking sheet you must ensure there is a record of the participant consenting to a blood sample before continuing.

5. If the participant has consented to a blood sample write down the time on the blood booking sheet. Ask what time they last had anything to eat and write this down. Hand them over to the phlebotomist, making sure that the phlebotomist is aware of their name and the correct ID number for the participant. Support the phlebotomist as needed.

6. If the participant is there to give a urine sample, give them a urine collection tray and their tube. Explain that they need to pee in the tray and then they transfer the urine into the tube (check that you are giving the participant the correct tube – their ID number should match to their name on the Name & ID spreadsheet.) Make sure the tube is only filled to half way (urine expands when frozen). They can dispose of the urine tray in the biohazard bag and
then give you the urine tube. You should use rubber gloves to handle the tubes.

7. If participants are there to give both a blood and a urine sample, ask them what they would like to do first (they might be busting!).

8. All urine tubes and vacutainers, will be taken by the phlebotomist for transfer to the lab, along with the biohazard bag. Please ensure that the phlebotomist takes everything away with them at the end of the day. Support as needed.

9. Please remember that participants are free to change their mind about providing a blood and urine sample at any time. If the phlebotomist is having trouble getting a sample make sure the participant is ok with continuing.

Please do not hesitate to contact us is you have any questions during data collection

Tessa Scott phone: 021 231 6263

Jill Haszard phone: 021 0244 8990

Meredith Peddie phone: 021 152 2274

REDCap Data Entering Protocol

To complete REDCap data entry you will need:

- This protocol
- Completed Blood pressure and anthropometic recording sheets
- Completed Previous day activity recalls
- A computer with internet access

Once you have taken the participant's anthropometric measurements and administered the activity recall you will need to enter this data into REDCap.

1. Log into REDCap - https://redcap.otago.ac.nz and enter your username and password (this will be your university student username and password).

2. You will be directed to the 'My Projects' tab, click on the project 'SuNDiAL 2020' which will take you to the SuNDiAL 2020 'Project Home' page.

3. On the left-hand side menu click 'Add / Edit Records'. From here you can select the ID number of the participant. You can type the number (need to type it fast) and the cursor will move to that number, then press enter to go to that record; or you can scroll through the list and click on the number to get to the record.

4. Click on the circle beside 'Anthropometry and Activity Recall Data' which will take you to the participant's page for entering this data (Please check the ID number (Record ID) is correct before you start entering data).

5. Put the cursor in the first field and enter the data. You can tab between fields or use the mouse and click in the field you want to enter data in. Please
   double check each entry is correct, that you have entered it in the correct field and that it is in the correct units.

6. Once you have finished, click the 'Save & Exit Form' button. A red dot will now show next to the 'Anthropometry and Activity Recall Data' instrument.

7. Repeat steps 3 - 6 for the next participant.

Appendix D: 24-hour recall recording sheet

First ☐ or Second ☐ 24 h Recall

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

QUICK LIST

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Ask about water consumption at the end of quick list

1

Ask about water consumption at the end of quick list

2

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

Detailed 24 h Recall

Time	Description of Food or Drink	Brand	Amount	Leftovers/Second helpings

Was salt added to any of the food reported (either at the table or in cooking/recipes) ? Yes ☐ No ☐ Don't know ☐ 3
If so was it iodised? Yes ☐ No ☐ Don't know ☐

Time	Description of Food or Drink	Brand	Amount	Leftovers/Second helpings

sundial PROJECT

Participant ID: _____ Interviewer: _____

Date: _____ Day of the Week: _____

Time	Description of Food or Drink	Brand	Amount	Leftovers/Second helpings

Was salt added to any of the food reported (either at the table or in cooking/recipes) ? Yes ☐ No ☐ Don't know ☐ 5

If so was it iodised? Yes ☐ No ☐ Don't know ☐

Time	Description of Food or Drink	Brand	Amount	Leftovers/Second helpings

6

RECIPES

Is this participant willing to participate in a second 24 recall? Yes ☐ No ☐

If so what time suits them to be rung?

Day of the week	Preferred time(s)
Monday	
Tuesday	
Wednesday	
Thursday	
Friday	
Saturday	
Sunday	

HEIGHT 1 (to nearest 0.1 cm)	
HEIGHT 2 (to nearest 0.1 cm)	
WEIGHT 1 (to nearest 0.1 kg)	
WEIGHT 2 (to nearest 0.1 kg)	
ULNA LENGTH 1 (to nearest 0.1 cm)	
ULNA LENGTH 2 (to nearest 0.1 cm)	

Do the height, weight and ulna measurements fall within 0.5 of each other?
(Subtract to find out e.g. HEIGHT 1 – HEIGHT 2)

YES (0.5 or lower): Don't take a third measurement

NO (greater than 0.5) Take a third measurement

HEIGHT 3 (to nearest 0.1 cm)	
WEIGHT 3 (to nearest 0.1 kg)	
ULNA LENGTH 3 (to nearest 0.1 cm)	

Appendix E: Sleep and wear-time diary

PARTICIPANT ID: _____

sundial
PROJECT

Accelerometer Sleep and Wear Time Diary

Accelerometer fitted: Day_____
Date_____ Time:_____

Accelerometer removed: Day_____
Date_____ Time:_____

Day One

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation
***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 2

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Two

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 3

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Three

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 4

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Four

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 5

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Five

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 6

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Six

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 7

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)

Day Seven

Date _____ Day of the Week _____ Participant ID: _____

During the day I removed the accelerometer *(please complete using the 24 h clock eg. 1 pm = 13:00):*

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

Removal time _____ back on: _____ Reason _____

During the day I did the following activity that might not have been recorded e.g swimming, biking or resistance activities (weights) *(please complete using the 24 h clock eg. 1 pm = 13:00)*:

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light* ☐ Moderate** ☐ Vigorous*** ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

Description of Activity _____ Time began: _____ Time ended: _____

Intensity of activity: Light ☐ Moderate ☐ Vigorous ☐

*Activities which do not markedly increase heart rate of breathing rate

** Activities that elevate heart rate and breathing, but during which you can hold a conversation

***Activities that involve considerable exertion, and during which you are breathing so hard you can talk

Sleep Log

Complete the morning of Day 8

What time did you lie down in bed last night (*end of day one*):		Record time (use 24 h clock)
What time did you try to go to sleep? (turned off light/put down phone)		Record time (use 24 h clock)
About how long do you think it took you to fall asleep?		Record minutes
What time did you wake up this morning? (*beginning of day two*)		Record time (use 24 h clock)
What time did you get out of bed this morning?		Record time (use 24 h clock)