The Geometric Framework and Nutrition in Older Age

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A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

at the University of Sydney

Faculty of Medicine

Sydney School of Public Health

University of Sydney

2016

Abstract

Aims: There were three main aims: To validate a diet history questionnaire (DHQ) used to collect dietary data of a group of older men; to describe energy and nutrient intakes, assess nutritional risk, and investigate factors associated with poor intake of energy and key nutrients in community-dwelling men; and to investigate the association between macronutrient intake and health outcomes of a group of older men living in Sydney, Australia.

Methods: This thesis analyses data from 761 community-dwelling men aged 75 years and older who participated in the five-year follow-up phase of the Concord Health and Ageing in Men project (CHAMP). The diet history questionnaire used to collect dietary data validated against a four-day weighed food record in 56 men aged 75 to 86 years (mean 79 years, SD 2.96). Dietary adequacy was assessed by comparing (unadjusted) median intakes to Nutrient Reference Values (NRVs). Attainment of NRVs of (unadjusted) total energy and key nutrients in older age (protein, iron, zinc, riboflavin, calcium and vitamin D) was incorporated into a "key nutrients" variable dichotomised as "good" (≥5) or "poor" (≤4). Using logistic regression modelling the associations between key nutrients with factors (sociodemographic, economic health and lifestyle factors) known to affect food intake were examined. The geometric framework, generalised additive models and multiple regression models were used to assess the association between macronutrient intake (protein, fat and carbohydrate) and the following health outcomes: total energy intake, body mass index (BMI), percentage body fat, waist-to-hip ratio, insulin, total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, homeostatic model assessment for insulin resistance (HOMA-IR), number of medical conditions, SF12 (MCS and PCF), GDS and frailty score.

Results: In the validation study involving 56 men, DHQ estimates of intakes tended to be higher than estimates from weighed food records. Differences between the two methods were

generally less than 20% with the exception of β-carotene (37%), vitamin E (25%) and vitamin A (24%). Both fixed and proportional biases were only present for retinol, β-carotene, magnesium, phosphorus and percentage of energy from protein. Most of the 761 men in CHAMP met their NRVs for most nutrients. However, only 1% of men met their NRV for vitamin D, only 19% for calcium, only 30% for potassium, and only 33% for dietary fibre. Multivariate logistic regression analysis showed that only country of birth was significantly associated with poor nutritional intake where Italian/Greek born men had poorer intakes of key nutrients. In adjusted analyses investigating the association between macronutrient intake and health outcomes, protein intake stood out. After adjustment for age, physical activity level, number of morbidities, marital status, income, education, frailty status and alcohol intake (for triglycerides only), low protein intake (adjusted by body weight) was associated with higher total energy intake, higher BMI, higher percentage body fat, higher waist-to-hip ratios, higher insulin levels, and higher HOMA-IR. High protein intake (adjusted by body weight) was associated with higher HDLc and triglycerides levels. Low carbohydrate intake (adjusted by body weight) was associated with poor body composition, whereas high carbohydrate intake was associated with better physical performance. Fat intake (adjusted by body weight) was higher when protein intake was low; however, fat intake had very little influence on any of the health outcomes investigated.

Conclusion: The DHQ used in CHAMP to measure the nutritional intake of its participants is appropriate to this age group and provides reasonably similar results to the 4dWFR for the majority of nutrients analysed. Dietary intakes of community-dwelling older Australian men were adequate for most nutrients. However only half of the participants met NRVs of ≥5 key nutrients and being born in Italy or Greece was associated with poor nutritional intake of key nutrients. Lower protein intake was associated with higher levels of the majority of the health outcomes investigated.

List of publication and conferences

Waern RV, Cumming RG, Blyth F, Naganathan V, Allman-Farinelli M, Le Couteur D, Simpson SJ, Kendig H, Hirani V. **Adequacy of nutritional intake among older men living in Sydney, Australia: findings from the Concord Health and Ageing in Men Project (CHAMP)**. The British journal of nutrition. 2015;114(5):821-821.

R. G. C., F. B. and V. N. designed and developed the project. R. V. R. W., M. A.-F. and R. G. C. designed the protocol for diet history measurement of dietary intake. R. V. R. W. collected the majority of nutritional data and trained the staff for nutritional data collection, conducted all the data analyses and wrote the first draft of the manuscript. V. H. and R. G. C. oversaw the statistical analyses. R. G. C., V. H., F. B., V. N., M. A.-F., D. L. C., H. K. and S. J. S. collaborated in writing. All authors reviewed and approved the final version of the manuscript. All authors had primary responsibility for the final content.

Waern Rosilene , Cumming R, Travison T, Blyth F, Naganathan V, Allman-Farinelli M, Hirani V. **Relative validity of a diet history questionnaire against a four-day weighed food record among older men in Australia: The Concord Health and Ageing in Men Project (CHAMP)**. J Nutr Health Aging. 2015;19(6):603-10.

R.C., F.B. and V.N. designed the Concord Health and Ageing in Men Project. R.W., V.H. and M.A.F. designed the validation study. R.W. performed statistical analysis and wrote paper. T.T. oversaw and assisted in statistical analyses. R.C., V.H., F.B., V.N., T.T. collaborated in writing. All authors reviewed and approved the final version of the manuscript. All authors had primary responsibility for final content.

