The development, validity and reproducibility of a tool (the Athlete Diet Index Questionnaire) to assess the dietary intake of high performing athletes

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Abstract

Background: Well-chosen eating strategies can enhance an athlete's health and sporting performance. It is important for sports dietitians and nutritionists to have access to accurate and reliable dietary assessment methods. Currently there is no population specific, simple food based dietary index suitable for the examination of diet quality among athletes. This study aimed to develop a diet quality index (the Athlete Diet Index Questionnaire (ADI-Q)) which focusses on the baseline nutrition requirements of high performing New Zealand athletes, and examine the validity and reproducibility of food groups, food variety, fluid consumption and eating habits within the ADI-Q.

Methods: The ADI-Q was developed for high performing athletes and was based on dietary components which reflect the Eating and Activity Guidelines for New Zealand Adults (EAGNZA). Athletes who represented their main sport at a regional level or above volunteered to participate in the study. During the first appointment athletes completed the ADI-Q (ADI-Q#1) and an estimated four-day food record (4DFR) (to assess relative validity). The test-retest reliability of ADI-Q#1 was assessed by a second administration of the ADI-Q (ADI-Q#2) four-weeks later. Both relative validity and reliability were assessed using paired-t tests, Pearson's correlation coefficients, Chi square analysis and Bland-Altman plots.

Results: Sixty-eight athletes (26 males, 43 females, 16-71 years) involved in more than 30 different sports completed the study. When assessing relative validity paired t-tests showed good agreement between servings of dried fruit/fruit juice, starchy vegetables, milk and/or milk alternatives, lean meat (beef, lamb, pork) and times treat food were consumed ($p>0.05$). Food groups found to be significantly different tended to have a lower mean number of servings for the ADI-Q#1 compared with 4DFR. Correlation coefficients ranged from 0.19 (servings of starchy vegetables) ($p>0.05$) to 0.66 (servings of non-starchy vegetables) ($p<0.05$) with an average correlation of 0.42. Variety of fruit and vegetables had an average correlation of 0.52. The majority of fluid components had good agreement with only servings of milk and/or milk alternatives and soft drinks/fizzy drinks/carbonated water found to be significantly different ($p<0.05$). Correlation coefficients ranged from -0.03 (flavoured water/sports water and coconut water) ($p>0.05$) to 0.77 (herbal tea) ($p<0.05$) with an average correlation of 0.39. Healthy versus less healthy options showed poor agreement between the ADI-Q#1 and the 4DFR with all components except the use of unsaturated fat being significantly different ($p<0.05$). Meal frequency showed good agreement with only consumption of morning tea found to be significantly different between methods ($p<0.05$). When assessing reproducibility, there was no significant difference found between most dietary components with the exception of servings of non-starchy vegetables, breads and cereals, meat alternatives, water and times takeaways were consumed ($p<0.05$). Significantly different food groups and fluids had a higher mean number of servings/times from ADI-Q#1 compared with ADI-Q#2. Correlation coefficients for food groups ranged from 0.18 (servings of lean meat) ($p>0.05$) to 0.63 (servings of starchy vegetables) ($p<0.05$) with an average correlation of 0.46. Variety of fruit and vegetables had an average correlation of 0.56. The correlation coefficients for fluid consumption ranged from -0.02 (servings of flavoured water/sports water) ($p>0.05$) to 0.91 (servings of coffee) ($p<0.05$) with an average correlation of 0.52. There was no significant difference between healthy versus less healthy options and meal frequency between the first and second administration of the ADI-Q.

Conclusions: The ADI-Q showed reasonable validity for the majority of dietary components when compared with a 4DFR. Reproducibility of the ADI-Q was moderate to high for majority of the dietary components. Further development of the ADI-Q and index score to assess diet quality may help to improve the analysis of dietary intake among high performing athletes.

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Abbreviation List

24hDR	Twenty-four-hour diet records
4DFR	Four-day food record
ADI-Q	Athlete Diet Index Questionnaire
ADI-Q#1	Athlete Diet Index Questionnaire appointment one
ADI-Q#2	Athlete Diet Index Questionnaire appointment two
AHEI	Australian Healthy Eating Index for Australian Adults
AI	Adequate Intake
ARFS	Australian Recommended Food Score
ARFS-P	Australian Recommended Food Score for Pre-schoolers
Aussie-DQI	Aussie Diet Quality Index
BCAAs	Branched chain amino acids
BMI	Body mass index
BW	Body weight
CHO	Carbohydrate
CVD	Cardiovascular disease
d	Day
DGI	Australian Diet Guideline Index
DLW	Doubly labelled water technique
DQI	Diet Quality Index
DQI-I	Diet Quality Index International
DQI-R	Diet Quality Index Revised
DQT	Diet Quality Tool

DR	Diet record
EAGNZA	Eating and Activity Guidelines for New Zealand Adults
FFQ	Food frequency questionnaire
FR	Food record
FUQ	Food use questionnaire
FQ	Food questionnaire
h	Hour
HEI	Healthy Eating Index
HEIFA	Healthy Eating Index for Australian Adults
HDI	Healthy Diet Indicator
IGF-1	Insulin-like growth factor 1
LOA	Limits of agreement
MDS	Mediterranean Score
MOH	Ministry of Health
MUFA	Monounsaturated fatty acids
MUHNRC	Massey University Human Nutrition Research Centre
NZDQI-A	New Zealand Diet Quality Index for Adolescents
NRV	Nutrient Reference Values
PUFA	Polyunsaturated fatty acids
RDI	Recommended Dietary Intake
SD	Standard deviation
SFA	Saturated fatty acids
T3	Triiodothyronine

VSSR	Virtual Self-Service Restaurant
y	Year

Chapter 1

Introduction

1. Introduction

Well-chosen nutrition strategies can enhance an athlete's health and sporting performance (American College of Sports Science, Academy of Nutrition and Dietetics, & Dietitians of Canada, 2016). Providing dietary guidance to athletes requires effective and accurate assessment of dietary intake. This can be challenging as athletes tend to have dietary intakes, which differ to those of the general population. Athletes can eat differently from day to day due to periodised training programs and they may also significantly alter their intake around competition periods. Key nutrition areas which need to be considered when working with athletes include; baseline nutrition, training nutrition and competition nutrition. Time spent by the athlete in each of these areas is illustrated in Figure 1.1.

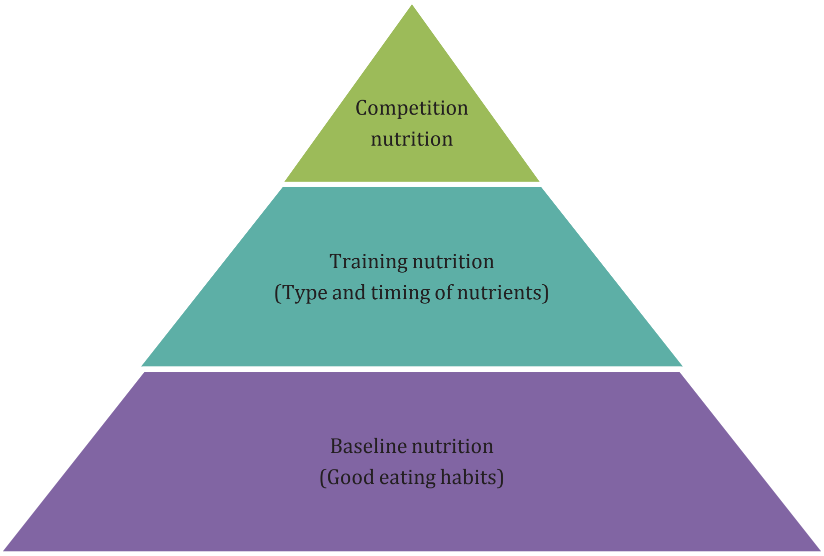

Figure 1.1 Key areas of nutrition which can impact an athlete's health and performance

Baseline nutrition (represented by the bottom layer of the pyramid) refers to national nutrition guidelines and describes the food needed to meet daily energy and nutrient requirements for growth and good health. Balanced baseline nutrition is important as New Zealand athletes (particularly non-professional athletes) typically spend most of their time doing non-athletic activities. For example, a field hockey player competing once per week (70-minute game), and training two hours per day six days per week would spend 92% of their time in non-athletic activities, approximately 7% of their time training and less than 1% of their time in competition. Meeting baseline requirements also provides the athlete with a platform for optimal performance and recovery.

The middle layer of the pyramid reflects an athlete's training nutrition, including pre, during and post training nutrition. The primary goal of the training diet is to provide nutritional support to allow the athlete to stay healthy and injury free while maximising adaptations to training in preparation to meet the performance demands of their event (American College of Sports Science et al., 2016). The training nutrition of an athlete can easily be achieved through manipulation of balanced baseline nutrition. This may include extra energy intake and or strategies for pre, during and post event nutrition.

Competition nutrition (represented by the top layer of the pyramid) can be achieved by manipulation of baseline and training nutrition. It should target specific nutrition related factors that may limit performance by causing fatigue and deterioration in skill or concentration over the course of the event (American College of Sports Science et al., 2016). Examples of nutrition related factors include: event specific factors (mode, intensity and duration), environment (temperature, altitude), appetite (feeling of fullness), gastrointestinal discomfort and food preferences; and again ensuring pre, during and post competition nutritional demands are met (American College of Sports Science et al., 2016).

Nutrient targets for training and competition nutrition should be individualised to the athlete and his or her event (American College of Sports Science et al., 2016). Body carbohydrate (CHO) stores provide an important fuel source for the brain and muscle during exercise. However, these stores are limited and must be regularly replenished by dietary intake of nutrient rich CHO foods such as bread, cereals, pasta, rice, fruits, vegetables and dairy products. General recommendations for CHO intake of athletes typically range from 3-10g/kg/d and depend on the fuel demands of training or competition, balance between performance and training adaptation goals, the athletes total energy requirements and body composition goals (American College of Sports Science et al., 2016). Protein recommendations for athletes range from 1.2-2.0g/kg body weight/day (BW/d). However more recently the regular spacing of intakes of modest amounts of high quality protein (0.3g/kg BW) after exercise and throughout the day has been recommended (American College of Sports Science et al., 2016). Athlete's protein requirements can generally be met by dietary intakes of protein food sources such as beef, lamb, pork, chicken, fish, legumes, eggs, dairy foods, nuts and seeds. Adequate but not excessive intakes of fat (approximately 20-35% total energy) are also required by athletes to support performance and recovery. Consuming less than 20% of total energy intake from fat does not benefit performance and extreme restriction may limit the food range needed to meet overall health and performance goals (American College of Sports Science et al., 2016). Athletes should also consume diets that provide at least the recommended dietary intake (RDI)/adequate intake (AI) for all micronutrients. Athletes who restrict energy intake, complete food groups from their diet, or follow other extreme dietary philosophies are at greatest risk of micronutrient deficiencies (American College of Sports Science et al., 2016). Staying well hydrated is also important to athletes. Dehydration can increase perception of effort and impair exercise performance; thus appropriate fluid intake pre, during and post exercise is important for health and optimal performance (American College of Sports Science et al., 2016).

Given the importance of the athlete's diet on health and performance it is important that the dietary intake of athletes can be assessed accurately. Traditional dietary assessment methods include 24-hour diet recalls, food frequency questionnaires (FFQs) and/or diet histories. These retrospective techniques can be used to examine the athlete's recent intake but depend heavily on memory and honesty (Magkos & Yannakoulia, 2003). Prospective methods such as duplicate portion and diet records (food diaries) monitor ongoing food consumption and are mostly affected by poor compliance and alteration of the athlete's usual intake (Magkos & Yannakoulia, 2003).

There are a number of limitations associated with traditional dietary assessment methods which need to be considered when assessing the dietary intake of athletes compared with the general population. Examples include under-reporting of intake (similar to the general population); allowing for additional serves of food groups and snacks to meet increased energy requirements and/or restrictive practices to make weight categories; beverage consumption to maintain adequate hydration pre, during and post training or competition; the use of supplements and ergogenic aids to enhance performance; and seasonality of sports (Magkos & Yannakoulia, 2003).

Given the differences that exist between athlete's dietary intake and those of the general population, dietary assessment methods developed specifically for athletes are warranted. Only a few dietary assessment tools have been developed and validated in athletic populations. These have included mainly FFQs (Braakhuis, Hopkins, Lowe, & Rush, 2011; Sunami et al., 2016), a food use questionnaire (Fogelholm & Lahtikoski, 1991), self-reported combined dietary data methods (weighed food diary plus 24 h recall) (Briggs, Rumbold, Cockburn, Russell, & Stevenson, 2015), a brief questionnaire to accurately assess calcium intake in female athletes (RAM) (Ward et al., 2004) and various online tools such as the digital dietary assessment tool (DATA) (Baker, Heaton, Stein, Nuccio, & Jeukendrup, 2014) and the virtual self-service restaurant (Baker et al., 2014; Scoffier, Gernigon, Billi, & d'Arripe-Longueville, 2013). These have been validated for intake of energy (Briggs et al., 2015; Scoffier et al., 2013), nutrients (Baker et al., 2014; Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Sunami et al., 2016; Ward et al., 2004) or food groups (Sunami et al., 2016).

Analysis of an athlete's dietary intake using the above dietary assessment methods can be time consuming and usually focuses on individual nutrients or food groups. However athletes do not consume nutrients or food groups in isolation, rather they consume combinations of nutrients and foods in the form of meals and snacks (Waijers, Feskens, & Ocke, 2007). Furthermore, the intake of nutrients and foods may interact, complicating the search for associations between single dietary factors and performance. For example, vitamin C enhances iron absorption (Hallberg, Brune, & Rossander, 1989), and caffeine has been shown to have an increased effect on accumulation of post exercise muscle glycogen when consumed in the presence of CHO (Pedersen et al., 2008).

A holistic alternative to the single nutrient or food approach is to look at diet quality which considers the diet as a whole, in which dietary patterns, and not single nutrients, are related to performance or health outcomes. Dietary pattern analysis resembles more closely the real world, in which nutrients and foods are consumed in combination (Waijers & Feskens, 2005). Dietary pattern analysis has been used extensively in non-athletic populations, but few studies have considered dietary patterns in an athletic population (Burrows, Harries, Williams, Lum, & Callister, 2016; Spronk, Heaney, Prvan, & O'Connor, 2015).

There are two approaches which can be used to measure dietary patterns. Firstly, empirically derived dietary patterns use methods such as factor and cluster analysis to generate patterns based on dietary data (Waijers & Feskens, 2005). Alternatively, theoretically defined indexes of diet quality measure the adherence to a set of national nutrition guidelines or a diet that has proven to be healthful like the Mediterranean diet (Wong, Parnell, Howe, Black, & Skidmore, 2013). Theoretically defined diet indexes consist of nutritional variables, generally nutrients and foods or food groups considered to be important to heath that are then quantified and summed to provide an overall measure (a score) of diet quality (Waijers et al., 2007). Commonly used diet indices include the Healthy Eating index (HEI); the Diet Quality Index (DQI); the Healthy Diet Indicator (HDI) and the Mediterranean Diet Score (MDS) (Waijers et al., 2007). Other benefits of diet indexes besides its whole diet approach include the fact that they can be designed to be easy to access (can be available on line), usually brief in context (lower participant burden) and easy to interpret (provides a single diet quality score) which means lower burden for the health professional or researcher.

Dietary assessment tools should be assessed for their validity and reproducibility in the population of interest prior to being used. When validating a dietary assessment tool it is important that an independent reference method with uncorrelated errors is used to ensure the tool measures what it intends to (Wong et al., 2013). Reference methods may include biomarkers or other dietary assessment methods such as extensive interview, diet record or recalls. There is no consensus on the type and number of statistical tests that should be used however it has recently been recommended that validation studies of dietary assessment tools use multiple statistical tests to ensure the researcher explores different facets of validity (Lombard, Steyn, Charlton, & Senekal, 2015).

Reproducibility (also known as reliability or repeatability) is the ability of an instrument to produce the same estimate on two different occasions (test-retest) assuming nothing has changed in the interim (Block & Hartman, 1989). Testing reproducibility is important as it can help identify problems in the design of dietary assessment methods, uncover inadequate instructions given to the participants prior to completion of the diet index and help to identify poor quality control (e.g. coding or typing errors) (Block & Hartman, 1989).

To date, no dietary indices have been developed or validated in an athletic population, nor has any study assessed the adherence of athletes to New Zealand food and nutrition guidelines. If such a tool was to be developed it could provide sporting personnel, health professionals and researchers with further insight into the dietary intake of athletes. It could be used to identify athletes who would benefit from dietary input, as a tool to educate athletes about dietary choices for optimal health and sports performance, or as a research tool to investigate associations between dietary intake and performance.

Aim and objectives

The aim of this research is to develop a valid and reproducible nutrition screening tool, known as 'the Athlete Diet Index Questionnaire' (ADI-Q) to rapidly and easily assess the diet quality (with a focus on baseline nutrition) of high performing athletes.

The objectives of this research are to:

- To design a tool (the ADI-Q) to assess the diet quality of high performing athletes.
- To validate the ADI-Q for food group intake, variety, fluid consumption and eating habits using a consecutive four day estimated food record.
- To assess the reproducibility of the ADI-Q for food group intake, variety, fluid consumption and eating habits by having athletes complete the ADI-Q on two occasions, four weeks apart.

Hypothesis

We hypothesise that the ADI-Q is a valid and reproducible way of assessing diet quality (food group intake, variety, fluid consumption and eating habits) in high performing athletes.

Thesis structure

This thesis is made up of four chapters. Chapter one introduces the scope and justification for this study. It also outlines the researcher's contributions made to this study (Table 1.1). The second chapter is a review of the literature covering the importance of nutrition for athlete's health and performance, nutrient guidelines for athletes, dietary assessment and challenges specific to athletes, a review of dietary assessment tools developed for athletic populations, and development and validation of dietary indices. The third chapter is a research study manuscript which includes a complete presentation of the research study conducted including an abstract, introduction, methods, results, discussion and conclusion. Finally, chapter four is a summary of the thesis, including overall conclusions, a reflection on strengths, limitations and recommendations for future research.

Researcher's contributions

Table 1.1 Researcher's contributions to this study

Author	**Contribution to thesis**
Rachel Blair	Main researcher, development of ADI-Q, application for ethics, implementation of computerised ADI-Q (survey monkey), participant recruitment, data collection, data entry (ADI-Q, four-day food records), statistical analysis, interpretation of results, author of thesis.
Dr Kathryn Beck	Main academic supervisor; development of study design, application for funding, development of ADI-Q, development of scoring and cut-off criteria, application for ethics, participant recruitment, data collection assistance, assistance with statistical analysis and interpretation of results, thesis revision and approval.
Dr Helen O Connor	Assistance with research design and academic supervision, development of ADI-Q, thesis revision.
Dr Pam Von Hurst	Assistance with academic supervision, assistance with development of ADI-Q, thesis revision.
Michelle Eickstaedt	Research assistant, participant recruitment, data collection, data entry.
Tanya Hamilton and Jeni Pearce	Assistance with development of ADI-Q, participant recruitment, assistance with feedback to athletes.
Dr Cathryn Conlon	Assistance with development of ADI-Q.
PC Tong	Assistance with implementation of computerised ADI-Q (survey monkey), assistance with equipment for data collection

ADI-Q-Athlete Diet Index Questionnaire

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Chapter 2

Literature Review

2. Literature Review

2.1 Introduction to the literature

This review of literature explores the dietary assessment of athletes. It begins by outlining how an athlete's diet can affect their performance. General dietary requirements of athletes are explored along with traditional dietary assessment methods and the challenges sports dietitians and nutritionists may face when assessing an athlete's intake. The development of diet indices used to measure theoretically derived dietary patterns is discussed, along with a review of original, Australian and a New Zealand diet index. This is followed by a review of newly developed dietary assessment tools (specifically for athletic populations) which have either been validated using a reference method (specifically a dietary assessment method such as food frequency questionnaire (FFQ) or food record) or assessed for reproducibility. Finally, the statistical analysis of validation and reproducibility studies is also discussed.

The following online databases were searched for relevant literature: Pubmed, Web of Science and Google Scholar with the publication period ranging from 1976 to 2016. Key search terms were used; validity, reproducibility, dietary assessment, diet index, diet quality, athletes, New Zealand. These terms were used in combination with the two function; 'AND' 'OR'. Journal articles matching the search criteria were reviewed along with relevant 'cited' articles. A manual search of the reference lists from review, validation and reproducibility articles was also conducted to identify further literature.

2.2 Dietary intake and performance

It is well known that effective nutrition strategies can play an important role in improving exercise performance. In addition, optimal nutrition assists by decreasing recovery time, preventing exercise-associated injuries due to fatigue, providing the fuel required during times of high-intensity training, and controlling weight (American College of Sports Science et al., 2016; Driskell & Wolinsky, 2011).

An athlete's dietary requirements can be considered in the form of baseline nutrition, training nutrition and competition nutrition. As most of an athlete's time is spent doing non-athletic activities (e.g. working, studying, spending time with friends and families, sleeping, recovery) it is important that baseline dietary requirements are met. Baseline nutrition focuses on the achievement of good eating habits and encompasses country specific food and nutrition guidelines.

Ensuring that baseline dietary requirements are met sets the platform for an athlete to achieve optimal health and performance. For example, in New Zealand it is recommended that the general population;

- Eat a wide variety of nutritious foods every day.
- Eat at least two servings of fruit every day.
- Eat at least three servings of vegetables every day.
- Eat six servings of grain food every day.
- Eat/drink at least two servings of milk and milk products every day.
- Eat at least two servings every day of legumes, nuts or seeds OR at least one serving of seafood, eggs, poultry or red meat every day.
- Choose and prepare foods with unsaturated fats, that are low in salt, with little or no sugar and that are mostly 'whole' or less processed.
- Make plain water your first choice over other drinks.

(Ministry of Health, 2015)

The time spent by the athlete in each of these areas (baseline, training and competition nutrition) can be illustrated by Figure 1.1. Once balanced baseline eating habits are established, an athlete is able to focus their attention on the dietary requirements for training and competition.

2.3 Athlete requirements

Three main nutrients from food supply athletes with energy. These are carbohydrates, protein and fat. All of these can be obtained from eating a variety of foods from the four main food groups (fruit and vegetables, breads and cereals (grain foods), milk and milk products and/or alternatives and meat and meat alternatives (legumes, nuts, seeds, fish and other seafood, eggs or poultry or red meat).

Carbohydrate

A key nutrient for athletes is carbohydrate (CHO). CHO is stored in muscle (as glycogen) and the liver and is the main fuel (in the form of glucose) for exercise. The body has a limited capacity to store CHO (can usually store enough glycogen for 60-90 minutes of high intensity exercise) which means these stores need to be replaced by nutrient rich CHO foods to support training (Burke & Deakin, 2010). Examples of such foods include; bread, cereals, pasta, rice, fruits, vegetables and dairy products. Foods high in refined sugar such as lollies, soft drinks, honey and jam also contain CHO and can help athletes who have high energy requirements however they are not a good source of protein, vitamins or minerals and should not take the place of nutrient rich CHOs (Burke, Bell, Cort, Cox, Farthing, Greenaway, Minehan, Petrunoff & Wood, 2016). Low body stores of CHO can result in fatigue, impairment of performance at training and/or during competition, and may have a negative impact on the athlete's immune system (American College of Sports Science et al., 2016).

CHO requirements of athletes will vary as they are influenced by training load (frequency, duration and intensity of training sessions) and the demands of competition. Therefore CHO intake should directly reflect an athlete's daily exercise levels (Burke & Deakin, 2010; American College of Sports Science et al., 2016). On high activity days CHO intake needs to be increased to ensure optimal exercise performance and recovery between exercise sessions and on low activity days CHO intake should be reduced to reflect a decreased training load. A summary of guidelines for CHO intake for athletes is presented in Table 2.1.

Table 2.1 Summary of guidelines for carbohydrate (CHO) intake by athletes (adapted from American College of Sports Science et al., 2016)

Intensity	Exercise	Carbohydrate targets	Comments on type and timing of carbohydrate intake
Light	Low intensity or skill based activities (e.g. skill based training session, pilates)	3-5g/kg/d	• Timing of CHO intake may be manipulated to promote high CHO availability for a specific session by consuming CHO before or during the session, or in recovery from a previous session. • Otherwise, as long as total fuel needs are provided, the pattern of intake may simply be guided by convenience and individual choice. • Athletes should choose nutrient-rich CHO sources to allow overall nutrient needs to be met.
Moderate	Moderate exercise program (~1h/d) (e.g. hockey game, gym program)	5-7g/kg/d	
High	Endurance exercise program (~1-3h/d moderate-high intensity exercise) (e.g. triathlon)	6-10g/kg/d	
Very High	Extreme exercise program (>4-5 h/d moderate-high intensity exercise) (e.g. marathon, ironman)	8-12g/kg/d	

h/d – hour per day
g/kg/d – grams per kilogram of body weight per day

Protein

Dietary protein is needed to support metabolic adaptation (changes in the body which allow the body to utilise energy more effectively and efficiently), repair damaged body tissues, and to support the building of new proteins in response to the effects of training. Protein requirements can fluctuate based on how experienced the athlete is (trained status), training load, and CHO and energy availability, however requirements are usually in the range of 1.2-2.0g/kg/day (American College of Sports Science et al., 2016). Daily protein intake goals can be met by a meal plan providing a regular spread of moderate amounts of high-quality protein foods across the day and following strenuous training (recovery) (American College of Sports Science et al., 2016). Recent recommendations suggest muscle adaptation to training can be maximised by 0.3g/kg protein after key exercise sessions and consumption of protein every 3-5 hours over multiple meals (American College of Sports Science et al., 2016). Examples of protein foods include beef, lamb, pork, chicken, fish, legumes, eggs, dairy foods, nuts and seeds.

Fat

Fat provides energy. It is an essential element of cell membranes and is needed to facilitate the absorption of fat-soluble vitamins A,D,E and K (American College of Sports Science et al., 2016; NZ Nutrition Foundation, 2017). The intake of fat by athletes is recommended to be in accordance with public health guidelines (20-30% of energy intake with <10% from saturated fat) and should be individualised based on training level and body composition goals (American College of Sports Science et al., 2016). Dietary sources of healthy fats include; nuts, seeds, reduced fat dairy foods, lean meat, fish, olives, avocadoes and most vegetable oils (e.g. olive oil) (NZ Nutrition Foundation, 2017).

While high fat low CHO diets have become popular, further research is warranted regarding the benefits as generally high fat diets reduce CHO availability and the capacity to use CHO effectively as a substrate for exercise (American College of Sports Science et al., 2016). Athletes who restrict fat to lose weight should be discouraged from implementing fat intakes below 20% of energy intake as it will reduce dietary variety and the intake of fat soluble vitamins and essential fatty acids such as omega 3 (American College of Sports Science et al., 2016).

Micronutrients

Exercise can stress metabolic pathways in which micronutrients are required and training may result in biochemical adaptations that increase the need for some micronutrients (American College of Sports Science et al., 2016). Athletes at risk of micronutrient deficiencies include those who restrict energy intake, rely on extreme weight loss practices, eliminate one or more food groups from their diet or consume poorly chosen diets (American College of Sports Science et al., 2016). Nutrients of importance include calcium, vitamin D, iron and some antioxidants (such as vitamin A, C and E, beta –carotene and selenium) among others. The functions and food sources of these nutrients are displayed in Table 2.2. Requirements for micronutrients in athletes can generally be met with a well-planned diet, with no additional need for dietary supplementation.

Table 2.2 Important nutrients which need to be considered when assessing the dietary intake of athletes (American College of Sports Science et al., 2016; NZ Nutrition Foundation 2016, 2016)

Nutrient	Function	Athletes at risk of low nutrient status	Food sources
Iron	Transports oxygen to all parts of the body including muscles and helps release energy from cells. Low iron levels lead to feelings of fatigue.	Athletes with limited iron intake from haem food sources (vegetarians), inadequate energy intake, periods of rapid growth, menstrual blood loss, foot strike hemolysis (distance runners), blood donation or injury or training at high altitudes.	Haem food sources include; lean meat, chicken and seafood. Haem sources are most readily absorbed. Non-haem iron can be found in foods such as tofu, iron-fortified breakfast cereals and cooked beans and lentils. Foods rich in vitamin C like kiwifruit or citrus fruit can help the absorption on non-haem iron. Tea and coffee will reduce the amount of iron absorbed by the body and are best to drink between meals.
Vitamin D	Key role in maintaining bone health. Research has also suggested a relationship between vitamin D and injury prevention, rehabilitation, improved neuromuscular function, increased type two fibre size, reduced inflammation, decreased risk of stress fracture and acute respiratory illness.	Athletes who live at latitudes >35th parallel, primarily train indoors, have a dark complexion, high body fat content, train in early mornings and evening when UVB levels are low and aggressive blocking of UBV exposure (clothing, equipment, and sunscreen).	Oily fish, such as canned tuna and salmon, eggs, lean meat and dairy products. Some margarines, milks and yoghurts fortified with vitamin D are also available in New Zealand. The majority of vitamin D is generated from exposure to sunlight.
Calcium	Essential for growth, maintenance, and repair of bone tissue; regulation of muscle contraction; nerve	Athletes with low energy availability, females with menstrual dysfunction and low dietary calcium intake.	Dairy products such as milk, yoghurt and cheese. Non-dairy sources such as fortified soy and rice milks, tofu,

Nutrient	Function	Athletes at risk of low nutrient status	Food sources
	conduction; and normal blood clotting.		sardines, some nuts (such as almonds), sesame seeds, broccoli, and fortified breakfast cereals and juices.
Antioxidants (e.g. vitamin A, C, E, beta-carotene and selenium)	Antioxidants protect cell membranes from oxidative damage.	Athletes who restrict energy intake, follow chronic low fat diet, limit dietary intake of fruits and vegetables and whole-grains.	Antioxidant rich foods include; citrus fruits, berries (cranberries, blueberries, blackberries), tomatoes, colourful vegetables (red cabbage, orange capsicum), onions, potatoes, walnuts, hazelnuts, brazil nuts, tea, coffee and cocoa.

Hydration

Staying well hydrated contributes to optimal health and athletic performance. In addition to usual daily water losses athletes need to replace sweat losses. Consequences of inadequate hydration include; cardiovascular strain, increased glycogen utilisation, altered metabolic and central nervous system function, and a greater rise in body temperature (American College of Sports Science et al., 2016). To preserve homeostasis, optimal body function, performance and perception of wellbeing athletes should strive to undertake strategies of fluid management before, during and after exercise to maintain a normal state of body water content (American College of Sports Science et al., 2016). In addition to water sweat also contains variable amounts of sodium and lesser amounts of potassium, calcium and magnesium (American College of Sports Science et al., 2016). Although water is the preferred fluid for rehydration it may be necessary for some athletes with intense or long training durations to consume sports drinks which help to replace the loss of these electrolytes. Strategies based on body weight and urine osmolality can be used to assess hydration status in athletes (American College of Sports Science et al., 2016).

Pre, during and post event nutrition

Nutrition strategies implemented in pre, during and post exercise need to promote optimal performance by addressing factors related to nutrition that can cause fatigue and deterioration in performance (power, strength, agility, skill and concentration) throughout or towards the end of the sporting event (American College of Sports Science et al., 2016). These factors may include dehydration, electrolyte imbalances, glycogen depletion, hypoglycaemia, gastrointestinal discomfort/upset, and disturbances to acid base balances (American College of Sports Science et al., 2016). Strategies include replacing key exercise fuels. For example, in some cases, pre-event nutrition may need to address the effects of other activities undertaken by the athlete during event preparation such as restrictive eating associated with 'making weight'. The comfort of the gastrointestinal tract throughout the event is important as it can affect performance. Nutrition needs to be considered after the event especially in cases where the athletes are involved in a tournament which spans days and weeks (American College of Sports Science et al., 2016). Meeting nutrient requirements for pre, during and post exercise depends on a variety of factors including the event (mode, intensity, duration of exercise), the environment, previous exercise, appetite and individual responses and preferences (American College of Sports Science et al., 2016). Food intake may also be governed by rules of the event and access to nutritional support.

2.4 Dietary assessment methods

An athlete's dietary intake can impact his/hers performance, therefore in order to fully understand the nutritional status of athletes and provide informed recommendations for optimal nutrition, accurate and complete dietary assessment methods are needed (Driskell & Wolinsky, 2011).

Regular assessment of an athlete's dietary intake (food, fluid, supplements), weight goals, training regimes and competition schedule can help to identify potential nutrition problems related to time of year, changes in training routine, health issues that may arise such as injuries or illness, and/or lifestyle changes (Driskell & Wolinsky, 2011).

Traditional dietary assessment tools may be used to analyse the intake of individual athletes and/or groups of athletes. These tools can be broken into two major categories known as retrospective and prospective methods. A full description of these dietary assessment tools is displayed in Table 2.3. Retrospective methods involve collecting data on food or beverages previously consumed and therefore depend on the subject's memory and honesty (Magkos & Yannakoulia, 2003). Examples of retrospective dietary assessment tools include; diet recalls, food-frequency questionnaires (FFQ) and diet history.

The major advantage of the 24-hour recall in the field of sports nutrition is that it involves only minimal subject burden. It can be scheduled around trainings and other daily activities, and can be conducted by a single face-to-face interview lasting approximately 15-30 minutes or via telephone. However, single 24 hour recalls may not be representative of an athlete's usual intake due to daily variation in exercise load and dietary intake. Ideally multiple recalls should be performed on days that reflect changes in the athlete's lifestyle, e.g. typical training days, competition and rest days (Magkos & Yannakoulia, 2003).

FFQs are self-administered tools which comprise of a list of foods or categories of foods with options too indicate frequency of consumption. FFQs may or may not assess the portion size of foods. There greatest limitation in sports nutrition is that they are population specific. The FFQ food list is usually developed using a large number of diet records or recalls to determine the most common food items for the population as a whole. Hence their applicability for assessing the intakes of people whose eating patterns deviate considerably from those of the general population may be limited. Unfortunately few FFQs have been developed (Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Pedisic, Bender, & Durakovic, 2008; Sunami et al., 2016) to assess the dietary intake of athletes making its application limited in this population (Magkos & Yannakoulia, 2003).

Diet histories have been used sparingly as an assessment tool in sports nutrition research, but are more common in practice (Magkos & Yannakoulia, 2003). Diet histories involve a combination of a 24-hour recall and FFQ to determine usual eating patterns. Although diet histories provide a comprehensive assessment of the usual diet and can include seasonal influences, they are time consuming, dependent on a skilled interviewer and rely on memory and the co-operation of the respondent (Burke & Deakin, 2010). Benefits of diet histories include the opportunity to explore social, behavioral and medical influences on food choice. They also allow the interviewer to investigate an athlete's knowledge, beliefs and attitudes as well as main sources of nutrition information (Burke & Deakin, 2010).

Prospective methods such as duplicate portion and diet records (also called food diaries) involve recording food and fluid intake as it is consumed. Duplicate portion involves chemically analysing duplicate samples of food and fluid for energy and nutrient content. It is a very accurate method but rarely used due to high participant burden and the expense and time consuming nature of analysis (Magkos & Yannakoulia, 2003).

Diet records can be weighed or estimated. Weighed food records require the participant to weigh each food item and fluid at the time of consumption. Although this increases accuracy it may be inconvenient for athletes who have irregular training and eating programs and lots of eating occasions (to meet nutritional needs). In order to meet high requirements athletes often have to eat on the move (for example, in the car on the way to and from training) and therefore weighing food becomes difficult (Magkos & Yannakoulia, 2003). Three days is usually the minimum for keeping a reliable diet record (Magkos & Yannakoulia, 2003). It should include days with different training demands, weekdays and a weekend day as these components can affect dietary intake significantly (Magkos & Yannakoulia, 2003). A seven day record may increase the reliability of the collected data but in general increasing the recording period demands greater subject co-operation and may lead to reduced compliance or deliberate alteration of dietary intake to simplify the recording process (Magkos & Yannakoulia, 2003). For athletes, a three to seven day monitoring period is believed to provide an accurate estimation of habitual energy and macronutrient consumption (Magkos & Yannakoulia, 2003).

Estimated diet records are commonly used to assess dietary intake in athletes, as they are generally easier for athletes to complete compared with weighed food records (Magkos & Yannakoulia, 2003). They still require the athlete to record all food and fluid consumed (on specified days), however the amount consumed can be estimated. Estimates can be made various ways for example; using household measures such as cups and spoons, or by comparing the quantity to an object for example a business card. Alternatively, weight can be estimated using a food portion size guide which includes pictures of previously weighed out portions (Nelson, Atkinson & Meyer, 1997).

A detailed description of all dietary assessment methods, their advantages and disadvantages are presented in Table 2.3.

Table 2.3 Characteristics, advantages and disadvantages of traditional dietary assessment methods (adapted from Magkos & Yannakoulia, 2003)

Dietary Assessment Method	Description	Advantages	Disadvantages
Retrospective techniques			
Diet recall	Participants are asked to list in detail all foods and beverages consumed within the past 24-hours.	• Relatively fast to complete • Low respondent burden • Minimal distortion of food intake • Interviewer can help prompt the memory of the athlete • Can be done in person or over the telephone	• May not be representative of usual intake as an athlete's diet can vary day to day depending on the type, intensity and duration of training. Multiple recalls need to be performed • Dependent on the athlete's memory and ability to estimate the quantity of a food or food group • The athlete may not have prepared the meal which could affect his/her recollection • Requires a trained or experienced interviewer
Food frequency questionnaire (FFQ)	A predetermined list of foods to assess dietary intake during a specific period. The time period can range from one day to several months.	• Can be self-administered • Relatively inexpensive • Can represent usual dietary intake • Can also provide quantitative information	• Respondent burden rises as the food list increases • Dependent on the athlete's memory and ability to quantify portion sizes • Over reporting may occur with long lists • Generally, does not include information on sports supplements and ergogenic aids • Each questionnaire is population specific and requires validation in the population of interest
Diet history	Participant describes all food and beverages consumed on a typical day; as well as completing an FFQ.	• Provides both qualitative and quantitative information • Captures day to day and seasonal variation • Uses a variety of methods to capture dietary intake data • Can obtain information on factor influencing the athlete's dietary intake	• Requires a trained or experienced interviewer • Time consuming and resource demanding • Relies heavily on memory • Expensive to conduct and analyse

Dietary Assessment Method	Description	Advantages	Disadvantages
Prospective techniques			
Duplicate portion	Participant collects duplicate samples from all food and drink consumed; these are subsequently analysed for energy and nutrient content.	• Most accurate • Independent of food databases	• Usual intake may be altered due to high participant burden • Chemical analysis of food is expensive and time consuming
Weighed diet record	Participant weighs items on a scale and records (at the time consumed) all food and beverages consumed. The subject also needs to record any uneaten items e.g. plate waste, apple core etc. Duration of the record is usually 3-7 days and often includes a weekend day.	• Increased accuracy with compliance of the athlete • Considered the gold standard for dietary assessment	• High respondent burden • Usual intake may be altered • Time consuming for athletes who are actively training and who have lots of eating occasions due to high energy requirements • May not be accurate if athletes forget to write down details (e.g. fluid consumed in training, brand names) • Less portable and athletes are often eating on the move
Estimated diet record	Participant estimates portion sizes using household measures (e.g. cup, teaspoon etc.) and records (at the time of consumption) all food and beverages consumed. Participant needs to record any uneaten items. Duration is usually 3-7 days and should include a weekend day.	• Acceptable accuracy • Increased compliance when compared to a weighed food record	• Usual intake may be altered • Time consuming for athletes who are actively training and who have lots of eating occasions due to high energy requirements • Compliance decreases as period of diet recording increases • May not be accurate if athletes forget to write down details (e.g. fluid consumed in training, brand names)

FFQ-Food frequency questionnaire

2.5 Dietary assessment issues in athletes

The ability of any participant including athletes to provide accurate dietary intake data depends on their motivation, literacy, memory, communication skills, and awareness of food intake (Burke & Deakin, 2010). There are a number of issues in assessing dietary intake, some of which apply to both the general population and athletic populations. When analysing the dietary intake of an athlete special consideration needs to be given to the following; potential under-reporting, adequacy of standard portion sizes, frequency of snacking, fluid intake, supplement use, weight control practices and seasonality of sport or activities.