20th IAGG World Congress of Gerontology and Geriatrics, 2013, Soul, South Korea; **The nutritional profile of older men living in Sydney, Australia: a preliminary analysis of data from the Concord Health and Ageing in Men Project (CHAMP)** – oral presentation

1st CEPAR International Conference, 2013, Sydney, Australia; **The nutritional profile of older men living in Sydney, Australia: a preliminary analysis of data from the Concord Health and Ageing in Men Project (CHAMP)** – oral presentation

12th National Conference of Emerging Researchers in Ageing, 2013, Sydney, Australia**; Diet history questionnaire for older men: development, use and preliminary validation** – oral presentation

52nd annual ASMR National Scientific Conference (NSC), 2013, Ballarat, Australia; **A snapshot of the nutritional adequacy of men participating in the Concord Health and Ageing in Men Project (CHAMP)** – oral presentation

9th Asia Pacific Conference on Clinical Nutrition 2015, Kuala Lumpur, Malaysia; **The geometric framework technique to assess the relationships between nutrition and frailty in a sample of Australian men** – poster presentation (Winner of 2015 Young Investigator Award)

International Conference on Frailty & Sarcopenia Research, 2015, Boston, USA; **The geometric framework technique to assess the relationships between nutrition and frailty in a sample of Australian men** – poster presentation

Acknowledgements

I would never have been able to complete this thesis if it wasn't for the guidance of CHAMP investigators, help and encouragement from my family and friends, and support from my husband.

I would like to express my gratitude to my supervisor, Professor Robert (Bob) Cumming, for his continuous support and guidance of my PhD study and related research. Bob regarded all my achievements – whether it was my first presentation in an international conference, the publication of my first paper or simply the resolution of a statistical related problem – with excitement and encouragement, he helped me overcome many obstacles, including with the English language. Bob's steadfast support and intellectual guidance have been invaluable over the years and I feel incredibly privileged to have had him as my supervisor, words fail me to properly thank him.

My associated supervisor Vasant Hirani has been the main pillar of support, guidance and motivation throughout my candidature, no question was inappropriate and no mistake was too silly for her, her kindness and humbleness are strong qualities that I will always admire and aspire to. I will cherish the memories of our conference trips, our Friday lunches and meetings.

A heartfelt thank you to Thomas Travison, David Le Couteur, David Raubenheimer and Stephen Simpson for sharing their statistical knowledge with me, without their help this thesis would not have been possible.

CHAMP research committee, collaborators and my associated supervisors have guided me throughout my PhD candidature. Thank you Fiona Blyth, Vasi Naganathan and Margaret Allman-Farinelli for all the advice, encouragement and support, I have been truly blessed to have such outstanding professionals guiding me in this journey.

Outside the Charles Perkins Centre and Concord hospital, I had the privilege to have Fiona O'Leary as my DAA mentor; our meetings provided me with a boost of energy and encouragement. I wouldn't have imagined what a great friend and mentor I was meeting when I first met Fiona in her office back when I was a MND student and she so kindly helped me with some statistical problems.

The completion of this thesis and my work with CHAMP was made a lot easier and more enjoyable because of the supporting team I had throughout my involvement with CHAMP. Janet has become a mother figure to me, I will always cherish our talks, her positiveness and words of encouragement. Alex and Kate Flinders are great friends who have helped me with data collection and project management, but they were also there whenever I needed a good laughter. Nilakshi is one of the most incredible person I have ever met; her kindness, warmth and professionalism have inspired me so much, she has provided extensive help with data collection and project management. Ben, has been by my side in some really important moments, he has provided me with some valuable advice and friendship. Mel, has not only helped me with many aspects of CHAMP's data collection but she has also introduced me to one of the most important things in my life – yoga – and for that I will always be grateful to her.

I don’t know where to start with CHAMP participants; they have been a major part of my life in the last years, and I can honestly say that of all the experiences I had during this PhD candidature, spending time with all and each of them has been the greatest. I get emotional just thinking about how much these men (and women) had shared with me: from recipes to family history, advice to cheeky jokes, tea and cookies to wisdom, I will forever be grateful to have been invited to these amazing people’s homes.

Outside of the university and hospital environment, I would like to show my gratitude to the amazing friends I have made and/or managed to keep during my PhD candidature, without their support and willingness to keep me sane, I wouldn’t have completed this thesis. I would also like to thank the Lees family and MJH team for everything they have done for me, I could not be here if it wasn’t for these amazing people who have accommodated and treated me like family.

Saving the most important for last, I wish to give my heartfelt thanks to my husband, Johan, whose unconditional love, patience, and continual support of my academic endeavours over the past several years enabled me to complete this thesis. Thank you for those weekends when you cleaned the house all by yourself so I could go to the beach with you, or for the hours you sat and listened to my presentations and problems. You have been patient with me when I was frustrated, you celebrated with me when even the littlest things went right, and you were there whenever I needed you to just listen.

Last but not least, I would like to thank my family, in special my mum, dad and sister who have believed and supported me throughout my life, I would not be here if it wasn’t for their encouragement, hard-work and example.

E por fim, eu gostaria de agradecer a minha família, especialmente minha mãe, pai e irmã, que acreditaram e me apoiaram durante toda a minha vida, eu não estaria aqui hoje se não fosse pelo incentivo, trabalho duro e exemplo que eles me deram.

Author's contribution

For my PhD candidature and development of this thesis, I led the nutrition component of the CHAMP study. My main responsibilities were collecting the majority of nutritional data of about 600 older men which occurred between February of 2012 and July of 2013, standardization of procedures for collection, coding and entry of these data as well as train other staff members involved in the nutrition component of the study. I was also responsible for the design, application and analysis of the validation study and for analyses of all the data presented in this thesis.