Under-reporting of habitual energy

Research has confirmed using the doubly labelled water technique (DLW) that there is a variable degree of under-reporting of habitual energy consumption among both non-athletic and athletic populations (Hill & Davies, 2001; Schoeller, 1995). The DLW technique has allowed the accurate validation of dietary assessment measures whereby under conditions of stable body weight, energy intake must equal energy expenditure (Thompson & Manore, 1998). Under-reporting may be intentional or unintentional. The most common reason for under-reporting among athletes include; alteration of usual intake during the period of monitoring (e.g. avoiding food due to having to write it down, not reporting foods or meals considered less desirable such as sweet or fatty foods or erroneous quantification or description while reporting food intake (e.g. estimating the gram amount of meat) (Magkos & Yannakoulia, 2003). Error from under-reporting can be quantified by monitoring body mass and/or body composition changes. A review published investigating the DLW technique to validate self-reported energy intake in athletes found that under-reporting accounted for 10-45% of total energy expenditure and is mainly due to under-recording rather than under eating (Hill & Davies, 2001). Research has also highlighted that under-reporting is variable among individual athletes and therefore precludes any kind of upward energy adjustment e.g. adding of energy that may help in obtaining a better estimate of an athlete's actual energy intake (Magkos & Yannakoulia, 2003).

The Goldberg Equation is often used in research for checking the under-reporting of dietary intakes in individuals and groups. The Goldberg equation calculates a cut-off (lower 95% confidence limit) below which it is unlikely that the mean intake represents either habitual intake for weight maintenance or a random low intake (Livingstone & Black, 2003). Based on this equation under estimates of energy (and hence nutrient) intake using food records have been reported in female endurance athletes (Schoeller, 1995), in female gymnasts (Jonnalagadda, Benardot, & Dill, 2000), in cyclists (Westerterp, Saris, van Es, & ten Hoor, 1986) and in Australian rugby players (Lundy, O'Connor, Pelly, & Caterson, 2006). In elite athletes preoccupied with weight or in those who need to maintain a lean body mass for their sport distortion of energy intake is likely to be high. In one study, 61% of gymnasts were classified as under reporters (Jonnalagadda et al., 2000).

Adequacy of standard portion sizes

Athletes typically have higher energy requirements than the general population. In order to meet these requirements, they may need to eat large amounts of food on one occasion. Standard servings sizes presented in commercial food models, as options in a FFQ or predetermined by dietitians may not be an accurate description of an athlete's diet (Magkos & Yannakoulia, 2003). Serving sizes and frequency options should therefore be considered when assessing the dietary intake of athletes.

Frequency of snacking

One way athletes can try to meet their increased requirements is by snacking frequently. Eating occasions can amount to as many as nine meals and snacks daily with snacks contributing anywhere from 17-22% (Ziegler, Jonnalagadda, Nelson, Lawrence, & Baciak, 2002) to 30-37% (van Erp-Baart, Saris, Binkhorst, Vos, & Elvers, 1989) of an athlete's total energy and macronutrient intake. This needs to be considered when assessing the dietary intake of an athlete as snacks can often be under reported (Magkos & Yannakoulia, 2003).

Fluid intake

Fluid consumption can be difficult to quantify and is often neglected during dietary assessment of individuals and athletes. Fluids consumed outside of meal times like sports drinks are especially prone to under-reporting compared to those consumed with meals (Poppitt, Swann, Black, & Prentice, 1998). An inadequate assessment of fluid intake may not be a problem when assessing the nutrient adequacy of a sedentary individual but is extremely important for athletes whose requirements are greater due to losing large amounts of fluid through sweat (American College of Sports Science et al., 2016). The use of practical indices such as weighing pre and post training or evaluating urine colour may be a better alternative to evaluating fluid intake in athletes (Magkos & Yannakoulia, 2003).

Supplement use

An athletes increased requirements can generally be met by a well-balanced and energy adequate diet without further supplementation. However, there are some exceptions such as an athlete who restricts certain food groups in order to lose body weight. Many supplements such as multivitamins, pre workout drinks, protein shakes, fat burners, creatinine and magnesium are still used by many athletes in an attempt to enhance performance (Lamb & Williams, 1991). This can affect the dietary assessment of athletes as they are often taken outside of meals, and may not be considered as food and therefore, likely to go misreported. Capturing this information requires trust and co-operation between the health professional (sports nutritionist or dietitian) and the athlete. Probing for this information and being familiar with a wide range of supplements and their use is also important for extracting this data from athletes (Magkos & Yannakoulia, 2003).

Weight-control practices

Some sports require athletes to maintain a low body weight or fat percentage, for example athletes who compete in sports imposing specific weight limits for competition (e.g. boxing, wrestling), or in sports in which low body weight is the norm (e.g. dancing, gymnastics) (Magkos & Yannakoulia, 2003). There may be additional pressure placed on some athletes by coaches and team mates and even social media (for example, people continuously posting pictures of food and themselves on Facebook and Instagram). Slimming techniques may include the ingestion of particular foods (e.g. liquid meal replacements, green tea, coffee), exclusion of food groups (e.g. dairy, breads and cereals), the use of diet pills (e.g. fat burners and laxatives) and binging and purging (Magkos & Yannakoulia, 2003). When assessing an athlete's dietary intake it is important to consider weight control practises such as these and the daily variation in food consumption they may introduce (Magkos & Yannakoulia, 2003).

Seasonality of sport activities and food consumption

Athletes are not only faced with the seasonal change in eating patterns, but changes as a result of the different cycles in their sports such as pre-and post-season training, in season training and pre- and post-competition regimes. Various nutritional markers (e.g. energy and macronutrient/micronutrient intakes, body composition and biochemical markers) may differ between training and competition seasons or low and high training periods (Magkos & Yannakoulia, 2003). Sports dietitians and or nutritionists need to be aware of the physical demands and periodicity of the individual sport concerned in order to interpret the results of the dietary assessment correctly and provide useful recommendations (Magkos & Yannakoulia, 2003).

2.6 Dietary assessment tools developed for use in athletic populations

There are few dietary assessment tools validated for use in an athletic population. A number of studies have compared the energy intake from food records with energy expenditure measured by DLW in specific athletic populations such as ballet dancers (Hill & Davies, 1999), basketball players (Silva et al., 2013), cross-country skiers (Sjodin, Andersson, Hogberg, & Westerterp, 1994), synchronized swimmers (Ebine, Feng, Homma, Saitoh, & Jones, 2000) and soccer players (Ebine et al., 2002). Most found a bias towards under-reporting of energy intake via the food records.

Dietary intake assessment tools have also been validated in athletes through the use of comparison with blood samples (e.g. antioxidant capacity (ferric-reducing ability of plasma) (Braakhuis et al., 2011), metabolic hormones (e.g. leptin, insulin, insulin-like growth factor 1 (IGF-1) and triiodothyronine (T3)) (Koehler, Achtzehn, Braun, Mester, & Schaenzer, 2013), urine (nitrogenous excretion) and indirect calorimetry (Koehler et al., 2010; Wardenaar et al., 2015).

A comprehensive literature review was conducted to find dietary intake assessment tools which had been validated against other prospective or retrospective dietary assessment methods (e.g. food records, FFQs and diet recalls) in athletes. Studies were found to include the following test tools; FFQs (Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Sunami et al., 2016) a combination of food diaries and diet recalls (Briggs et al., 2015), self-administered checklists (Ward et al., 2004) and a variety of online tools (Baker et al., 2014; Scoffier et al., 2013). Most of the studies used food records as the reference method (Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Scoffier et al., 2013; Ward et al., 2004) while others used observations (Briggs et al., 2015) and 24-h recalls (Baker et al., 2014; Sunami et al., 2016). Sample sizes ranged from 12 to 171 athletes with majority of the studies only assessing the dietary intake of athletes from a few select sports. A variety of statistical test were used to assess validity (paired t-tests, correlation coefficients, cross classification and Bland-Altman plots), however majority did use correlation coefficients (Braakhuis et al., 2011; Sunami et al., 2016) or intra-class correlation (Baker et al., 2014; Ward et al., 2004). Only one study validated the test method for food groups (Sunami et al., 2016) whilst the others looked at energy intake and nutrients (e.g. macronutrients (CHO, protein, fat), micronutrients (sodium, calcium, iron), total antioxidant intake) (Baker et al., 2014; Briggs et al., 2015; Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Scoffier et al., 2013; Sunami et al., 2016; Ward et al., 2004). To date no dietary assessment methods have been developed or validated specifically for the assessment of overall dietary patterns (combinations of foods eaten as part of the total diet) in an athletic population. Only three of the studies tested reliability (Braakhuis et al., 2011; Pedisic et al., 2008; Ward et al., 2004). Correlations were also used by these studies as the statistical measure of choice. Time between retesting ranged from one week to eight weeks. A summary of these studies is presented below in Table 2.4 and 2.5.

Table 2.4 Dietary assessment tools validated for athletes against prospective or retrospective dietary assessment tools

*Table excludes tools validated against DLW techniques, hormones, urine excretion and indirect calorimetry

Author, Year, Country	Sample size and participant characteristics	Assessment tool	Reference tool	Validated for	Main statistical finding	Conclusions
Baker et al. (2014), UK	87 male and female competitive athletes from soccer, tennis, basketball, football, golf, lacrosse, baseball, softball, track and field, wrestling, boxing, ice hockey, figure skating and dance (14-20y)	Digital dietary assessment tool for athletes (DATA). Modified 24-h recall method and integrated, customized nutrient database	Registered Dietitians (RDs) direct observations and 24-h dietary recall interviews	Energy, CHO, protein, total fat, water, sodium, calcium and iron intake	Paired differences between DATA and observations were not significant for carbohydrate and protein but were significant for energy. No differences between DATA and interviews for energy, carbohydrate or protein	DATA was found to have good relative validity for group level comparisons in athletes. This was not the case at the individual level especially in athletes with higher energy and nutrient intakes. DATA could be a useful athlete-specific, digital alternative to conventional 24-h dietary recall methods at the group level
Sunami et al. (2016), Japan	171 college athletes from soccer, basketball, track and field, handball, tennis, judo, or volleyball sports clubs of universities	FFQ assessing intake over past month	3-day non-consecutive 24-hour dietary recall	19 food groups (e.g. cereals, fruits, milk and dairy products) and 35 nutrients (e.g. energy, macronutrients, micronutrients and fibre)	FFQ underestimated energy intake by ~10%. For 35 nutrients, the CC was 0.30 (males) and 0.32 (females). For 19 food groups, the CC was 0.32 (males) and 0.34 (females). For both nutrient and food groups, cross classification indicated extreme misclassification rates of 3-5%	The FFQ developed and validated for middle aged persons had comparable validity among young athletes. The FFQ may be useful for assessing habitual dietary intake in collegiate athletes, especially for calcium, vitamin C, vegetables, fruits, and milk and dairy products
Fogelholm and Lahtikoski (1991), Finland	84 male athletes who competed regularly in endurance events, ball games and other events (24 ± 4y)	Food use questionnaire (FUQ)comprising 122 questions	7-day food record	Energy and Nutrient intake (e.g. CHO, proteins, fats, thiamine, vitamin C, calcium,	In FUQ-1, the reported nutrient intake tended to be overestimated compared to the 7DR, whereas in FUQ-2 comparable results on a	The food use questionnaire agreed well with the food record on a group level, if a typical portion size was used. Agreement on an individual level was not quite as good

Author, Year, Country	Sample size and participant characteristics	Assessment tool	Reference tool	Validated for	Main statistical finding	Conclusions
				magnesium, iron and zinc).	group level for all nutrients, except for proteins and fats. The percentage of participants similarly classified into tertiles (7DR vs. FUQ-1 or FUQ-2) varied from 37-54%	
Braakhuis et al. (2011), USA and NZ	113 athletes (17-36y) from Rowing NZ and local rowing clubs	Quantitative FFQ comprising 70 food items assessing intake over past month	7-day food diary and blood test	Total antioxidant intake and food group antioxidant intake	Correlations were highest for antioxidants from cereal (0.55). Correlations were also high for tea and coffee (0.51) and moderate for vegetables (0.34) and fruit (0.31).	The FFQ was considered valid for estimating antioxidant intake in athletes and less labour intensive than a 7-day food record
Briggs et al. (2015), UK	12 male adolescent soccer players (13.8±0.6y)	Self-reported weighed food diary, supplemented with a 24-h recall	Researcher observed energy intake	Energy intake	Participant's under-reported energy intake when using the self-reported combined dietary data method in comparison to observations.	The combined dietary data method collection method could be used interchangeably with the observed technique in the population studied providing an appropriate adjustment is made for under-reporting
Ward et al. (2004), USA	35 female collegiate athletes from basketball, cross-country, field hockey, soccer, volleyball teams (17-21y)	Rapid Assessment Method (RAM), a self-administered calcium checklist	6 days of diet records (DRs)	Calcium intake	Mean calcium intake did not differ significantly between the RAM and DRs. Agreement between the RAM and DRs was moderate (r=0.42). The RAM overestimated calcium intake from fruits/vegetables and sugars/fats and	The RAM briefly and accurately estimates calcium intake in female collegiate athletes compared to DRs

Author, Year, Country	Sample size and participant characteristics	Assessment tool	Reference tool	Validated for	Main statistical finding	Conclusions
					underestimated intake from meat/legumes	
Scoffier et al. (2013), France	Four populations: Adolescents (n=21) Adolescent athletes in high risk sports (weight major preoccupation) (n=22) Adolescent athletes in other sports (n=20) Adults (n=23)	Virtual self-service restaurant (VSSR) (computerised tool)	One day food intake report	Energy intake	Student t tests for paired samples (energy intake from the VSSR and food records) for each population were not significant ($p<0.05$). Linear regression was significant for all populations demonstrating the two variables were related	Showed preliminary evidence of validity and reliability, can be used to promote educational nutrition programs for sedentary and athletic populations

d-day/s; h-hour/s; y-years; BMI-Body mass index; DRs-diet records; FFQ-Food frequency questionnaires; FUQ-Food use questionnaire; RAM-rapid assessment measure; DATA-Digital dietary assessment tool for athletes; VSSR-Virtual self-service restaurant

Table 2.5 Reproducibility of dietary assessment tools using an athletic population

Author, Year, Country	Sample size and participant characteristics	Assessment tool	Time frame between appointments	Reproducibility method	Main statistical finding	Conclusions
Pedisic et al. (2008), Croatia	83 university students (7-10.5 hours of exercise per week)	Questionnaire containing 104 questions. Divided into FFQ (74 questions regarding frequency and beverage items and usual food preparation methods) and general questionnaire (demographics, energy expenditure, dietary regimen (vegetarian), dietary habits (frequency of meals), diet characteristics before during and after training)	Four-eight weeks	Reproducibility of quantitative and qualitative data in relation to dietary habits as well as macronutrient and micronutrient intake	Pearson's correlations for males ranged from 0.51 for copper to 0.95 for alcohol (average correlation of 0.68). In female's correlations ranged from 0.30 for alcohol to 0.78 for calcium (average correlation of 0.60). Correlations for the general questionnaire were 0.83 for males and 0.86 for females.	The newly developed FFQ enables cost-effective assessment of dietary habits in Croatian athletes and other physically active individuals, as well as demonstrates acceptable reproducibility
Braakhuis et al. (2011a), USA and New Zealand	20 athletes from Rowing New Zealand and local rowing clubs (17-36y)	Quantitative FFQ	One week	Reproducibility of total antioxidant intake and food group antioxidant intake	One week test-retest reliability was high (0.83)	One-week test-retest reliability of the questionnaire's estimates of antioxidant intake in participants was high. The FFQ appears trustworthy for estimating antioxidant intake
Ward et al. (2004), USA	57 female collegiate athletes from	Rapid Assessment Method (RAM), a	Two weeks	Reproducibility of calcium intake	The RAM demonstrated adequate test-retest	This study demonstrates that a simple, inexpensive self-

Author, Year, Country	Sample size and participant characteristics	Assessment tool	Time frame between appointments	Reproducibility method	Main statistical finding	Conclusions
	basketball, cross-country, field hockey, soccer, volleyball teams (17-21y)	self-administered calcium checklist			reliability over two weeks. Mean calcium intake on the second administration of the RAM was lower than the first. Agreement between the two administrations was moderate (r=0.58)	administered checklist can estimate calcium intake reliably and accurately in female collegiate athletes

y-years; BMI-Body mass index; DRs-diet records; FFQ-Food frequency questionnaires; RAM-rapid assessment measure

2.7 Dietary analysis

Once dietary intake data has been collected it is traditionally converted into nutrients and food data and compared to nutrient reference values (NRVS) or food based dietary guidelines (such as national dietary guidelines). A more recent and holistic approach is the assessment of dietary patterns. These approaches will be discussed below.

Converting foods into nutrients using food composition data

Dietary intake data is commonly converted into nutrient and food group based data. However, the conversion of food into nutrients provides another source of error and reflects the skills and knowledge of the researcher (e.g. how to choose foods not instantly matched in the food composition database), the method of data collection (can result in lack of specificity in the description of food or quantities consumed, food preparation methods, edible portions, weight for volume) and the food composition database used for analysis (Burke & Deakin, 2010). Food composition databases can include; free internet based options such as Food Standards Australia and New Zealand (NUTAB 2010) (Food Standards Australia New Zealand, 2015), or more expensive nutritional-analysis software packages such as FoodWorks (FoodWorks 8 Professional, 2016). Both are based on the New Zealand Food Composition Database (FOODfiles 2014) (The New Zealand Institute for Plant and Food Research limited and the Ministry of Health, 2015).

Food composition databases are expensive to develop and often do not contain the large number of foods consumed in everyday life, so inappropriate food substitutes, omissions of foods and guesswork substantially distort accuracy of dietary intake analysis (Burke & Deakin, 2010). Defining a coding and food substitute protocol to address these issues is crucial for minimising error before data analysis (Burke & Deakin, 2010).

When interpreting, nutrient data derived from food composition data, and entering food intake data for nutrient analysis there are several limitations that should be considered**.** Food composition data are only estimates of nutrient composition and the nutrient composition of any given food is not constant (Pennington, 2008). The variation is highest for micronutrients and also varies for food grown in different geographical regions within the same country of origin. Different cooking and processing technologies also introduce wider variation (Burke & Deakin, 2010; Pennington, 2008). Food composition data are specific to the country of origin and for this reason using an American database to analyse the dietary data of an athlete who lives in New Zealand is less than ideal (Burke & Deakin, 2010; Pennington 2008). Furthermore, food composition data also rapidly evolves due to changes to plant and animal breeding, food regulations and processing techniques and so do not always contain all foods available for consumption in the country of origin (Burke & Deakin, 2010).

Where a specific food or ingredient is unavailable in the food composition tables, substitutes have to be made. Adding information from food labels to food composition data is less than ideal because labels are not a complete representation of the nutrient composition of the food (Burke & Deakin, 2010). Finally, errors in coding and entering dietary intake data occur in both trained and untrained data entry operators. Errors in coding can be attributed to different interpretations of foods and food substitutes (Burke & Deakin, 2010). This error can be limited by having few people coding or entering data. Finally, there is room for error which is specific to athletes. Athletes do not necessarily eat the serve sizes described on food labels or which are specified in dietary assessment programs. Therefore the use of default serving sizes may be inappropriate and requires manual changes to food weight/volumes on the program to avoid errors (Burke & Deakin, 2010). It is also important to mention that most databases contain few fluid replacement beverages and supplements (e.g. electrolyte drinks, protein powders, protein bars and gels) or fashionable 'superfoods' consumed by athletes (e.g. kale, chia seeds, cocoa nibs) making the appropriateness of any database for athletes limited and the need for substitute foods greater.

Interpreting dietary intakes

On determining a participant's nutrient intake, it can then be compared to nutrient reference values (NRVs), food based dietary guidelines (such as the Eating and Activity Guidelines for New Zealand Adults) or athlete specific recommendations to determine the adequacy of their dietary intake. NRVs and dietary guidelines are based on scientific knowledge and are population specific.

Nutrient Reference Values

NRVS are a family of population specific recommendations (reference values) which outline the amount of nutrients required, on an average daily basis for adequate function preventing nutrient deficiency and to decrease the risk of chronic diet related diseases (Burke & Deakin, 2010). The various reference values used in New Zealand and their definitions are presented in Table 2.6.

Table 2.6 Definitions of the Nutrient Reference Values used to interpret dietary intake data (National Health and Medical Research Council, 2006)

Nutrient Reference Value (NRV)	Definition
Estimated Average Requirement (EAR)	A daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender
Recommended Dietary Intake (RDI)	The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98 per cent) healthy individuals in a particular life stage and gender group
Adequate Intake (AI)	The average daily nutrient intake level based on observed or experimentally-determined approximations or estimates of nutrient intake
Estimated Energy Intake (EER)	The average dietary energy intake that is predicted to maintain energy balance in a healthy adult of defined age, gender, weight, height, and level of physical activity, consistent with good health.
Upper level of Intake	The highest average daily nutrient intake likely to pose no adverse health effects to almost all individuals in the general population. As intake increases above the upper level, the potential risk of adverse effects increases

NRVs for micronutrients are safe to use for athletes because of the wide safety margins for nutrient recommendations. Adjustment may need to be made for some nutrients in athletes with very high energy expenditures or diets that have poor nutrient bioavailability (such as vegetarians). For example the EAR for iron is 1.3-1.7 times higher for athletes and 1.8 times higher for vegetarians (non-athlete) to account for low bioavailability (Institute of Medicine, 2002).

Dietary guidelines

Dietary guidelines are evidenced based, population specific recommendations which provide guidance on foods, food groups and dietary patterns that protect against chronic disease and provide the nutrients required for optimal health and wellbeing (National Health and Medical Research Council, 2013). Dietary guidelines such as the Eating and Activity Guidelines for New Zealand Adults base their recommendations on whole foods like fruit, vegetables and breads and cereals (grains) rather than individual nutrients. This practical approach makes them easier to apply.

Dietary patterns consistent with dietary guidelines will allow the general population to meet nutrient requirements if adhered to (National Health and Medical Research Council, 2013). These same recommendations are appropriate for nutrition education of athletes (baseline nutrition) and are used by dietitians when assessing the nutrient density of the diet and advising athletes about food choice (Burke & Deakin, 2010).

Athlete specific recommendations

In addition to nutrient reference values (NRVs) and dietary guidelines, there are a number of other resources sports dietitians or nutritionists can use to make food, fluid and supplementation recommendations to athletes. These include specific recommendations in the form of position statements such as the recently revised joint position statement produced by the American College of Sports Science et al. (2016), and consensus statements and sport specific recommendations (Burke, Cox, Culmmings, & Desbrow, 2001; Phillips & Van Loon, 2011; Von Duvillard, Braun, Markofski, Beneke, & Leithauser, 2004). Quantitative amounts (in grams) of CHO and protein intakes are accepted as the benchmark for recommending and assessing nutrient intakes in athletes. These values can be adjusted for body mass and type, intensity and duration of exercise (Burke & Deakin, 2010). Examples of specific recommendations for CHOs based on exercise intensity are presented in Table 2.1.

Limitations of Nutrient Reference Values and dietary guidelines

In nutrition research the focus is generally on the role of single nutrients in diet-disease relations. However, foods and nutrients are not consumed in isolation. Our diet consists of a variety of foods and nutrients consumed in varying amounts (meals) according to individual preference. This makes it difficult to separate out the specific effects of nutrients or foods (Waijers & Feskens, 2005). For example, vitamin C enhances iron absorption (Hallberg et al., 1989). Analyses of individual foods or nutrients often ignore the potential interaction between components of a diet and health outcome. Therefore a method to evaluate diet quality, considering the diet as a whole, in which dietary patterns and not individual nutrients are related to health outcomes and performance is warranted (Waijers & Feskens, 2005).

2.8 Dietary patterns

A holistic alternative to the single nutrient or food approach is to look at diet quality which considers the diet as a whole, in which dietary patterns, not single nutrients, can be related to performance or health outcomes. Dietary pattern analysis resembles more closely the real world, in which nutrients and foods are consumed in combination (Waijers & Feskens, 2005). There are two types of dietary pattern analysis; theoretically and empirically defined dietary patterns.

Empirically derived dietary patterns

Empirically also known as *'a posteriori'* approach are dietary patterns which have not been defined in advance. Instead statistical methods are used to generate patterns from dietary data. This means empirically defined diet patterns do not depend on how authors define a healthful pattern. In nutrition epidemiology factor and cluster analysis are two commonly used methods used to derive eating patterns (Waijers & Feskens, 2005).

Theoretically defined indexes of diet quality

Theoretically defined dietary patterns are created based on current nutritional knowledge. They consist of nutritional variables, usually nutrients and foods or food groups considered to be important or detrimental to heath. All index variables are quantified and summed to provide an overall measure of diet quality (Waijers et al., 2007). The definition of diet quality depends on attributes selected by the investigator but is usually built upon current nutrition knowledge (e.g. national dietary guidelines) or theory or based on a diet that has proven healthful such as the Mediterranean diet (Waijers et al., 2007). The four original indexes commonly referred to and/or validated most extensively include The Healthy Eating index (HEI) (Kennedy, Ohls, Carlson, & Fleming, 1995), the Diet Quality Index (DQI) (Patterson, Haines, & Popkin, 1994), the Healthy Diet Indicator (HDI) (Huijbregts et al., 1997)and the Mediterranean Score (MDS) (Trichopoulou et al., 1995). Indices such as these have been revised and validated for other populations such as Australian adults and pre-schoolers. These include the Australian Diet Guideline Index (DGI) (McNaughton, Ball, Crawford, & Mishra, 2008), the Australian Recommended Food Score (ARFS) (Collins et al., 2015), the Australian Healthy Eating Index for Australian adults (AHEI) (Roy, Hebden, Rangan, & Allman-Farinelli, 2016), the Diet Quality Tool (Aussie-DQI) (Zarrin, Ibiebele, & Marks, 2013), and the New Zealand Diet Quality Index for Adolescents (NZDQI-A) (Wong et al., 2013). Table 2.7 includes the original four dietary indices (prior to being revised) as well as indices developed for

Australian and New Zealand populations. The results of the original validation studies are included in the table.

Table 2.7 Description of the four original diet indices (prior to being revised), and Australian and New Zealand specific indices

*Table does not include indices developed specifically for children. HEI did include young participants but had a variety of ages

Author, year	Index	Participants	Guidelines Index Based on	Validation Method	Outcome measure	Score	Results
Original Diet Indices							
Kennedy et al. (1995)	Healthy Eating Index (HEI)	7443 US participants (>2 y)	US Food Guide Pyramid and Dietary Guidelines for Americans	24-h recall and 2-d record	Nutrient adequacy	10 components. Score ranges from 0 (worst)- 100 (best)	The HEI correlated positively and significantly with most nutrients. As the total HEI increased, intake for a range of nutrients also increased (energy, protein, Vitamin A, E, C, B6 & B12, thiamine, riboflavin, niacin, folate, calcium, phosphorous, magnesium, iron and zinc)
Patterson et al. (1994)	Diet Quality Index (DQI)	5484 US adults (>21 y)	Eight National Research Council diet and health recommendations	24-h recall and 2-d record	Nutrient adequacy	8 components. Score ranges from 0-16, where 0 indicates an excellent diet	Lower index score positively associated with vitamin and mineral intakes and negatively associated with fat intake
Huijbregts et al. (1997)	Healthy Diet Indicator (HDI)	3045 European (Netherlands, Italy, Finland) men (50-70y)	WHO dietary recommendations for preventing chronic disease	Diet History	All mortality	Score ranges from 0-9 (9 indicates better adherence to WHO dietary recommendations)	Large variation in intake between three countries. HDI is useful in evaluating the relationship of mortality to dietary patterns.
Trichopoulou et al. (1995)	The Mediterranean Diet Score (MDS)	182 Greek Elderly	Mediterranean diet	190-item FFQ	All mortality	8 components. Score ranges from 0-8 where a high score indicates a better diet	17% reduction in mortality for 1 unit increase in the 8-point score

Author, year	Index	Participants	Guidelines Index Based on	Validation Method	Outcome measure	Score	Results
Australian Diet Quality Indices							
McNaughton et al. (2008)	Australian Diet Guideline Index (DGI)	8220 Australian Adults (≥19 y)	Australian Healthy Eating Guidelines	108-item FFQ and food habits questionnaire	Nutrient adequacy	15 components. Score ranges from 0-150 with a higher score reflecting increased compliance with dietary guidelines	Higher DGI scores were associated with lower intakes of energy, total fat, and saturated fat and higher intakes of fibre, beta carotene, vitamin C, folate, calcium and iron
Collins et al. (2015)	The Australian Recommended Food Score (ARFS)	96 Australian adults (30-75y)	Australian Dietary Guidelines	120-item FFQ	Nutrient adequacy	8 components. Score ranges from 0-73 with a higher score reflecting increased compliance with dietary guidelines	The ARFS was correlated with FFQ nutrient intakes, particularly fibre, vitamin A, beta-carotene and vitamin C (0.53), and mineral intakes, particularly calcium, magnesium and potassium (0.32)
Roy et al. (2016)	Healthy Eating Index for Australian Adults (HEIFA-2013)	100 young adults (18-34 y)	Updated Dietary Guidelines for Australians 2013	74 item-FFQ and a 5 non-consecutive WFR	Nutrient adequacy and dietary variety	11 components. Score ranges from 0-100 with a higher score reflecting increased compliance with dietary guidelines	A higher score was associated with higher diet quality, including a low intake of saturated fat and sodium and a high intake of selected vitamins and minerals. Low correlations with energy were observed
Zarrin et al. (2013)	Aussie Diet Quality Index (Aussie-DQI)	10 851 Australian adults (>19 y) 1447 (>25 y)	National Dietary Guidelines linked to the Australian National Health Priority Areas	24hr recall and FFQ	Nutrient adequacy, risk of cancer and all-cause mortality	11 components. Score ranges from 0-120. A higher score reflected better compliance	The Aussie-DQI successfully measured diet quality and showed that men, younger adults, current smokers and those overweight/obese were less likely to consume foods that

Author, year	Index	Participants	Guidelines Index Based on	Validation Method	Outcome measure	Score	Results
						with the dietary guidelines.	meet dietary recommendations. A high diet quality is associated with decreased risk of cancer mortality among men
O'Reilly & McCann. (2012)	Diet Quality Tool (DQT)	37 with established CVD attending cardiac rehabilitation	Heart Foundations secondary prevention guidelines	4DFR	Nutrient adequacy specifically related to the prevention of CVD	13 components. Score ranges from 0-130 with a higher score reflecting greater level of compliance with the Heart Foundation guidelines	Feasible and useful dietary assessment tool within a hospital cardiac rehabilitation program. Lower DQT scores were shown to have higher % energy from saturated fat and lower intakes of fibre and omega-3 fatty acids as measured by the 4DFR
New Zealand Diet Quality Indices							
Wong et al. (2013)	NZ Diet Quality Index for Adolescents (NZDQI-A)	41 NZ (Dunedin) adolescents (14-18 y)	New Zealand Food and Nutrition Guidelines for Adolescents	FQ and 4DFR	Diet adequacy (adherence to serving recommend ation of all major food groups) and diet variety	5 components. Score ranges from 0-100 with a higher score reflecting a better diet quality	Higher NZDQI-A were associated with more desirable fat and iron intakes. Scores derived from either the FQ and 4DFR were comparable and reproducible when repeated within 2 weeks. The NZDQI-A was relatively valid and reliable in ranking diet quality in adolescents at a group level even in small sample size

Cardiovascular disease-CVD; HEI-Healthy Eating Index; DQI-Diet Quality Index; HDI-Healthy Diet Indicator; MDS-Mediterranean Diet Score; DGI-Dietary Guideline Index; ARFS-Australian Recommended Food Score; HEIFA- Healthy Eating Index for Australian Adults; Aussie-DQI- Aussie Diet Quality Index; DQT- Diet Quality Tool; NZDQI-A-NZ Diet Quality Index for Adolescents; FFQ-food frequency questionnaire; 4DFR-four-day food record, FQ-food questionnaire

Use of dietary indices in an athletic population

To date only two studies have used dietary indices to measure the diet quality of athletes (Burrows et al., 2014; Spronk et al., 2015). Both studies were recently conducted and used the Australian Recommended Food Score (ARFS) (Collins et al., 2015) as well as an adapted version (Adapted Australian Recommended Food Score (A-ARFS)) (Collins, Young, & Hodge, 2008). However, no dietary indices have previously been validated for use in an athletic population. Only one study in the literature has developed a dietary index for use in New Zealand (Wong et al., 2013). Although the NZDQI-A was based on New Zealand dietary guidelines they were adolescent specific. These vary slightly from adult guidelines for example adolescents are recommended to have at least three servings of milk and/or milk alternatives per day where as adults are only recommended to have at least two servings per day (Ministry of Health, 2011, 2015). To date there has been no diet quality indexes developed or validated to measure the dietary intake of an athletic population.

2.9 Development of diet quality indexes

Developing an index of overall diet quality involves many choices related to the variables or index components to be included, the cut-off values and their scoring. The steps for creating an index of diet quality have been outlined in Figure 2.1.

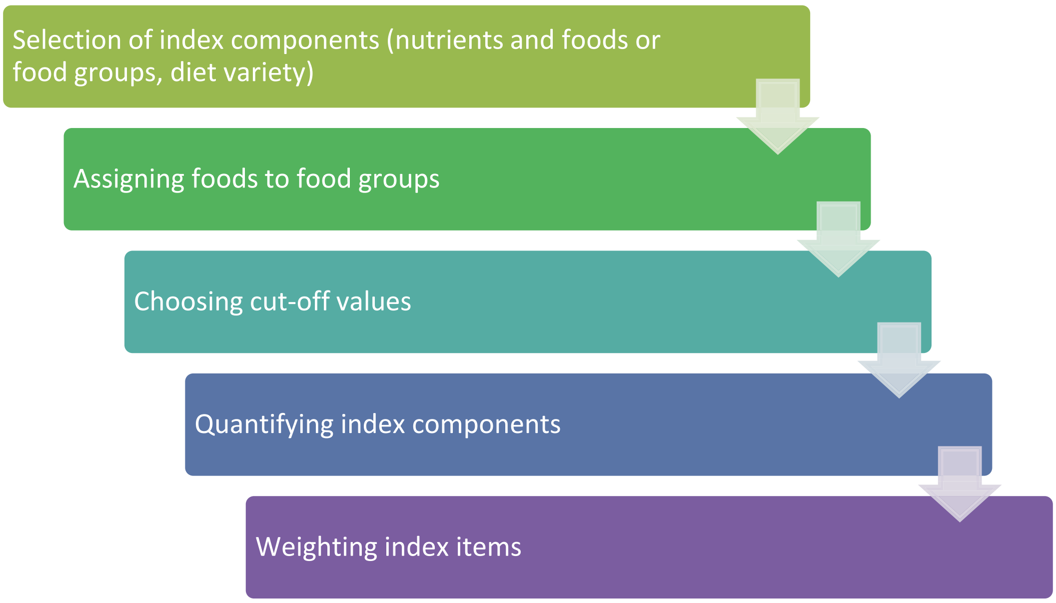

Figure 2.1 Steps involved in the construction of an index of overall diet quality

Index components and assigning food to food groups

Index components usually consist of nutrients and/or foods or food groups that are assumed to be either healthy or unhealthy and are generally based on national dietary guidelines. Some indexes consist solely of food groups or foods, others only of nutrients, and some both. Refer to Table 2.8 for a list of dietary components and corresponding diet indices.

Food groups which appear in almost all food containing indexes are fruits and vegetables (grouped together or separately), cereals and grains, and meat and meat products. Legumes, milk (and dairy products), fish, and nuts (and soya) are also included in some indexes. Other food items include olive oil, bread, potatoes, red and processed meat, poultry and cheese (Waijers & Feskens, 2005). Food items selected as index components often reflect the most recent nutritional knowledge for example fish has only been included in more recent indexes (Waijers & Feskens, 2005). Intake of foods can be expressed in grams but is often expressed as number of servings (Waijers & Feskens, 2005). Alcohol can be included as a food (number of glasses per day) or as a nutrient (grams of ethanol per day) (Waijers & Feskens, 2005). Indices should also consist of foods eaten in that country (culturally appropriate). Once index components have been chosen, foods need to be assigned to them. For some foods this might be easy and others more difficult. For example, should a food group labelled 'milk and dairy' include cheese or ice cream (Waijers et al., 2007).

Nutrients which often occur as index components include total fat, saturated fatty acids (SFA) or the ratio of monounsaturated fatty acids (MUFA) to SFA, cholesterol and alcohol. Sodium, carbohydrates (complex), dietary fibre and protein are also commonly used (Waijers & Feskens, 2005). The units in which intake is expressed differ between indexes and between nutrients. For example total fat or SFA is usually expressed in energy percent (energy %) and micronutrients are expressed in micrograms or as a percentage of recommended dietary intake (Waijers & Feskens, 2005). It is recommended that at least two macronutrients be included in diet quality scores and to use simple variables such as SFA instead of ratio of MUFA:SFA (Waijers & Feskens, 2005).

Another index component sometimes included is dietary variety or diversity (found in the Healthy Eating Index (HEI) and Dietary Guidelines Index (DGI)). Dietary diversity refers to the number of different foods or food groups consumed in a given period. As people with a varied diet or high energy requirements usually score high it has been suggested that completing the Diet Variety Score (DVS) in addition to the index score may be a more acceptable approach (Waijers et al., 2007).

Table 2.8 Overview of dietary variables included in previous diet quality indices (includes sub score components) (adapted from Waijers et al (2007))

Dietary Variable	Name of Diet Index
Nutrients	
Total Fat (g)	DQI, HEI
SFA (g)	DQI, HEI, HDI
Ratio of MUFA or PUFA or SFA	MDS
PUFA (g)	HDI
Protein (g)	DQI, HDI
Complex carbohydrate (g)	DQI, HDI
Dietary fibre (g)	HDI
Mono- and disaccharides (g)	HDI
Cholesterol (mg)	DQI, HDI, HEI
Alcohol (9g)	MDS, DGI, Aussie-DQT
Sodium (mmol or mg/d)	DQI, HEI, Aussie-DQT, HEIFA
Calcium (mg)	DQI
Percentage of total energy from SFA (%)	Aussie-DQT, HEIFA
Percentage of total energy from sugar (%)	Aussie-DQT, HEIFA
Foods/Food groups	
Fruit and Vegetables (serves)	DQI, HDI
Fruit (serves)	MDS, HEI, NZDQI-A, DGI, ARFS, DQT, Aussie-DQT, HEIFA
Vegetables (serves)	MDS, HEI, NZDQI-A, DGI, ARFS, DQT, Aussie-DQT, HEIFA
Bread/cereal/grain (serves)	MDS, HEI, NZDQI-A, DGI, ARFS, Aussie-DQT, HEIFA
Type of breads/cereal/grain (whole grain vs non whole grain) (%)	DGI, DQT, HEIFA
Meat and meat alternatives (serves)	MDS, HEI, NZDQI-A, DGI, ARFS, Aussie-DQT, HEIFA
Lean meat (lean meat and alternatives vs total meats and alternatives) (%)	DGI, HEIFA
Legumes (and nuts and seeds) (serves)	MDS, HDI
Processed meat (serves)	Aussie-DQT
Fish (white/oily/I don't eat fish)	DQT
Trimming the fat off meat (never/rarely/sometimes/usually/I don't eat meat)	DGI, DQT

Milk and milk products (serves)	MDS, HEI, NZDQI-A, DGI, ARFS, HEIFA
Type of milk usually consumed (low-fat vs whole milk) (%)	DGI, DQT, HEIFA
Type of spread usually put on bread (margarine, dairy blends, butter)	DQT
Fluids (serves)	DGI
Water (serves or proportion of total fluids)	DGI, ARFS, HEIFA
Alcohol (serves)	DGI, HEIFA
Added salt (never/rarely/sometimes/usually)	DQT, DGI
Extra foods (high fat/sugar/salt) (serves or number of times per day/week)	DGI, ARFS, DQT, HEIFA
Variety	
Dietary Variety/diversity	HEI, NZDQI-A, DGI, Aussie-DQT, HEIFA

SFA- Saturated fatty acids; MUFA- Monounsaturated fatty acids; PUFA- Polyunsaturated fatty acids
DQI-Diet Quality Index; HEI-Healthy Eating Index; HDI-Healthy Diet Indicator; MDS-Mediterranean Diet Score; NZDQI-A-New Zealand Diet Quality Index for Adolescents; DGI-Australian Diet Guideline Index; ARFS-Australian Recommended Food Score; DQT-Diet Quality Tool; Aussie-DQT-Aussie Diet Quality Tool; HEIFA-Healthy Eating Index for Australian Adults

Scoring and cut-offs

Once index components have been chosen they need to be quantified. The first step is to determine an intake cut-off or range for each index component in order to distinguish between healthy and less desirable consumption levels (Waijers & Feskens, 2005). There are different ways to decide on cut offs. The most straightforward way is to attribute a score of '0' if consumption of an index component is lower than the cut-off and '1' if consumption is higher than the cut-off (Waijers & Feskens, 2005). The MDS uses a group median as the cut-off for each index component. This has no relation with a healthy level of intake however it does mean half the population will score positively and half negatively. Other indexes components are categorized or scaled based on current views on what is a healthy level of intake (based on adherence to national dietary guidelines) (Waijers & Feskens, 2005). Instead of just one cut-off value some indexes contain a lower cut off, an intermediate range, and an upper boundary example (Waijers & Feskens, 2005). This will help account for index components which can be considered both beneficial and detrimental to health such as meat. Consumed in moderate quantities (no more than 500g per week) meat is considered beneficial as it contributes to protein and iron requirements (Ministry of Health, 2015). However high consumption is considered detrimental because of the relatively high saturated fat content (cardiovascular risk) and presence of other harmful substances (charring has been linked to increased cancer risk) (Cancer Society of New Zealand, 2012).

Weighting different index items is also important and can affect the overall score. In most indices, all individual components have the same weight (e.g. each component (nutrient or food group) contributes equally to the total score). But not all components have the same health impact (Waijers & Feskens, 2005). Index items which affect health to a greater degree should be weighted more heavily however this is complex and may affect the indexes predictive capacity and validity (Waijers & Feskens, 2005). Weighting of index components needs to be considered when developing an index.

Total consumption or energy intake may be a confounder and should be considered (Waijers & Feskens, 2005). This is a concern for individuals who have high energy needs such as athletes. A high intake will more easily meet requirements for a number of food group servings or specific cut-offs. A high index score would therefore be achieved, but an athlete may not have a well-balanced or varied diet. Diet variety faces the same problem where individuals (like athletes) with high intakes are more likely to consume a larger variety of foods. Some scores have allowed for energy intake by adjusting for daily intakes of males and females (MDS). The HEI score reflects intake as a proportion of the number of servings recommended for the appropriate energy intake level, based on sex and age (Waijers & Feskens, 2005).

Issues to consider in developing a diet index for athletes

Athletes often consume special or different foods (sport supplements e.g. protein shakes, protein bars, electrolyte drinks). These foods may not easily fit into traditional food groups. Additional dietary components need to be considered, or alternatively how they are assigned to current food groups. A large variety of serving size options need to be available as some athletes restrict intake to make weight categories while others have high requirements to meet increased training demands. Additional questions may need to be added as supplementary questions to the index in order to understand the athlete's dietary habits for example training regime, injuries, supplementation (if not included in the index), demographics (age, gender). It is important that the purpose of an index is considered for example, whether the index might focus on baseline nutrition, training/competition nutrition or both. These will be discussed in more detail below.

2.10 Methods used to validate newly developed indices

Validation of a dietary assessment tool is the process of determining the accuracy by which the method measures actual dietary intake over a specified time period (Lombard et al., 2015). All new dietary assessment methods should be validated. Validation of the method is required to demonstrate the magnitude and direction of measurement error, potential causes of measurement error, and to identify ways in which these errors can be minimised or accounted for in further analysis (Lombard et al., 2015). Validation also provides information on possible misclassification, which is important when diet-disease associations are being investigated (Lombard et al., 2015).

There are three different types of validation which can be used; content validity, construct validity and relative validity. Content validity is the degree to which the test tool measures what it is designed to (Kaplan, Bush, & Berry, 1976). In the context of diet quality indices, content validity measures qualitatively the extent to which an index addresses aspects of diet quality specified by national dietary guidelines. Content validity is considered during the selection of dietary components and is measured by checking index components against dietary guidelines (population specific).

Construct validity examines relationships between the instrument and variables known to be related to the index (Kaplan et al., 1976). An example includes a study completed by Wong et al. (2013) who used construct validity to assess whether there would be a positive relationship between a higher NZDQI-A score calculated from the food questionnaire and more favourable nutrient intakes reported by the 4DFR.

Relative validity (also known as criterion) is when the test method is compared with a reference method that measures the same underlying concept over the same time period. For example Wong et al. (2013) examined correlations between the NZDQI-A scores derived from a food questionnaire to those derived from a 4DFR (for five index components). Ideally the reference method should have been shown to have a degree of demonstrated validity although not necessarily providing an exact measure of the truth (Lombard et al., 2015). Both the test and reference measure will have some degree of inaccuracy and internal measurement error and thus must be independent in order to avoid a correlation error. For example a FFQ method that relies on memory can be validated against weighed food records that do not require the subject to recall their intake (Lombard et al., 2015).

Factors affecting validation studies

Validating dietary assessment tools is complex and relies on ability of participants to report accurate dietary intake information (Lombard et al., 2015). Other factors which affect the validation process include; the characteristics of the population, the type of dietary assessment method used (questionnaire design and quantification), the type of reference method used (adequacy of reference data, sequence of data collection (whether the reference method is applied in a random order or not), quality control of data management, the sample size and seasonality (Lombard et al., 2015).

Respondent characteristics

Literacy can affect self-administered questionnaires/diet indexes and interviews may be required in such cases (Block & Hartman, 1989). Other factors such as obesity status of the participants have been known to affect quality of the dietary data particularly that of diet records (Block & Hartman, 1989). As previously mentioned athletes have numerous eating occasions in order to meet increased recommendations (and often eat on the go). This could affect the quality of dietary data (under-reporting due to high participant burden) as sometimes athletes are unable to record at the time (whilst training or during competition) what they have eaten or had to drink and may forget to record this later. It is also essential that the researcher generates enthusiasm for the study and makes sure the participant understands the importance of accuracy when reporting their dietary intake (Block & Hartman, 1989).

Questionnaire design and quantification factors

The food list (index components) may be incomplete or fail to include the important population sources of nutrients (Block & Hartman, 1989). A questionnaire or index which only has a few categories to describe frequency of consumption will have less precision and may be less valid when compared to reference data (Block & Hartman, 1989). Furthermore, a questionnaire or index that does not have a variety of portion sizes (number of servings) for most or all foods/food groups will have less validity (Block & Hartman, 1989). This is important for populations with high requirements like athletes who need to eat extra servings of particular food groups to meet training and competition nutrition requirements (for example breads and cereals, milk and milk alternatives and meat and meat alternatives to meet CHO and protein requirements). Alternatively, the food list (index components) may also be too extensive and could introduce noise into estimates (Block &

Hartman, 1989). The method by which nutrients and foods/food groups are quantified on the list also affects validity (Block & Hartman, 1989). Providing examples of what one serving size is equivalent to in real food (for example 1 serving of meat is equivalent to 2 chicken drumsticks) is helpful for the participant and could help improve the accuracy of dietary intake data and therefore validity (Block & Hartman, 1989). Attention should be paid to the design of the questionnaire to ensure errors such as recording answers in the wrong place or difficult wording of questions are minimised as these could affect validity (Block & Hartman, 1989).

Reference measure

Food records may be used as the reference method when validating diet indices (O'Reilly & McCann, 2012; Roy et al. 2016; Wong et al, 2013). The number of days required for adequate reference data depends on the dietary components in question (research suggests approximately three to five days for macronutrients and seven to ten for micronutrients) (Block & Hartman, 1989). As mentioned earlier to gather adequate dietary intake data from athletes they must keep a food diary for at least three days (Magkos & Yannakoulia, 2003). Other non-dietary data methods can be used as a reference measure these include; the doubly labelled water technique (real energy intake), 24-h urine samples, hormones and other biomarkers. It has also been suggested that the test measurement be administered prior to the reference measure. If the reference measure is completed first it could draw attention to the athlete’s diet and alter normal dietary patterns (Cade, Thompson, Burley, & Warm, 2002).

Quality control of data management

The quality control of data management can affect both validation and reproducibility. Coding or data entry errors, either in the reference or the test method data may produce disagreement between the two methods (Block & Hartman, 1989).

2.11 Analysis of validation studies

Once dietary intake data has been generated it can be analysed using various statistical methods which reflect different facets of validation such as agreement, association, or bias at group and individual level (Lombard et al., 2015). The most commonly used tests in dietary assessment include paired t-tests/Wilcoxon rank test, percent difference, correlation coefficients, cross classification, weighted kapa coefficients and Bland Altman analysis (Lombard et al., 2015).

Correlation coefficients (Pearson's, Spearman or Intra class) are widely used in validation studies and measure the strength and direction of the association between the two different measurements at individual levels (Lombard et al., 2015). Correlation coefficient values can range from between -1 (perfect negative correlation) to 1 (perfect positive correlation) with a coefficient of zero reflecting no linear relationship between the two measurements (Lombard et al., 2015). These tests should not be used as the sole determinant of validity as they do not show any insight into the level of agreement between the two methods (Lombard et al., 2015). Correlations can be described by the following descriptors: 0-0.1, insubstantial; 0.1-0.3 low; 0.3-0.5 moderate; 0.5-0.7 high; 0.7-0.9 very high and 0.9-1 nearly perfect (Cohen, 1988; Hopkins, Marshall, Batterham, & Hanin, 2009).

Paired t-tests or Wilcoxon signed rank tests reflect agreement between two measures at group level (Lombard et al., 2015). Assessment of mean percent difference between the reference and test measure reflects agreement at group level (size and direction of error at group level) (Lombard et al., 2015).

Cross classification of participants for both the test and reference method into tertiles, quartiles or quintiles (depending on the sample size) allows calculation of the percentage of participants correctly classified in the same category and the percentage misclassified in the opposite category (Lombard et al., 2015). Accurate classification is important and indicates to what extent the dietary assessment method is able to rank participants correctly, thus reflects agreement at the individual level (Lombard et al., 2015). This is particularly important in studies looking at the investigation of diet disease associations. However, cross classification is limited in that percentage of agreement includes agreement by chance. This can be eliminated by performing weighted kapa coefficient statistic as this test is used for data ranked into categories or groups and excludes agreement occurring by chance (Lombard et al., 2015).

Bland-Altman analysis reflects the presence, direction and extent of bias, as well as the level of agreement between two measures at the group level (Lombard et al., 2015). Spearman correlation coefficients are calculated between the mean of the two methods and the mean difference of the two methods to establish the association between the size of the error (or difference between the two methods) and the mean of the two methods, which reflect the presence of proportional bias as well as the direction thereof (Lombard et al., 2015). Plots are created by plotting the difference between the measurements (test-reference measure) (y-axis) against the mean of the two measures (test measure + reference measure/2) (x-axis) for each participant to illustrate the magnitude of disagreement, identify outliers and trends in bias (Lombard et al., 2015). The limits of agreement (95% confidence limits of normal distribution) are calculated as the mean difference +/- 1.96 standard deviation (SD) and reflect over and underestimation of estimates (Lombard et al., 2015).

There is no consensus on type and number of statistical tests that should be ideally applied to assess validity of dietary assessment (Lombard et al., 2015). However, the number of tests typically used varies from one to three (Lombard et al., 2015). Using multiple tests will allow different facets of validity be investigated (Lombard et al., 2015).

2.12 Methods used to assess reproducibility of dietary assessment tools

Reproducibility is the ability of an instrument to produce the same estimate on two different occasions, assuming nothing has changed in the interim (Block & Hartman, 1989). Reproducibility studies do not indicate whether the instrument is producing the correct answer only whether it is producing the same answer. Reproducibility is relatively easy to do and can help confirm validity (Block & Hartman, 1989). Assessing reproducibility can also uncover problems in instrument design, respondent instructions, or quality control that can aid the investigator in improving the dietary assessment method/diet index (Block & Hartman, 1989). Once reproducibility is known the investigator can also decide whether two administrations of the dietary assessment method instead of one is needed in the study design (Block & Hartman, 1989).

However, testing the reproducibility of a diet index can be affected by several factors; the ability of the participants to estimate their diets reliably (for example quantifying the number of servings of a particular food group), and real dietary change during the elapsed time between the two administrations (Block & Hartman, 1989). For this reason, the length between the two administrations is important. Four to eight weeks is considered long enough to minimise the participant remembering their answers from the first administration but short enough to minimise real dietary change (Block & Hartman, 1989). This can be an issue for athletes due to the periodic nature of their training which comes with change in dietary requirements. Finally, the variability of the questionnaire can affect the reproducibility of a dietary assessment tool. For example, a questionnaire with less options for number of servings per food group has less variability and is likely to produce a higher reproducibility score (Block & Hartman, 1989). Again this is difficult for athletes who need a vast range of servings due to increased carbohydrate or protein requirements when their training load increases (Block & Hartman, 1989). The error in questionnaire design or in providing adequate instructions to the participants can also affect reproducibility for example if the participant or interviewer put the answer in the wrong place (Block & Hartman, 1989).

A variety of statistical tests can also be used to analyse reproducibility of dietary assessment methods including paired t-tests, correlation coefficients, cross classification and weight kappa statistics and Bland-Altman plots as previously explained for the statistical analysis of validation studies. A common statistical analysis used is intra class correlations which can be used to assess the consistency between measures of the same class (e.g. measures of the same thing) (Field, 2009).

Many studies have shown correlations between repeat administrations of questionnaires ranging from approximately 0.5-0.8, for various nutrients (Block & Hartman, 1989). Studies in groups with a very routine, repetitive diet tend to have higher reproducibility than studies in groups with a varied diet (Block & Hartman, 1989). That is the same instrument can have different reproducibility in different populations. This should be kept in mind when testing reproducibility of dietary assessment methods used to assess the dietary intake of athletes whose diet is affected by differences in pre, during and post training regime. Few studies have assessed the reproducibility of dietary assessment tools developed for athletic populations (Braakhuis et al., 2011; Pedisic et al., 2008; Ward et al., 2004).

2.13 Summary

It is well known that effective nutrition strategies can enhance the health and performance of athletes. Establishing balanced baseline nutrition (adherence to national food based dietary guidelines) is important as majority of an athlete’s time is spent doing non-athletic activities. Once this has been achieved the athlete can then spend time perfecting training and competition nutrition. When analysing the dietary intake of athletes the following need to be considered; potential under-reporting, adequacy of standard portion sizes, frequency of snacking, fluid intake, supplement use, weight control practises and seasonality of sport activities and food consumption. Traditional dietary assessment methods such as FFQs, 24-h recalls and food records have all been used to measure the dietary intake of athletes. However, these methods can be time consuming and are often associated with high participant burden for busy athletes. They also usually focus on individual nutrients or foods however; people do not consume these dietary components in isolation they consume combinations of foods. An alternative approach is to analyse dietary patterns. These can be measured using statistical techniques such as factor and cluster analysis or by diet quality indices based on adherence to national dietary guidelines. Development of diet indices requires selection of index components (nutrient, foods and/or food groups), cut off points and scoring methods. All index components are then quantified and summed to provide an overall measure of diet quality which can then be compared to nutrient intakes and outcomes such as health and performance. Like all new dietary assessment methods, diet indices need to be assessed for validity and reproducibility. There are three methods used to measure the validity of an index; content, construct and relative validity. Often a combination of these methods is used. It is also important that dietary assessment methods are validated using the population of interest. Reproducibility is the ability of an instrument to produce the same estimate on two different occasions, assuming nothing has changed in the interim (Block & Hartman, 1989). It is relatively easy to do and is an effective way to uncover problems in instrument design or quality control that can aid the investigator in improving the dietary assessment method and in turn validity (Block & Hartman, 1989). Two studies have recently considered the use of dietary indices in athletic populations (Burrows et al., 2014; Spronk et al., 2015). However, no studies have investigated the validity and reproducibility of dietary indices in athletic populations.

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Chapter 3

Manuscript

The development, validity and reproducibility of a tool (the Athlete Diet Index Questionnaire) to assess the dietary intake of high performing athletes

3. Manuscript

3.1 Abstract

Background: Well-chosen eating strategies can enhance an athlete's health and sporting performance. It is important for sports dietitians and nutritionists to have access to accurate and reliable dietary assessment methods. Currently there is no population specific, simple food based dietary index suitable for the examination of diet quality among athletes. This study aimed to develop a diet quality index (the Athlete Diet Index Questionnaire (ADI-Q)) which focusses on the baseline nutrition requirements of high performing New Zealand athletes, and examine the validity and reproducibility of food groups, food variety, fluid consumption and eating habits within the ADI-Q.

Methods: The ADI-Q was developed for high performing athletes and was based on dietary components which reflect the Eating and Activity Guidelines for New Zealand Adults (EAGNZA). Athletes who represented their main sport at a regional level or above volunteered to participate in the study. During the first appointment athletes completed the ADI-Q (ADI-Q#1) and an estimated four-day food record (4DFR) (to assess relative validity). The test-retest reliability of ADI-Q#1 was assessed by a second administration of the ADI-Q (ADI-Q#2) four-weeks later. Both relative validity and reliability were assessed using paired-t tests, Pearson's correlation coefficients, Chi square analysis and Bland-Altman plots.

Results: Sixty-eight athletes (26 males, 43 females, 16-71 years) involved in more than 30 different sports completed the study. When assessing relative validity paired t-tests showed good agreement between servings of dried fruit/fruit juice, starchy vegetables, milk and/or milk alternatives, lean meat (beef, lamb, pork) and times treat food were consumed ($p>0.05$). Food groups found to be significantly different tended to have a lower mean number of servings for the ADI-Q#1 compared with 4DFR. Correlation coefficients ranged from 0.19 (servings of starchy vegetables) ($p>0.05$) to 0.66 (servings of non-starchy vegetables) ($p<0.05$) with an average correlation of 0.42. Variety of fruit and vegetables had an average correlation of 0.52. The majority of fluid components had good agreement with only servings of milk and/or milk alternatives and soft drinks/fizzy drinks/carbonated water found to be significantly different ($p<0.05$). Correlation coefficients ranged from -0.03 (flavoured water/sports water and coconut water) ($p>0.05$) to 0.77 (herbal tea) ($p<0.05$) with an average correlation of 0.39. Healthy versus less healthy options showed poor agreement between the ADI-Q#1 and the 4DFR with all components except the use of unsaturated fat being significantly different ($p<0.05$). Meal frequency showed good agreement with only consumption of morning tea found to be significantly different between methods ($p<0.05$). When assessing reproducibility, there was no significant difference found between most dietary components with the exception of servings of non-starchy vegetables, breads and cereals, meat alternatives, water and times takeaways were consumed ($p<0.05$). Significantly different food groups and fluids had a higher mean number of servings/times from ADI-Q#1 compared with ADI-Q#2. Correlation coefficients for food groups ranged from 0.18 (servings of lean meat) ($p>0.05$) to 0.63 (servings of starchy vegetables) ($p<0.05$) with an average correlation of 0.46. Variety of fruit and vegetables had an average correlation of 0.56. The correlation coefficients for fluid consumption ranged from -0.02 (servings of flavoured water/sports water) ($p>0.05$) to 0.91 (servings of coffee) ($p<0.05$) with an average correlation of 0.52. There was no significant difference between healthy versus less healthy options and meal frequency between the first and second administration of the ADI-Q.

Conclusions: The ADI-Q showed reasonable validity for the majority of dietary components when compared with a 4DFR. Reproducibility of the ADI-Q was moderate to high for majority of the dietary components. Further development of the ADI-Q and index score to assess diet quality may help to improve the analysis of dietary intake among high performing athletes.

3.2 Introduction

Adequate nutrition (food and fluid) is needed to fuel athletes during times of high physical exercise, to maintain weight, replenish glycogen stores, and provide adequate protein to build and repair tissue (American College of Sports Science et al., 2016). Therefore, it is important for athletes to choose effective nutrition strategies to not only improve their health but to optimise performance and recovery. Key nutrition areas which need to be considered when working with high performing athletes include baseline nutrition, training nutrition and competition nutrition. Baseline nutrition refers to the food and fluid athletes need to meet daily energy and nutrient requirements for good health. Balanced baseline nutrition is important as athletes spend the majority of their time undertaking non-athletic activities such as recovery. Meeting baseline requirements also provides the athlete with a platform for optimal performance and recovery.

Sports dietitians and nutritionists need to have access to accurate and reliable dietary assessment methods in order to provide athletes with effective nutrition strategies. Traditional methods such as 24-hour diet recalls, food frequency questionnaires (FFQs) and diet histories have all been used to measure the dietary intake of athletes. These retrospective methods rely heavily on the athlete's memory and honesty (Magkos & Yannakoulia, 2003). Prospective techniques such as weighed or estimated diet records monitor ongoing food consumption, however are likely to be affected by poor compliance and alteration of the athlete's usual intake (Magkos & Yannakoulia, 2003). When conducting dietary assessment of athletes, a number of factors need to be considered. These include under-reporting, additional snacking, high fluid requirements, the use of supplements, seasonality of sport and weight management (Driskell & Wolinsky, 2011).

Analysis of dietary intake data from athletes using traditional dietary assessment methods typically focuses on single nutrients or food groups, however more recently research among athletes has explored their diet quality. (T. Burrows et al., 2016; Spronk et al., 2015). The use of a diet index is one way in which diet quality can be explored. The index provides a summary of dietary patterns (combinations of foods eaten as part of the total diet) as a composite score according to predefined criteria of what constitutes a healthy or unhealthy diet (Wong et al., 2013). They can be based on foods, nutrients or a combination of both, and typically measures the degree of adherence to a set of national nutrition guidelines or a recommended diet prototype such as the Mediterranean diet (Wong et al., 2013). Better index scores tend to be associated with more favourable nutrient and food intake (Wong et al., 2013).

Newly developed dietary assessment tools should be assessed for their validity (do they measure what they intend to measure) and their reproducibility (ability to produce the same estimate on two different occasions, assuming nothing has changed in the interim) using a variety of statistical tests (Block & Hartman, 1989).To date only a few dietary assessment methods have been developed and validated specifically in athletic populations. These have included mainly FFQs (Braakhuis et al., 2011; Sunami et al., 2016), diet recalls (Briggs et al., 2015; Baker et al., 2014), an online virtual self-service restaurant (Scoffier et al., 2013) or brief questionnaire's (Fogelholm & Lahtikoski, 1991; Ward et al., 2004). These dietary assessment tools have mostly been validated for intake of energy (Briggs et al., 2015; Scoffier et al., 2013) and nutrients (Baker et al., 2014; Braakhuis et al., 2011; Fogelholm & Lahti-Koski, 1991; Sunami et al., 2016; Ward et al., 2004) with only a single tool being validated for food groups (Sunami et al., 2016). Few studies have looked at the reproducibility of dietary assessment tools in athletes (Braakhuis et al., 2011; Pedisic et al., 2008; Ward et al., 2004).

Currently no dietary indices have been developed or validated in an athletic population, nor has any study assessed the adherence of athletes to the New Zealand Eating and Activity Guidelines. The development of such an index could help identify athletes who would benefit from further dietary advice, be used to educate athletes on dietary choices for optimal health and sports performance or be used in research. Other benefits for using indices to assess the dietary intake of athletes includes; they are easy to access (available online), usually brief in context (lower participant burden), easy to interpret (single score) and lower burden for the health professional or researcher.

Therefore, the aim of this research is to develop a valid and reproducible tool, known as 'the Athlete Diet Index Questionnaire' (ADI-Q) to assess the diet quality of high performing athletes, which focusses on food group intake, variety, fluid consumption and eating habits.

3.3 Methods

Study design and participants

The majority of this research was conducted in Auckland at the Massey University Human Nutrition Research Centre (MUHNRC). Inclusion criteria were; high performing athletes (defined as representing their main sport at regional level or above) and aged 16 years or older. All sporting codes had the opportunity to participate in this study. For validation studies of dietary assessment methods, a sample size of more than 100 participants is recommended (Serra-Majem et al., 2009). Athletes from throughout New Zealand were recruited through extensive modes such as mass media (newspapers, social networking websites), promotional flyers and posters, emails and phone calls to national sporting institutes and organisations, secondary schools, sport dietitians, nutritionists and sports physiotherapists along with face to face presentations to sports groups including Harbour Sport and the Massey University Academy of Sport.

The study protocol was reviewed and approved by the Massey University Human Ethics Committee: Northern (Application 15/37). All participants provided written informed consent prior to participating in the study and were able to opt out of the study at any time. Participants were reimbursed with $40 in vouchers for taking part in the study.

Development of the Athlete Diet Index Questionnaire

The nutrition screening tool ‘the Athlete Diet Index Questionnaire’ (ADI-Q) (Appendix B) was developed by the lead researcher and two academic supervisors in consultation with sports nutritionists, registered dietitians, athletes and sport personnel. A Māori Advisor at Massey University was also consulted to ensure the ADI-Q was culturally appropriate (e.g. incorporating foods and names of foods consumed in New Zealand such as kaimoana (seafood), watercress and taro). The nutrition screening tool (the ADI-Q) contained four parts. This study focuses on the questions contained in part two of the ADI-Q which was created to measure the quality of an athlete’s dietary intake via adherence to national food based guidelines (The Eating and Activity Guidelines for New Zealand Adults). The three additional sections contained questions related to the athlete’s main sport, training regime, goals and injuries (part one); health, special diets and supplement use (part three); and demographic questions (age, gender, ethnicity, country of birth, height and weight). These components provide information on other aspects considered important for interpreting the dietary habits of athletes.

Dietary components

Dietary components for part two of the ADI-Q were based on the Eating and Activity Guidelines for New Zealand Adults (EAGNZA). The format was modelled on other diet indices created for the general population in New Zealand and Australia (CSIRO, 2016; Wong et al, 2013). A large number of questions were derived from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Healthy Diet Score (CSIRO, 2016) and adapted to meet the needs of athletes (for example a large number of servings were able to be selected for each dietary component and sport specific drinks were added to the fluids list e.g. sports drinks (Powerade and Gatorade)). Questions were designed to ask the participant to select the time frame (e.g. yearly, monthly, weekly, daily, not applicable) and frequency (e.g. 0-14+ serves) in which each dietary component was normally consumed. A list of dietary recommendations, their corresponding dietary component and choices provided from part two of the ADI-Q are presented in Table 3.1 below.

Table 3.1 Dietary components of the ADI-Q according to the EAGNZA (Ministry of Health, 2015)

Dietary Guideline	Dietary Component	Response
Eat a variety of nutritious foods every day	Which of the following fruit have you eaten over the last seven days?	Apple or pear, banana, canned or stewed fruit, citrus fruit (e.g. orange, mandarin, tangelo, grapefruit, lemon), feijoa, grapes, kiwifruit, rhubarb, stone fruits (e.g. peach, nectarine, plum, apricot), strawberries or other berries (e.g. blueberries, blackberries, boysenberries, raspberries), tropical fruits (e.g. pineapple, mango, pawpaw, watermelon), other (please specify)
	Which of the following vegetables have you eaten over the past seven days?	Asparagus, avocado, beetroot, broccoli, cabbage/ brussel sprouts, capsicum, carrot, cassava, cauliflower, corn, courgette, cucumber, eggplant or aubergine, green beans, kumara, lettuce or green salad, mixed vegetables, mushrooms, onions/garlic/celery/leeks, parsnip, peas, potato or taewa (Maori potato), pumpkin, taro, tomato, yam, other (please specify)
Eat at least 2 servings of fruit every day	How often do you usually eat fruit (include fresh, frozen and canned fruit)	Never, yearly, monthly, weekly, daily
	How many servings of fruit do you usually eat in the timeframe selected above (do not include fruit juice or dried fruit)?	0-14+ serves
	How often do you usually eat dried fruit or juice?	Never, yearly, monthly, weekly, daily
	How many servings of dried fruit or juice do you usually eat in the timeframe selected above?	0-14+ serves
Eat at least 3 servings of vegetables every day	How often do you usually eat starchy vegetables?	Never, yearly, monthly, weekly, daily
	How many servings of starchy vegetables do you usually eat in the timeframe selected above?	0-14+ serves
	How often do you usually eat non-starchy vegetables?	Never, yearly, monthly, weekly, daily

Dietary Guideline	Dietary Component	Response
	How many servings of non-starchy vegetables do you usually eat in the timeframe selected above?	0-14+ serves
Eat at least 6 servings of grain food every day	How often do you eat breads and cereals	Never, yearly, monthly, weekly, daily
	How many servings of breads and cereals do you usually eat in the timeframe selected?	0-14+ serves
Choose mostly whole grain and those naturally high in fibre	How often do you choose whole grain breads and cereals over more refined breads and cereals?	Never, rarely (1/4 of the time), sometimes (1/2 of the time), mostly (3/4 of the time), always, not applicable I don't eat breads and cereals
Eat/drink at least 2 servings of milk and milk products ever day	How oft do you eat or drink milk or milk alternatives?	Never, yearly, monthly, weekly, daily
	How many servings of milk or milk alternatives do you usually eat/drink in the timeframe selected above?	0-14+ serves
Choose low-fat or reduced-fat milk and milk products	How often do you choose low fat milk or milk alternatives over standard or regular milk or milk alternatives?	Never, rarely (1/4 of the time), sometimes (1/2 of the time), mostly (3/4 of the time), always, not applicable I don't eat or drink milk or milk alternatives
Eat at least 2 servings every day of legumes, nuts or seeds OR at least 1 serving of seafood, eggs, poultry or red meat every day	How often do you usually eat red meat (e.g. beef, lamb, pork, venison, veal, corned beef or silverside)	Never, yearly, monthly, weekly, daily
	How many servings of red meat do you usually select in the timeframe selected above?	0-14+ serves
	How often do you usually eat chicken (do not include chicken nuggets)?	Never, yearly, monthly, weekly, daily
	How many servings of chicken do you usually select in the timeframe selected above?	0-14+ serves

Dietary Guideline	Dietary Component	Response
	How often do you usually eat kaimoana (fish and other seafood)?	Never, yearly, monthly, weekly, daily
	How many servings of kaimoana do you usually select in the timeframe selected above?	0-14+ serves
	How often do you usually meat alternatives?	Never, yearly, monthly, weekly, daily
	How many servings of meat alternatives do you usually eat in the timeframe selected above?	0-14+ serves
Choose and prepare foods with:	How often do you remove the fat from meat or the skin from chicken?	Never, rarely (1/4 of the time), sometimes (1/2 of the time), mostly (3/4 of the time), always, not applicable I don't eat meat or chicken
Unsaturated fats instead of saturated fats	How many times have you had processed meat in the timeframe selected above?	0-14+ times
That are low in salt (sodium); if using salt use iodised salt	How often do you have treat foods (biscuits, cakes, sweets, lollies, chocolates, ice blocks, or puddings)?	Never, yearly, monthly, weekly, daily
With little or no added sugar	How many times do you have treat foods in the timeframe selected above?	0-28+ times
That are mostly 'whole' or less processed	How often do you usually have takeaway foods (KFC, Mc Donald's, Burger King, fish and chips, deep fried chicken, commercial burgers, pizza, mince pies, sausage rolls, pastries, hot chips, wedges or savoury snacks (e.g. potato chips)	Never, yearly, monthly, weekly, daily

Dietary Guideline	Dietary Component	Response
	How many times do you have takeaways in the timeframe selected above?	0-28+ times
	How often do you cook with or add the following unsaturated fats to food (e.g. margarine, olive oil) rather than saturated fats (e.g. butter, cream, sour cream)?	Never, rarely (1/4 of the time), sometimes (1/2 of the time), mostly (3/4 of the time), always, not applicable I don't cook with or add any fats to foods
	How often do you add salt to foods in cooking or at the table?	Never, rarely (1/4 of the time), sometimes (1/2 of the time), mostly (3/4 of the time), always
Make plain water your first choice over other drinks: 8 cups for females including plain water, milk 10 cups for males including plain water, milk	How often do you usually have the following drinks; flavoured water/ vitamin water / sports water, sports drinks (e.g. Gatorade, Powerade), coconut water, water (including water added to protein shakes), milk and/or milk alternatives (including milk added to protein shakes, Up and Go's, Fast Start and flavoured milk), fruit juice, soft drinks/fizzy drinks/carbonated drinks, herbal tea, tea, drinking chocolate, milo, cocoa, coffee and energy drinks	Never, yearly, monthly, weekly, daily
		0-20+ serves
If you drink alcohol keep your intake low:	How often do you usually drink alcohol?	Never, yearly, monthly, weekly, daily
2 standard drinks per day for females 3 standard drinks per day for males	How many standard drinks do you usually have in the timeframe selected above?	0-14+ serves

Dietary Guideline	Dietary Component	Response
Meal frequency [a]	How often would you have breakfast, morning tea, lunch, afternoon tea, evening meal and supper	Never, rarely (1/4 of the time), sometimes (1/2 the time), mostly (3/4 of the time), always

EAGNZA – Eating and Activity Guidelines for New Zealand Adults; ADI-Q – Athlete Diet Index Questionnaire
[a] Not based on a guideline from the EAGNZA

Pre-testing of the ADI-Q

The ADI-Q was pre-tested on several occasions during the design stages; both on paper and online by athletes and coaches from New Zealand and Australia who provided feedback regarding how long the ADI-Q took to complete and understanding of questions asked. Four sports dietitians from New Zealand and Australia offered suggestions which included; the re-wording of questions, adding additional examples of serving sizes, addition of food items and possible questions to be considered for inclusion. They also identified some technical problems with the online version (e.g. being able to skip questions which required answers). All suggestions were considered, changes were made and further pre-testing occurred on the changes implemented.

Computerised format of ADI-Q

The final computerised format of the ADI-Q was placed on the survey software, Survey Monkey (SurveyMonkey INC, 2016) and took approximately 10-15 minutes to complete. Each section had a brief explanation regarding the questions that followed. The majority of the questions were in multi choice format or a drop-down menu where athletes selected their responses from a list. To progress through the instrument all questions needed to be completed, this prevented participants accidentally omitting a response. A progress bar and thoughtful messages like 'you have completed more than 50% of the survey' were included in the computerised format to maintain participant motivation during the completion of the ADI-Q.

Phases of data collection

The study was conducted in three phases; phase one included the first administration of the ADI-Q (onsite); phase two involved participants keeping an estimated 4DFR (relative validity) and phase three was the second administration of the ADI-Q (offsite) which was to be used to test reliability of the tool. Below is a detailed description of the participant's involvement in each phase.

Phase one of the ADI-Q study

Phase one (initial appointment) of the ADI-Q study took approximately one hour. It was completed either onsite at the Massey University Human Nutrition Research Centre (MUHNRC) or offsite at a location with internet access (e.g. one high school in Manawatu and one in Hawkes Bay). Each participant was given a unique ID number which was used to maintain confidentiality throughout the study. Standard order of procedures (SOPS) were developed and followed to ensure the same techniques (e.g. to measure height and weight) were used and order of administration (e.g. complete the training and supplement questionnaire followed by ADI-Q) was followed for each participant (Appendix B).

Anthropometric measurements were taken which included height (portable stadiometer: Seca, model #213) and weight (Wedderburn). Two measurements were recorded with a third being completed if the measurement error was greater than 1%. Participants were then required to complete a series of online questionnaires including a training and supplement questionnaire which took approximately five minutes to complete. It included questions on the athlete's current weekly training regime and supplement intake during the last month (brand, dosage, frequency of vitamin, mineral, sports or any other supplement).

The second online questionnaire was the ADI-Q which takes approximately 10-15 minutes to complete. Participants were given a copy of the "What does a 'serving' look like?" guide based on recommendations from the New Zealand Ministry of Health to assist in estimations of number of serves (Appendix B) (Healthy Food Guide, 2015). The recommended number of serves for each food group was blanked out to prevent biasing of answers from participants.

A trained member of the research team was present at all times during the completion of the first appointment so any questions the participant/s had could be addressed.