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Abbreviations

%E	Percentage of energy
4d WFR	Four-day weighed food records
4dWFR	Four-day weighed food records
ACE	Addenbrooke's Cognitive Examination
ADG	Australian dietary guidelines
ADL	Activities of Daily Living
AHS	Australian Heath Survey
AI	Adequate Intake
ALP	Alkaline phosphatase
ALT	Alanine Aminotransferase
AMDR	Acceptable Macronutrient Distribution Range
ANZSCO	Australian and New Zealand Classification of Occupations
AUSNUT 2007	Australian nutrient database
AUSNUT	Australian nutrient database
BMD	Bone Mineral Density
BMI	Body mass index
BMR	Basal metabolic rate
C	Carbohydrate
CAGE	Cut Down, Annoyed, Guilty, Eye-opener (in the context of the questionnaire)
CALD	Culturally and linguistically diverse
CHAMP	Concord health and ageing in men project
CI	Confidence interval
DEXA	Dual-Energy X-ray Absorptiometry

DHQ	Diet history questionnaire
EAR	Estimated Average Requirement
EER	Estimated energy requirements
F	Fat
FEV1	Forced Expiratory Volume exhaled at the end of first second of forced expiration
FFQ	Food frequency questionnaire
GAM	Generalized additive model
GDP	Gross Domestic Product
GDS	Geriatric Depression Scale
GF	Geometric framework
HDLc	High-density lipoprotein cholesterol
IADL	Instrumental Activities of Daily Living
ICIQ	International Consultation on Incontinence Questionnaire
InCHIANTI	Invecchiare in Chianti, aging in the Chianti area
IPSS	International Prostate Symptoms Score
IQCODE	Informant Questionnaire on Cognitive Decline in the Elderly
LDLc	Low-density lipoprotein cholesterol
LNAA	Large neutral amino acids
LOA	Limits of agreement
MATeS	Men in Australia telephone survey
MD	Mediterranean diet
MMSE	Mini–Mental State Examination
MOW	Meals on wheels
MrOS	Osteoporotic fracture in men study

NHANES	National health and nutrition examination survey
NRV	Nutrient Reference Values
OARS	Older American Resource Scale
OmniHeart	Optimal Macronutrient Intake Trial to Prevent Heart Disease
OR	Odds ratios
P	Protein
PAL	Physical activity level
PAL	Physical activity level
PASE	Physical activity scale for the elderly
PSA	Prostate-Specific Antigen
RDI	Recommended Dietary Intake
SD	Standard deviation
SF12	Short Form-12
SMA	Standard major axis
TEE	Total energy expenditure
UL	Upper Level of intake

Thesis structure

This thesis has been divided into two parts: PART ONE covering the Introduction and Methodology of this thesis, and PART TWO covering the Research Findings. PART ONE (Introduction and Methodology) contains three chapters: CHAPTER 1 (Introduction), CHAPTER 2 (Methods) and CHAPTER 3 (Study participants). PART TWO (Research Findings) contains four chapters: CHAPTER 4 (Relative validity of a diet history questionnaire against a four-day weighed food record among older men in australia: the Concord Health and Ageing in Men Project (CHAMP)); CHAPTER 5 (Adequacy of nutritional intake among older men living in Sydney, Australia - findings from the Concord Health and Ageing in Men Project (CHAMP)); CHAPTER 6 (The geometric framework, nutrition and health in older men); CHAPTER 7 (Conclusion). CHAPTER 1 provides a background of the main topics of this thesis: ageing in Australia, nutrition of older people, protein leverage and the geometric framework, and ends with the objectives of this thesis. Recruitment of the sample, assessment procedures and statistical methods used in several sections of the thesis are described in CHAPTER 2. Statistical methods specific to individual sections of this thesis are presented in the relevant chapter. In CHAPTER 3 participants' characteristics are described. In PART TWO of the thesis, studies reporting research findings are described. These studies are presented as they were published or are intended to be published in peer-reviewed journals; therefore, some repetition of literature reviews and methods is present. Chapter 4 and 5 have been published in peer-reviewed journals; Chapter 6 is written in a thesis chapter format and should result in several articles in the future. In CHAPTER 7 I synthesise the results of this thesis and end with relevant public health implications and suggestions for future research.

PART ONE: INTRODUCTION AND METHODOLOGY

CHAPTER 1. INTRODUCTION

1.1. Ageing in Australia

Population ageing is a global occurrence impacting health patterns in almost all countries (1, 2). In Australia, the number of individuals aged 65 years and over is rapidly increasing as a result of the ageing of the large post-war baby-boom cohort and rising of life expectancy at age 65 years (3). It is expected that between 2012 and 2061, the proportion of people aged 65 and over living in Australia will go from 14% to 25%, and the proportion of people aged 85 and over will rise 4.2% (from 1.8% in 2012 up to 6% in 2061) with a remarkable increase proportion of men in this age group (35% up to 46%) (4).

Australia has become an ethnically diverse nation with migrants bringing their culture, language, religion, eating patterns, foods and recipes to their new home (5). Older overseas born Australians are more likely to be from European origins (3, 5). Some evidence suggests that dietary preferences established in younger ages can influence food choices in later life (6), therefore, it is possible that older individuals main retain the same dietary patterns as they had in their country of birth and this may have a direct effect on their health. For example, the Mediterranean dietary pattern has been linked to many health benefits such as reduced incidence of cancer, Parkinson's and Alzheimer's disease (7); given that the majority of immigrants aged 65 and over in Australia are Greek or Italian born (8), it is likely that they have retained similar dietary habits to those developed in younger age and that that may have been, at least in part, the reason for their longevity.