Phase two of the ADI-Q study – Relative validity of the ADI-Q

An estimated food record (4DFR) (Appendix B) was used as the reference method for validation of the ADI-Q. Athletes were allocated four consecutive days which included one weekend day, one rest day and one hard training day to ensure any differences in dietary intake would be accounted for. This was based on their current training regime at the time of their initial appointment.

Participants were given instructions by trained researchers on how to keep an estimated food record. This included watching audio visual instructions created by nutritionists and dietitians at the Massey University Human Nutrition Research Centre (MUHNRC). Participants were asked to record all food, fluids and supplements consumed over the four- day period in detail. This included; time, location (e.g. at home or the game), brand names (e.g.Sanitarium, Pams), type (e.g. full fat or trim milk), cooking methods (e.g. poached or fried), quantity (e.g. household measures such as one cup of grated cheese or a palm size piece of cooked chicken). Athletes were also given a food portion guide

(Nelson et al., 1997) which they could use to help estimate portion size) and the portion of food not eaten (e.g. one apple, core not eaten or one medium kumara peeled). Athletes were instructed to record any homemade recipes and provide researchers with packaging for ease of data entry. The food diaries were sent back to the Massey University Human Nutrition Research Centre (MUHNRC) via a self-addressed envelope given to the athletes at their first appointment. All food diaries were followed up with a phone call or email to ensure accuracy of the dietary data collected.

Phase three of the ADI-Q study – Reproducibility of the ADI-Q

Four weeks after the initial appointment athletes completed the training and supplement questionnaire (revised version Appendix B) and ADI-Q for a second time either online, at home or at the Massey University Human Nutrition Research Centre.

Participants completed the questionnaires in the same order as the initial appointment and were provided with the "What does a 'serving' look like?" guide like at their initial appointment to help complete ADI-Q#2 (Healthy Food Guide, 2015). The training and supplement questionnaire differed from the initial appointment. Athletes were not required to complete a detailed outline of their current training regime instead they were asked to describe if their training or dietary intake had changed since their first appointment and if yes to provide a description. They were also asked if they had taken and vitamins, minerals, sport supplements or other dietary supplements over the last month since their initial appointment.

Data handling and analysis

Relative validity of the ADI-Q was assessed by comparing responses from the ADI-Q#1 (first appointment) with those derived from the 4DFR, and reproducibility by comparing the first and second administrations of the ADI-Q.

ADI-Q

Data from the ADI-Q#1 was exported from Survey Monkey into excel spread sheets. All the excel data was checked to ensure there was no missing data by both the researcher and research assistant. Demographic data including ethnicity and the athletes main sport were grouped for ease of analysis. Major ethnic groups were identified using results from the New Zealand Census (Statistics New Zealand, 2015). Sports groups were determined based on common attributes (e.g. endurance, aesthetic). Responses (timeframe and number of servings) were converted into daily or weekly amounts so comparisons could be made with the 4DFR. The following conversion factors were used to convert responses into daily amounts; yearly was divided by 365; monthly was divided by 28; weekly was divided by seven and daily amounts remained the same. For example, if a participant selected that they had fruit weekly and 14 serves this would be divided by seven to get a daily amount of two serves. To convert responses into weekly amounts; daily was multiplied by seven; weekly remained the same; monthly was divided by four and yearly divided by 52. For example, if a participant selected that they had one serve of lean meat (beef, lamb, pork) daily it was multiplied by seven to get a weekly amount of seven serves of lean meat. No conversions were necessary for food variety (fruit and vegetables) healthy food choices (for example do you choose wholegrain breads and cereals?), and meal frequencies. The same process was used for data from the ADI-Q#2.

Four-day food records

Food groups, fluids, food variety, healthy food choices and meal frequency

Individual food items from the 4DFR had to be assigned to corresponding dietary components from the ADI-Q (see assumptions in Appendix B). The quantity of individual food items over the four days were added to get one overall number of serves or times consumed for each dietary component (for food groups, fluids, variety). For example, if one piece of bread and one cup of rice was consumed over four days, this was equivalent to two servings of breads and cereals within four days. Examples from the Ministry of Health Eating and Activity Guidelines were used to help determine servings sizes when analysing the 4DFRs. (Ministry of Health, 2015). These were then converted into daily or weekly amounts for comparison with ADI-Q#1. The following conversion factors were used; to get a daily amount the total number of servings or times consumed from the 4DFR was divided by four and to get a weekly amount the total number of servings or times consumed from the 4DFR was divided by four and then multiplied by seven. For example, if a participant had 12 servings of breads and cereals in four days they would have a daily amount of three serves of breads and cereals.

Dietary habit data also had to be extracted from the 4DFR and coded to reflect the ADI-Q. For example, the question "How often do you choose wholegrain breads and cereals?" was answered on the ADI-Q as never; rarely (1/4 of the time); sometimes (1/2 the time); mostly (3/4 of the time); always or not applicable. From the 4DFD, the total amount of breads and cereals over four days was summed, and the proportion of wholegrain food items determined. If the participant had no breads and cereals, it was coded not applicable; if wholegrain breads and cereals were consumed 0-25% of the time this was coded as never or rarely; 25-75% was coded as sometimes; and 75-100% was coded as mostly or always. Meal frequency data was also determined from the 4DFRs and coded to reflect the ADI-Q (never, rarely (1/4 of the time), sometimes (1/2 the time), mostly (3/4 of the time) and always). For example, if someone had breakfast once in the four days they were coded as having breakfast 1/4 of the time (rarely).

FoodWorks – Nutrient analysis

The 4DFRs were entered into FoodWorks 8 (FoodWorks 8 Professional, 2016) which is based on the New Zealand Food Composition Database (The New Zealand Institute for Plant and Food Research limited & the Ministry of Health, 2015) to determine energy, macro-and micronutrient intake. For home-made recipes, all individual ingredients were entered into FoodWorks as a 'recipe' taking into account the number of serves the recipe provided. Similar products/generic products were used for food items which couldn't be located. Conversion factors were used for raw ingredients, to ensure the cooked proportion was used for analysis (for example all raw meat was multiplied by 0.7 and all raw vegetables multiplied by 0.8 to allow for cooking loses). The Australian database was used to ensure accurate analysis of some sports supplements (e.g. clean lean protein and Red 8 protein) and less common foods such as chia seeds, cocoa and kale. The data was entered by one research assistant and one Master's of Science Nutrition and Dietetics student (lead researcher). The data was checked by the research assistant using energy and nutrient values in excess of recommendations in order to identify incorrectly entered data. Main assumptions made for the entry of data into FoodWorks can be found in Appendix B.

Statistical analysis

All statistical analyses were conducted using SPSS 23.0 for windows (IBM Corp, Released 2015). All data was assumed to be normally distributed based on the central limit theorem (Field, 2009). Descriptive statistics of continuous demographic variables (age, height, weight) were reported as means and standard deviations (SD) whilst categorical demographic data (gender, ethnicity, main sport, highest representative level) were reported as count (n) and corresponding percentage (%). Frequency of servings from each ADI-Q component were also reported for responses form the ADI-Q#1 and 4DFR as count (n) and corresponding percentage (%) (Appendix A). In addition, the percentage of participants meeting the recommendations from the EAGNZA were calculated.

To assess relative validity of the ADI-Q individual dietary components from the ADI-Q were compared with corresponding components derived from the 4DFR using a range of statistical methods. These included; paired t-tests, effect size, Pearson's correlation coefficients, Chi square tests and Bland-Altman plots.

Paired t-tests are used in validation studies to determine agreement between two measures (ADI-Q#1 and 4DFR) at the group level (Lombard et al., 2015) with the significance level of the p-value set at <0.05, two tailed. The effect size was calculated as an objective measure of the importance of an effect using the formula $r=\sqrt{t^2/t^2+df}$ where t is the test statistic from the paired t-test, and df the degree of freedom. Analysis of the effect size was based on recommendations from Field (2009); small effect when r=0.1, medium effect when r=0.3, and a large effect when r=0.5.

Pearson's correlation coefficients were used to determine the strength and direction of association between the ADI-Q#1 and 4DFR (Lombard et al., 2015). The relationship between dietary components from each assessment tool was reported in accordance with Cohen (1988), and Hopkins et al (2009) descriptors for correlation coefficients; 0.9-1 almost perfect; 0.7-0.9 very high; 0.5-0.7 high; 0.3-0.5 moderate; 0.1-0.3 low and 0-0.1 insubstantial.

Chi square tests were used to assess the relative validity of dietary habits (healthy compared with less healthy options and meal frequency) between the ADI-Q#1 and 4DFR.

Finally, the presence, direction and extent of bias as well as agreement between the ADI-Q#1 and 4DFRs at the group level was assessed using Bland-Altman plots (Lombard et al., 2015). The limits of agreement (LOA) were determined by computing the mean difference ±1.96 standard deviations (SD) and reflect over and underestimation of estimates (Lombard et al., 2015).

Reproducibility of the ADI-Q#1 and ADI-Q#2 was assessed using the same variety of statistical tests used to determine relative validity. All tests were two-tailed with the significance level of the p-value set at <0.05.

3.4 Results

The results presented focus on participant characteristics, adherence to the EAGNZA, followed by results describing the validity and reproducibility of the ADI-Q.

Participant characteristics

A total of 92 athletes were recruited to participate in the Athlete Diet Index Questionnaire (ADI-Q) study. Between appointment one (ADI-Q#1) and the completion of the study 17 participants withdrew (mainly due to time constraints including training/sporting commitments). An additional six participants appeared to have unreliable data including unusual servings selected for core food groups (e.g. 12 serves of chicken daily, 14 serves of fruit per day) and were therefore removed prior to analysis. This left a final sample size of 69 athletes of whom 68 (one participant's food diary was not returned) were used to validate the ADI-Q#1 against the 4DFR. Sixty-seven participants were used to test the reproducibility of the ADI-Q by completing ADI-Q#2 four weeks later (two participants did not complete the online ADI-Q#2).

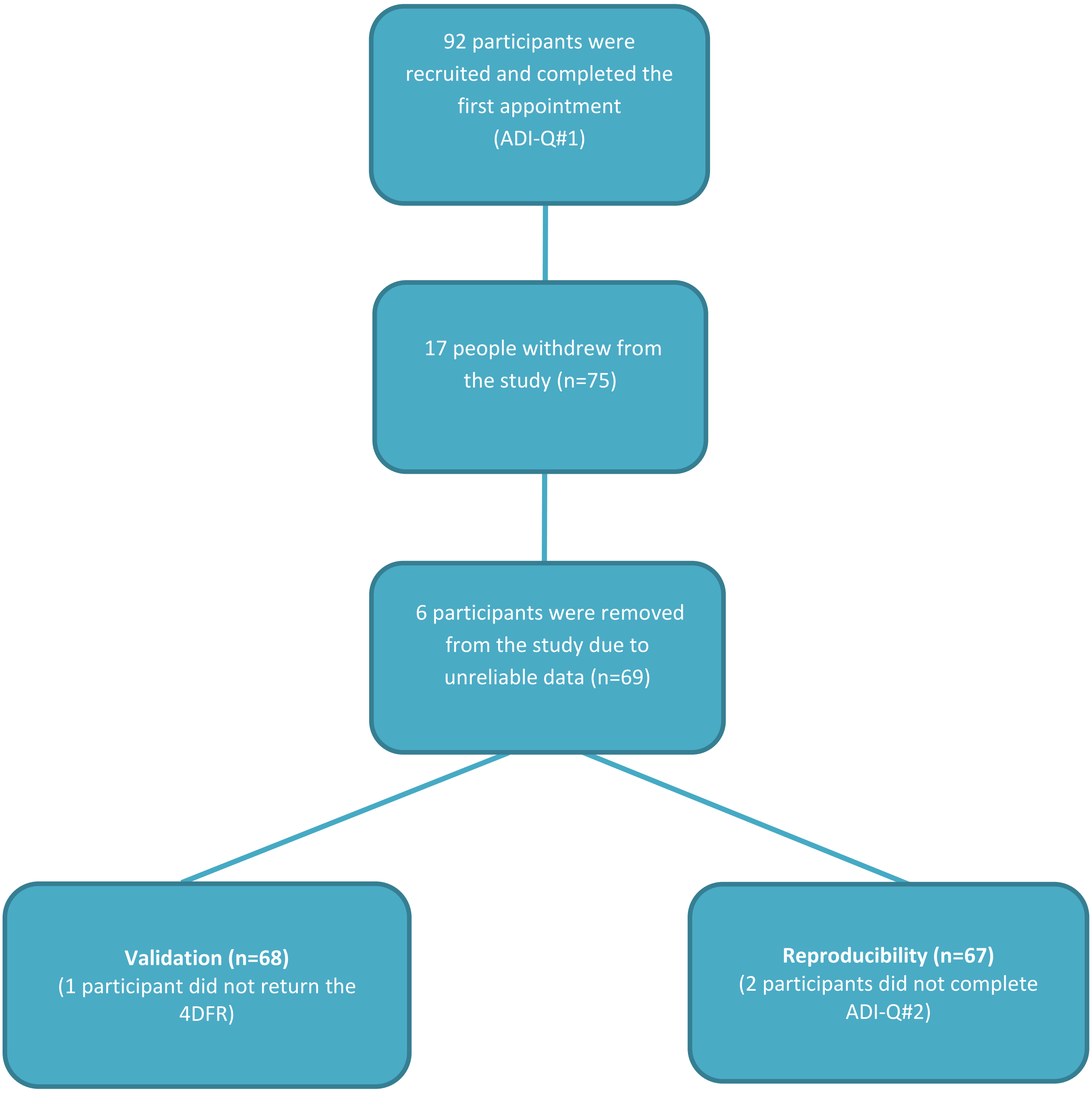


Figure 3.1 Study flow diagram showing number of participants used to validate the ADI-Q and test its reproducibility

Demographic characteristics of the sample are presented in Table 3.2. Approximately 62% of the athletes were female and ranged in age from 16 to 73 years, with a mean age of 23±10 years. Many ethnicities were represented however the majority were European (78.3%). Participants were involved in more than 30 different sports. Team sports reflected the main sport for most participants (39.1%). Athletes were training on average 13.94±4.94 hours per week.

Table 3.2 Participant characteristics of athletes (n=69)

Characteristics	Total	Female	Male
Age (years)[a]	23±10	22±10	25±11
Gender [b]	69 (100.0)	43 (62.3)	26 (37.7)
Height (m) [a]	1.71±0.11	1.60±0.10	1.80±0.10
Weight (kg) [a]	68.7±13.4	61.2±8.7	80.9±10.2
BMI (kg/m^2) [a]	23.4±3.0	22.5±2.6	24.9±3.1
Ethnicity [b]			
European	54 (78.3)	31 (57.4)	23 (42.6)
Māori	7 (10.1)	5 (71.4)	2 (28.6)
Asian	5 (7.2)	4 (80.0)	1 (20.0)
Pacific Islander	2 (2.9)	2 (100.0)	0 (0.0)
Middle Eastern/Latin American/African	1 (1.4)	1 (100.0)	0 (0.0)
Main sport [b]			
Athletics	4 (5.8)	2 (50.0)	2 (50.0)
Aesthetic sports (gymnastics, figure skating)	6 (8.7)	5 (83.3)	1 (16.7)
Combat sports (boxing, karate, judo, mixed martial arts)	3 (4.3)	2 (66.7)	1 (33.3)
Power sports (weightlifting, powerlifting)	4 (5.8)	2 (50.0)	2 (50.0)
Endurance sports (triathlon, swimming, running, cycling)	11 (15.9)	8 (72.7)	3 (27.3)
Precision sports (archery, golf, shooting)	3 (4.3)	2 (66.7)	1 (33.3)
Racquet sports (badminton, squash, tennis)	3 (4.3)	1 (33.3)	2 (66.7)
Team sports (soccer/football, hockey, rugby, netball, basketball, rugby sevens, cricket)	27 (39.1)	16 (59.3)	11 (40.7)
Water sports (water polo, kayaking, rowing, sailing)	8 (11.6)	5 (62.5)	3 (37.5)

Characteristics	Total	Female	Male
Highest representative level [b]			
Regional - competitive/representative	8 (11.6)	6 (75.0)	2 (25.0)
National	19 (27.5)	13 (68.4)	6 (31.6)
International - age group	21 (30.4)	12 (57.1)	9 (42.9)
International - open	21 (30.4)	12 (57.1)	9 (42.9)

BMI: body mass index kg/m^2
[a] Values are mean±SD
[b] Values are frequency (n) and (%)

Over three quarters (81.2%) of the athletes had taken dietary supplements, sports foods or ergogenic aids. These included multi vitamins and minerals (36% of athletes), iron (19%), calcium (7%), magnesium (23%), vitamin D (7%), omega 3 (28%), probiotics (13%), carbohydrate/electrolyte drinks (49%), sports bars (16%) or gels (13%), liquid meal replacements (3%), pre-workouts (9%), protein powders (42%), caffeine (32%), Beta-alanine (4%) and nitrates or beetroot juice (1%). Seven percent ticked 'other' and specified the following; vitamin C, lester oil, wheatgrass shots, spirulina, glucosamine and branched chain amino acids (BCAAs) within four weeks of participating in the study. More than half of the athletes (88.4%) perceived their nutrition knowledge to be average or above. The majority (92.8%) of athletes rated their food and fluid intake as average or above with regards to meeting their training and general health needs.

Table 3.3 Additional participant characteristics (n=69)

Characteristics	Total n (%)	Female n (%)	Male n (%)
Carded athlete [a]	12 (17.4)	9 (75.0)	3 (25.0)
Taken supplements in the last 4 weeks (1st appointment)	56 (81.2)	32 (57.1)	24 (42.9)
Carrying an injury (1st appointment)	20 (29.0)	14 (70.0)	6 (30.0)
Current illness or chronic condition (1st appointment)	3 (4.3)	3 (100.0)	0 (0.0)
Current allergies or intolerances			
Yes	5 (7.2)	5 (100.0)	0 (0.0)
No	53 (76.8)	30 (56.6)	23 (43.4)
Not sure	11 (15.9)	8 (72.7)	3 (27.3)
Vegetarian or vegan	4 (5.8)	4 (100.0)	0 (0.0)
Athletes perceived nutrition knowledge			

Characteristics	Total n (%)	Female n (%)	Male n (%)
Excellent	2 (2.9)	1 (50.0)	1 (50.0)
Above average	34 (49.3)	21 (61.8)	13 (38.2)
Average	25 (36.2)	13 (52.0)	12 (48.0)
Below average	8 (11.6)	8 (100.0)	0 (0.0)
Athlete perceived rating of food and fluid intake			
Excellent	4 (5.8)	1 (25.0)	3 (75.0)
Above average	30 (43.5)	16 (53.3)	14 (46.7)
Average	30 (43.5)	21 (70.0)	9 (30.0)
Below average	4 (5.8)	4 (100.0)	0 (0.0)
Poor	1 (1.4)	1 (100.0)	0 (0.0)

[a] Carded-athletes – Athletes who receive performance support (e.g. injury and illness prevention and rehabilitation, strength and conditioning, nutrition, athlete life advice, performance and technique analysis, physiology, psychology, and performance planning) from High Performance Sport New Zealand.

Ministry of Health Eating and Activity Guidelines for Adults vs the ADI-Q#1 and 4DFR

Dietary components consumed from the first administration of the ADI-Q (ADI-Q#1) and the 4DFR are shown in Appendix A (Table 1 shows frequency and variety of dietary components; Table 2 shows frequency of fluid consumption). Also, shown in Appendix A are the frequency of participants choosing healthy compared with less healthy options, and the frequency of meals and snacks from ADI-Q#1 and the 4DFR.

The mean number of servings for each major dietary component is presented in Table 3.4 along with the percentage of participants who meet the Ministry of Health (MOH) Eating and Activity guidelines for recommended number of serves per day or week.

More than 50% of athletes who completed both the ADI-Q#1 and 4DFR met the food based dietary guidelines for number of servings of fruit, vegetables, milk and milk products and/or milk alternatives and lean meat and/or meat alternatives (combined). However, the percentage of athletes who meet recommendations appears to be a lot higher for servings of fruit from the ADI-Q#1 compared with the 4DFR and lower for servings of vegetables. The proportion of athletes meeting recommendations for servings of milk and/or milk alternatives plus lean meat and/or meat alternatives is approximately the same between dietary assessment methods.

Less than 35% of participants met recommendations for servings of breads and cereals. This was lower from the ADI-Q#1 (17.3%) when compared to the 4DFR (33.8%).

The majority of the athlete's total fluid intake was from water (69% from the ADI-Q#1 and 73% from the 4DFR) (data not shown) which is in-line with the EAGNZA. However, when looking at the proportion of male and female athletes who meet the recommended 8-10+ cups of plain water per day, less than fifty percent of participants actually met these recommendations. Only 12% of male athletes met recommendations using the 4DFR, which is lower than 42.2% from the ADI-Q#1. All participants met the recommendation for alcohol of no more than two standard drinks per day for females and three standard drinks per day for males according to both the ADI-Q#1 and 4DFR.

The majority of athletes reported consuming treat food or takeaways more than once per week. The proportion of athletes exceeding the recommendations to limit these foods is similar when using either the ADI-Q#1 or 4DFR to measure intake (for example treat food, 88.4% from the ADI-Q#1 and 80.9% from the 4DFR).

Table 3.4 ADI-Q#1 and 4DFR compared with Ministry of Health Eating and Activity Guidelines for Adults (19-64 years)

ADI-Q Component	EAGNZA (per day)	Mean number of servings (per day) AD1#1 (n=69) [a]	Mean number of servings (per day) 4DFR (n=68) [a]	Proportion (%) who meets recommendations AD1#1	Proportion (%) who meets recommendations 4DFR
Servings of fruit	2+	2.30±1.29	2.00±1.33	75.3	57.3
Servings of vegetables	3+	3.04±1.89	3.60±1.84	58.0	73.5
Servings of breads and cereals (Grain food)	6+	3.54±2.72	4.81±2.01	17.3	33.8
Servings of milk and milk products/and or milk and milk product alternatives	2+	2.13±1.64	2.10±1.19	63.7	64.7
Servings of red meat, poultry, fish other seafood	1+	1.22±2.26	1.65±1.17	68.1	83.8
Servings of meat alternatives	2+	1.16±1.43	1.59±1.14	33.2	44.0
Servings of legumes, nuts, seeds OR fish and other seafood, eggs or poultry (e.g. chicken), or red meat [b]	2+ OR 1+	-	-	73.9	89.7
Red meat per week	Less than 500g (~<5 serves)	4.01±4.69	3.94±3.39	76.7	66.3
Processed meat (per week)	<1x week	1.46±1.54	3.26±3.24	27.5	29.4
Total fluids [c]	-	10.90±5.85	9.15±4.36	-	-
Water [d]	8-10+	7.55±4.59	6.65±3.51	-	-
Water - Female [d]	8+	6.84±4.28	6.60±3.92	30.3	37.3
Water - Male [d]	10+	8.73±4.92	6.72±2.75	42.2	12.0
Treat food (per week) [e]	<1x week	3.80±4.56	4.28±4.29	11.6	19.1
Takeaways (per week) [e]	<1x week	0.87±0.77	3.32±2.64	31.9	22.1
Alcohol - Female	2 or less standard drinks	0.02±0.15	0.09±0.37	100.0	100.0
Alcohol - Male	3 or less standard drinks	0.08±0.27	0.08±0.28	100.0	100.0

ADI-Q - Athlete Diet Index Questionnaire; ADI-Q#1 - Athlete Diet Index Questionnaire 1st appointment; 4DFR – four-day food record.

[a] Number of servings are reported as mean±SD.
[b] The proportion of participants who had either 2+ servings of legumes, nuts, seeds or 1+ serving of fish and other seafood, eggs or poultry (e.g. chicken) or red meat
[c] Total fluids – Includes all fluid components
[d] Water – Does include water added to protein shakes for 4DFR. Have chosen to use water for recommendations as is the preferred choice recommended by the Eating and Activity Guidelines
[e] Eating and Activity Guidelines states to limit these foods

The radar plot (Figure 3.2) shows the mean number of servings consumed by the participants from the ADI-Q#1 and 4DFR vs the Ministry of Health (MOH) Eating and Activity Guidelines. For example, the MOH recommends at least 6 servings of breads and cereals per day. From the radar plot, it can be seen that participants are not meeting these guidelines.

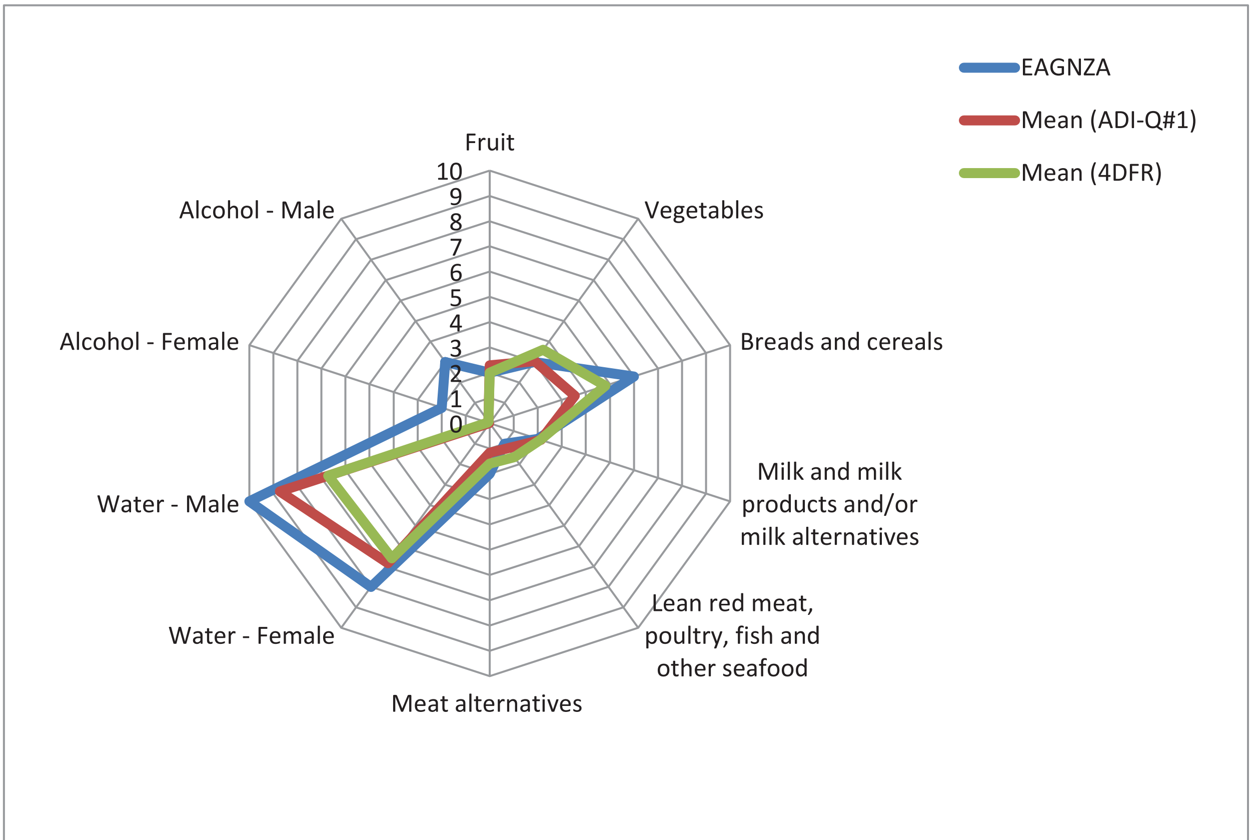


Figure 3.2 Radar plot of mean number of serves from ADI-Q#1 and 4DFR vs Ministry of Health Eating and Activity Guidelines for Adults

Energy intake assessed using the 4DFR

The mean energy intake for participants from the 4DFR was 10590.24 ± 2851.79kJ/d. Energy intake ranged from 5731kJ/d to 17765kJ/d. Female participants had an average energy intake of 9457 ± 2478kJ/d compared to male participants whose was 12495 ± 17765kJ/d.

Relative validity of the Athlete Diet Index Questionnaire (ADI-Q)

Validation of the ADI-Q#1 with the 4DFR was undertaken using a variety of statistical tests including paired t-tests, Pearson's correlation coefficients (Table 3.5 and 3.6) and Chi-square analysis (Table 3.6 and 3.7). Bland-Altman plots were also created to visually demonstrate the level of agreement between the two dietary measures at the group level (Lombard et al., 2015).

Food groups

The mean numbers of food group servings are presented as means±SD in Table 3.5. Using paired t-tests the following dietary components were found to be significantly different ($p<0.05$) between ADI-Q#1 and the 4DFR; servings of fruit; non-starchy vegetables; breads and cereals; lean meat, chicken and kaimoana; meat alternatives; and number of times processed meat and takeaways were consumed. When comparing mean values between both dietary assessment methods servings of fruit was significantly higher and servings of non-starchy vegetables; breads and cereals; lean meat, chicken and kaimoana and number of times processed meat and takeaways were consumed were significantly lower from the ADI-Q#1 compared with the 4DFR. A large effect ($r=0.5$) was found for times processed meat and takeaways were consumed. A medium effect ($r=0.3$) was found for servings of fruit; non-starchy vegetables; breads and cereals; servings of lean meat, chicken and kaimoana; and meat alternatives.

Pearson's correlation coefficients ranged from 0.19 (servings of starchy vegetables) to 0.66 (servings of non-starchy vegetables) with an average correlation of 0.42. Most of the correlations were significant ($p<0.05$) with the exception of servings of starchy vegetables, breads and cereals, lean meat (beef, lamb, pork) per week and number of times processed meat was consumed.

Food variety

Paired t-tests were not used to assess the agreement between methods for variety of fruit and vegetables as data was left in its raw form (variety of fruit and vegetables consumed over seven days from the ADI-Q#1 and variety of fruit and vegetables consumed over four days from the 4DFR). Correlations ranged from 0.48 (variety of fruit) to 0.55 (variety of vegetables) with an average correlation of 0.52. Both correlations were significant ($p<0.05$).

Table 3.5 Comparison between dietary components (food groups and variety) from the ADI-Q#1 and the 4DFR (n=68)

ADI-Q dietary components	ADI-Q#1 Mean daily dietary intake (mean ± SD)	4DFR Mean daily dietary intake (mean ± SD)	Mean difference (mean ± SD)	Paired t-test (p-value)	Effect size (r)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of fruit	2.31±1.30	2.00±1.33	0.31±1.19	0.036	0.25	0.590	<0.001
Servings of dried fruit/fruit juice	0.34±0.89	0.40±0.65	-0.06±0.90	0.590		0.357	0.003
Variety of fruit (per week or per 4 days)[a]	4.18±1.44	3.28±1.57	-	-		0.483	<0.001
Servings of starchy vegetables	0.78±0.90	0.74±0.70	0.04±1.03	0.725		0.190	0.121
Servings of non-starchy vegetables	2.28±1.57	2.87±1.70	-0.59±1.35	0.002	0.40	0.661	<0.001
Variety of vegetables (per week or per 4 days)[a]	11.54±3.87	9.36±3.03	-	-		0.547	<0.001
Servings of bread and cereals	3.56±2.73	4.81±2.01	-1.25±2.99	0.001	0.39	0.234	0.054
Servings of milk and/or milk alternatives	2.13±1.66	2.10±1.19	0.03±1.34	0.857		0.601	<0.001
Servings of lean meat (lamb, pork, beef) (per week)	4.01±4.69	3.94±3.39	0.07±5.16	0.907		0.217	0.076
Total servings of lean meat, poultry and kaimoana (per day)	1.22±1.27	1.65±1.17	-0.43±1.24	0.006	0.33	0.486	<0.001

ADI-Q dietary components	ADI-Q#1 Mean daily dietary intake (mean ± SD)	4DFR Mean daily dietary intake (mean ± SD)	Mean difference (mean ± SD)	Paired t-test (p-value)	Effect size (r)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Times consumed processed meat (per week)	1.43±1.52	3.26±3.24	-1.84±3.28	<0.001	0.49	0.210	0.085
Servings of meat alternatives	1.18±1.44	1.59±1.14	-0.41±1.25	0.008	0.32	0.549	<0.001
Times consumed treat food (per week)	3.54±4.07	4.28±4.29	-0.74±3.85	0.120		0.576	<0.001
Times eaten takeaways (per week) [c]	0.87±0.77	3.32±2.64	-2.46±2.50	<0.001	0.70	0.322	0.007

ADI-Q- Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; 4DFR-four-day food record; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)
Data collected for fruit, vegetables, breads and cereals, milk and milk alternatives, meat and meat alternatives are reported as number of servings
Data collected for processed meat, treat food and takeaways were reported as times participant had that food item. The amount of each food item was not considered. The number of times the food item was eaten in the 4DFR was divided by four and multiplied by seven to convert to a weekly amount
[a] Variety - Data collected for variety is in its raw form e.g. ADI-Q#1 is the number of different fruits/vegetables consumed in the last seven days and the 4DFR is the number of different fruits/vegetables consumed over four days; n=67 for variety as one participant only completed 3 days of 4DFR
[b] To determine the number of servings of lean meat per week from the ADI-Q#1; daily amounts were multiplied by seven, monthly amounts were divided by 4 and yearly amounts divided by 52
[b] To determine the number of servings of lean meat per week from the 4DFR the total sum of meat over four days was divided by four to get a daily amount and then multiplied by seven to get a weekly amount
[c] Takeaway data includes all food eaten outside of the home (e.g. food eaten at restaurants, sushi, subway, McDonalds)

Fluids

The mean number of fluid servings are presented as means±SD in Table 3.6. Using paired t-tests it was found that servings of milk and milk alternatives and soft drinks/fizzy/carbonated drinks were significantly different ($p<0.05$) between ADI-Q#1 and the 4DFR. When comparing mean values between both dietary assessment methods servings of milk and/or milk alternatives were higher from the ADI-Q#1 and lower from the ADI-Q#1 for soft drinks/fizzy/carbonated drinks. A large effect ($r=0.5$) was found for servings of milk and milk alternatives. A medium effect ($r=0.3$) was found for servings of soft drinks/fizzy drinks/carbonated drinks. Other fluids were not significantly different between ADI-Q#1 and the 4DFR.

Correlations ranged from -0.03 (servings of flavoured water/sports water and coconut water) to 0.77 (servings of herbal tea) with an average correlation of 0.39. Most of the correlations were significant ($p<0.05$) with the exception of flavoured water/sports water, coconut water and powdered drinks/cordial.

Table 3.6 Comparison between dietary components (fluids) from the ADI-Q#1 and the 4DFR (n=68)

ADI-Q Dietary component	ADI-Q#1 Mean daily dietary intake (mean ± SD)	4DFR Mean daily dietary intake (mean ± SD)	Mean difference (mean ± SD)	Paired t-test (p-value)	Effect size (r)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of flavoured water, sports water	0.01±0.12	0.04±0.21	-0.03±0.24	0.321		-0.026	0.832
Servings of sports drinks	0.22±0.91	0.15±0.50	0.07±0.83	0.470		0.422	<0.001
Servings of coconut water	0.06±0.38	0.03±0.17	0.03±0.42	0.568		-0.027	0.827
Servings of water [b]	7.56±4.62	6.65±3.51	0.91±4.67	0.112		0.367	0.002
Servings of milk and/or milk alternatives [c]	1.37±1.35	0.50±0.68	0.87±1.08	<0.001	0.63	0.610	<0.001
Servings of fruit juice	0.07±0.32	0.10±0.35	-0.03±0.34	0.484		0.470	<0.001
Servings of soft drinks/fizzy drinks/ carbonated drinks	0.01±0.12	0.29±0.73	-0.28±0.71	0.002	0.37	0.286	0.018
Servings of powdered drinks/cordials	0.01±0.12	0.07±0.50	-0.06±0.49	0.321		0.229	0.060
Servings of herbal teas	0.46±0.85	0.37±0.83	0.09±0.57	0.203		0.774	<0.001
Servings of tea [d]	0.50±1.28	0.26±0.68	0.24±1.17	0.103		0.411	<0.001
Servings of hot chocolate/ milo/cocoa [e]	0.10±0.31	0.10±0.35	0.00±0.35	1.000		0.455	<0.001
Servings of coffee [f]	0.53±0.76	0.57±0.78	-0.04±0.56	0.517		0.738	<0.001
Servings of energy drinks	0.00[a]±0.00	0.00[a]±0.00	[a]	[a]		[a]	[a]

ADI-Q Dietary component	ADI-Q#1 Mean daily dietary intake (mean ± SD)	4DFR Mean daily dietary intake (mean ± SD)	Mean difference (mean ± SD)	Paired t-test (p-value)	Effect size (r)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of alcohol	0.04±0.21	0.09±0.33	-0.04±0.32	0.260		0.375	0.002

ADI-Q- Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; 4DFR-four-day food record; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)

[a] Unable to be computed as the number of servings is constant

[b] Water - includes water added to protein shakes/meal replacements

[c] Milk and milk alternatives - includes milk added to protein shakes/meal replacements, breakfast drinks (Up and Go) and flavoured milk

[d] Tea includes black tea and tea made with milk

[e] Hot chocolate/milo/cocoa - includes café style hot chocolates made mostly with milk, cold milos made mostly with milk and milos made mostly with water

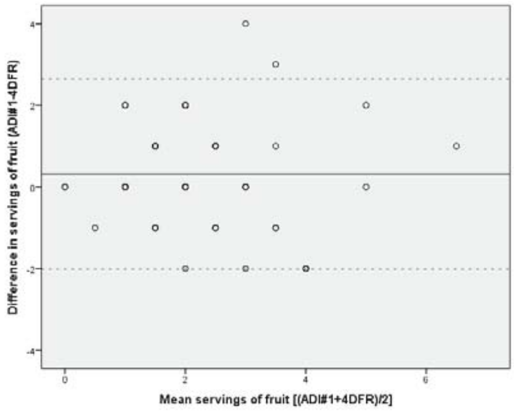
[f] Coffee includes both instant coffee made mostly with water, café style coffee made mostly with milk (including mochaccinos) and iced coffee

Bland-Altman plots (food groups and fluids)

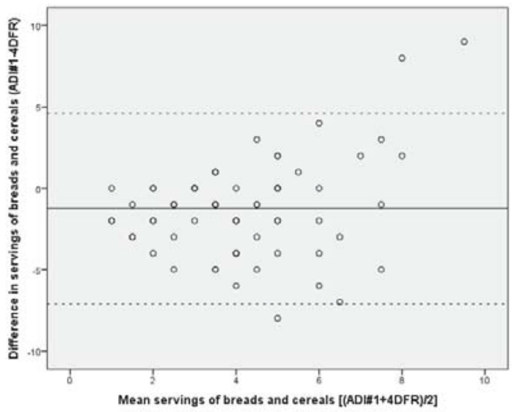
Bland-Altman plots were created to assess the strength of agreement between dietary components from the ADI-Q#1 and 4DFR. Examples of Bland-Altman plots for servings of fruit, breads and cereals, water per day and times treat food consumed per week are shown in Figure 3.3 with a solid line representing the mean difference between the two dietary methods and dashed lines representing the limits of agreement (LOA= mean difference +/- 1.96 standard deviations) (Lombard et al., 2015). Additional Bland-Altman plots are displayed in Appendix A.