Ageing affects people across many domains including health, housing, income, and social and economic participation (9). For instance, ageing increases the risk of functional decline and the prevalence and incidence of conditions such as incontinence, falls, malnutrition and

depression (10). In terms of living arrangements, we can expect to have more older people living alone in the future because of smaller families, fewer older people living with their children and increasing divorce rates (11). These demographic changes are likely to have an impact on the Australian economy; for instance, it is estimated that by 2060, an extra 6% (going from 8% in 2011-12 to 14% in 2059-60) of the Australian Gross Domestic Product (GDP) will be spent on health care, age pensions and aged care (12).

Therefore, it is essential that research is conducted to addresses issues associated with the changing burden of disease that will occur with an ageing population (13).

1.2. Nutrition in older people

Nutrition is an important adaptable factor that influences health in old age (14). Adequate nutritional intake is linked to reduced morbidity, mortality and improved quality of life in older age (15). The Melbourne Longitudinal Studies on Healthy Ageing Program (MELSHA) - an Australian longitudinal study - recently reported that nutrition at baseline was an independent predictor of older people's 'ageing well', defined as continuing to live in the community with independence in daily living, and good self-rated health and psychological well-being (16).

Nutritional requirements of older individuals are similar or greater than younger adults (17). However, older individuals are likely to have lower nutritional intakes than their younger counterparts (17-20). Age-related physiological factors such as decline in sensorial ability (e.g. taste and smell) and appetite, earlier satiety and reduced physical activity and resting metabolic rates may contribute to a decline in dietary intake in older age (19). Socio-

economic and psychological changes observed in older people are also linked with lower dietary intake and increased risk of nutritional inadequacy (20-26). For example, in older men, lack of cooking skills, nutritional knowledge and social engagement are all associated with decline in dietary intake (27). Factors such as country of origin (28), living conditions (25, 26) and physical disability (29) have also be reported to increase the likelihood of nutritional inadequacy. For older men living alone, the risk of inadequacy is even greater than for women due to their limited domestic experience (planning, shopping and cooking meals) (27, 30) and reliance on clubs, family and 'ready meals' to provide dietary intake.

1.3. Population-based studies of diet in older Australians

A literature review was completed on MedLine/OVID using the following search terms: Aged, 80 and over and aged, Australia, diet, male, humans, nutrition survey OR energy intake and nutrition survey. A total of 15 studies were identified. Selected papers were manually reviewed for cross-references. Only studies that reported specifically nutrient intake of older individuals and included male participants were considered suitable for this review. Papers investigating dietary patterns, validity of dietary methods and nutritional intake of subjects with specific health issues or living in high level aged care facilities were disregarded. Results from the latest Australian Health Survey (AHS)(31), was also included in this review.

Studies investigating the overall nutritional intake (i.e. not focused on a specific nutrient) of aged individuals are scarce in Australia; apart from the recent AHS, there is no recent and comprehensive study investigating the dietary intake of older Australians. Moreover, the focus of research in nutrition has shifted from nutrients to foods and dietary pattern in recent

years (32), and many studies fail to report individuals' nutrient intakes. Ideally, both food and nutrient intake should be reported so comparison can be made and trends can be investigated.

The most recent AHS included the National Nutrition and Physical Activity Survey (NNPAS) and aimed to provide a better understanding of the health of people living in Australia. The nutritional data of 12,153 participants aged 2 years and older (including 585 males aged 70+) were obtained through a single 24-hour dietary recall. Although this was a comprehensive survey with a considerable sample of older participants, the dietary assessment tool used (a single 24-hour recall) only provides information of a single day's intake and participants' eating patterns are likely to vary from day-to-day. In order to improve reliability of data, 64% of the respondents were interviewed for a second time within 8 days of the first interview; the second 24-hour recall data were used to estimate and remove within-person variation, and to derive a usual nutrient intake distribution for the population (33).

The survey found that compared to their younger counterparts, males aged 71 years and over were less likely to meet their requirements for protein (absolute intake), riboflavin, vitamin B6, calcium, selenium and zinc. About 14% of males aged 71 years and over failed to meet their requirements for protein (absolute intake), about 20% had inadequate intake of riboflavin (vitamin B2), 53% had inadequate intake of carbohydrate (as percentage of energy), 57% had inadequate intake of vitamin B6, 64% had inadequate intake of magnesium, 66% had inadequate intake of zinc, 47% had intake of sodium above the upper level of intake, and as much as 90% of males aged 71 years and over had inadequate calcium intakes (31). Compared to female participants, males aged 71 years and over had lower intakes of fat and protein and were less likely to meet their requirements for magnesium,

phosphorus, selenium, sodium and zinc. Compared to males aged 51 to 70 years, males aged 71 years and over had a higher consumption of fats and oils, fruit and fruit products, soups, sugar products and dishes, and a lower consumption of vegetables, seeds and nuts, meat, poultry, game and fish, and cereal and its products; these could be related with some of the dietary inadequacies found in this group (34).

Apart from the AHS, in Australia the only other population-based study in the last twenty years to report the dietary intake of older individuals was the Blue Mountains Eye Study (BMES) (35, 36). Two publications derived from this study; the first one published in 1999, described the dietary intakes - measured through a 145-item food frequency questionnaire (FFQ) - of 2873 free-living middle-aged and older Australians. They also investigated the socio-demographic characteristics associated with attainment or non-attainment of dietary goals. They found that intakes of vitamin A and C, iron and potassium were adequate for the majority of male participants aged 75 and over; absolute intake of alcohol, cholesterol, sodium, calcium and magnesium were adequate for about half in the same age group; and less than a third of these participants had adequate intake of total and saturated fat and carbohydrate. Socio-demographic characteristics associated with attainment of dietary goals for men were age, marital status, living arrangements, country of birth, education, job history, income and independence for shopping, cleaning and reading (35).