Visual inspection of the Bland Altman plots suggests that as the mean number of servings and/or times consumed increases for each dietary component there was a greater difference between the number of servings from the ADI#1 and 4DFR. The majority of measures fell between the LOA for each dietary component with noticeable outliers displayed outside the LOA.

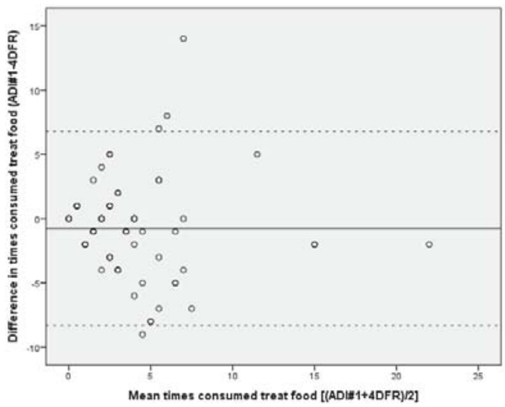
Bland–Altman plots of relative validity for dietary components from the ADI-Q#1 and 4DFR (n=68)



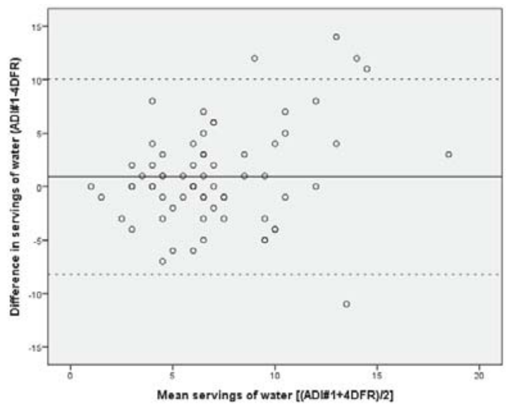
(A): Bland-Altman plot of servings of fruit



(B): Bland-Altman plot of servings of breads and cereals



(C): Bland-Altman plot of times consumed treat food (per week)



(D): Bland-Altman plot of servings of water

Figure 3.3 Bland-Altman plots of the agreement between intakes (A) servings of fruit, (B) servings of breads and cereals, (C) times consumed treat food (per week), (D) servings of water.

Healthy versus less healthy options

Chi-square tests were used to analyse healthy compared with less healthy options (Table 3.7). Three categories were created by combining counts from never and rarely together, sometimes, and mostly and always together. Not applicable (N/A) counts were not included in the statistical analysis. The majority of healthy options were found to be significantly different ($p<0.05$) between dietary assessment methods indicating a large difference in count between categories. For example, for the question 'How often do you choose wholegrain breads and cereals?' 14.7% of participants reported sometimes from the ADI-Q#1 compared with 38.2% from the 4DFR. The question 'How often do you choose unsaturated fats?' was the only healthy option found not to be significantly different ($p>0.05$) with good agreement between categories for both dietary assessment methods (for example 56.7% of participants reported mostly/always choosing unsaturated fat from the ADI-Q#1 compared with 58.7% from the 4DFR).

Table 3.7 Comparison between dietary components (healthy versus less healthy options) from the ADI-Q#1 and 4DFR

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) 4DFR	Pearson's Chi-Square P-value
How often do you choose wholegrain breads and cereals?	Never/rarely	5 (7.4)	16 (23.5)	<0.001
	Sometimes	10 (14.7)	26 (38.2)	
	Mostly/Always	53 (77.9)	26 (38.2)	
How often do you choose low fat milk and milk alternatives?	Never/rarely	22 (32.8)	22 (32.8)	0.041
	Sometimes	8 (11.9)	19 (28.4)	
	Mostly/Always	37 (55.2)	26 (38.8)	
How often do you remove the skin/fat from meat and chicken?	Never/rarely	12 (18.5)	1 (1.6)	0.005
	Sometimes	10 (15.3)	15 (23.4)	
	Mostly/Always	43 (66.2)	48 (75.0)	
How often do you choose unsaturated fats?	Never/rarely	9 (13.4)	12 (19.0)	0.502
	Sometimes	20 (29.9)	14 (22.2)	
	Mostly/Always	38 (56.7)	37 (58.7)	

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) 4DFR	Pearson's Chi-Square P-value
How often do you add salt to food and in cooking?	Never/rarely	30 (44.1)	44 (64.7)	<0.001
	Sometimes	12 (17.6)	22 (32.4)	
	Mostly/Always	26 (38.2)	2 (2.9)	

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; 4DFR-four-day food record
Data collected for healthy versus less healthy options from the ADI-Q#1 were reported as the following frequencies; never; rarely (1/4 of the time); sometimes (1/2 of the time); mostly (3/4 of the time); always and N/A (not applicable)
Data collected for healthy versus less healthy options from the 4DFR were calculated for example by counting the total amount of breads and cereals over four days and then calculating the proportion of which were wholegrain options. The proportion was then coded with a response using the following; never or rarely 0-25%; sometimes 25-75%; mostly or always 75-100%

Frequency of meals

Categories for frequency of meals were created as outlined above for healthy versus less healthy options. The only meal frequency found to be significantly different (p<0.05) was 'how often do you have morning tea?' indicating a large difference between categories for both dietary assessment methods. For example, 17.6% report having morning tea sometimes from the ADI-Q#1 compared with 7.4% from the 4DFR (Table 3.8).

Table 3.8 Comparison between dietary component (frequency of meals) from the ADI-Q#1 and 4DFR

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) 4DFR	Pearson's Chi-Square P-value
How often do you have breakfast?	Never/rarely	0 (0)	0 (0)	0.500 [a]
	Sometimes	1 (1.5)	0 (0)	
	Mostly/Always	67 (98.5)	68 (100)	
How often do you have morning tea? (68/68)	Never/rarely	4 (5.9)	13 (19.1)	0.021
	Sometimes	12 (17.6)	5 (7.4)	
	Mostly/Always	52 (76.5)	50 (73.5)	
How often do you have lunch?	Never/rarely	0 (0)	0 (0)	0.248 [a]
	Sometimes	0 (0)	2 (2.9)	
	Mostly/Always	68 (100)	66 (97.1)	
How often do you have afternoon tea?	Never/rarely	6 (8.8)	5 (7.4)	0.951
	Sometimes	12 (17.6)	12 (17.6)	

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) 4DFR	Pearson's Chi-Square P-value
	Mostly/Always	50 (73.5)	51 (75.0)	
How often do you have an evening meal?	Never/rarely	0 (0)	0 (0)	[b]
	Sometimes	0 (0)	0 (0)	
	Mostly/Always	68 (100)	68 (100)	
How often do you have supper? [c]	Never/rarely	26 (38.8)	29 (42.6)	0.875
	Sometimes	19 (28.4)	17 (25.0)	
	Mostly/Always	22 (32.8)	22 (32.4)	

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; 4DFR-four-day food record

[a] Fishers test was used for cell counts <5

[b] No statistics are computed because choice evening meal is a constant

[c] Missing data for ADI-Q#1 supper counts n=1

Data collected for meal frequency were reported as how often participant had each meal; never; rarely (1/4 of the time); sometimes (1/2 of the time), mostly (3/4 of the time), always.

Data for 4DFR were coded as the following – for example breakfast; never (never had breakfast); rarely (had breakfast one out of the four days); sometimes (had breakfast twice out of the four days); mostly (had breakfast three times out of the four days); always (had breakfast four times out of the four days)

Reproducibility of the Athlete Diet Index Questionnaire (ADI-Q)

Sixty-seven participants completed the ADI-Q approximately four weeks apart. To measure reproducibility between the administration of ADI-Q#1 and ADI-Q#2 the following statistical methods were used; paired t-tests, Pearson's correlation coefficients (Tables 3.9 and 3.10), Chi-square tests (Tables 3.10 and 3.11) and Bland-Altman plots (Figure 3.4). Reproducibility of the ADI-Q was also completed with the removal of participants who reported a significant change (n=13) to their diet during the four weeks. As this did not appear to affect the reproducibility this was not reported. Results however can be found in Appendix A.

Food groups

The mean±SD of each food group from the ADI-Q#1 and ADI-Q#2 are presented in Table 3.9. The only food groups found to be significantly different ($p<0.05$) were non-starchy vegetables, breads and cereals, meat alternatives and times takeaways were consumed. All significantly different ($p<0.05$) dietary components were higher from the ADI-Q#1 compared with the ADI-Q#2. A medium effect ($r=0.3$) was also found for each of these dietary components.

Pearson's correlation coefficients between ADI-Q#1 and ADI-Q#2 ranged from 0.18 (servings of lean meat (beef, lamb, pork) (per week)) through to 0.63 (servings of starchy vegetables) with an average correlation of 0.46. All correlations were significant ($p<0.05$) except total servings of lean meat (beef, lamb, pork) (per week).

Food variety

Paired t-tests could be performed for variety of fruits and vegetables when assessing reproducibility of the ADI-Q as both administrations looked at consumption over the last seven days. Food variety was found to have good agreement between methods ($p>0.05$) with correlation coefficients ranging between 0.38 (variety of fruit) to 0.75 (variety of vegetables) with an average correlation of 0.56. Both correlations were significant ($p<0.05$).

Table 3.9 Comparison between mean dietary components (food groups and variety) from ADI-Q#1 and ADI-Q#2 (n=67)

ADI-Q dietary components	ADI-Q#1 Mean daily dietary intake (Mean ± SD)	ADI#2 Mean daily dietary intake (Mean ± SD)	Mean difference (Mean ± SD)	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of fruit	2.31±1.31	2.42±1.55	-0.10±1.50	0.570		0.459	<0.001
Servings of dried fruit/fruit juice	0.36±0.92	0.28±0.60	0.08±0.91	0.504		0.337	0.005
Variety of fruit (per week)	4.16±1.44	3.78±1.41	0.39±1.60	0.051		0.375	0.002
Servings of starchy vegetables	0.81±0.89	0.87±0.82	-0.06±0.74	0.509		0.631	<0.001
Servings of non-starchy vegetables	2.28±1.57	1.81±1.32	0.48±1.40	0.007	0.33	0.542	<0.001
Variety of vegetables (per week)	11.48±3.91	11.31±4.18	0.16±2.89	0.643		0.748	<0.001
Servings of bread and cereals	3.60±2.74	2.93±2.27	0.67±2.64	0.041	0.25	0.456	<0.001
Servings of milk and/or milk alternatives	2.18±1.64	1.85±1.47	0.33±1.69	0.117		0.413	0.001
Servings of lean meat (lamb, pork, beef) (per week)[a]	4.10±4.73	4.16±5.63	-0.06±6.67	0.942		0.181	0.143

ADI-Q dietary components	ADI-Q#1 Mean daily dietary intake (Mean ± SD)	ADI#2 Mean daily dietary intake (Mean ± SD)	Mean difference (Mean ± SD)	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Total servings of lean meat (beef, lamb, pork), chicken and kaimoana (per day)	1.24±1.28	1.03±1.34	0.21±1.40	0.222		0.428	<0.001
Times consumed processed meat (per week)	1.46±1.56	1.58±1.48	-0.12±1.63	0.550		0.427	<0.001
Servings of meat alternatives	1.18±1.45	0.88±1.21	0.30±1.22	0.049	0.24	0.592	<0.001
Times consumed treat food (per week)	3.91±4.58	3.09±3.73	0.82±3.68	0.072		0.624	<0.001
Times consumed takeaways (per week)[b]	0.88±0.77	0.67±0.55	0.21±0.73	0.020	0.28	0.421	<0.001

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment, ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)
Data collected for fruit, vegetables, breads and cereals, milk and milk alternatives, meat and meat alternatives are reported as number of servings
Data collected for processed meat, treat food and takeaways were reported as times participant had that food item. The amount of each food item was not considered.
The number of times the food item was eaten in the 4DFR was divided by four and multiplied by seven to convert to a weekly amount
[a] To determine the number of servings of lean meat per week from the ADI#1 daily amounts were multiplied by seven, monthly amounts divided by 4 and yearly amounts divided by 52.
[a] To determine the number of servings of lean meat per week from the 4DFRF the total sum of meat over four days was divided by four (daily amount) and multiplied by seven (weekly amount)
[b] Takeaway data includes all food eaten outside of the home (e.g. food eaten at restaurants, sushi, subway, McDonalds)

Fluids

The mean±SD of each fluid from the ADI-Q#1 and ADI-Q#2 are presented in Table 3.10. The only fluid found to be significantly different ($p<0.05$) were servings of water which had a medium effect size ($r=0.3$) and was higher from the ADI-Q#1 compared with the ADI-Q#2.

Pearson's correlation coefficients for the ADI-Q#1 and ADI-Q#2 are also presented in Table 3.10. The correlations ranged from -0.02 (servings of flavoured water/sports water) through to 0.92 (servings of coffee) with an average correlation of 0.52. Most correlations were significant ($p<0.05$) with the exception of servings of flavoured water/sports water, sports drinks and coconut water.

Table 3.10 Comparison between mean dietary components (fluid) from ADI-Q#1 and ADI-Q#2 (n=67)

ADI-Q dietary components	ADI-Q#1 Mean daily dietary intake (Mean ± SD)	ADI-Q#2 Mean daily dietary intake (Mean ± SD)	Mean difference (Mean ± SD)	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of flavoured water, sports water	0.01±0.12	0.03±0.17	-0.02±0.21	0.568		-0.022	0.862
Servings of sports drinks	0.22±0.92	0.12±0.37	0.10±0.96	0.374		0.098	0.428
Servings of coconut water	0.06±0.39	0.03±0.17	0.03±0.39	0.531		0.202	0.101
Servings of water [b]	7.63±4.59	6.72±3.34	0.91±3.59	0.042	0.25	0.630	<0.001
Servings of milk and/or milk alternatives [c]	1.37±1.36	1.52±1.22	-0.15±1.26	0.335		0.529	<0.001
Servings of fruit juice	0.09±0.34	0.09±0.34	0.00±0.25	1.000		0.732	<0.001
Servings of soft drinks/fizzy drinks/ carbonated drinks	0.01±0.12	0.00±0.00	0.02±0.02	0.321		[a]	[a]
Servings of powdered drinks/cordials	0.01±0.12	0.04±0.27	-0.03±0.03	0.321		0.436	<0.001
Servings of herbal teas	0.46±0.86	0.37±0.76	0.09±0.06	0.159		0.804	<0.001
Servings of tea [d]	0.51±1.28	0.33±0.75	0.18±0.15	0.233		0.377	0.002
Servings of hot chocolate/ milo/cocoa [e]	0.12±0.33	0.16±0.41	-0.05±0.04	0.260		0.640	<0.001
Servings of coffee [f]	0.52±0.77	0.61±0.92	-0.09±0.05	0.057		0.915	<0.001
Servings of energy drinks	0.00[a]±0.00	0.00[a]±0.00	[a]	[a]		[a]	[a]
Servings of alcohol	0.04±0.21	0.06±0.24	-0.02±0.12	0.321		0.859	<0.001

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)

[a] Unable to be computed as the number of servings is constant

[b] Water - includes water added to protein shakes/meal replacements

[c] Milk and milk alternatives - includes milk added to protein shakes/meal replacements, breakfast drinks (e.g. Up and Go) and flavoured milk

[d] Tea includes black tea and tea made with milk

[e] Hot chocolate/milo/cocoa - includes café style hot chocolates made mostly with milk, cold milos made mostly with milk and milos made mostly with water

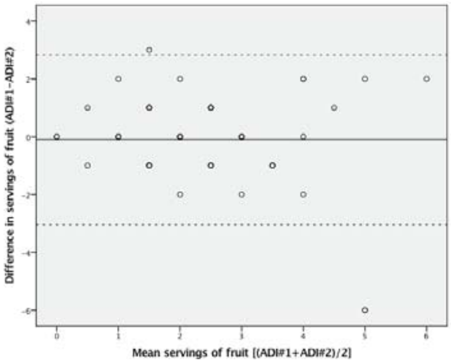
[f] Coffee includes both instant coffee made mostly with water, café style coffee made mostly with milk (including mochaccinos) and iced coffees

Bland-Altman plots (food groups and fluids)

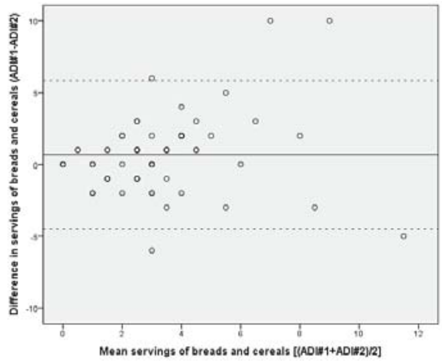
Bland-Altman plots were created for all food groups and fluids consumed regularly by participants to assess the strength of agreement between dietary intake data from the ADI-Q#1 and ADI-Q#2 (Lombard et al., 2015). Examples of Bland-Altman plots for servings of fruit, breads and cereals, water and times consumed treat food (per week) are displayed in Figure 3.4 with a solid line representing the mean difference between the two dietary assessment methods and dashed lines representing the limits of agreement (LOA= mean difference +/- 1.96 standard deviations) (Lombard et al., 2015). Additional Bland-Altman plots are displayed in Appendix A.

Visual inspection of the Bland Altman plots suggests that as the mean number of servings increases for each dietary component there was a greater difference between the number of servings from the ADI-Q#1 and ADI-Q#2. It is also important to note that the majority of measures fell between the LOA for each dietary component with noticeable outliers displayed outside the dashed lines.

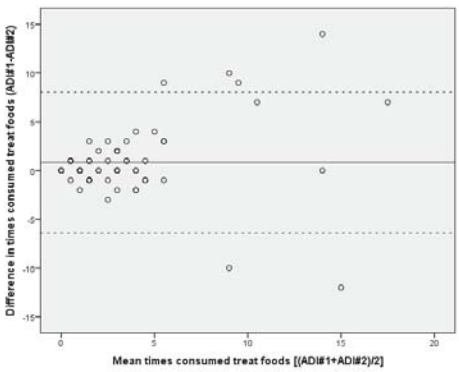
Bland–Altman plots of reproducibility for dietary components from the ADI-Q#1 and ADI-Q#2 (n=67)



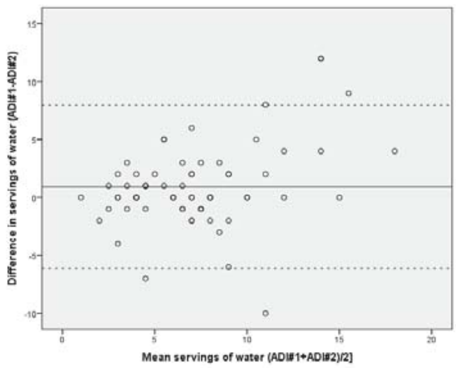
(E) Bland-Altman plot of servings of fruit



(F) Bland-Altman plot of servings of breads and cereals



(G) Bland-Altman plot of times consumed treat foods (per week)



(H) Bland-Altman plot of servings of water

Figure 3.4 Bland-Altman plots of the agreement between intakes (E) servings of fruit, (F) servings of breads and cereals, (G) times consumed treat food (per week), (H) servings of water.

Healthy versus less healthy options

Chi-square tests were used to analyse healthy compared with less healthy options (Table 3.11). None of the options were found to be significantly different ($p<0.05$) with good agreement between categories for both dietary assessment methods. For example, for the question 'How often do you add salt to food and in cooking?' 35.8% reported mostly/always from the ADI-Q#1 and 32.8% from the ADI-Q#2.

Table 3.11 Comparison between dietary components (healthy versus less healthy options) from the ADI-Q#1 and ADI-Q#2

ADI-Q dietary component	Response	n (%)ADI-Q#1	n (%)ADI-Q#2	Pearson's Chi-Square p value
How often do you choose wholegrain breads and cereals?	Never/rarely Sometimes Mostly/Always	5 (7.5) 11 (16.4) 51 (76.1)	6 (9.0) 10 (14.9) 51 (76.1)	0.933
How often do you choose low fat milk and milk alternatives?	Never/rarely Sometimes Mostly/Always	22 (33.3) 8 (12.1) 36 (54.5)	20 (29.9) 12 (17.9) 35 (52.2)	0.637
How often do you remove the skin/fat from meat and chicken?	Never/rarely Sometimes Mostly/Always	12 (18.8) 10 (15.6) 42 (65.5)	15 (23.1) 7 (10.8) 43 (66.2)	0.648
How often do you choose good fats (unsaturated)?	Never/rarely Sometimes Mostly/Always	9 (13.6) 20 (30.3) 37 (56.1)	13 (19.7) 18 (27.3) 35 (53.0)	0.641
How often do you add salt to food and in cooking?	Never/rarely Sometimes Mostly/Always	30 (44.8) 13 (19.4) 24 (35.8)	30 (44.8) 15 (22.4) 22 (32.8)	0.891

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment, ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment
Data collected for healthy versus less healthy options from the ADI-Q#1 and ADI-Q#2 were reported as the following frequencies; never; rarely (1/4 of the time); sometimes (1/2 of the time); mostly (3/4 of the time); always and N/A (not applicable)

Frequency of meals

Frequency of all meals were not significantly different (p>0.05) between the ADI-Q#1 and ADI-Q#2 showing good agreement between categories for both dietary assessment methods. For example, 0% of people from the ADI-Q#1 and ADI-Q#2 reported never/rarely having breakfast (Table 3.12).

Table 3.12 Comparison between dietary component (meal frequency) from the ADI-Q#1 and ADI-Q#2

ADI-Q dietary component	Response	n (%)ADI-Q#1	n (%)ADI-Q#2	Pearson's Chi-Square p value
How often do you have breakfast?	Never/rarely	0 (0)	0 (0)	0.500[a]
	Sometimes	1 (1.5)	2 (3.0)	
	Mostly/Always	66 (98.5)	65 (97.0)	
How often do you have morning tea? [b]	Never/rarely	4 (6.0)	7 (10.6)	0.614
	Sometimes	12 (17.9)	12 (18.2)	
	Mostly/Always	51 (76.1)	47 (71.2)	
How often do you have lunch?	Never/rarely	0 (0)	0 (0)	0.500[a]
	Sometimes	0 (0)	1 (1.5)	
	Mostly/Always	67 (100)	66 (98.5)	
How often do you have afternoon tea? [b]	Never/rarely	6 (9.0)	7 (10.6)	0.940
	Sometimes	12 (17.9)	11 (16.7)	
	Mostly/Always	49 (73.1)	48 (72.7)	
How often do you have an evening meal?	Never/rarely	0 (0)	1 (1.5)	0.500[a]
	Sometimes	0 (0)	0 (0)	
	Mostly/Always	67 (100)	66 (98.5)	
How often do you have supper? [b c]	Never/rarely	26 (39.4)	22 (33.3)	0.647
	Sometimes	18 (27.3)	17 (25.8)	
	Mostly/Always	22 (33.3)	27 (40.9)	

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment, ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment
[a] Fishers test was used for cell counts <5
[b] Missing data for ADI-Q#2 morning tea n=1, afternoon tea n=1, supper n=1
[c] Missing data for ADI-Q#1 supper counts n=1
Data collected for meal frequency were reported as how often participant had each meal; never; rarely (1/4 of the time); sometimes (1/2 of the time), mostly (3/4 of the time), always

3.5 Discussion

Overall findings

To our knowledge, this is the first study to develop and validate a diet quality index to measure the adherence of high performing athletes to food based dietary guidelines. Relative validity of the Athlete Diet Index Questionnaire (ADI-Q) was assessed using a four-day food record (4DFR) while reproducibility of the tool was determined by having the athletes complete the ADI-Q on two separate occasions approximately four weeks apart. A variety of statistical methods were used with the ADI-Q appearing to have reasonable validity and moderate to high reproducibility for the majority of dietary components.

Adherence to the Eating and Activity Guidelines for New Zealand Adults

Achieving baseline nutrition (adherence to food based dietary guidelines) is important for athletes as they spend most of their time undertaking non-athletic activities (Figure 1.1). Although not the main focus of this research we were still able to compare responses from both the Athlete Diet Index Questionnaire one (ADI-Q#1) and four-day food record (4DFR) to the Eating and Activity Guidelines for New Zealand Adults (EAGNZA).

More than half of the athletes who completed both the ADI-Q#1 and 4DFR met recommended food based dietary guidelines for servings of fruit, vegetables, milk and milk products and/or milk alternatives, and meat or meat alternatives. However, less than 35% of participants met recommendations for servings of breads and cereals according to both the ADI-Q#1 and the 4DFR. This is concerning as breads and cereals are considered to be an important source of carbohydrate (CHO) for athletes. CHOs are a key nutrient required to fuel athletes during prolonged bouts of exercise (Jeukendrup, 2004). As the bodies stores of CHO are limited it is important for athletes to eat dietary sources of CHO such as breads and cereals each day.

The majority of athletes consumed less than 500g of red meat per week (76.7% from ADI-Q#1 and 66.3% from the 4DFR) however approximately 70% of athletes consumed processed meats more than once per week according to both the ADI-Q#1 and 4DFR.

Less than half of participants met the recommendations of at least 8-10 cups of plain water per day. Only 12% of male athletes met recommendations of 10 or more cups per day using the 4DFR compared to 42.2% from the ADI-Q#1. For females, 30.3% met the recommendations of eight plus cups per day according to the ADI-Q#1 and 37.3% according to the 4DFR. Adequate hydration is important for athletes (Magkos & Yannakoulia, 2003), however consumption is especially difficult to quantify. Athletes often consume fluids outside of meal times and during training, making it prone to under-reporting when using traditional dietary assessment methods like food records (Magkos & Yannakoulia, 2003). The majority of the athlete's total fluid intake was from water for both the ADI-Q#1 and 4DFR). All athletes reported meeting the recommendations for alcohol of two or less standard drinks per day for females and three or less standard drinks per day for males from both ADI-Q#1 and the 4DFR.

The majority of athletes were having treat food (over 80% from ADI-Q#1 and the 4DFR) and takeaways (over 65% from ADI-Q#1 and the 4DFR) more than once a week when analysing results from both the ADI-Q#1 and 4DFR.

Relative validity

Food groups and variety

There was a significant difference between the mean number of servings for fruit; non-starchy vegetables; breads and cereals; lean meat, poultry and kaimoana (seafood) and meat alternatives consumed per day and times processed meat and takeaways were consumed per week ($p<0.05$). These significantly different food groups tended to have a lower mean number of servings and times consumed for the ADI-Q#1 compared with the 4DFR with the exception of servings of fruit per day. All dietary components that were significantly different had a medium to large effect size ($r=0.25$-0.70) suggesting meaningful differences (Field, 2009). The definition of a takeaway was not clearly defined within the ADI-Q and therefore it was difficult to determine which food items to consider a takeaway from the 4DFR. As a result, all food items purchased from cafes, restaurants, fast food outlets (including sushi and subway which are often considered healthy alternatives to takeaways) and savoury snacks such as potato chips were counted as takeaways. This could explain the significant difference between mean times takeaways were consumed from the ADI-Q#1 and 4DFR.

Pearson's correlation coefficients were used to measure the strength and direction of association between the ADI-Q#1 and 4DFR. A high correlation (0.5-0.7) was observed for servings of fruit, non-starchy vegetables, milk and/or milk alternatives, meat alternatives per day and times treat food were consumed per week. A moderate correlation (0.3-0.5) was observed for servings of dried fruit/fruit juice, lean meat poultry and kaimoana eaten per day and times takeaways were eaten per week. Finally, a low correlation (0.1-0.3) was observed for servings of starchy vegetables, breads and cereals eaten per day and servings of lean meat and times processed meat was consumed per week.

All correlations between the ADI-Q#1 and 4DFR for food groups were found to be significant ($p<0.05$) with the exception of starchy vegetables, breads and cereals, lean meat (per week) and times processed meat consumed (per week). An average correlation of 0.42 for all food group components was observed suggesting an overall moderate association between the ADI-Q#1 and 4DFR (Cohen, 1988; Hopkins et al., 2009).

Bland-Altman plots display good agreement between the ADI-Q#1 and 4DFR for majority of the food groups as most of the data was observed within the LOA (mean difference ± 1.96 standard deviations). Visual inspection of the plots also suggests that the difference between the ADI-Q#1 and 4DFR increased as the mean dietary intake increased.

All correlations between the ADI-Q#1 and 4DFR for food variety were found to be significant ($p<0.05$). A high correlation (0.5-0.7) was found for variety of vegetables and a moderate correlation (0.3-0.5) for variety of fruit. An average correlation of 0.52 for dietary variety of fruit and vegetables suggests overall a high association between dietary methods (Cohen, 1988; Hopkins et al., 2009).

Fluids

The majority of fluid dietary components were not significantly different when compared using paired t-tests. Servings of milk and/or milk alternatives and soft drinks/fizzy drinks/carbonated water were found to be significantly different between the ADI-Q#1 and 4DFR ($p<0.05$). These components were found to have a medium (soft drinks/fizzy drinks/carbonated drinks) and large effect size (milk and milk alternatives) suggesting meaningful differences (Field, 2009).

Correlation coefficients for fluids ranged from -0.03 (servings of flavoured water/sports water and coconut water) ($p>0.05$) to 0.77 (servings of herbal tea) ($p<0.05$) with an average correlation of 0.39 suggesting an overall moderate correlation (Cohen, 1988; Hopkins et al., 2009). All correlations were significant ($p<0.05$) except for servings of flavoured water/sports water, coconut water and powdered drinks/cordials.

Bland-Altman plots were only created for fluids being regularly consumed for example water. The majority of the data fell within the LOA allowing obvious outliers to be observed. Again, as the mean number of servings increased so did the difference between the ADI-Q#1 and 4DFR.

Healthy versus less healthy options

Chi square tests were used to assess the relative validity of healthy compared with less healthy dietary components. There was poor agreement between dietary methods (ADI-Q#1 and 4DFR) for these components with all components except the use of unsaturated fat compared with saturated fat being significantly different ($p<0.05$). Visual inspection of the frequencies for each category; never/rarely, sometimes and mostly/always show discrepancies resulting in poor agreement.

At times, it was difficult to convert data from the 4DFR into data which could be compared to the ADI-Q#1 particularly for healthy compared with less healthy eating options. While consumption of wholegrain breads and cereals, reduced fat milk and unsaturated versus saturated fat were determined as a proportion and then categorised (not applicable, never, rarely, sometimes, mostly and always), this was difficult to do for intake of salt and removal of fat/skin off meat/chicken. This may in part explain the poor relative validity for these components. The 4DFR may not be appropriate for validating some healthy eating habits from the ADI-Q.

Meal frequency

Responses from the ADI-Q#1 and 4DFR confirmed that few athletes tended to skip meals with the majority (greater than 50%) of athletes having three meals and three snacks per day (Appendix A, Table 4). All meal times (breakfast, lunch, afternoon tea, the evening meal and supper) except morning tea were found to have good relative validity ($p>0.05$) between the ADI-Q#1 and 4DFR. At times, it was difficult to determine particular meal occasions from the 4DFR as athletes sometimes trained early, often during the day and late at night, affecting timing of traditional meal occasions. For example, athletes may consider a second breakfast eaten after early morning training, as either breakfast or morning tea. This could explain the poor validity for morning tea.

Reproducibility

Food groups and variety

Few dietary components were found to be significantly different ($p<0.05$) when using paired t-tests to assess the level of agreement suggesting good reproducibility of the ADI-Q. Non-starchy vegetables, breads and cereals, meat alternatives, and times takeaways were consumed (per week) were the only food group components with significantly different means ($p<0.05$). For each of these components the mean number of servings or times consumed were greater for the ADI-Q#1 when compared with the ADI-Q#2. All significant food group components demonstrated a medium effect size (r=0.24-0.33) suggesting reasonable differences (Field, 2009).

A high correlation coefficient (0.5-0.7) was observed for servings of starchy vegetables, non-starchy vegetables, meat alternatives per day and times treat food were consumed per week. A moderate correlation (0.3-0.5) was observed for servings of fruit, dried fruit/fruit juice, bread and cereals, milk and/or milk alternatives, lean meat, chicken and kaimoana per day and times processed meat and takeaways were consumed per week. A low correlation (0.1-0.3) was found for servings of lean meat per week. Only servings of lean meat (per week) produced a non-significant correlation. An average correlation of 0.46 for all food group components was observed suggesting an overall moderate association (Cohen, 1988; Hopkins et al., 2009).

Bland Altman plots for food groups generally showed good agreement with few data points being located outside the LOA. Again, as the mean number of servings increased (particularly for breads and cereals and treat food), the difference between the number of servings from the ADI-Q#1 and ADI-Q#2 increased.

Correlations between the ADI-Q#1 and ADI-Q#2 for food variety were found to be significant ($p<0.05$). A very high correlation (07-0.9) was observed for variety of vegetables and a moderate correlation (0.3-0.5) for variety of fruit per week. An average correlation of 0.56 for dietary variety of fruit and vegetables suggests a high association between administrations of the ADI-Q (Cohen, 1988; Hopkins et al., 2009).

Fluids

The only fluid component found to have little agreement between administrations of both ADI-Qs using paired t-tests was water ($p<0.05$) with a higher mean number of servings reported from ADI-Q#1. The effect size was medium suggesting a reasonable difference (Field, 2009). The amount of water an athlete drinks can be hard to quantify as it is often consumed outside of meal times and during training or an event. This could explain the poor agreement between administrations.

Correlation coefficients ranged from -0.02 (servings of flavoured water/sports water) ($p>0.05$) through to 0.92 (servings of coffee) ($p<0.05$) with an average correlation of 0.52 suggesting an overall high association of fluids between administrations (Cohen, 1988; Ward et al., 2004).

Visual inspection of Bland-Altman plots showed few outliers (data outside the limits of agreement). As the mean number of servings of water increased so did the difference in servings of water between administrations of the ADI-Q.

Healthy versus less healthy options

All healthy compared with less healthy options were found to have high reproducibility using Chi-square tests ($p>0.05$). Visual inspection of the frequency between categories for both appointments shows good agreement across options. For example, for the question 'How often do you choose wholegrain breads and cereals?' 76.1% choose mostly/always from both the ADI-Q#1 and ADI-Q#2.

Meal frequency

Meal frequency was also found to have high reproducibility with all Chi-square p values >0.05, suggesting majority of the athlete's meal occasions remained unchanged during the period of the study.

Changes in dietary intake and the effects on reproducibility

Reproducibility of the ADI-Q may be affected if the athletes changed their diet during the study period (between administration of ADI-Q#1 and ADI-Q#2) due to seasonal training demands. To allow for the possibility of this the athletes were asked at the time of completing ADI-Q#2 if they had made any changes to their diet during the study period. Thirteen (19.4%) of the participants reported making changes to their diet during this time. Changes included; adding fat, adding salmon to help with satiety, eating more red meat, adding some gluten back into diet, increasing the amount of food due to a lack in energy, decreasing CHO intakes, decreasing sugar/refined sugar, decreasing dairy, decreasing portion size as close to racing season (to achieve race weight), decreasing the amount of food due to a decrease in training load and eating 'clean' as part of a gym challenge.

The reproducibility of the results was minimally affected when these 13 participants were removed from data analysis. There was a slight variation in the dietary components found to be significantly different with correlation coefficients ranging from 0.09-0.66 for food groups; -0.02-0.89 for fluids and 0.40-0.68 for variety of fruit and vegetables. All healthy compared with less healthy options and meal frequencies showed good agreement between administrations with Chi square p values >0.05. These results are displayed in Appendix A.

Comparisons with other literature

Relative validity

Few dietary assessment validation studies have been conducted in an athletic population (Baker et al., 2014; Braakhuis et al., 2011; Briggs et al., 2015; Fogelholm & Lahtikoski, 1991; Scoffier et al., 2013; Sunami et al., 2016; Ward et al., 2004) and only one has validated a dietary assessment method for food groups (Sunami et al., 2016). A food frequency questionnaire developed for middle aged people was validated for young athletes using three non-consecutive 24-hour dietary recalls (Sunami et al., 2016). The validity of both nutrients and food groups were assessed. Crude correlation coefficients for individual food items ranged from 0.04 to 0.57 with a median correlation of 0.34 for males and -0.01 to 0.59 with a median correlation of 0.33 for females. Sunami et al. (2016) also produced energy adjusted correlation coefficients with median correlations of 0.30 for males and 0.31 for females. Our study showed correlations ranging from; 0.19-0.66 with a mean correlation of 0.42 for food groups, 0.48-0.55 with a mean correlation of 0.52 for food variety and -0.03-0.77 with a mean correlation of 0.39 for fluids. The range in correlation coefficients appears similar to this study however mean correlations are higher in our study. Direct comparisons should however be interpreted with care as Sunami et al (2016) produced median correlations separately for both males and females.

As far as we are aware, only one index has been developed for use in New Zealand populations (Wong et al., 2013). Wong et al. (2013) developed and validated the first food based diet index for New Zealand adolescents (NZDQI-A). Correlation coefficients between the NZDQI-A and 4DFR for individual dietary components such as fruit, vegetables, cereal, dairy and meat ranged from 0.21 to 0.57, which is similar to the correlations for individual food groups found in this research.

Reproducibility

Few studies have tested the reproducibility of dietary assessment methods in athletes (Braakhuis et al., 2011; Pedisic et al., 2008; Ward et al., 2004) with most looking at the reproducibility of nutrients not food groups. A study conducted by Pedisic et al (2008) assessed the reproducibility of a comprehensive FFQ tailored for the assessment of dietary habits among athletes and other physically active individuals in Croatia. Participants completed the FFQ on two occasions one month apart (similar to this study). Pearson's correlation coefficients were used to determine the agreement between nutrient intakes. In males Pearson's correlations ranged from 0.51 for copper to 0.95 for alcohol with an average correlation of 0.68. In female's correlations ranged from 0.30 for alcohol to 0.78 for calcium, with an average correlation of 0.60. Although average correlations are slightly higher than this research, a direct comparison is not possible as results looked at reproducibility of nutrients not food groups. Pedisic et al. (2008) also found that the mean intake was higher in the first than in the second administration of the FFQ for almost all nutrients. This was also the case for repeat administrations of the ADI-Q for food groups and fluids, which were significantly different between administrations. It is important to note that Pedisic et al. (2008) analysed nutrient data seperately for males and females as research suggests that reproducibility coefficents may be associated with gender. This could warrant further research regarding the reproducibility of the ADI-Q.

Reproducibilty of dietary assessment tools in other athletic populations have found correlations of 0.52 for calcium (Ward et al, 2004) and 0.83 for total antioxidant intake (Braakhuis, 2011). However it is difficult to compare studies due to the use of nutrients rather than food groups, and different time frames between administration of the tools.

Study strength and limitations

This study assessed both the validity and reproducibility of the ADI-Q, which is a strength, particularly as few studies have measured both in an athletic population (Braakhuis et al., 2011; Ward et al., 2004). Furthermore, a range of statistical analysis techniques were used to assess the validity and reproducibility of the ADI-Q. As no one statistical test has been suggested to assess validity of dietary assessment it was important for this study to use a wide variety of tests to ensure different facets of validity were explored (Block & Hartman, 1989).

Respondent characteristics can influence any type of research. To limit this it has been suggested that validation studies of new dietary assessment methods require a sample size of more than 100 participants (Serra-Majem et al., 2009). Unfortunately, due to the busy nature of the athletic population only 69 participants were able to take part in this study and therefore results should be interpreted with caution. A small sample size may have restricted the ability to detect good agreement between the two dietary methods (Wong et al., 2013). However, these numbers are comparable to other dietary assessment validation studies undertaken in athletes, whereby study numbers have ranged from 12 (Briggs et al., 2015) to 171 (Sunami et al., 2016). All participants were volunteers and therefore may be considered more motivated to accurately complete the ADI-Q and 4DFR, which may enhance the validity of the ADI-Q. Athletes representing approximately 30 different sports were involved in the study while the majority of other studies completed within athletic populations tended to only have participants from a few select sports for example; rowers (Braakhuis et al., 2011) and soccer players (Braakhuis et al., 2011; Briggs et al., 2015).

Another important limitation for the validity of newly developed dietary assessment methods (such as diet index) can include questionnaire design. Developing a dietary assessment tool like the ADI-Q involves many researcher decisions particularly in regards to the choice of dietary components. Prior to developing the ADI-Q, an extensive literature review of other diet indices designed for the general New Zealand and Australian population was conducted. This was to ensure we had a complete questionnaire specifically related to the baseline nutrition requirements of athletes (Waijers et al., 2007).

Strengths associated with the questionnaire design include:

- Extensive consultation and pre-testing to ensure the questionnaire was appropriate for and understood by athletes.
- Additional serving sizes were available as an option for each food group allowing the higher dietary intakes of athletes to be considered.
- Athlete specific products such as sports waters and sports drinks were included in the fluids list.

  The questionnaire included additional sections such as 'training or event details' and 'special diet and supplements'. Information from these sections could be helpful when interpreting the dietary intake of athletes

Limitations associated with questionnaire design may include:

- Protein shakes were not included in the ADI-Q list but were frequently consumed according to the food record.
- For some fluids, e.g. tea, coffee, hot chocolate/milo/cocoa there was no differentiation between being made with mostly milk or mostly water.
- The use of 'times' instead of 'servings' for processed meat, treat food and takeaways could have been confusing for participants.
- It was not specified clearly what takeaways to include when asked how many times the participant consumes takeaways e.g. only fast foods or café and restaurant meals as well?
- Participants were asked to include savoury snacks like potato chips in their answer for times consumed takeaways. Further discussion is needed to distinguish if an additional question is needed for this food item.

Participants need to be provided thorough and accurate instructions when completing any type of dietary assessment method. Failure to do so can affect both the validity and reproducibility of data. To minimise this effect examples of how to answer questions, portion size examples for servings and a serving size guide was made available to participants when completing the ADI-Q both onsite at the Massey University Human Nutrition Research Centre and at home (ADI-Q#2). Additional education was also provided to individual athletes before completing the 4DFR (e.g. audio visual instructions (created by nutritionists and dietitians at the MUHNRC) were watched by each participant) to help improve the accuracy of correctly completing the 4DFR.

Data from the 4DFRs needed to be converted into equivalent data to the ADI-Q before validity could be assessed. This was particularly difficult for the coding (not applicable, never, rarely, sometimes, mostly, always) of healthy compared with less healthy options. For example, the use of salt. You cannot calculate a proportion by dividing the amount of times the participant had salt by the total number of meals as salt is not regularly consumed or appropriate to have at every meal. The same applies for the trimming of fat from meat or removal of skin from chicken as not all meats (e.g. mince) come with removable fat or skin.

It was also difficult at times to determine which dietary component (food group or fluid) from the ADI-#1 best reflected individual food items from the 4DFR. For example, protein or sports bars could contribute to either meat alternatives (nut based bars), breads and cereals (cereal based bars) or treat foods (main ingredient sugar). A list of assumptions can be found in Appendix B.

Choosing an appropriate reference method to determine validity of newly developed dietary assessment tools is also important. Biomarkers such as blood samples are sometimes used, however they can be expensive, invasive and are nutrient specific (e.g. 24-hour urinary nitrogen for protein). The ADI-Q focuses on overall diet quality (food group intake, variety, fluid consumption and eating habits) rather than specific nutrients meaning the usefulness of biomarkers is likely to be limited. An estimated food record was chosen as the reference method for this study as it is one of the most accurate dietary assessment tools, and less burdensome than a weighed food record (Burke et al., 2001). Food records have also been used by other validation studies completed among athletes (Braakhuis et al., 2011; Fogelholm & Lahtikoski, 1991; Scoffier et al., 2013; Ward et al., 2004). Although food records are not reliant on memory they can be time consuming especially for an athlete who is actively training with lots of eating occasions and this may result in under-reporting of dietary intake. To minimise the effects of this on this study each food diary was followed up with an email or phone call to ensure the accuracy and detail of information received.

The Goldberg equation is a well-known equation which has been used to identify over and under-reporting in dietary records. However, research suggests the Goldberg equation may not be useful in an athletic population (Burke, 2006). This is because some of the assumptions needed may not apply to athletes. For example, the Goldberg equation assumes that body weight remains stable if there is energy balance and that there is not huge day-to-day variability in food intake. For athletes, this often is not the case as athletes may purposely eat more the day before a competition or eat less on competition day due to nerves. This would not indicate over or under-reporting just changes in eating behaviours due to competition (Burke, 2006). The energy intake for the 4DFR for this study ranged from 5731kJ to 17765kJ/d, which appears to be a reasonable energy intake for an athletic population (Grandjean, 1997). Given the limitations of using the Goldberg equation in athletic populations and reasonable reporting of energy intakes no energy adjustments were made to allow for under-reporting.

Four consecutive days was chosen as the monitoring period for this study as for athletes a three to seven day diet monitoring period is suggested to provide accurate estimations of habitual energy and macronutrient consumption (Magkos & Yannakoulia, 2003). An additional strength was that dietary data was collected on days which reflected different training intensities as this is known to affect dietary intake. However, the period of time the 4DFR covered may not reflect the athlete's responses to the first administration of the ADI-Q.

3.6 Conclusions

In conclusion, the ADI-Q may provide a useful way to accurately and efficiently assess the baseline nutrition of high performing athletes throughout New Zealand. The ADI-Q showed reasonable validity of food groups, fluids, food variety and meal frequencies however, validity was poor for healthy food choices. Reproducibility was moderate to high, with the majority of dietary components showing good agreement and strength of association between administrations four weeks apart.

This tool could be used to identify athletes who are at risk of meeting food based dietary guidelines and would benefit from further dietary advice. It could also be used as an interactive dietary assessment tool for athletes and high performing coaches. Additional research and development of the ADI-Q and an index score to assess diet quality could help to further improve analysis of dietary intake among athletes.

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Chapter 4

Conclusion

4. Conclusion and recommendations

Accurate and efficient dietary assessment tools are needed to assess the dietary intake of high performing athletes. This information can then be used to provide the athletes with nutrition strategies designed to enhance their health and sporting performance.

A comprehensive literature review was conducted regarding the validation of dietary assessment tools used to determine the intake of an athletic population. A key finding was that very few tools exist and only one assesses the relative validity for intake of food groups (Sunami et al., 2016). Traditional dietary assessment methods such as diet records, food frequency questionnaires and 24-h diet recalls have been used to assess the dietary intake of athletes however these methods have a high participant and researcher burden, and are typically associated with the analysis of single nutrients and foods/food groups. However, nutrients and foods are not eaten in isolation, but in combinations that are likely to interact. Recently, research has begun to consider the diet quality of athletes (Burrows et al., 2016; Spronk et al., 2015). One way of assessing the complexity of the athlete's diet involves the use of a diet quality index. An index provides a summary of dietary patterns as a composite score according to predefined criteria of what constitutes a healthy or unhealthy diet (Wong et al., 2013). They can be based on foods, nutrients or a combination of both, and typically measures the degree of adherence to a set of national nutrition guidelines or a recommended diet prototype such as the Mediterranean diet (Wong et al., 2013). To our knowledge there are currently no diet indices which have been developed and validated to assess the dietary intake of athletes.

With this in mind the objectives of the present study, were to; design a tool (the ADI-Q) to assess the diet quality of high performing athletes; validate the ADI-Q for diet quality (food group intake, variety, fluid consumption, healthy compared with less healthy options and meal frequency) using a consecutive four day estimated food record and assess the reproducibility for diet quality by having athletes complete the ADI-Q on two occasions, four weeks apart.

The final design of the Athlete Diet Index Questionnaire (ADI-Q) includes four parts. Part two of the ADI-Q was designed to assess the adherence of athletes to food based dietary guidelines (specifically the Eating and Activity Guidelines for Adults). Parts one, three and four include additional questions on other aspects (e.g. training regime, injuries, sport supplement use, demographic questions) considered important for interpreting the dietary habits of athletes. The tool was based on other dietary assessment questionnaires, is culturally appropriate, computerised and only takes approximately 10-15 minutes to complete. The ADI-Q could currently be used to identify athletes who are at risk of not meeting food based guidelines and who may benefit from seeing a sports dietitian or nutritionist. It could be used as an education tool for teachers or coachers and as a research tool.

When compared to a four-day food record (4DFR) the ADI-Q has reasonable relative validity for majority of the dietary components. Pearson's correlations suggested a moderate association for food groups and fluids and high association for food variety. These were similar to, if not better than the correlations produced for food groups by Sunami et al. (2016) when validating an FFQ in college athletes. All frequencies of meals except morning tea showed good agreement between dietary assessment methods (ADI-Q and 4DFR). Agreement between healthy compared with less healthy dietary components was poor, with only the use of unsaturated fat found to have good relative validity between the ADI-Q#1 and 4DFR. This may be related to the difficulty associated with the conversion of this data from the 4DFR into data which could be compared to the ADI-Q#1. For example, the use of salt and the removal of fat/skin from meat and/or chicken.

The ADI-Q had moderate to high reproducibility when athletes completed the ADI-Q a second time (ADI-Q#2), four weeks later. The majority of food groups and fluids showed good agreement between mean intakes for both administrations with moderate to high correlations for food groups, food variety and fluids found between the ADI-Q#1 and ADI-Q#2. Reported meal frequencies and healthy dietary habits were similar between both administrations of the ADI-Q. Few studies in athletes have assessed the reproducibility of dietary assessment tools in athletes making it difficult to make comparisons with other literature.

Strengths and limitations have been discussed in chapter 3. Strengths included the assessment of both the validity and reproducibility of the ADI using a variety of statistical measures. This study had a comparable sample size to other dietary assessment validation studies performed within an athletic population. All participants were volunteers and therefore may have been more motivated to complete the study which could have enhanced the validity of the ADI-Q. Extensive research went into the choice of dietary components within the ADI-Q, but not all foods relevant for athletes were captured (e.g. protein shakes). Like with many other studies investigating dietary intake, a number of assumptions needed to be made (Appendix B). Assigning individual food items from the 4DFR to corresponding food groups from the ADI-Q proved difficult at times in an athletic population. For example, not all protein or sports bars were able to be assigned to the same food group. Instead it was decided that nut based bars would contribute to meat alternatives, cereal based bars to breads and cereals, and bars whose main ingredient was sugar to treat food (although this may not always be appropriate for an athletic population).

Further development of the ADI-Q dietary components would be beneficial. The following suggestions are recommended to improve the utility of the ADI-Q:

- The use of serving sizes for processed meat, treat foods and takeaways instead of number of times consumed.
- Further clarification as to the definition of takeaway foods and/or the inclusion of additional questions for different types of takeaways, For example, fast food versus food from cafes or restaurants; and savoury snacks (e.g. potato chips).
- The addition of photographs representing serving sizes of food items to the online version of the ADI-Q.
- Ensure all dietary components have been considered for athletes e.g. the addition of protein shakes to the fluids section.
- Fluids such as tea, coffee and hot chocolate/milo/cocoa could be split into made with mostly water or mostly milk.

Ultimately, the development of a single composite score for the ADI-Q to assess an athlete's adherence to food based dietary guidelines (Eating and Activity Guidelines for New Zealand Adults) may be useful. This would involve developing a scoring method for the dietary components of the ADI-Q. Careful consideration would need to be given to how points are allocated and the weighting of each index component. The requirements of training and competition nutrition would also need to be considered. Finally, the adaptation of the ADI-Q for use in other countries is recommended. Further testing of the validity and reproducibility of the ADI-Q will be needed following these changes.

Finally, in conclusion, the ADI-Q may provide a useful way to accurately and efficiently assess the baseline nutrition of high performing athletes throughout New Zealand. The ADI-Q demonstrated reasonable validity for food groups, fluids, food variety and meal frequencies however, validity was poor for healthy food choices. The ADI-Q demonstrated moderate to high reproducibility, with the majority of dietary components showing good agreement and strength of association when the ADI-Q was administered four weeks later.

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Appendix A - Supplementary Results

Frequency of dietary components ADI-Q#1 versus 4DFR

Table 1 Frequency of food group servings from the ADI-Q#1 (1st appointment) and 4DFR

ADI-Q dietary component	Number of serves/times	n (%) of participants scoring from ADI-Q#1 (n=69)	n (%) of participants scoring from 4DFR (n=68)
Servings of fruit (per day)			
	0	3 (4.3)	4 (5.9)
	1	14 (20.3)	25 (36.8)
	2	25 (36.2)	21 (30.9)
	3	21 (30.4)	9 (13.2)
	4+	6 (8.7)	9 (13.2)
Servings of dried fruit/fruit juice (per day)			
	0	53 (76.8)	46 (67.6)
	1	12 (17.4)	18 (26.5)
	2+	4 (5.8)	4 (5.9)
Variety of fruit (Not including dried fruit or fruit juice) (per week or per 4 days) [a]			
	0	0 (0.0)	3 (4.5)
	1	2 (2.9)	4 (6.0)
	2	6 (8.7)	13 (19.4)
	3	14 (20.3)	21 (31.3)
	4	19 (27.6)	10 (14.9)
	5	15 (21.7)	10 (14.9)
	6	11 (15.9)	5 (7.5)
	7+	2 (2.9)	1 (1.5)
Servings of starchy vegetables (per day)			
	0	32 (46.4)	28 (41.2)
	1	24 (34.8)	30 (44.1)
	2	9 (13.0)	10 (14.7)
	3	4 (5.8)	0 (0.0)
Servings of non-starchy vegetables (per day)			
	0	6 (8.7)	0 (0.0)
	1	19 (27.5)	14 (20.6)
	2	18 (26.1)	23 (33.8)
	3	10 (14.5)	9 (13.2)
	4	13 (18.8)	13 (19.1)
	5+	3 (4.3)	9 (13.2)
Variety of vegetables (including starchy and non-starchy vegetables) (per week or per 4 days) [a]			
	≤2	0 (0.0)	0 (0.0)
	3	1 (1.4)	0 (0.0)
	4	1 (1.4)	3 (4.5)
	5	0 (0.0)	3 (4.5)
	6	4 (5.8)	6 (9.0)

ADI-Q dietary component	Number of serves/times	n (%) of participants scoring from ADI-Q#1 (n=69)	n (%) of participants scoring from 4DFR (n=68)
	7	7 (10.1)	5 (7.5)
	8	6 (8.7)	11 (16.4)
	9	6 (8.7)	6 (9.0)
	10	3 (4.3)	14 (20.9)
	11	8 (11.6)	8 (11.9)
	12+	33 (47.8)	11 (16.4)
Servings of breads and cereals (per day)			
	0	6 (8.7)	0 (0.0)
	1	9 (13.0)	1 (1.5)
	2	11 (15.9)	5 (7.4)
	3	15 (21.7)	15 (22.1)
	4	9 (13.0)	12 (17.6)
	5	7 (10.1)	12 (17.6)
	6	5 (7.2)	11 (16.2)
	7+	7 (10.1)	12 (17.6)
Servings of milk and milk alternatives (per day)			
	0	8 (11.6)	4 (5.9)
	1	17 (24.6)	20 (29.4)
	2	24 (34.8)	20 (29.4)
	3	10 (14.5)	14 (20.6)
	4	5 (7.2)	9 (13.2)
	5+	5 (7.2)	1 (1.5)
Servings of lean meat (beef, lamb, pork) (per week) [b]			
	0	5 (7.2)	11 (16.2)
	1	7 (10.1)	5 (7.4)
	2	16 (23.2)	8 (11.8)
	3	15 (21.7)	10 (14.7)
	4	10 (14.5)	11 (16.2)
	5	3 (4.3)	3 (4.4)
	6	2 (2.9)	2 (2.9)
	7+	11 (15.9)	10 (14.7)
Total servings of lean meat, chicken and kaimoana (per day)			
	0	22 (31.9)	11 (16.2)
	1	25 (36.2)	24 (35.3)
	2	14 (20.3)	15 (22.1)
	3	4 (5.8)	15 (22.1)
	4+	4 (5.8)	3 (4.4)
Processed meat (times per week)			
	0	19 (27.5)	20 (29.4)
	1	27 (39.1)	0 (0.0)
	2	8 (11.6)	14 (20.6)
	3	8 (11.6)	0 (0.0)
	4	4 (5.8)	17 (25.0)
	5	2 (2.9)	6 (8.8)
	6	0 (0.0)	0 (0.0)
	7+	1 (1.4)	11 (16.2)
Servings of meat alternatives (per day)			
	0	32 (46.4)	8 (11.8)

ADI-Q dietary component	Number of serves/times	n (%) of participants scoring from ADI-Q#1 (n=69)	n (%) of participants scoring from 4DFR (n=68)
	1	14 (20.3)	30 (44.1)
	2	11 (15.9)	19 (27.9)
	3	8 (11.6)	6 (8.8)
	4	1 (1.4)	3 (4.4)
	5	2 (2.9)	2 (2.9)
	6+	1 (1.4)	0 (0.0)
Treat food (times per week)			
	0	8 (11.6)	13 (19.1)
	1	20 (29.0)	0 (0.0)
	2	6 (8.7)	20 (29.4)
	3	9 (13.0)	0 (0.0)
	4	11 (15.9)	12 (17.6)
	5	3 (4.3)	6 (8.8)
	6	1 (1.4)	0 (0.0)
	7+	11 (15.9)	17 (25.1)
Takeaways (times per week) [c]			
	0	22 (31.9)	15 (22.1)
	1	37 (53.6)	0 (0.0)
	2	7 (10.1)	16 (23.5)
	3	3 (4.3)	0 (0.0)
	4	0 (0.0)	19 (27.9)
	5	0 (0.0)	10 (14.7)
	6	0 (0.0)	0 (0.0)
	7+	0 (0.0)	8 (11.8)

ADI-Q- Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; 4DFR-four-day food record

Data collected for fruit, vegetables, breads and cereals, milk and milk alternatives, meat and meat alternatives are reported as number of servings

Data collected for processed meat, treat food and takeaways were reported as times participant had that food item. The amount of each food item was not considered. The number of times the food item was eaten in the 4DFR was divided by four and multiplied by seven to convert to a weekly amount

[a] Variety - Data collected for variety is in its raw form e.g. ADI-Q#1 is the number of different fruits/vegetables consumed in the last seven days and the 4DFR is the number of different fruits/vegetables consumed over four days. n=67 for variety of 4DFR as one participant only completed 3 of the 4 days

[b] To determine the number of servings of lean meat per week from the ADI-Q#1 daily amounts were multiplied by seven, monthly amounts divided by 4 and yearly amounts divided by 52.

[b] To determine the number of servings of lean meat per week from the 4DFRF the total sum of meat over four days was divided by four (daily amount) and multiplied by seven (weekly amount)

[c] Takeaway data includes all food eaten outside of the home (e.g. food eaten at restaurants, sushi, subway, McDonalds e.t.c)

Table 2 Frequency of fluid servings from the ADI-Q#1 (1st appointment) and 4DFR

ADI-Q dietary components	Number of serves per day	% of participants scoring from ADI-Q#1 (n=69)	% of participants scoring from 4DFR (n=68)
Servings of flavoured water			
	0	68 (98.6)	65 (95.6)
	1	1 (1.4)	3 (4.4)
Servings of sports drinks			
	0	60 (87.0)	61 (89.7)
	1	7 (10.1)	5 (7.4)
	2+	2 (2.9)	2 (2.9)
Servings of coconut water			
	0	67 (97.1)	66 (97.1)
	1+	2 (2.9)	2 (2.9)
Servings of water [a]			
	0	0 (0.0)	1 (1.5)
	1	5 (7.2)	1 (1.5)
	2	1 (1.4)	3 (4.4)
	3	4 (5.8)	7 (10.3)
	4	7 (10.1)	9 (13.2)
	5	5 (7.2)	6 (8.8)
	6	11 (15.9)	9 (13.2)
	7	8 (11.6)	6 (8.8)
	8	9 (13.0)	11 (16.2)
	9	2 (2.9)	5 (7.4)
	10	6 (8.7)	0 (0.0)
	11	0 (0.0)	3 (4.4)
	12+	11 (15.9)	7 (10.3)
Servings of milk or milk alternatives [b]			
	0	18 (26.1)	40 (58.8)
	1	27 (39.1)	23 (33.8)
	2	15 (21.7)	4 (5.9)
	3	5 (7.2)	1 (1.5)
	4+	4 (5.8)	0 (0.0)
Servings of fruit Juice			
	0	64 (92.8)	62 (91.2)
	1	4 (5.8)	5 (7.4)
	2	1 (1.4)	1 (1.5)
Servings of soft drinks/fizzy drinks/carbonated drinks			
	0	68 (98.6)	53 (77.9)
	1	1 (1.4)	13 (19.1)
	2+	0 (0.0)	2 (3.0)
Servings of cordial/powdered fruit drinks			
	0	68 (98.6)	66 (97.1)
	1+	1 (1.4)	2 (2.9)
Servings of herbal tea			
	0	48 (69.6)	53 (77.9)
	1	14 (20.3)	9 (13.2)
	2+	7 (10.1)	6 (8.8)
Servings of tea [c]			
	0	54 (78.3)	55 (80.9)
	1	7 (10.1)	11 (16.2)

ADI-Q dietary components	Number of serves per day	% of participants scoring from ADI-Q#1 (n=69)	% of participants scoring from 4DFR (n=68)
	2	4 (5.8)	0 (0.0)
	3+	4 (5.8)	2 (2.9)
Servings of drinking chocolate/milo/cocoa [d]			
	0	61 (88.4)	62 (91.2)
	1+	8 (11.6)	6 (8.8)
Servings of coffee [e]			
	0	42 (60.9)	40 (58.8)
	1	20 (29.0)	18 (26.5)
	2	5 (7.2)	9 (13.2)
	3	2 (2.9)	1 (1.5)
Servings of energy drinks			
	0	69 (100)	68 (100)
Servings of alcohol			
	0	66 (95.7)	63 (92.6)
	1+	3 (4.3)	5 (7.4)

ADI-Q – Athlete Diet Index Questionnaire; ADI-Q#1 – Athlete Diet Index Questionnaire 1st appointment; 4DFR – four-day food record
Data collected for fluids reported as number of servings participant had.
[a] Water - includes water added to protein shakes/meal replacements.
[b] Milk and milk alternatives - includes milk added to protein shakes/meal replacements, breakfast drinks (Up and Go) and flavoured milk.
[c] Tea includes black tea and tea made with milk.
[d] Hot chocolate/milo/cocoa - includes café style hot chocolates made mostly with milk, cold milos made mostly with milk and milos made mostly with water.
[e] Coffee includes both instant coffee made mostly with water, café style coffee made mostly with milk (including moccas) and iced coffees.

Table 3 Frequency of participants who chose healthy and less healthy options from the ADI-Q#1 (1st appointment) and 4DFR

ADI-Q dietary component and response	n (%) of participants scoring from ADI-Q#1 (n=69)	n (%) of participants scoring from 4DFR (n=68)
How often do you choose wholegrain options?		
Never	0 (0.0)	4 (5.9)
Rarely	5 (7.2)	12 (17.6)
Sometimes	11 (15.9)	26 (38.2)
Mostly	33 (47.8)	25 (36.8)
Always	20 (29.0)	1 (1.5)
N/A - I don't eat breads and cereals	0 (0.0)	0 (0.0)
How often do you choose low fat milk or milk alternatives?		
Never	13 (18.8)	8 (11.8)
Rarely	9 (13.0)	14 (20.6)
Sometimes	8 (11.6)	19 (27.9)
Mostly	12 (17.4)	20 (29.4)
Always	25 (36.2)	6 (8.8)
N/A - I don't drink or eat milk or milk alternatives	2 (2.9)	1 (1.5)
How often do you remove the fat/skin from lean meat or chicken?		
Never	8 (11.6)	1 (1.5)
Rarely	5 (7.2)	0 (0.0)
Sometimes	10 (14.5)	15 (22.1)
Mostly	23 (33.3)	25 (36.8)
Always	20 (29.0)	23 (33.8)
N/A I don't eat meat or chicken	3 (4.3)	4 (5.9)
How often do you use or add unsaturated fats to meals/cooking?		
Never	5 (7.2)	6 (8.8)
Rarely	5 (7.2)	6 (8.8)
Sometimes	20 (29.0)	14 (20.6)
Mostly	25 (36.2)	18 (26.5)
Always	13 (18.8)	19 (27.9)
N/A - I don't cook with or add any fats to food	1 (1.4)	5 (7.4)
How often do you add salt to cooking or at the table?		
Never	12 (17.4)	26 (38.2)
Rarely	18 (26.1)	18 (26.5)
Sometimes	13 (18.8)	22 (32.4)
Mostly	23 (33.3)	1 (1.5)
Always	3 (4.3)	1 (1.5)

ADI-Q – Athlete Diet Index Questionnaire; ADI-Q#1 – Athlete Diet Index Questionnaire 1st appointment; 4DFR – four-day food record

Data collected for healthy versus less healthy options from the ADI-Q#1 were reported as the following frequencies; never; rarely (1/4 of the time); sometimes (1/2 of the time); mostly (3/4 of the time); always and N/A (not applicable)

Data collected for healthy versus less healthy options from the 4DFR were calculated for example by counting the total amount of breads and cereals over four days and then calculating the proportion of which were wholegrain options. The proportion was then coded with a response using the following - never =0%, rarely <25%, sometimes 25-75%, mostly >75%, always 100%

Table 4 Frequency of meals from the ADI-Q#1 (1st appointment) and 4DFR

ADI dietary component and response	n (%) of participants scoring from ADI#1 (n=69)	n (%) of participants scoring from 4DFR (n=68)
How often would you have breakfast?		
Never	0 (0.0)	0 (0.0)
Rarely	0 (0.0)	0 (0.0)
Sometimes	1 (1.4)	0 (0.0)
Mostly	8 (11.6)	4 (5.9)
Always	60 (87.0)	64 (94.1)
How often would you have a mid-morning snack (food or drink between breakfast and mid-day meal)?		
Never	1 (1.4)	5 (7.4)
Rarely	3 (4.3)	8 (11.8)
Sometimes	12 (17.4)	5 (7.4)
Mostly	24 (34.8)	24 (35.3)
Always	29 (42.0)	26 (38.2)
How often would you have lunch?		
Never	0 (0.0)	0 (0.0)
Rarely	0 (0.0)	0 (0.0)
Sometimes	0 (0.0)	2 (2.9)
Mostly	6 (8.7)	5 (7.4)
Always	63 (91.3)	61 (89.7)
How often would you have a mid-afternoon snack (food or drink between a mid-day meal and evening meal)?		
Never	2 (2.9)	3 (4.4)
Rarely	4 (5.8)	2 (2.9)
Sometimes	12 (17.4)	12 (17.6)
Mostly	21 (30.4)	14 (20.6)
Always	30 (43.5)	37 (54.4)
How often would you have an evening meal?		
Never	0 (0.0)	0 (0.0)
Rarely	0 (0.0)	0 (0.0)
Sometimes	0 (0.0)	0 (0.0)
Mostly	4 (5.8)	8 (11.8)
Always	65 (94.2)	60 (88.2)
How often would you have supper (food or drink after an evening meal but before bed)? [a]		
Never	6 (8.8)	12 (17.6)
Rarely	20 (29.4)	17 (25.0)
Sometimes	19 (27.9)	17 (25.0)
Mostly	19 (27.9)	13 (19.1)
Always	4 (5.9)	9 (13.2)

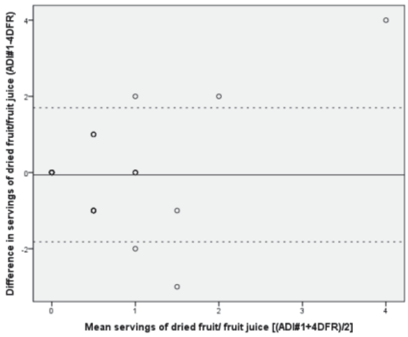
ADI-Q – Athlete Diet Index Questionnaire; ADI-Q#1 – Athlete Diet Index Questionnaire 1st appointment; 4DFR – four-day food record

[a] One response missing from supper ADI-Q#1

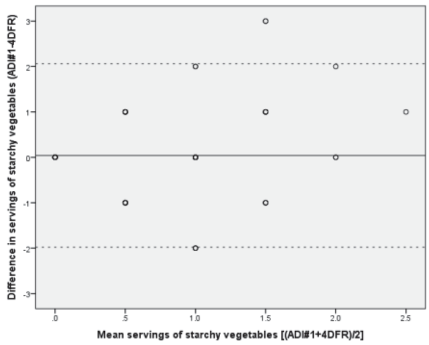
Data collected for meal frequency were reported as how often participant had each meal; never; rarely (1/4 of the time); sometimes (1/2 of the time), mostly (3/4 of the time), always.

Data for 4DFR were coded as the following – example breakfast; never (never had breakfast); rarely (had breakfast one out of the four days); sometimes (had breakfast twice out of the four days); Mostly (had breakfast three times over four days); always (had breakfast four times over four days)

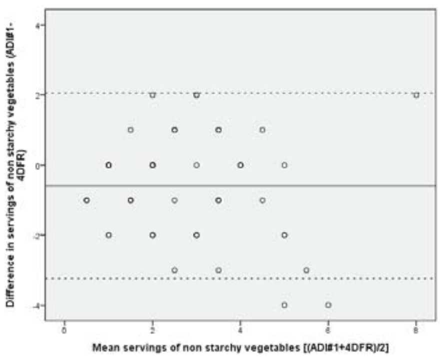
Additional Bland-Altman plots for relative validity for dietary components from the ADI-Q#1 versus 4DFR (n=68)



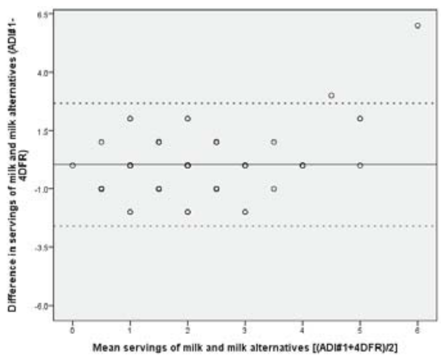
(I): Bland-Altman plot of servings of dried fruit/fruit juice



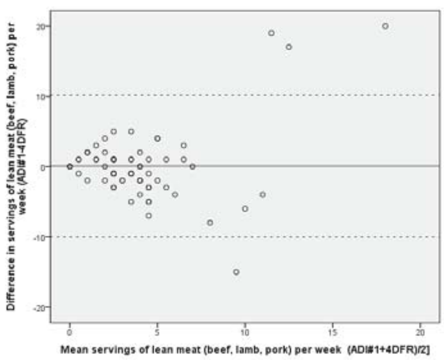
(J): Bland-Altman plot of servings of starchy vegetables



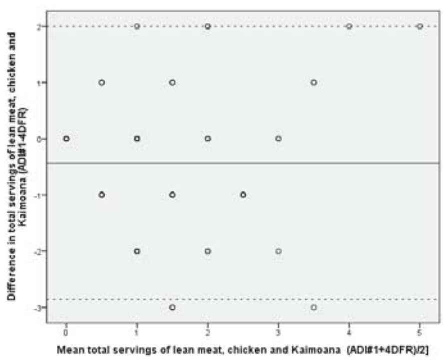
(K): Bland-Altman plot of servings of non-starchy vegetables



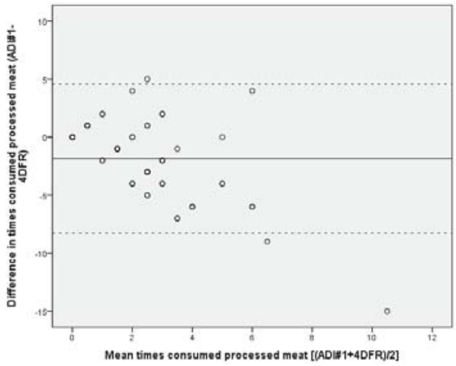
(L): Bland-Altman plot of servings of milk and milk alternatives



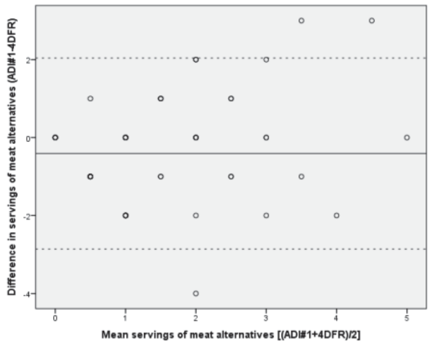
(M): Bland-Altman plot of servings of lean meat (beef, lamb, pork) (per week)



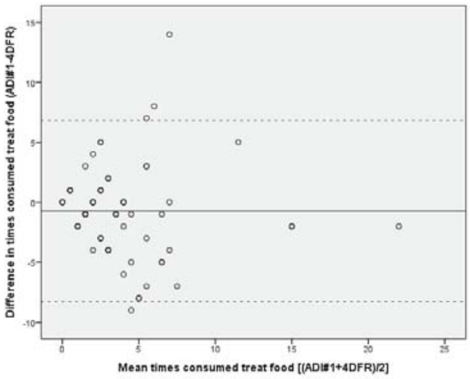
(N): Bland-Altman plot of servings of lean meat, chicken and kaimoana



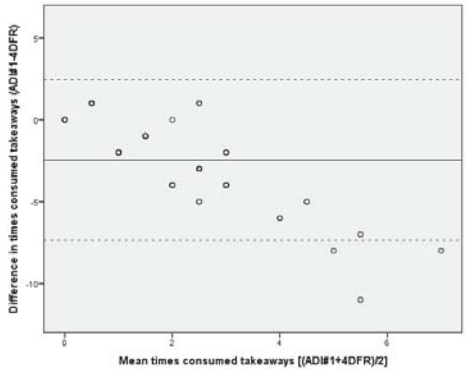
(O): Bland-Altman plot of times processed meat consumed (per week)



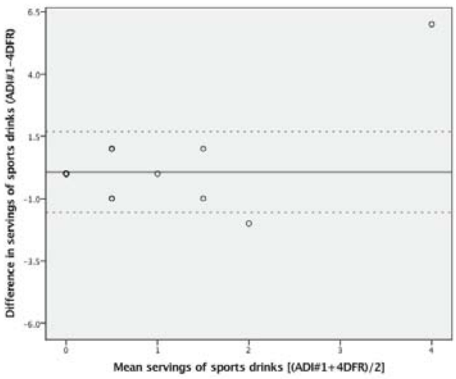
(P): Bland-Altman plot of servings of meat alternatives



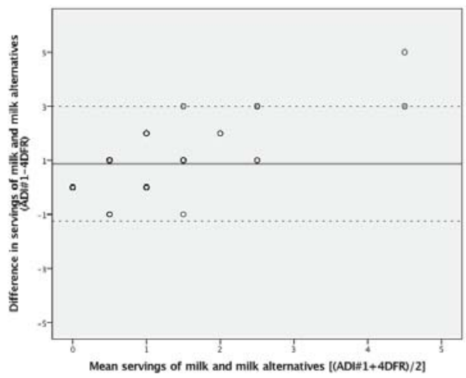
(Q): Bland-Altman plot of times treat food consumed (per week)



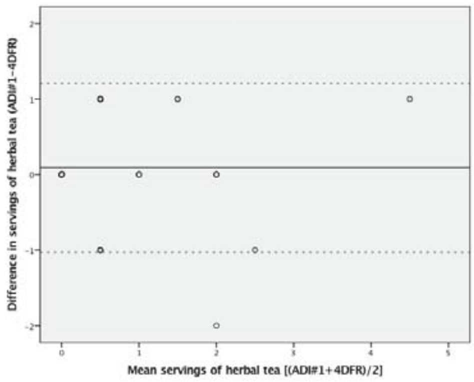
(R): Bland-Altman plot of times takeaways consumed (per week)



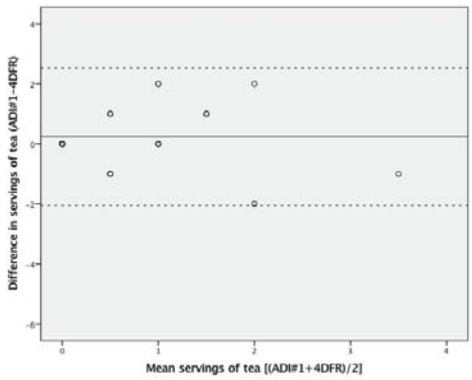
(S): Bland-Altman plot of servings of sports drinks



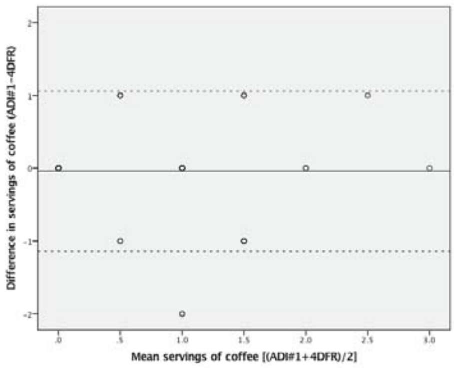
(T): Bland-Altman plot of servings of milk and milk alternatives