The second publication from the BMES assessed both nutrient intake and food trends of 1166 participants with complete FFQ (41% men) aged 60 years and over at baseline (1992-1994); the group was followed up for 10 years (baseline, 5 and 10-year follow-up). The results showed some interesting changes in male participants' (n=475) dietary intakes: there

was a decrease in overall total, polyunsaturated and saturated fat intake, and an increase in long chain omega 3 polyunsaturated fatty acids (all as absolute intake adjusted for energy and as percentage of energy); absolute intake (adjusted for energy) of protein, monounsaturated fatty acids and fibre tended to decrease amongst male participants; and in terms of micronutrient intake, it was found that folate and sodium intake (adjusted for energy) tended to increase while zinc intake tended to decrease during the 10 years of follow-up. The authors proposed that some of these nutritional intake changes could have been attributed to physical changes associated with ageing such as poorer dentition, a concept well supported by the fact that the study participants tended to increase the intake of canned fruit, avocado, eggs and softer meat as they grew older. The increase in the consumption of long shelf life products such as canned fruit and fish was also proposed to be related to convenience of easier preparation and lack of opportunities for grocery shopping that may occur in older age, but the authors also acknowledged that some of these changes may also reflect changes in the food supply during the study period (10 years) (36).

In summary, the two studies to investigate the dietary intake of older male individuals living in Australia have shown that the intakes of protein, zinc, calcium, sodium and magnesium are likely to be inadequate in this group.

Table 1.1 Population-based studies that have reported the dietary intake of older male Australians

Author	Year	Title	Sample and location	Dietary assessment	Nutrients investigated	Results (males only)
V M Flood, G Burlutsky, K L Webb, J J Wang, W T Smith and P Mitchell	2010	Food and nutrient consumption trends in older Australians: a 10-year cohort study (36)	1166 participants aged 49 years and over (mean age was 62 at baseline and 73 at 10-year follow-up) living in Sydney, Australia	145-item FFQ	Energy, carbohydrate, sugars, protein, fat, saturated fat, MUFA, PUFA, LC n-3 PUFA, alcohol, fibre, folate, vit. B12, calcium, sodium, iron, zinc	↓fat, saturated fat, PUFA (both as % of energy and absolute intake adjusted for energy); ↓ intake of protein, MUFA, fibre and zinc intake (adjusted for energy); ↑ intake of LC n-3 PUFA (as % of energy and absolute intake adjusted for energy), folate and sodium (adjusted for energy)
K. L. Webb, W. N. Schofield, R. Lazarus, W.Smith, P. Mitchell, S. R. Leeder	1999	Prevalence and socio-demographic predictors of dietary goal attainment in an older population (35)	2873 participants aged 49 years and over (32% of the men aged 70+) living in Sydney, Australia	145-item FFQ	Total and saturated fat, carbohydrate, alcohol, dietary cholesterol, sodium, fibre, vit. A and C, iron, calcium, zinc, potassium and magnesium.	Intakes of vit. A and C, iron and potassium was adequate for most participants; alcohol, cholesterol, sodium, calcium and magnesium intake was adequate for ~50% of participants; less than 1/3 of participants had adequate intake of total and saturated fat and carbohydrate

FFQ. Food frequency questionnaire; EAR, estimated average requirement; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; LC, long chain; n-3, omega 3; vit., vitamin; vit. B1, thiamine, vit. B2, riboflavin; vit. B3, niacin.

Table 1.1 Population-based studies that have reported the dietary intake of older male Australians (continued)

Author	Year	Title	Sample and location	Dietary assessment	Nutrients investigated	Results (males only)
Australian Bureau of Statistics (ABS) and Food Standards Australia New Zealand (FSANZ)	2011-2012	National Nutrition and Physical Activity Survey (NNPAS)	12 153 participants, 349 males aged 75+	A single 24-hour dietary recall	Total energy, protein, total, saturated, monounsaturated, polyunsaturated fat, linoleic acid, alpha-linolenic acid, total LC n-3 fatty acids, trans fatty acids, carbohydrate, total sugars, starch, dietary fibre, alcohol, preformed and pro vit. A, vit. A retinol equivalent, vit. B1, B2, B3, B6, B12, C and E niacin equivalent, folate, natural, folic acid, total folates, folate equivalent, calcium, iodine, iron, magnesium, phosphorus, potassium, selenium, sodium, zinc, caffeine and cholesterol.	2% not meeting requirement for folate equivalent in food and for vit. C, 10% for vit. B1, 13% for vit. A (retinol equivalent), 15% for vit. B12, 20% for vit. B2, 57% for vit. B6, 10% above and 1% below AMDR for fat, 16% below and 1% above AMDR for protein, 14% below EAR for protein, 90% for calcium, 66% for zinc, 64% for magnesium, 12% not meeting requirement for selenium, 4% for iodine; 3% for iron; 47% had intake of sodium above UL, 53% with intakes below AMDR for carbohydrate, 16% below and 1% above AMDR for protein, 14% below EAR for protein.