(U): Bland-Altman plot of servings of herbal tea

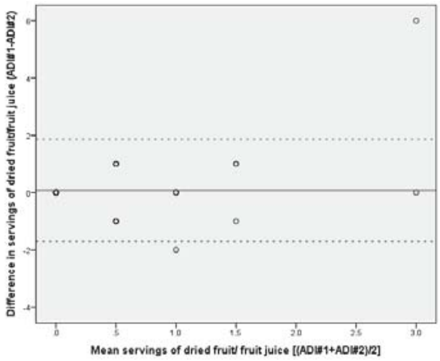


(V): Bland-Altman plot of servings of tea

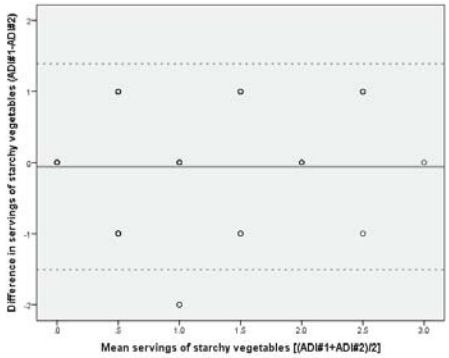


(W): Bland-Altman plot of servings of coffee

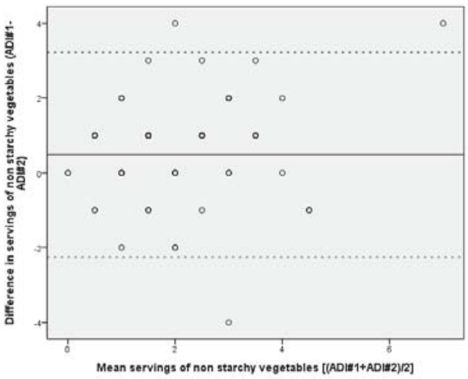
Additional Bland–Altman plots of reproducibility for dietary components from the ADI-Q#1 and ADI-Q#2 (n=67)



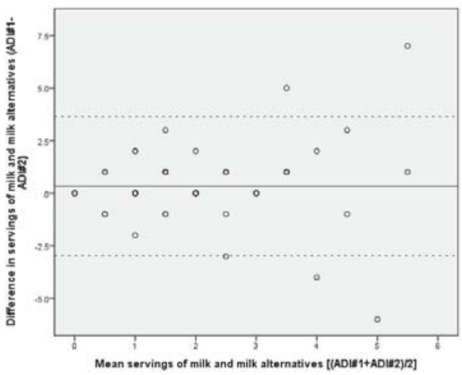
(X): Bland-Altman plot of servings of dried fruit/ fruit juice



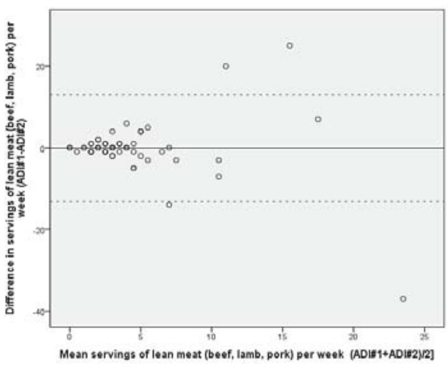
(Y): Bland-Altman plot of servings of starchy vegetables



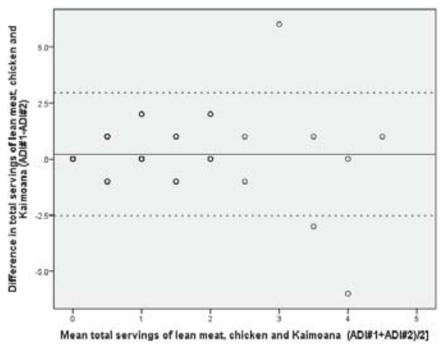
(Z): Bland-Altman plot of servings of non-starchy vegetables



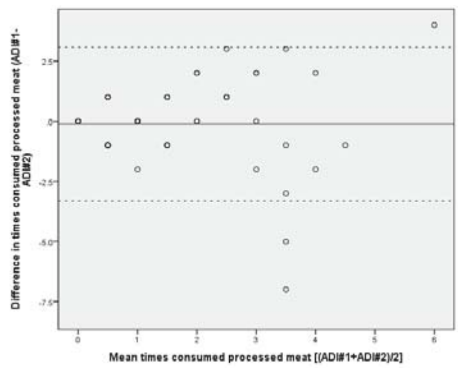
(AA): Bland-Altman plot of servings of milk and milk alternatives



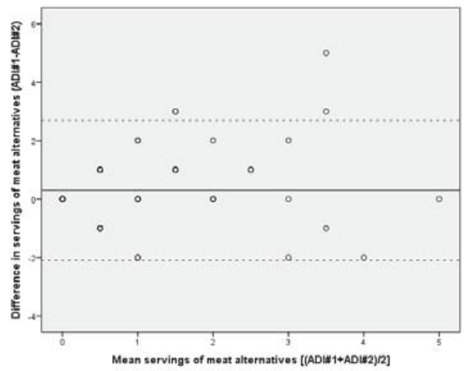
(AB): Bland-Altman plot of servings of lean meat (beef, lamb, pork) (per week)



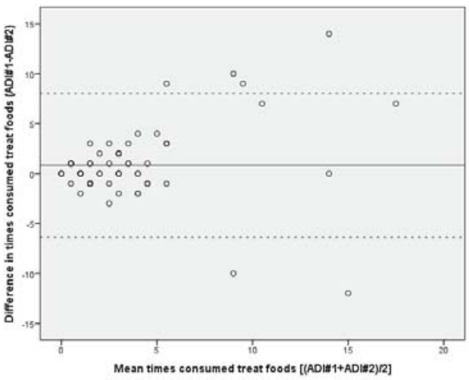
(AC): Bland-Altman plot of servings of lean meat, chicken and kaimoana



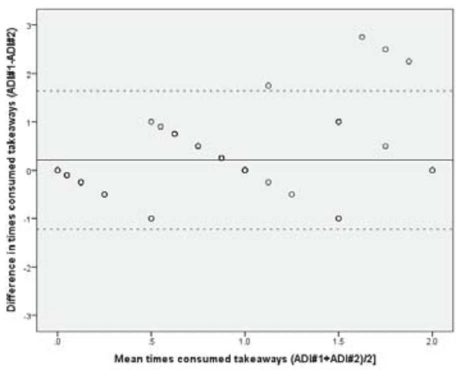
(AD): Bland-Altman plot of times consumed processed meat



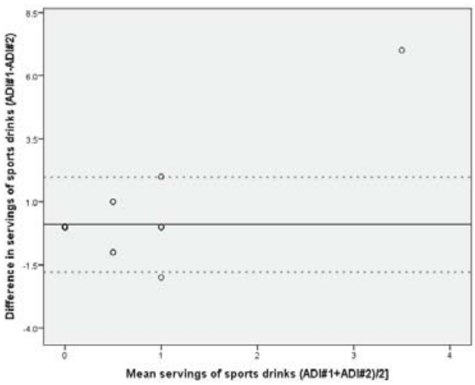
(AE): Bland-Altman plot of servings of meat alternatives



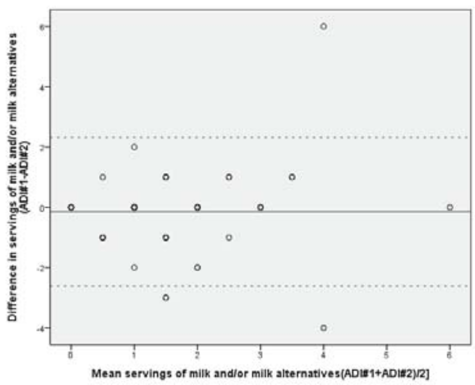
(AF): Bland-Altman plot of times consumed treat foods



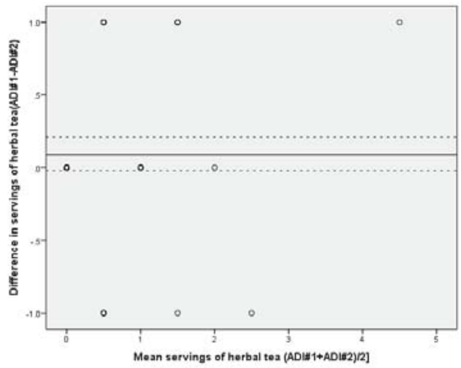
(AG): Bland-Altman plots of times consumed takeaways



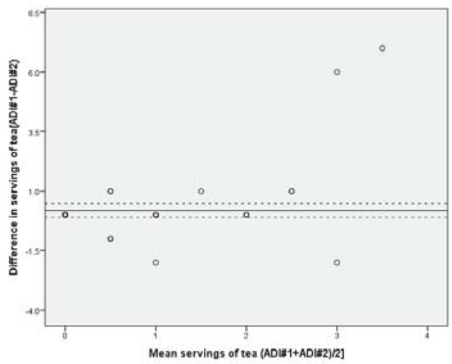
(AH): Bland-Altman plot of servings of sports drinks



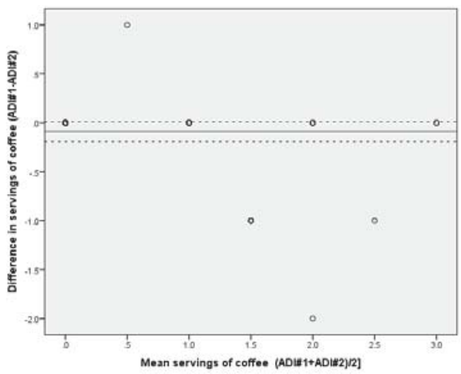
(AI): Bland-Altman plot of servings of milk and milk alternatives



(AJ): Bland-Altman plot of servings of herbal tea



(AK): Bland-Altman plot of servings of tea



(AL): Bland-Altman plot of servings of coffee

Reproducibility of the ADI-Q#1 and ADI-Q#2 including only participants who did not make any changes to their diet between appointment one and two*

*Table 5 Comparison between mean dietary components (food groups and variety) from the Athlete Diet Index Questionnaire one (ADI-Q#1) with the Athlete Diet Index Questionnaire two (ADI-Q#2) (n=54)**

ADI-Q Dietary Component Food	ADI-Q#1 Mean dietary Intake (Mean ± SD)	ADI-Q#2 Mean dietary Intake (Mean ± SD)	Mean difference (Mean ± SD)	Paired t-test (p-value)	Effect size (r)	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of fruit	2.33±1.35	2.37±1.64	-0.04±1.58	0.864		0.456	0.001
Servings of dried fruit/fruit juice	0.39±1.00	0.24±0.58	0.15±0.92	0.242		0.421	0.002
Variety of fruit (per week)	4.09±1.53	3.59±1.33	0.50±1.58	0.023	0.31	0.400	0.003
Servings of starchy vegetables	0.85±0.90	0.91±0.85	-0.06±0.74	0.582		0.646	<0.001
Servings of non-starchy vegetables	2.20±1.66	1.72±1.27	0.48±1.50	0.022	0.31	0.502	<0.001
Variety of vegetables (per week)	10.96±3.67	10.61±3.69	0.35±2.95	0.385		0.678	<0.001
Servings of breads and cereals	3.70±2.93	3.04±2.45	0.67±2.90	0.097		0.430	0.001
Servings of milk and/or milk alternatives	2.15±1.72	1.87±1.51	0.28±1.81	0.263		0.379	0.005

Servings of lean meat (lamb, pork, beef) (per week) [a]	3.91±4.67	4.06±6.06	-0.15±7.33	0.882		0.085	0.542
Total servings of lean meat, chicken and kaimoana (per day)[a]	1.26±1.35	1.04±1.41	0.22±1.51	0.285		0.401	0.003
Times consumed processed meat (per week)	1.50±1.65	1.63±1.41	-0.13±1.45	0.515		0.555	<0.001
Servings of meat alternatives	1.15±1.45	0.80±1.16	0.35±1.28	0.048	0.27	0.538	<0.001
Times consumed treat food (per week)	4.30±4.98	3.22±3.76	1.07±3.80	0.042	0.27	0.655	<0.001
Times eaten takeaways (per week)[b]	0.87±0.80	0.67±0.56	0.20±0.79	0.069		0.363	0.007

ADI-Q#1=Athlete Diet Index Questionnaire 1st appointment, ADI-Q#2=Athlete Diet Index Questionnaire 2nd appointment; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)
Mean daily intake and mean difference is reported as mean ±SD
Data collected for fruit, vegetables, breads and cereals, milk and milk alternatives, meat and meat alternatives are reported as number of servings Data collected for processed meat, treat food and takeaways were reported as times participant had that food item. The amount of each food item was not considered. The number of times the food item was eaten in the 4DFR was divided by four and multiplied by seven to convert to a weekly amount
[a] To determine the number of servings of lean meat per week from the ADI-Q#1 daily amounts were multiplied by seven, monthly amounts divided by 4 and yearly amounts divided by 52
[a] To determine the number of servings of lean meat per week from the 4DFRF the total sum of meat over four days was divided by four to get a daily amount and multiplied by seven to get a weekly amount
[b] Takeaway data includes all food eaten outside of the home (e.g. food eaten at restaurants, sushi, subway, McDonalds)

*Table 6 Comparison between mean dietary components (fluid) from the Athlete Diet Index Questionnaire one (ADI-Q#1) with the Athlete Diet Index Questionnaire two (ADI-Q#2) (n=54)**

ADI-Q Dietary Component Fluid	ADI-Q#1 Mean dietary Intake (Mean ± SD)	ADI-Q#2 Mean dietary Intake (Mean ± SD)	Mean difference	Paired t-test (p-value)	Effect size	Pearson's correlation coefficient (r)	Pearson's correlation - significance
Servings of flavoured water, sports water	0.02±0.14	0.02±0.14	0.00±0.19	1.000		-0.019	0.892
Servings of sports drinks	0.24±0.99	0.09±0.29	0.15±0.98	0.271		0.182	0.187
Servings of coconut water	0.06±0.41	0.00±0.00	0.06±0.41	0.322		[a]	[a]
Servings of water [b]	8.00±4.70	6.83±3.45	1.17±3.70	0.024	0.30	0.626	>0.001
Servings of milk and/or milk alternatives [c]	1.41±1.43	1.54±1.30	-0.13±1.26	0.453		0.579	>0.001
Servings of fruit juice	0.11±0.37	0.09±0.35	0.02±0.24	0.569		0.786	>0.001
Servings of soft drinks/fizzy drinks/ carbonated drinks	0.00 [a] ±0.00	0.00 [a] ±0.00	[a]	[a]		[a]	[a]
Servings of powdered drinks/cordials	0.02±0.14	0.06±0.30	-0.04±0.27	0.322		0.434	0.001
Servings of herbal teas	0.44±0.86	0.33±0.70	0.11±0.50	0.109		0.813	>0.001
Servings of tea [d]	0.57±1.40	0.35±0.78	0.22±1.36	0.234		0.331	0.015
Servings of hot chocolate/ milo/cocoa [e]	0.11±0.32	0.11±0.32	0.00±0.28	1.000		0.625	>0.001
Servings of coffee [f]	0.48±0.69	0.57±0.86	-0.09±0.40	0.096		0.888	>0.001
Servings of energy drinks	0.00[a]±0.00	0.00[a]±0.00	[a]	[a]		[a]	[a]

Servings of alcohol	0.06±0.23	0.07±0.26	-0.02±0.14	0.322		0.857	>0.001

ADI-Q#1=Athlete Diet Index Questionnaire 1st appointment, ADI-Q#2=Athlete Diet Index Questionnaire 2nd appointment; Significant difference between the two dietary methods $p<0.05$ (paired t-test, two tailed)

[a] Unable to be computed

[b] Water - includes water added to protein shakes/meal replacements

[c] Milk and milk alternatives - includes milk added to protein shakes/meal replacements, Up and Go's, Fast Start and flavoured milk

[d] Tea includes black tea and tea made with milk

[e] Hot chocolate/milo/cocoa - includes café style hot chocolates made mostly with milk, cold milos made mostly with milk and milos made mostly with water

[f] Coffee includes both instant coffee made mostly with water, café style coffee made mostly with milk (including mochaccinos) and iced coffee

*Table 7 Comparison between dietary components (healthy versus less healthy options) from the AD-QI#1 with the ADI-Q#2**

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) ADI-Q#2	Pearson's Chi-Square P-value
How often do you choose wholegrain breads and cereals	Never/rarely Sometimes Mostly/Always	5 (9.3) 11 (20.4) 38 (70.4)	6 (11.1) 10 (18.5) 38 (70.3)	0.933
How often do you choose low fat milk and milk alternatives	Never/rarely Sometimes Mostly/Always	18 (34.0) 7 (13.2) 28 (52.8)	16 (29.6) 11 (20.4) 27 (50.0)	0.602
How often do you remove the skin/fat from meat and chicken	Never/rarely Sometimes Mostly/Always	10 (19.6) 9 (17.6) 32 (62.7)	13 (25.0) 6 (11.5) 33 (63.5)	0.607
How often do you choose good fats (unsaturated)	Never/rarely Sometimes Mostly/Always	9 (16.7) 14 (25.9) 31 (57.4)	11 (20.4) 15 (27.8) 28 (51.8)	0.824
How often do you add salt to food and in cooking	Never/rarely Sometimes Mostly/Always	24 (44.4) 11 (20.4) 19 (35.2)	22 (40.8) 15 (27.8) 17 (31.5)	0.666

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment
Data collected for healthy versus less healthy options from the ADI-Q#1 and ADI-Q#2 were reported as the following frequencies; never; rarely (1/4 of the time); sometimes (1/2 of the time); mostly (3/4 of the time); always and N/A (not applicable)

*Table 8 Comparison between dietary component (meal frequency) from the ADI-Q#1 and ADI-Q#2**

ADI-Q dietary component	Response	n (%) ADI-Q#1	n (%) ADI-Q#2	Pearson's Chi-Square P-value
How often do you have breakfast?	Never/rarely	0 (0.0)	0 (0.0)	0.500 [a]
	Sometimes	1 (1.9)	2 (3.7)	
	Mostly/Always	53 (98.1)	52 (96.3)	
How often do you have morning tea? [b]	Never/rarely	3 (5.6)	5 (9.5)	0.501
	Sometimes	9 (16.7)	12 (22.6)	
	Mostly/Always	42 (77.7)	36 (67.9)	
How often do you have lunch?	Never/rarely	0 (0.0)	0 (0.0)	0.500 [a]
	Sometimes	0 (0.0)	1 (1.9)	
	Mostly/Always	54 (100.0)	53 (98.1)	
How often do you have afternoon tea? [b]	Never/rarely	4 (7.5)	5 (9.4)	0.776
	Sometimes	9 (16.7)	11 (20.8)	
	Mostly/Always	41 (75.9)	37 (69.8)	
How often do you have an evening meal?	Never/rarely	0 (0)	1 (1.9)	0.500 [a]
	Sometimes	0 (0)	0 (0.0)	
	Mostly/Always	54 (100.0)	53 (98.1)	
How often do you have supper? [b c]	Never/rarely	22 (41.5)	21 (39.6)	0.976
	Sometimes	12 (22.6)	12 (22.6)	
	Mostly/Always	19 (35.9)	20 (37.7)	

ADI-Q-Athlete Diet Index Questionnaire; ADI-Q#1-Athlete Diet Index Questionnaire 1st appointment; ADI-Q#2-Athlete Diet Index Questionnaire 2nd appointment

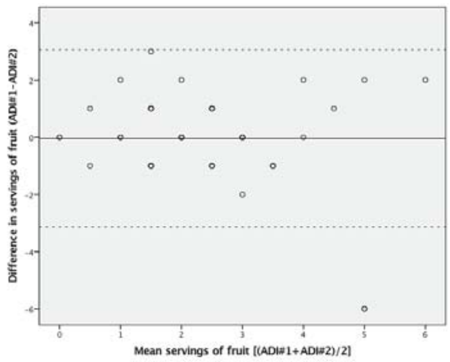
[a] Fisher test was used for cell counts <5

[b] Missing data for ADI-Q#2 morning tea n=1, afternoon tea n=1, supper n=1

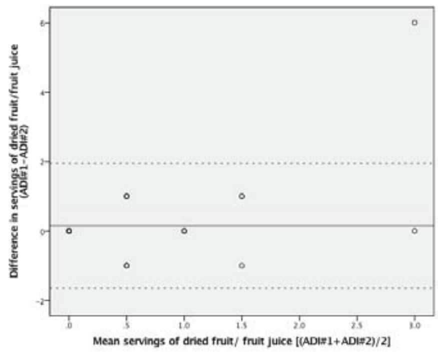
[c] Missing data for ADI-Q#1 supper counts n=1;

Data collected for meal frequency were reported as how often participant had each meal; never; rarely (1/4 of the time); sometimes (1/2 of the time), mostly (3/4 of the time), always.

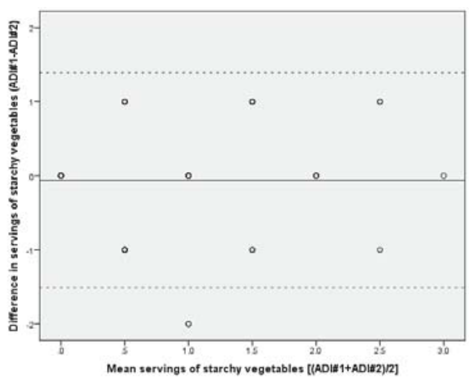
Additional Bland-Altman plots for reproducibility of dietary components (food groups and fluids) for participants who did not make any changes to their intake during appointment one and two (n=54)*



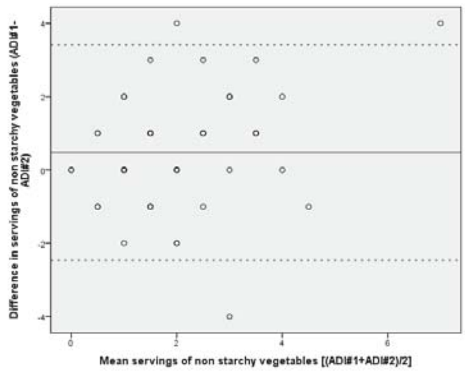
(AM): Bland-Altman plot of servings of fruit



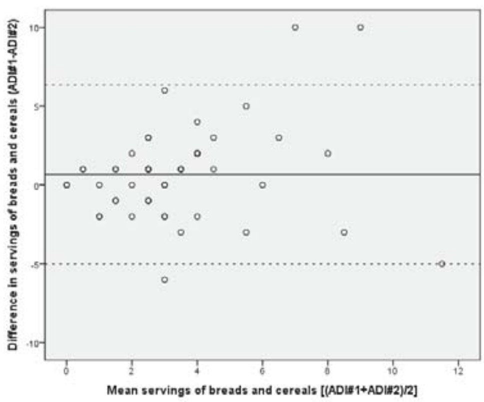
(AN): Bland-Altman plot of servings of dried fruit/fruit juice



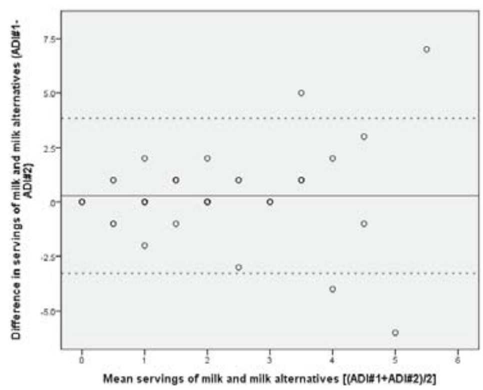
(AO): Bland-Altman plot of servings of starchy Vegetables



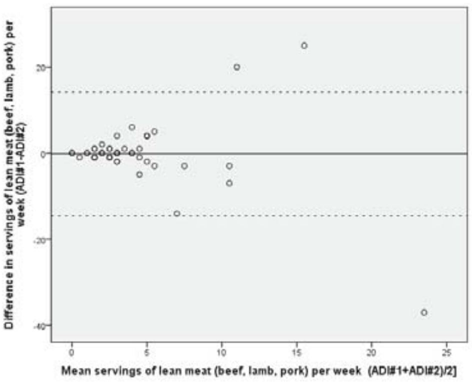
(AP): Bland-Altman plot of servings of non-starchy vegetables



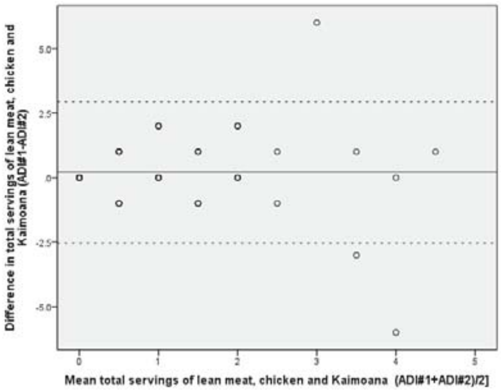
(AQ): Bland-Altman plot of servings of breads And cereals



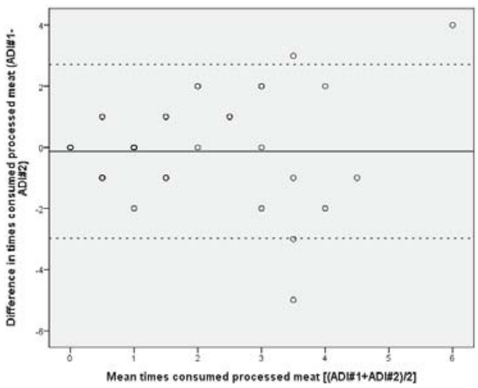
(AR): Bland-Altman plot of servings of milk and milk alternatives



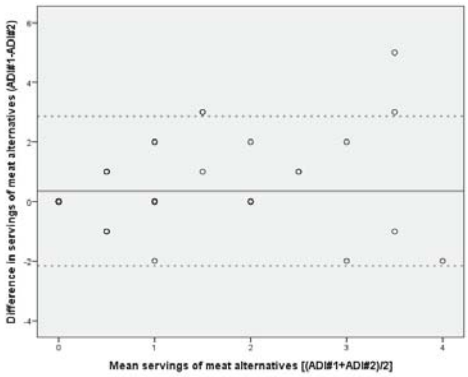
(AS): Bland-Altman plot of servings of Lean meat (beef, lamb, pork) (per week)



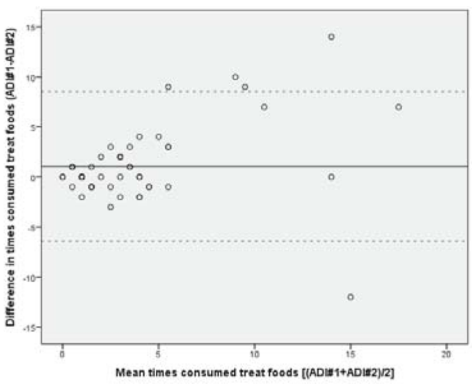
(AT): Bland-Altman plot of lean meat, chicken and kaimoana



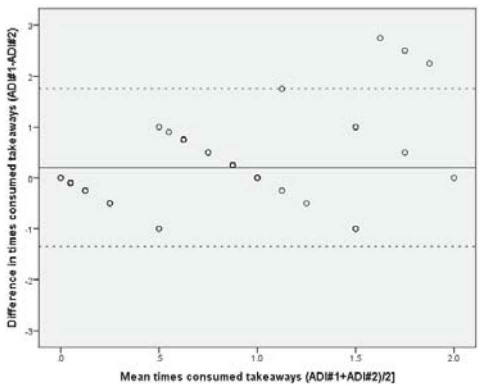
(AU): Bland-Altman plot of times consumed processed meat



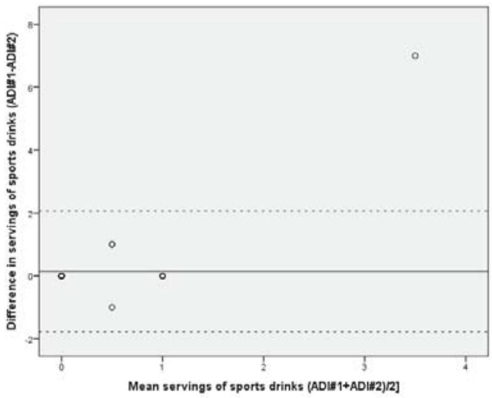
(AV): Bland-Altman plot of servings of meat alternatives



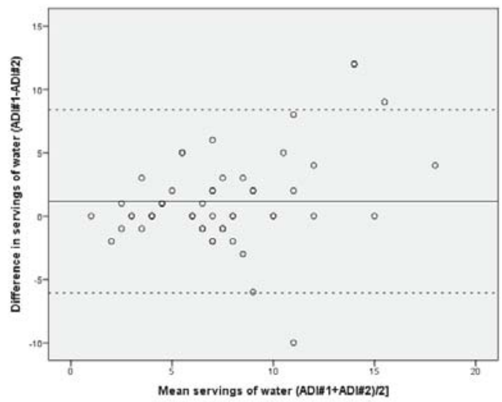
(AW): Bland-Altman plot of times consumed treat food



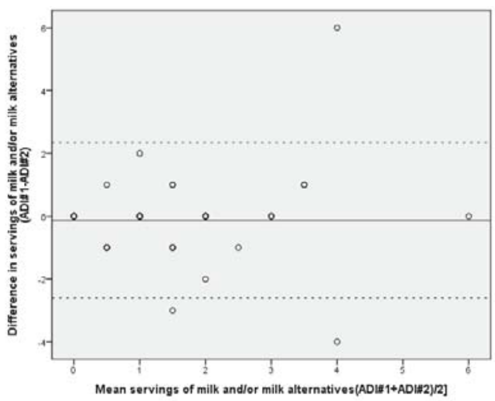
(AX): Bland-Altman plot of times consumed takeaways



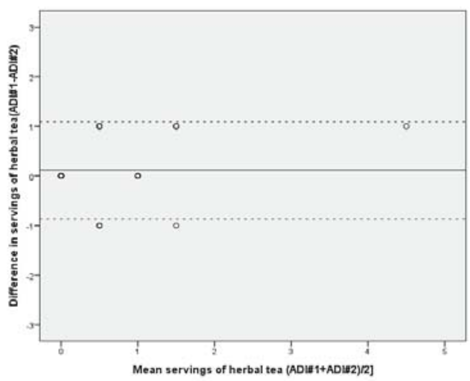
(AY): Bland-Altman plot of servings of sports drinks



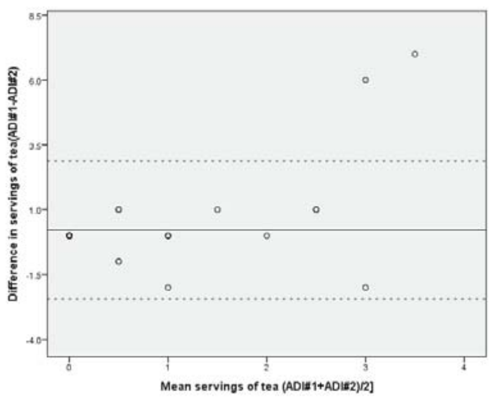
(AZ): Bland-Altman plot of servings of water



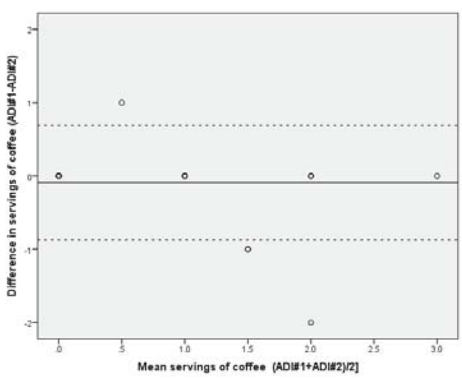
(AAA): Bland-Altman plot of servings of milk and milk alternatives



(AAB): Bland-Altman plot of servings of herbal tea



(AAC): Bland-Altman plot of servings of tea



(AAD): Bland-Altman plot of servings servings of coffee

Appendix B – Questionnaires and Supplementary Material

Information sheet

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

The Athlete Diet Index Questionnaire (ADI-Q) Study: The Development and Validation of a Tool to Assess Dietary Intake in Athletes

INFORMATION SHEET

We would like to invite you to take part in the Athlete Diet Index Questionnaire study, which aims to develop and validate a tool to assess dietary quality in high performing athletes. This study is being conducted as part of an MSc (Human Nutrition and Dietetics) thesis through Massey University. This study is being conducted by Rachel Blair (MSc Human Nutrition and Dietetics student), Dr Kathryn Beck, Dr Pamela von Hurst, Dr Cath Conlon, Owen Mugridge and Michele Eickstaedt (School of Food and Nutrition, Massey University), and Dr Helen O'Connor (Discipline of Exercise and Sports Science, University of Sydney, Australia). Please read this Information Sheet carefully before deciding whether or not to participate.

Researcher(s) Introduction

The lead researchers for this study are Rachel Blair and Dr Kathryn Beck.

Rachel Blair
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Massey University, Albany
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Dr Kathryn Beck
NZ Registered Dietitian and Senior Lecturer
School of Food and Nutrition
Massey University, Albany
Email: k.l.beck@massey.ac.nz
Phone: (09) 213 6662

<u>Why is this research important?</u>

An athlete's dietary intake can impact his/hers performance, therefore it is important to be able to assess dietary intake accurately. This study aims to investigate how well a newly developed dietary assessment tool (the Athlete Diet Index Questionnaire) measures the dietary intake of high performing athletes compared with more traditional dietary assessment methods such as food records.

The Athlete Diet Index Questionnaire (ADI-Q) has several potential applications. These include:

- Identifying athletes that would benefit from additional dietary advice.
- As an interactive dietary education tool for athletes and coaches.
- As a tool to use in future research studies.

Participant Identification and Recruitment

We are looking to recruit 100 athletes from high performance programmes, national sporting institutes or organisations and universities/secondary schools with sport academies. Athletes must compete at regional representative level (eg. represent Auckland or equivalent) or above for their main sport. We are looking for both males and females 16 years and above. Participants will be reimbursed with $40 vouchers on completion of the study, either given in person or sent by post.

Project Procedures

Athletes will be required to complete the following:

Appointment 1: Visit Massey University or sporting organisation

We will ask you to attend Massey University or an alternative sporting organisation. This appointment will take **approximately 1 hour**. We will ask you to do the following:

1. Complete a **training, supplement use and dietary questionnaire** (takes 5 minutes to complete).
2. Complete the **Athlete Diet Index Questionnaire** which focuses on overall intake of food groups and food variety, as well as questions about demographics (eg. age, ethnicity), training information, medical conditions, special diets and supplement use (10 minutes to complete).
3. Complete a **food frequency questionnaire** which asks about usual dietary intake of foods in the past month (30 minutes to complete).
4. **Body composition measurements** including height and weight measured using an electronic scale and stadiometer (5 minutes to complete).

In between appointments 1 and 2:

We will also ask you to complete a **4 day food and training diary** during this time, where we will ask you to record all training and everything you eat and drink. In between appointments 1 and 2 we will ask that you don't make any major changes to your dietary intake.

Appointment 2 (approximately 4 weeks following appointment 1): Visit Massey University or sporting organization or complete in the comfort of your own home via a website link.

This will take approximately 40 minutes and will include the same questionnaires as completed at appointment 1 (with some small changes to the training, supplement use and dietary questionnaire).

What are the benefits and risks of taking part in this study?

You will receive general feedback on your dietary intake at the end of the study, as well as individual copies of the Ministry of Health Food and Nutrition Guidelines for Healthy Adolescents/Adults, and links to websites providing evidence based sports nutrition information. Participating in the study will contribute to the development of tools to assess dietary intake in athletes effectively. Social or cultural discomfort may be caused from having body composition measures taken. The body composition assessment will require you to wear minimal clothing, e.g. shorts and a t-shirt; if for cultural or religious reasons you need to remain covered we will respect this. The height measurement involves standing upright, and the researcher bringing a head plate gently onto the top of your head and compressing the hair if necessary. All participants will be treated with respect and measurements will be conducted in privacy. We will explain all measurements and ask for your permission prior to undertaking these measurements. You may also be accompanied by a support person.

Data Management

How will the data be used?

The data will be used only for research purposes only. Data collected will be confidential and no individual will be able to be identified. Participation or non-participation will not affect participation or standing in any sporting programme.

How will the data be stored?

Participants will be identified only by a unique study identification code and all data forms will use this code. The data forms will be stored in a locked filing cabinet in the Human Nutrition Research Unit, Albany Campus, Massey University. The electronic data will be stored on computers, which are protected by passwords, in locked offices of the Human Nutrition Research Unit. Consent forms will be stored separately to data forms in a locked office in the Human Nutrition Research Unit, Albany Campus, Massey University.

How will the data be disposed of?

At the end of this study the list of participants and their study identification codes will be disposed of. Any raw data on which the results of the project depend will be retained in secure storage for 10 years after which time it will be destroyed.

How will I access a summary of the project findings?

A summary of the project findings will be available to all study participants and you will be sent this information via email.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time up until 3 months after you have completed the study.
- Ask any questions about the study at any time during participation

- Provide information on the understanding that your name will not be used unless you give permission to the researcher
- Be given access to a summary of the project findings when it is concluded

Human Ethics Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application 15/37. If you have any concerns about the conduct of this research, please contact Dr Andrew Chrystall, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x43317 email humanethicsnorth@massey.ac.nz.

Researcher(s)/Project contacts:

Below are contact details for researchers involved in this study. Please do not hesitate to contact any of the researchers if you have any further questions.

Dr Kathryn Beck
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Massey University, Albany
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Phone: (09) 213 6662

Rachel Blair
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Michele Eickstaedt
Research Assistant
School of Food and Nutrition
Massey University, Albany
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Thank you for considering participating in this study!

Consent form

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

The Athlete Diet Index Questionnaire (ADI-Q) Study: The Development and Validation of a Tool to Assess Dietary Intake in Athletes

PARTICIPANT CONSENT FORM – Individual (16 years and over)

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I agree to participate in this study under the conditions set out in the Information Sheet

Individual consent:

Signature: .... **Date:** ....

Full Name - printed ....

The Athlete Diet Index Questionnaire

Note this is a word document copy of the computerised format

Part 1: Training or event details

Part 1 of the Athlete Index requires you (the participant) to answer questions specific to your training and main sport or event.

Please enter your unique participant code:

Are you a Paralympian?

Yes
No

What is your main sport or event (where relevant)?

Paralympics
Alpine skiing
Archery
Athletics
Badminton
Biathlon
Boccia
Canoe
Cross-country skiing
Cycling
Equestrian
Football 5-a-side
Goalball
Ice Sledge Hockey
Judo
Powerlifting
Rowing
Sailing
Shooting
Sitting volleyball
Swimming
Table tennis
Taekwondo
Triathlon
Wheelchair basketball

Wheelchair curling
Wheelchair dance sport
Wheelchair fencing
Wheelchair rugby
Wheelchair tennis

Team sports
Netball
Rugby
Rugby league
Rugby sevens
Hockey - *Is your main position a goalie?*
Soccer / Football - *Is your main position a goalie?*
Basket ball
Volleyball
Beach volleyball
Handball

Endurance sports – cycling, running, triathlon, race walking
Triathlon - *Sprint distance 750m swim, 20km cycle, 5km run; Olympic / standard distance – 1.5km swim, 40km cycle, 10km run; Long distance 4km swim, 120km cycle, 30km run; Half iron man 1.9km swim, 90km cycle, 21.2km run; Ironman 3.8km swim, 180km cycle, 42.2km run*
Cycling -*Track; Road; Mountain bike; BMX*
Running -*10km; Half marathon; Marathon; Cross country*
Race walking

Sports in or on the water
Swimming - *Pool, Open water*
Rowing - *Open weight; Light weight*
Kayaking / canoeing
Sailing
Diving
Synchronised swimming
Water polo

Track and field
Sprinting - *100m; 200m; 400m; 110m hurdles; 400m hurdles*
Track – 800; 1500m; Mile; 3000m steeplechase; 5000m
Jumping - *Triple jump; Long jump; High jump; Pole vault*
Heptathlon
Decathlon

Ball, racquet, club and bat
Tennis
Squash
Badminton
Table tennis
Golf

Gymnastics and dance
Gymnastics – *Artistic; Rhythmic*

Dance - *Ballet; Jazz; Tap, Hip hop*
Trampoline

Winter sports
Alpine skiing
Biathlon
Bobsleigh
Cross country skiing
Curling
Figure skating
Freestyle skiing
Ice hockey
Luge
Nordic combined
Short track speed skating
Skeleton
Ski jumping
Snowboard
Speed skating

Combat sports
Boxing
Judo
Karate
Taekwondo
Wrestling
Fencing

Target sports
Archery
Shooting

Power sports
Weightlifting

Horse racing or equestrian
Horse racing / jockey
Equestrian

Fitness sports
Gym / weight training
CrossFit

Other sports
Modern pentathlon
Other, please specify

For your main sport / event, what is the highest level you participate / compete in?