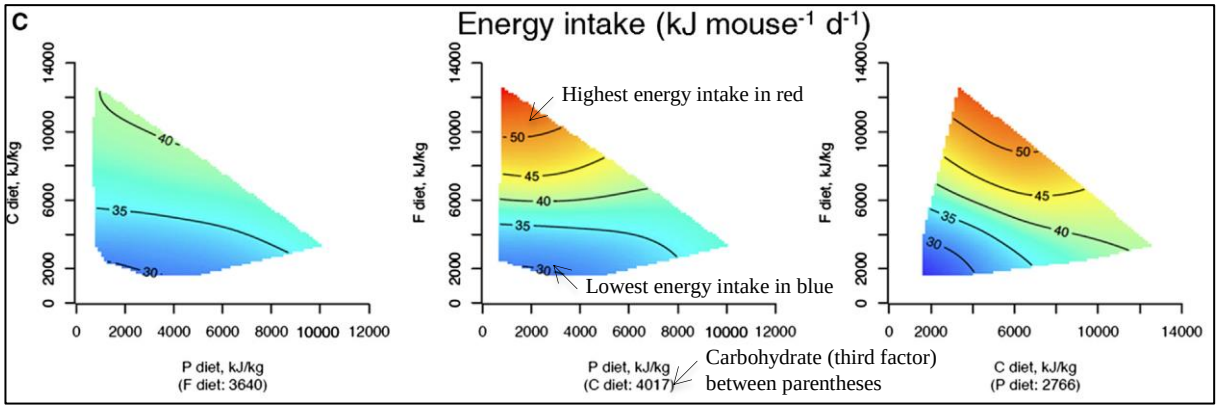
FFQ. Food frequency questionnaire; EAR, estimated average requirement; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; LC, long chain; n-3, omega 3; vit., vitamin; vit. B1, thiamine, vit. B2, riboflavin; vit. B3, niacin.

1.4. The geometric framework

The Geometric Framework (GF) is a state-space modelling approach used to investigate how different species address issues related to balancing multiple and varying nutritional needs in a multidimensional and variable environment (37, 38). The unique characteristic, and probably the main strength of the GF, is that it permits visualisation of associations of complex nutritional systems in a simple way, and complemented with generalized additive models (GAM), is a powerful approach to be used to solve issues of applied nutrition.

In the GF, a model of subjects' dietary intake is constructed as an n-dimensional state-space in which each n-component of the diet is represented by separate axes (three in the case of macronutrients: carbohydrate [C], fat [F] and protein [P]). Therefore, three 2D slices are presented to show all three nutrient dimensions (C, F, P) with the third factor at its median shown below the X axis in parentheses. Responses of individuals, such as total energy intake or body mass index (BMI), are mapped on the n-dimensional nutritional space by plotting response surfaces. These response surfaces are presented in a colour gradient where highest values are presented in red and lowest in blue, much like a heat map. The ideal or undesirable range of intakes associated with individuals' response can then be visualized (see Figure 1.1).

Figure 1.1 Response surfaces showing the relationship between macronutrient intake and total energy intake (kJ/day) of 858 mice on 25 different diets (39).



Adapted from 'The ratio of macronutrients, not caloric intake, dictates cardio-metabolic health, aging, and longevity in ad libitum-fed mice, Cell Metabolism, 2014 (39). Mouse $^{-1\ d-1}$, intake per mouse per day.

The GF has been applied in many animal species including insects, birds, fish, rats, mice, and humans to investigate associations between nutritional intake and factors such as reproduction, growth, cardio-metabolic health and energy intake (37, 39-47). For instance in a recent study involving 858 mice fed on 25 different diets, *Salon-Biet et al* found that low protein and high carbohydrate diets were associated with increases in lifespan, lower blood pressure, better glucose tolerance, higher high-density lipoprotein cholesterol (HDLc), lower low-density lipoprotein cholesterol (LDCc) and triglycerides (39). Another study involving mated female flies that were allowed ad libitum access to one of 28 diets with varied ratio and concentration of yeast to sugar, found that a diet that increased flies' longevity (low P:C) was not the same as the diet that provided highest egg production, illustrating that one single diet is not capable of providing all the nutrients required for all of an individual's needs (48).

There have only been three publications involving human subjects that have utilized the GF (45-47). Two papers come from an observational study of 156 pregnant women from the Women and Their Children's Health (WATCH) study - a prospective, longitudinal cohort that started in July 2006 in Newcastle, Australia. Nutritional data, reflecting intake in the previous

three months, was collected between 18 and 24 weeks and again between 36 and 40 weeks of gestation using a validated 74-item food frequency questionnaire (FFQ). The first paper investigated the relationship between maternal intake of vitamins, minerals and daily servings of food groups during pregnancy and the health of their children (45); in the second paper the association between maternal nutrition during pregnancy and intrauterine development of fetal body composition was investigated (46). In both papers, the overall conclusion was that maternal macronutrient intake during pregnancy affects the health of their offspring, particularly, fetal body composition.

The third publication utilizing the GF in humans was a review compiling the data of 38 published experimental trials that measured ad libitum intake in subjects confined to menus differing in macronutrient composition; the aim of this review was to investigate participants' protein appetite or 'protein leverage' (discussed in the next section of this chapter). The authors concluded that protein dilution in the diet may have a detrimental effect to humans health e.g. excessive energy intake and obesity (47).

This thesis presents the first population-based study involving older people to use the GF. The thesis uses data from the Concord Health and Ageing in Men Project (CHAMP) – a longitudinal cohort study of older men in Sydney, Australia (described in detail in CHAPTER 2). Other potential uses for the GF includes investigation of associations between types of fats (mono-, polyunsaturated and saturated fatty acids) or protein (animal vs vegetable) in relation to health outcomes. These are not covered in this thesis.

1.5. Protein leverage

Protein, despite being a very important nutrient for the maintenance of good health throughout the lifespan, generally has a very small contribution to human total energy intake when compared to the other macronutrients (fat and carbohydrate). At the same time, protein is a highly satiating nutrient and is tightly regulated in the human diet (49-51).