School
Local - recreational/social

Regional – competitive/representative
National
International - age group
International - open
Other (please specify)

Are you a carded athlete for your main sport or on the Pathway to Podium programme?

Yes
No

If yes, please state at what level

Carded level 1
Carded level 2
Carded level 3
Pathway to Podium

If yes, please state what nutrition information you have received

One on one nutrition sessions through High Performance Sport New Zealand or P2P
Group nutrition sessions through High Performance Sport New Zealand or P2P
No nutrition sessions (one on one or group) through High Performance Sport New Zealand or P2P
Other (please specify)

Are you currently involved in any other sport(s), exercise or training regimes?

Yes
No

If yes, please select all sport(s), exercise or training regimes that apply

Team sports
Netball
Rugby
Rugby league
Rugby sevens
Hockey - *Is your main position a goalie?*
Soccer / Football - *Is your main position a goalie?*
Basket ball
Volleyball
Beach volleyball
Handball

Endurance sports – cycling, running, triathlon, race walking
Triathlon - *Sprint distance 750m swim, 20km cycle, 5km run; Olympic / standard distance – 1.5km swim, 40km cycle, 10km run; Long distance 4km swim, 120km cycle, 30km run; Half iron man 1.9km swim, 90km cycle, 21.2km run; Ironman 3.8km swim, 180km cycle, 42.2km run*

Cycling -*Track; Road; Mountain bike; BMX*
Running -*10km; Half marathon; Marathon; Cross country*
Race walking

Sports in or on the water
Swimming - *Pool, Open water*
Rowing - *Open weight; Light weight*
Kayaking / canoeing
Sailing
Diving
Synchronised swimming
Water polo

Track and field
Sprinting - *100m; 200m; 400m; 110m hurdles; 400m hurdles*
Track – 800; 1500m; Mile; 3000m steeplechase; 5000m
Jumping - *Triple jump; Long jump; High jump; Pole vault*
Heptathlon
Decathlon

Ball, racquet, club and bat
Tennis
Squash
Badminton
Table tennis
Golf

Gymnastics and dance
Gymnastics – *Artistic; Rhythmic*
Dance - *Ballet; Jazz; Tap, Hip hop*
Trampoline

Winter sports
Alpine skiing
Biathlon
Bobsleigh
Cross country skiing
Curling
Figure skating
Freestyle skiing
Ice hockey
Luge
Nordic combined
Short track speed skating
Skeleton
Ski jumping
Snowboard
Speed skating

Combat sports
Boxing

Judo
Karate
Taekwondo
Wrestling
Fencing

Target sports
Archery
Shooting

Power sports
Weightlifting

Horse racing or equestrian
Horse racing / jockey
Equestrian

Fitness sports
Gym / weight training
CrossFit
Pilates
Yoga
Walking
Jogging
Recovery sessions

Other sports
Modern pentathlon
Other, please specify

How many hours each day in total do you usually spend training and competing for ALL sports / events?

Monday	Sliding scale 0-12+ hours
Tuesday	Sliding scale 0-12+ hours
Wednesday	Sliding scale 0-12+ hours
Thursday	Sliding scale 0-12+ hours
Friday	Sliding scale 0-12+ hours
Saturday	Sliding scale 0-12+ hours
Sunday	Sliding scale 0-12+ hours

In your current training phase, what are you aiming to achieve? (Please select up to three choices in each category that apply to you)

Increase speed

Improve aerobic fitness
Increase strength / power
Improve skills or technique
Improve tactical ability
Gain weight
Gain muscle mass
Lose weight
Lose body fat
Maintain current weight
Improve fitness
Improve health
Increase energy
Feel better
Prehab / Rehab

Do you currently have any injuries that limit your ability to participate or compete in sport, exercise or training?

Yes
No

If yes, what best describes your injury

Stress fractures - bone
Soft tissue injuries e.g. muscle, tendon, ligament
Osteoarthritis
Wound healing
Other (please specify)

Part 2: Baseline diet

Part 2 of the Athlete Diet Index Questionnaire requires you (the participant) to answer questions about your baseline (everyday) diet/eating habits

Fruit and Vegetables:

How often do you usually eat fruit (include fresh, frozen and / or canned fruit; do not include juice or dried fruit)?

Never
Yearly
Monthly
Weekly
Daily

How many servings of fruit do you usually eat in the timeframe selected above? (include fresh, frozen and / or canned fruit; do not include fruit juice or dried fruit)?

Examples of a serving may include

- *1 medium apple, pear, banana or orange*
- *2 small apricots or plums*
- *½ cup of fresh fruit salad*
- *½ cup stewed fruit (fresh, frozen, or canned)*

Sliding scale 0-14 serves

How often do you usually eat dried fruit or juice?

Never
Yearly
Monthly
Weekly
Daily

How many servings of dried fruit or juice do you usually eat in the timeframe selected above?

Examples of a serving may include

- *1 cup fruit juice (250ml)*
- *2 Tablespoons dried fruit*

Sliding scale 0-14 serves

Which of the following fruit have you eaten over the last 7 days? (include fresh, frozen and / or canned fruit; do not include fruit juice or dried fruit) (Please select all that apply)

Banana

Apple or pear

Citrus fruit (eg. range, mandarin, tangelo, grapefruit, lemon)

Kiwifruit (green or gold)

Stone fruits (eg. each, nectarine, plum, apricot)

Strawberries or other berries (eg. blueberries, blackberries, boysenberries, raspberries)

Canned or stewed fruit (eg. canned peaches)

Tropical fruit (eg. pineapple, mango, pawpaw, watermelon)

Feijoa

Grapes

Rhubarb

Other (please specify)

How often do you usually eat starchy vegetables?

Examples could include potato, kumara, taewa (Māori potato), parsnip, yam (Pacific or NZ), taro or cassava

Never
Yearly
Monthly
Weekly
Daily

How many servings of starchy vegetables do you usually eat in the timeframe selected above?

Examples of a serving may include

- *1 medium or ½ cup of potato, kumara, taewa (Māori potato), parsnip, yam (Pacific or NZ), taro or cassava*
- *1 medium sized green banana*

Sliding scale 0-14+ serves

How often do you usually eat non-starchy vegetables? (include fresh, frozen and / or canned)

Examples could include pūhā, watercress, silver beet, spinach, kamokamo (squash), carrot, broccoli, bok choy, cabbage, taro leaves, peas, corn, salad or mixed vegetables, tomato

Never
Yearly
Monthly
Weekly
Daily

How many servings of non-starchy vegetables do you usually eat in the timeframe selected above? (include fresh, frozen and / or canned)

Examples of a serving may include

- *½ cup of cooked vegetables (e.g. pūhā, watercress, silver beet, spinach, kamokamo (squash), carrot, broccoli, bok choy, cabbage, peas, corn, mixed vegetables)*
- *½ cup salad*
- *1 tomato or ½ cup of canned tomatoes*

Sliding scale 0-14 serves

Which of the following vegetables have you eaten over the last 7 days? (Please select all that apply)

Potato or taewa (Māori potato)

Kumara

Parsnip

Yam

Taro

Cassava

Peas

Carrot

Corn

Green beans

Courgette

Pumpkin

Broccoli

Cauliflower

Cabbage, brussel sprouts

Puha, watercress, silver beet, spinach, bok choy

Lettuce or green salad

Cucumber

Tomato

Capsicum (red, green, yellow, orange)

Avocado

Asparagus

Eggplant or aubergine

Mushroom

Onions, garlic, celery, leeks

Beetroot

Mixed vegetables

Other (please specify)

Breads and cereals:

How often do you usually eat breads and cereals?

Examples could include bread, cereal, oats, pasta, noodles, quinoa, rice, cassava, muffins, scones, crackers, pancakes, pikelets, muesli bars, cereal bars

Never
Yearly
Monthly
Weekly
Daily

How many servings of breads and cereals do you usually eat in the timeframe selected above?

Examples of a serving may include

- *2 breakfast wheat biscuits*

- *1 wholegrain bread roll*
- *1 sandwich slice rēwena bread*
- *1 sandwich slice wholegrain bread*
- *½ cup muesli*
- *½ cup of cooked porridge*
- *1 cup of cooked pasta, noodles, quinoa or rice*
- *1 cup cooked rice*
- *2 crackers or plain sweet biscuits*
- *1 scone or wholemeal muffin*
- *1 cup of cornflakes*
- *1 pancake or 2 pikelets*
- *1 muesli bar or cereal bar*

Sliding scale 0-14 serves

How often do you choose whole grain breads and cereals (e.g. whole grain or multigrain breads, porridge or oats, oatmeal, oat flakes, bran based breakfast cereals, brown rice, wholemeal pasta, quinoa, buckwheat, food made with wholegrain, whole wheat or rye flour; food made from wheat flakes, whole barley, bulgur wheat) **rather than more refined breads and cereals?** (e.g. white breads, cornflakes, rice bubbles, white rice, white pasta, food made with white flour)

Never
Rarely (1/4 of the time)
Sometimes (1/2 of the time)
Mostly (3/4 of the time)
Always
Not applicable – I don't eat breads and cereals

Milk or milk alternatives:

How often do you usually eat or drink milk or milk alternatives?

Examples could include milk (cow's goats, sheep, flavoured), plant based milks (soy, rice, nut), yoghurt, dairy food, cheese, milk based dishes such as custard, ice cream

Never
Yearly
Monthly
Weekly
Daily

How many servings of dairy or dairy alternatives do you usually eat in the timeframe selected above?

Examples of a serving may include

- *1 large glass of milk (250ml)*
- *1 small pottle of yoghurt*
- *2 slices of cheese (40g) or ½ cup grated cheese*

- *1 cup of ice cream or custard*

Sliding scale 0-14 serves

How often do you choose low fat or reduced fat milk or milk alternatives (e.g. lite, trim, super trim) over standard or regular milk alternatives (e.g. whole or full cream)?

Never
Rarely (1/4 of the time)
Sometimes (1/2 of the time)
Mostly (3/4 of the time)
Always
Not applicable – I don't drink or eat milk or milk alternatives

Meat/Meat alternatives:

How often do you usually eat red meat (e.g. beef, lamb, pork, venison, veal, corned beef or silverside) (do not include sausages, frankfurters, luncheon, ham, bacon, pastrami, salami, canned corned beef)?

Never
Yearly
Monthly
Weekly
Daily

How many servings of red meat do you usually eat in the timeframe selected above?

Examples of a serving may include

- *2 slices of cooked meat (approximately100g) (e.g. roast beef, lamb or pork)*
- *1 medium fillet of steak (100-120g)*
- *¾ cup of mince or casserole (195g)*

Sliding scale 0-14 serves

How often do you usually eat chicken (do not include chicken nuggets)?

Never
Yearly
Monthly
Weekly
Daily

How many servings of chicken do you usually eat in the timeframe selected above?

Examples of a serving may include

- *100g (palm size) of cooked chicken (e.g. chicken breast)*
- *2 chicken drumsticks*
- *1 chicken thigh*

Sliding scale 0-14 serves

How often do you remove the fat from meat or the skin from chicken?

Never
Rarely (1/4 of the time)
Sometimes (1/2 of the time)
Mostly (3/4 of the time)
Always
Not applicable – I don't eat meat or chicken

How often do you usually eat kaimoana* (fish and other seafood) (do not include fish cakes or fish fingers)?

*Kaimoana includes all fish and seafood including salmon, tuna, mackerel, sardines, kuku (mussels), paua, eel

Never
Yearly
Monthly
Weekly
Daily

How many servings of kaimoana (fish or seafood) do you usually eat in the timeframe selected above?

Examples of a serving may include:

- *1 medium fillet of cooked fish (100g)*
- *1 medium paua or kina (100-120g)*
- *95g tin of fish*

Sliding scale 0-14 serves

How often do you eat processed meats such as sausages, frankfurters, ham, luncheon, bacon, pastrami, salami, canned corned beef, chicken nuggets, fish cakes or fish fingers?

Never
Yearly
Monthly
Weekly
Daily

How many times have you had processed meats in the timeframe selected above?

Sliding scale 0-14 times

How often do you usually eat meat alternatives?

Examples include eggs, tofu, legumes, nuts and seeds*

** Legumes includes cooked dried beans (baked beans), split peas (dahl), lentils, chickpeas (hummus)*

Never
Yearly
Monthly
Weekly
Daily

How many servings of meat alternatives do you usually eat in the timeframe selected above?

Examples of a serving may include:

- *1 egg*
- *¾ cup of cooked dried beans, peas or lentils*
- *¾ cup of tofu*
- *1/3 cup of nuts or seeds*

Sliding scale 0-14 serves

Fluids:

* 66. How often do you USUALLY have the following drinks? (PLEASE provide an answer for all fluids listed)

For example, if you have 2 glasses of milk a week please select WEEKLY from the Timeframe drop down menu and 2 from the Serves drop down menu.

1 cup (250mls) = 1 serve

	Timeframe	Serves
Flavoured water / Vitamin water / Sports water		
Sports drinks (e.g. Gatorade, Powerade)		
Coconut water		
Water		
Milk (including milk alternatives)		
Fruit juice		
Soft drinks / fizzy drinks / carbonated drinks		
Cordial / powdered fruit drinks		
Herbal tea		
Tea		
Drinking chocolate, milo, cocoa		
Coffee		
Energy drinks		

When training what type of fluid do you usually drink (select as many as apply)?

Flavoured water / sports water

Coconut water

Water

Cow's milk (or alternative)

Fruit juice

Soft drinks / fizzy drinks / carbonated drinks

Cordial / powdered fruit drinks

Sports drinks

Energy drinks

No fluid when training

Other (please specify)

Alcohol:

How often do you usually drink alcohol?

Never
Yearly
Monthly
Weekly
Daily

How many standard drinks of alcohol do you usually drink in the timeframe selected above?

A standard drink is 1 can of beer (330ml), 1 glass of wine (100ml), 1 Ready to Drink (RTDs), 1 shot/nip of spirits (30ml)

Sliding scale 0-14 serves

On any one drinking occasion, what is the maximum number of standard drinks you would have?

A standard drink is 1 can of beer (330ml), 1 glass of wine (100ml), 1 Ready to Drink (RTDs), 1 shot/nip of spirits (30ml)

Sliding scale 0-20 serves

How many alcohol free days do you have per week?

Sliding scale 1-7 days

Other foods:

How often do you have biscuits, cakes, sweets, lollies, chocolates or ice blocks or puddings (e.g. fruit pies, crumbles, sponge puddings, steamed puddings; do not include milk based puddings such as custard or ice cream)?

Never
Yearly
Monthly
Weekly
Daily

How many times do you have biscuits, cakes, sweets, lollies, chocolates or ice blocks, or puddings in the timeframe selected above?

Sliding scale 0-28 times

How often do you have takeaway foods such as KFC, McDonalds, Burger King, fish and chips, deep fried chicken, commercial burgers, pizza, mince pies, sausage rolls, pastries, hot chips, wedges or savoury snacks (e.g. potato chips)?

Never
Yearly
Monthly
Weekly
Daily

How many times do you have takeaways in the timeframe selected above?

Sliding scale 0-28 times

How often do you cook with or add the following fats to food (margarine, olive oil, canola oil, rice bran oil, avocado oil, sunflower oil, safflower oil) **rather than cooking with or adding the following fats to food** (butter, cream, sour cream, lard, ghee, coconut cream/oil or palm oil)?

Never
Rarely (1/4 of the time)
Sometimes (1/2 of the time)
Mostly (3/4 of the time)
Always
Not applicable – I don’t cook with or add any fats to foods

How often do you add salt to foods in cooking or at the table?

Never
Rarely (1/4 of the time)
Sometimes (1/2 of the time)
Mostly (3/4 of the time)
Always

Meals:

How often would you have breakfast?

Never Rarely Sometimes Mostly Always

How often would you have a mid -morning snack (food and drinks between breakfast and mid-day meal (not including water))?

Never Rarely Sometimes Mostly Always

How often would you have a lunch?

Never Rarely Sometimes Mostly Always

How often would you have a mid-afternoon snack (food and drinks between mid-day meal and evening meal (not including water))?

Never Rarely Sometimes Mostly Always

How often would you have an evening meal or dinner?

Never Rarely Sometimes Mostly Always

How often would you have supper (food and drinks after the evening meal and before bed (not including water))??

Never Rarely Sometimes Mostly Always

Part 3: Special diets and supplements

Part 3 of the Athlete Diet Index Questionnaire requires you (the participant) to answer questions about special diets (vegetarian, vegan, allergies) and supplements (vitamins, minerals, ergogenic aids)

Do you currently have any illnesses or chronic conditions?

Yes
No

If yes, please select (Please select all that apply)

Asthma
Low bone density (osteopenia)
Insulin dependent diabetes mellitus (type 1)
Non-insulin dependent diabetes mellitus (type 2)
High cholesterol or high lipids
Hypertension
Iron deficiency
Vitamin B12 deficiency
Folate deficiency
Inflammatory bowel conditions (e.g. Crohn or ulcerative colitis)
Cardiac condition
Kidney condition
Liver condition
Other (please specify)

Do you have any food allergies, food intolerances or digestive disorders?

Yes
No
Not sure

If yes, please specify (Please select all that apply)

Peanut allergy
Nut allergy
Milk allergy
Lactose intolerance
Fish/shellfish allergy
Egg allergy
Wheat allergy
Wheat intolerance
Coeliac disease
Gastric reflux
Irritable bowel syndrome
Other (please specify)

Are you currently following a vegetarian or vegan diet?

Yes
No
If yes, please specify

Are you currently following any of the diets listed below? (Please select all that apply)

No special diet
Healthy balanced diet
High fat
Low fat
Low cholesterol
High carbohydrate
Low carbohydrate
High fibre
High protein
Low protein
Low calorie/kilojoule
High calorie/kilojoule
Gluten free
Low gluten
Wheat free
Low wheat
Dairy free
Low dairy
Lactose free
Low lactose
FODMAP free
Low FODMAP
Peanut free
Nut free
Fish/shellfish free
Egg free
Other (please specify)
Clean eating
Paleo
Zone
Other (please specify)

Where do you get your dietary advice from? (please select all that apply)

Nutritionist
Dietitian
Specialist sports dietitian or performance nutritionist
Doctor
Coach
Teammates
Fitness trainer or strength and conditioning coach
Teammates
Friends

Parents
Gym staff
Internet
Books
Magazines
Other (please specify)

How would you rank your nutrition knowledge?

Excellent
Above average
Average
Below average
Poor
Not sure

How do you rate your food and fluid intake with regards to meeting your training / general health needs?

Excellent
Above average
Average
Below average
Poor
Not sure

Have you used any of the following dietary or sports supplements in the past 4 weeks? (Please select all that apply)

No
Multi vitamin & mineral
Iron
Calcium
Magnesium
Vitamin D
Omega-3 (fish oil)
Probiotics (non-food, i.e. from capsule or powder)
Carbohydrate / electrolyte drink (sports drink)
Oral rehydration solutions / electrolyte replacement
Sports bars
Sports gels
Sports confectionary e.g. sports beans
Liquid meal supplements e.g. Complan, Sustagen Sport
Fat burners
Pre workout supplements
Protein powders
Creatine
Caffeine *(e.g. in tablets, energy drinks, as a pre-workout supplement, as coffee, caffeinated sports gels)*

Sodium bicarbonate
Beta-alanine
Nitrates or beetroot juice
Colostrum
Other (please specify)

Part 4: Background Information

Part 4 of the Athlete Diet Index Questionnaire requires you (the participant) to answer basic demographic questions (D.O.B, ethnicity, height, weight)

State which gender group you belong to

Male
Female
Gender diverse

If female or gender diverse, are you currently pregnant?

Yes
No

When is your date of birth?

Day	Month	Year

State which ethnic group or groups you belong to

European
- European, not further defined
- New Zealand European
- British and Irish
- Cornish
- English
- Irish
- Manx
- Scottish
- Welsh
- Dutch
- Greek
- Polish
- South Slav
- Croatian
- Dalmatian
- Macedonian
- Serbian
- Slovenian
- Bosnian
- Italian
- German
- Australian

- Albanian
- Armenian
- Austrian
- Belgian
- Bulgarian
- Belorussian
- Czech
- Danish
- Estonian
- Finnish
- French
- Hungarian
- Icelandic
- Latvian
- Lithuanian
- Maltese
- Norwegian
- Portuguese
- Romanian
- Russian
- Slovak
- Spanish
- Swedish
- Swiss
- Ukrainian
- American
- Canadian
- South African, not elsewhere classified
- Afrikaner
- Zimbabwean
- European, not elsewhere classified

Māori

- Māori

Pacific Peoples

- Pacific Peoples, not further defined
- Samoan
- Cook Islands Maori
- Rarotongan
- Tongan
- Niuean
- Tokelauan
- Fijian
- Australian Aboriginal
- Hawaiian
- Kiribati
- Nauruan
- Papua New Guinean
- Pitcairn Islander
- Rotuman

Tahitian
Solomon Islander
Tuvaluan
Ni Vanuatu

Asian
Asian, not further defined
Southeast Asian
Filipino
Cambodian
Vietnamese
Burmese
Indonesian
Laotian
Malay
Thai
Chinese
Hong Kong Chinese
Cambodian Chinese
Malaysian Chinese
Singaporean Chinese
Taiwanese
Indian
Bengali
Fijian Indian
Indian Tamil
Punjabi
Sikh
Anglo Indian
Sri Lankan
Sinhalese
Sri Lankan Tamil
Japanese
Korean
Afghani
Bangladeshi
Nepalese
Pakistani
Eurasian
Asian, not elsewhere classified

Middle Eastern/Latin American/African
Middle Eastern
Arab
Assyrian
Egyptian
Iranian/Persian
Iraqi
Israeli/Jewish
Jordanian
Kurd

- Lebanese
- Moroccan
- Palestinian
- Syrian
- Turkish
- Latin American
- Argentinian
- Brazilian
- Chilean
- Colombian
- Mexican
- Peruvian
- Uruguayan
- African
- Jamaican
- Kenyan
- Nigerian
- African American
- West Indian
- Somali
- Eritrean
- Ethiopian
- Ghanaian

Other Ethnicity

- North American Indian
- Mauritian
- South African Coloured
- New Zealander

In which country do you live currently?

New Zealand
Australia
Other (please specify)

What is your height (cm)?

What is your weight (kg)?

Serving size guide used during completion of the ADI-Q

(Healthy Food Guide, 2015)

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
TE WĀHANGA PŪTAIAO

Participant ID number:…………………..

The Athlete Diet Index Questionnaire (ADI-Q) Study: The Development and Validation of a Tool to Assess Dietary Intake in Athletes

Training, supplement use and dietary questionnaire

Section 1: Training (Appointment 1 only)

1) **Please describe your usual weekly training during the season?**

	Details of type of training	Time
Example	*Weight training* *Net session (bowling or batting)*	1 hour 30 minutes
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		
Sunday		

Section 2: Supplements (Appointment 1 and 2)

1) **Did you take any vitamin and/or mineral capsules/tablets at any time during the past month?**

Yes ☐ **No** ☐

If yes, please list the brand name of the supplement, the type of supplement, the number taken, the frequency of intake and the dose (including units) and the reason for taking?

eg. Healtheries Iron & vitamin C, 1 taken every 2nd day, ferrous gluconate (170mg) providing elemental iron (20mg) and vitamin C (40mg), taken because I was feeling tired

____

____

____

2) **Did you take any sports supplements at any time during the past month? (including sports drinks, sports gels sports bars, liquid meal supplements, protein supplements, herbal supplements)**

Yes ☐ **No** ☐

If yes, please list the brand name / type of sports supplement, the frequency of intake and the dose (including units), and the reason for taking.

eg. Powerade (750ml) taken every day during evening training (5x/week) for the past 3 years

____

____

____

3) Did you take any other dietary supplements during the past month? (for example, omega-3 tablets, evening primrose oil, performance enhancers, herbal supplements)

Yes ☐ **No** ☐

If yes, please list the brand name of the supplement, the type of supplement, the number taken and the frequency of intake and the dose (including units)?

eg. Omega 3 supplements, 1 capsule taken per day for the past 3 months, contains 180mg eicosapentaenoic acid (EPA) & 120mg docosahexaenoic acid (DHA) 1000mg, took for aching joints

____

____

____

Section 3: Training & dietary changes (Appointment 2 only)

1) Has your training changed since your 1st appointment?

Yes ☐ **No** ☐

If yes, please describe

____

____

____

2) Have you made any changes to your diet since your 1st appointment?

Yes ☐ **No** ☐

If yes, please describe

____

____

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

The Athlete Diet Index Questionnaire

(ADI -Q) Study

4 Day Food & Training Record

Thank you very much for taking part in the Athlete Diet Index Questionnaire (ADI-Q) Study. We are extremely grateful for your time, effort and commitment!

If you have any questions, please contact Rachel Blair on 0274243323 or Kathryn Beck on (09) 213 6662 or email ADI@massey.ac.nz

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

What to do?

- Record all that you eat and drink, and all training undertaken on the following dates.

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

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

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

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

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

- For training, record the type of training you were doing, the length of time, and the intensity (easy,

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

Describing Food and Drink

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

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

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

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

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

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

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

General description	Food record description
Apple	1 x 120g Granny Smith Apple (peeled, core not eaten – core equated to ¼ of the apple)

Fried chicken drumstick	100g chicken drumstick (100g includes skin and bone); fried in 3 Tbsp Fern leaf semi-soft butter

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

<u>Recording the amounts of food you eat</u>

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

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

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

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

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

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

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

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

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

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

Example day

Time and place food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method) Complete description of training	Amount consumed (units, measures, weight)
Example7: 55am *At home*	Sanitarium weetbix	2 weetbix
" "	Anchor Blue Top milk	150ml
" "	Chelsea white sugar	2 heaped teaspoons
" "	Orange juice (Citrus Tree with added calcium – nutrition label attached)	1 glass (275 ml)
10.00am In car	Raw Apple (gala)	Ate all of apple except the core, whole apple was 125g (core was ¼ of whole apple)
12.00pm At home	Home made pizza (recipe attached)	1 slice (similar size to 1 slice of sandwich bread, 2 Tbsp tomato paste, 4 olives, 2 rashers bacon (fat removed), 1 Tbsp chopped spring onion, 3 Tbsp mozzarella cheese)
1.00pm At work	Water	500ml plain tap water
3.00pm At work	Biscuits	6 x chocolate covered Girl Guide biscuits (standard size)
5.00-6.35pm At training	Gatorade, Fierce Berry Flavour	600ml bottle

6.00pm At home	Lasagne	½ cup cooked mince, 1 cup cooked Budget lasagne shaped pasta , ½ cup Wattie's creamy mushroom and herb pasta sauce, ½ cup mixed vegetables (Pam's carrots, peas and corn), 4 Tbsp grated Edam cheese
6.30pm At home	Banana cake with chocolate icing (homemade, recipe attached)	1/8 of a cake (22cm diameter, 8 cm high), 2 Tbsp chocolate icing
" "	Tip Top Cookies and Cream ice cream	1 cup (250g)
7.30pm At home	Coffee	1 tsp Gregg's instant coffee 1 x 300ml cup of water 2 Tbsp Meadow fresh blue top milk 2 tsp sugar

<u>Describing Training</u>

Please record all training undertaken while completing this diary. An example is provided below.

Sport / exercise	Time of day	Duration of training	Intensity (Easy, Medium, Hard, Very Hard)
Run *Netball training*	*6.30am* *5.00pm*	*30 minutes* *15 minutes team talk* *40 minutes skill-based* *30 minutes game*	*Medium* *Easy* *Medium* *Hard*

Date________________________________ DAY 1

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

Recipes (Day 1)

Training diary

Day 1 – Date ____________________________

Sport / exercise	Time of day	Duration of training	Intensity (Easy, Medium, Hard, Very Hard)
Run *Netball training*	*6.30am* *5.00pm*	*30 minutes* *15 minutes team talk* *40 minutes skill-based* *30 minutes game*	

Order of events for data collection

The Athlete Diet Index Questionnaire

Order of Events

(Mark off on checklist as each component is completed)

1. Welcome participant and allocate participant ID
2. Ask participants voucher preference (Westfield/Petrol) & address
3. Ensure participant has read information sheet
4. Get participant to sign consent form
5. Take participants height and weight
6. Complete training, supplement use and dietary questionnaire – handwritten
7. Complete ADI-Q – online
8. Complete FFQ – online
9. Watch estimated food diary video
10. Demonstrate how to weigh food and tell participant about uploading photos of meals to drop box
11. Give participants hard copy of four-day food diary & self-addressed envelope
12. Allocated participant 4 consecutive days
13. Allocate participant scales (optional)
14. Explain follow up procedures
15. Answer any questions

Standard order of procedures

SOP – Height - approx. 2-3 mins

1) Please use the transportable stadiometer (Secca) located in room 27.08 (BIA room).
2) Ask the participant to remove their shoes.
3) The participant is required to stand with their heels together and the heels, buttocks and upper part of the back touching the scale.
4) Make sure the participants head is level and they are looking straight ahead.
5) Bring the headboard down firmly on top of the participant's head, compressing the hair as much as possible.
6) Record height.
7) Repeat the height measurement. If the measurement is not within 1% (~1.5cm) of the first measurement a third measure should be taken.
8) The mean value is used if two measurements are taken, and the median value is used if three measurements are taken.

SOP – Weight – approx. 2-3 mins

1) Please use the white Wedderburn scales located in room 27.08 (BIA room).
2) Make sure the scales are on a flat hard surface.
3) Ask the participant to remove their shoes and anything from their pockets.
4) Turn the scales on using the button located at the front of the scales in the middle.
5) Check the scale is reading zero.
6) Ask participant to step onto the centre of the scales without support and the weight distributed evenly on both feet.
9) When the scale stabalises please record weight.
10) Repeat the protocol. If the measurement is not within 1% (~0.5kg) of the first measurement a third measure should be taken.
11) The mean value is used if two measurements are taken, and the median value is used if three measurements are taken.

SOP – Training, supplement use and dietary questionnaire – approx.5 mins

1. Log into the following address: https://www.surveymonkey.com/r/training1
2. Give participants their ID # to be used in all online questionnaires.
3. Go through examples on the questionnaire with the participant to ensure correct detail.
4. Take notes of participants heaviest and lightest training days which will be used to allocate the days for the food and training records.
5. Ensure participant completes all the required sections.

SOP – Athlete Diet Index Questionnaire (ADI-Q) – approx. 10 mins

1) This questionnaire starts straight after the training and supplement questionnaire. When completing the ADI-Q participants are required to think about their usual intakes. Ensure each computer has a copy of the **serving size examples** from the Healthy Food Guide available – tell participant this may assist them to answer the questions.
2) Enter the participants ID.
3) Tell participant to ask the researcher if they have any questions while completing the ADI-Q.
4) Ensure participant completes the ADI-Q.

SOP – Food frequency questionnaire – approx. 20 mins (takes longer than the ADI-Q to complete)

1) Log into the following address: https://www.surveymonkey.com/r/ADI-FFQ
2) Read through **ALL** the instruction with the participant. Tell participants that the FFQ is based on the foods and beverages they consumed during the past 4 weeks.
3) **Provide another example** to check understanding – Flavoured milk – if you typically have 2 glasses (500ml) of flavoured milk on one day 3x per week you would select 2 cups or 500ml, 2-3x/week.
4) **Each food question relates to all food listed** (e.g. for onions, leeks or garlic), the participant should consider onions, leeks AND garlic when making their response (ie. they should not focus on just one of these vegetables).
5) Enter the participants ID.
6) Tell participant to ask the researcher if they have any questions while completing the FFQ.

SOP – Four-day food and training record – approx. 10mins

1) Watch estimated food diary video located on desktop.
2) Demonstrated how to weigh food (optional for participant).
3) Explain drop box protocol to participant (Upload photos of meals to drop box).
4) Ask participant if they have any questions.
5) Provide participant with copy of four-day food and training record.
6) Allocate participant 4 consecutive days (at least 1 weekend day, 1 rest day and participants heaviest training day).
7) Provide participant with scales (optional).
8) Record set of scales participant is using.

Examples of food groups and serving sizes from the Eating and Activity Guidelines

**The following examples were used to derive serves from the four-day food records*

Food group	Advice	Serving size examples
Vegetables and fruit (includes fresh and frozen)	At least 5 servings per day: at least 3 servings of vegetables and at least 2 servings of fruit	• ½ cup of cooked vegetables or ½ cup of salad • 1 medium potato, or similar size piece of kumera, yam or taro • 1 medium apple, pear, banana or orange • ½ cup of fresh or stewed fruit salad
Grain foods	At least 6 servings per day (mostly whole grain and those naturally high in fibre)	• 2 breakfast wheat biscuits • 1 whole grain bread roll or 1 sandwich slice or wholegrain bread • ½ cup cooked porridge/rolled oats or ½ cup muesli • 1 cup of cooked pasta or brown rice
Milk and milk products	At least 2 servings per day (choose low- or reduced- fat options)	• 1 glass (250ml) of milk or calcium-added soy or rice milk • 1 small pottle of yoghurt (125-150g) • 2 slices (40g) of cheese
Legumes[a], nuts, seeds, fish and other seafood, eggs, poultry or red meat with fat removed	At least 2 servings of legumes, nuts and seeds per day OR At least 1 serving of fish and other seafood, eggs, poultry or red meat per day	• ¾ cup of cooked dried beans, peas or lentils • Small handful (30g) of nuts or seeds • 1 egg • 2 chicken drumsticks or 1 chicken leg • 2 slices of cooked meat (100g) (e.g. roast lamb, chicken, beef or pork) • ¾ cup of mince or casserole
Drinks	Female – 8+ cups (~2000ml) Male – 10+ cups (~2500ml)	• 1 cup (250mls) plain water • 1 cup (250mls) low fat milk

Alcohol	Female – no more than 2 standard drinks per day Male – no more than 3 standard drinks per day	• 330ml can of beer at 4% alcohol • 100ml glass of wine @ 12.5% alcohol

[a] legumes include lentils, split peas, chickpeas and cooked dried beans (e.g. red kidney beans, baked beans)

(Ministry of Health, 2015)

Additional food group assumptions

**All assumptions were based on Eating and Activity Guidelines for New Zealand Adults*

Food Group/Food	Assumption
Fruit	
2 small feijoas	1 serve
1 handful of grapes	1 serve
1 large banana	1 ½ serve
Starchy Vegetables (includes hot chips)	
½ cup hot chips	1 serve
Vegetables	
½ avocado	1 serve
Breads and cereals (Includes cereal based muesli bars, muffins, scones)	
1 Farrahs wrap	1 serve
1 slice of pizza	1 serve
2 rice cakes	1 serve
8-10 small plain rice crackers	1 serve
1 sachet of oats	1 serve
10 pretzels	1 serve
Dairy and dairy alternatives	
1 coffee sachet	~100ml milk = 0.4 of serve
Meat alternatives (Includes nut based muesli bars and coconut)	
1 small handful nuts/seeds	1 serve
2 TB peanut butter	1 serve

Assumptions for FoodWorks

Food	Assumption
Aioli	Mayonnaise commercial
Banana (without peel)	Small = 101g Medium = 118g Large = 136g
Balsamic vinaigrette	Dressing, vinaigrette
Broccoli	1 small broccoli = 1 cup chopped = 78g
Burgerfuel – peanut piston	Wholemeal commercial roll – 1.5 bun Beef, patty, McDonalds – 1 patty Lettuce, raw – 0.25 cup Tomato, whole, raw 40g (2 slices) Sauce, simmer, satay, heated – 2 tsp
Butter	Butter, regular, regular salt 1 serve = 1 tsp
Capsicum	Yellow – Green Orange - Red
Cherry Tomatoes	17g
Dried cranberries	1 handful = 20g
Eggs	Scrambled eggs = enter as boiled egg plus water/milk
Eggs sizes	4 = 35g 5 = 44g 6 = 53g 7 = 62g 8 = 68g
Feijoa (without peel)	Approx. 42g
Frozen berries	= blueberries raw as no frozen mixed berry option
Heaped teaspoon/tablespoon	1.25 tsp or 1.25 tb
Herb and garlic salt	1 tsp = ½ tsp iodised salt + ½ tsp garlic powder
Margarine lite	Choose margarine reduced fat
McDonalds drink volumes	Small – 229ml Medium – 328ml Large – 501ml
McDonalds chip sizes	Small – 72g Medium – 104g Large – 128g
Milk	Light blue = 1.5% fat Trim = 0.3% fat Full fat = Milk, cow, standard 3.3% fat, fluid Full fat silver top = 4% fat Yellow top = Milk, cow, high calcium 0.1% fat, fluid, fortified
Mince	Premium = < 5% fat Prime = <10% fat Standard = 10-20% fat
Mouthful water	50mls
Natural yoghurt	Yoghurt, plain, unsweetened
Nespresso	Assumed cheapest coffee arpeggio from Australian database
Nuts	1/3 cup nuts = approx. 40g

Oil	If cooked in and amount not specified choose 1 Tb Choose vegetable blend if not specified
Peanut butter	Salt and sugar added unless specified
Potato	Approx. 4 halves to 1 cup
Raw meat	70% of the weight provided is the weight of the cooked meat
Raw vegetables	80% of the weight provided is the weight of the cooked vegetables
Salt	A pinch is 1.25g
St Pierre's sushi	30g of rice, sushi, cooked, from Californian roll 1g seaweed, dried Fillings approx. 14g
Streaky bacon	1 piece = 21g
Tomato	1 slice = 20g
Uncooked pasta/rice	Multiply raw weight by 2.43
Up and go	Liquid breakfast, assorted flavours, up & go, Sanitarium, fortified
Watties Hasbrowns	Potato, hash brown, commercial
Teaspoon	5g
Dessertspoon	10g
Tablespoon	15g

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