Protein intake requirement is affected by a number of factors such an individual's age, sex and level of activity (41, 52). In a situation where the diet does not provide enough protein to meet the individual's protein requirements, three possible situations may occur:

1- Increase overall intake so protein requirements are met, in which case there will be over-consumption of fat, carbohydrate and energy;

2- Consume enough carbohydrate and fat to meet their requirements, but under-consume protein;

3- Maintain an energy balance, where energy shortage from protein counter-balances the energy excess of carbohydrate and fat (53).

Whichever situation arises from a macronutrient-unbalanced diet, the ultimate outcome will be a compromise in intake; most likely - and possibly a major factor in the development of obesity and metabolic diseases (47) - there will be a tendency to increase overall dietary intake so that protein requirements are met - the rule of compromise (47, 54). This is due to the protein appetite that is stimulated by a decrease in the proportion (contribution to total energy) of dietary protein also known as 'protein leverage' (53).

The continuous increase in the obesity rates in most countries in the world raises a question regarding the role of protein in the diet: protein has a small contribution to total energy, is tightly regulated, yet it may have just enough influence over human's eating behaviour to explain obesity (53).

The protein leverage hypothesis developed by Simpson and Raubeheimer (53) has been verified in a number of species including monkeys (55), pigs (56, 57), rodents (57, 58), birds (59), fish (60), insects (41) and humans (47, 61, 62). An experimental study involving lean subjects showed a 12% increase in total energy intake when protein contribution to total energy dropped from 15% to 10%, and for every 1kJ decrease in protein intake below the 15% level, there was a 4.5kJ increase in the consumption of non-protein nutrients (fat and carbohydrate). However, the same study showed that when protein intake increased from 15% to 25%, there was no decrease in total energy intake (54). In another experimental study involving lean subjects given three types of diets (5%, 15% and 30% protein), total energy intake decreased when protein contribution went from 15% to 30% (61). Therefore, it seems that energy intake is likely to rise if protein intake is low, but energy intake may not decrease if protein intake is too high. A possible explanation would be that the consequences of under consumption of protein - impaired growth, loss of lean mass, compromised reproduction - are much worse than those of excessive protein consumption (47).

In terms of protein consumption as a percentage of total energy, very little has changed over the past three decades (53, 62), for instance, findings from a longitudinal study involving women residing in Metropolitan Cebu City, Philippines showed that compared to carbohydrate and fat, the amount of consumed calories derived from protein had remained

nearly the same over a period of 20 years, even after controlling for absolute intake of each macronutrient in the diet.

However, even a small change in protein intake as a percentage of energy can have a significant impact on health, for example, when the macronutrient (protein, carbohydrate and fat) supply of 13 countries (Australia, Canada, Denmark, Finland, France, Germany, Italy, Netherlands, New Zealand, Spain, Sweden, UK and USA) were compared against obesity rates of between the years of 1970 and 2000, countries where the percentage of protein had fallen the most were found to have the highest incidence of obesity (53).

In this thesis, the protein leverage hypothesis will be investigated amongst community-dwelling older men participating in the CHAMP study.

1.6. Thesis objectives

The specific objectives of the research described in this thesis were:

1. To describe and assess the nutritional intake of a representative sample of men aged 75 years and over living in Australia, and in particular investigate:
    - Participants' dietary intake in comparison with current nutritional recommendations of energy and nutrients.
    - Factors associated with having a poor intake of key nutrients in older age.
2. To evaluate the relative validity of the diet history questionnaire used in CHAMP compared with a 4-day weighed food record.
3. To investigate protein leverage hypothesis amongst community-dwelling older men.

4. To use the Geometric Framework to investigate associations between macronutrient intake and the following health outcomes: body composition, cardiovascular, metabolic and general health, and frailty.

CHAPTER 2. METHODS

2.1. The CHAMP study

The Concord Health and Ageing in Men Project (CHAMP) is a prospective cohort study designed to explore the relationship between major health issues and ageing amongst community dwelling men aged 70 years and older. Recruitment and baseline assessment of participants occurred between January 2005 and June 2007; two-year follow-up assessments began in January 2007 and finished in October 2009; five-year follow-up assessments occurred between August 2010 and July 2013. This thesis is based around the five-year follow-up data.

2.1.1. Cohort selection

The goal of the selection process was to recruit a representative group of older men. To do this, the names and addresses of all men aged 70 and over living within three adjacent Local Government Areas (Burwood, Canada Bay and Strathfield) were obtained using the electoral roll. These are the three Local Government Areas located near Concord Hospital in the inner Western region of Sydney, Australia. The only exclusion criterion was living in a residential aged care facility. Eligible men in the study were sent a letter describing the study, and if they had a listed telephone number, were telephoned about one week later. Men without listed telephone numbers who did not respond to the first letter were sent a second invitation letter. Recruitment occurred sequentially across the geographic area, with invitation letters being sent out each week during the recruitment period.

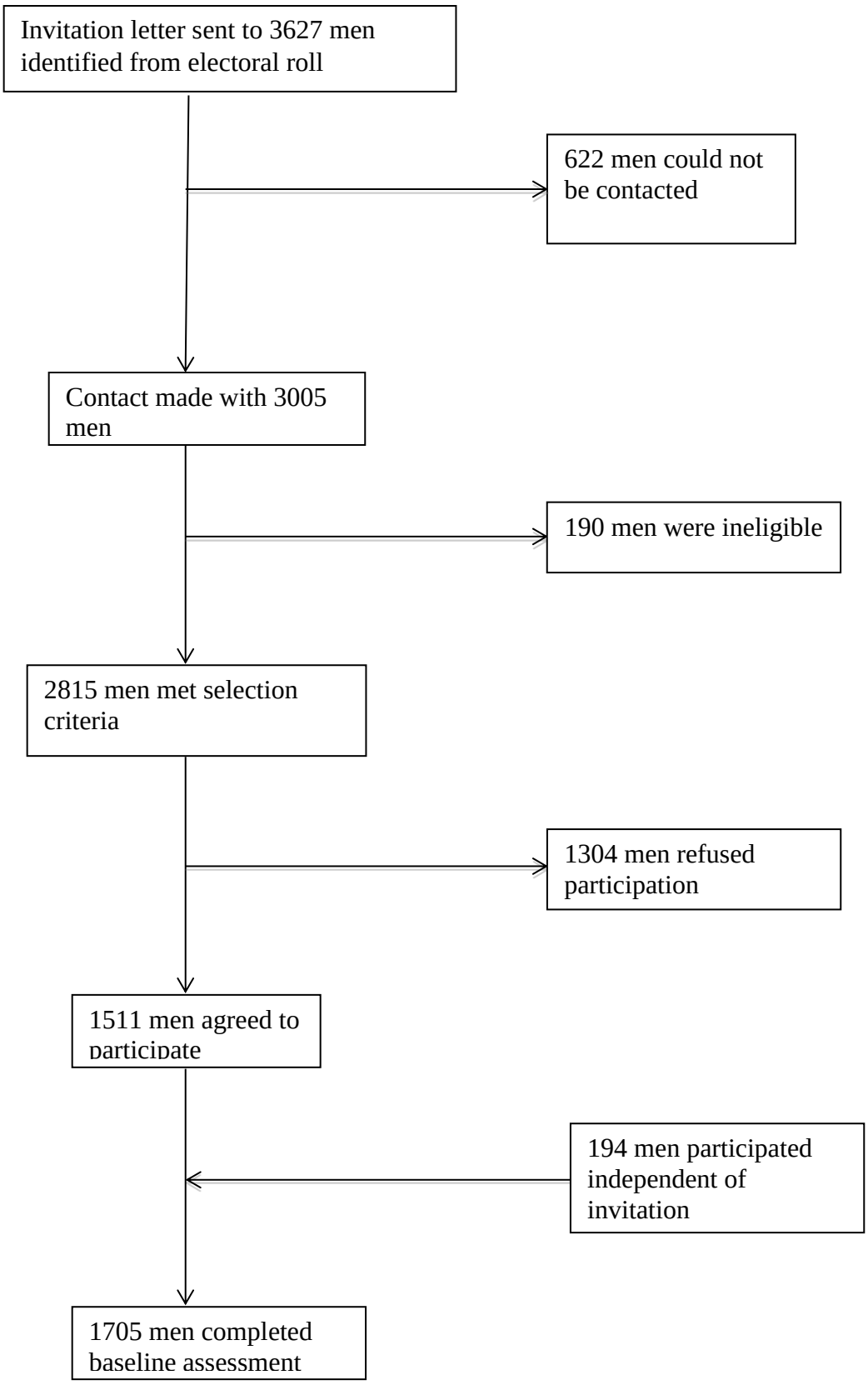
Invitations letters were sent to 3,627 men and contact was made with 3,005. Most of the 622 men who were not contacted did not have a listed telephone number. One hundred and ninety of the contacted men were not eligible for the study because they had moved out of the study

area, had moved into a nursing home or had died. Of the 2,815 eligible men with whom contacted was made, 1,511 participated in the study (63). An additional 194 eligible men living in the study area had been told about the study by friends or read reports in local newspapers and were recruited before receiving invitation letter. The participation rate of CHAMP was 47% (numerator=1705 [1511+194]; denominator= 3631 [3627 invitations sent + 194 participated independent of invitation later -190 ineligible]).

Figure 2.1 summarises the baseline recruitment process. The baseline participation rate of 47% was similar to other large epidemiological studies involving older men and a clinic visit such as the Australian Longitudinal Study of Ageing (response rate=55%) (64), the Dubbo Osteoporosis Epidemiological Study (response rate= 46%) (65) and the Massachusetts Male Ageing study (response rate=52%) (66).

Baseline assessments were repeated after two and then five years (details of the follow-up are in Chapter 3). A total of 1366 (80% of baseline sample) participants returned to two-year follow-up and 954 (56% of baseline sample) to five-year follow-up assessments, however, because nutritional data collection was only introduced during five-year follow-up assessment, two-year follow-up data is not included in this thesis.

Figure 2.1 Flow chart showing CHAMP recruitment process with sample size at baseline



2.2. Assessment procedure

A wide range of data has been collected in CHAMP; these data were obtained through self-reported questionnaires, clinical assessments and dietary assessment. **Table 2.1** summarises the diversity of data obtained in CHAMP. Assessments were conducted at baseline, two-year and five-year follow-up, with most, but not all, data collected at all three time points **(see table 2.1).** Data used in this thesis were mainly obtained during the five-year follow-up, except for some baseline data that do not change with time such as country of birth. Only data used in this thesis are described in detail.

Table 2.1 Information collected in CHAMP during the three assessment waves

Information	Method	Baseline	2-year follow-up	5-year follow-up
Self-reported				
Physical activity	PASE (67)	✓	✓	✓
Psychological health	CAGE (68), Geriatric Depression Scale (15-item) (69, 70), Goldberg Anxiety Scale (71), IQCODE (72, 73), Neuropsychiatric inventory (NPI) (74)	✓	✓	✓ (except CAGE)
Social support	Duke Social Support Index (11-item) (75, 76)	✓	✓	✓
Urinary symptoms	IPSS (77), ICIQ (78)	✓	✓	✓
Nutritional intake	Diet history questionnaire	✕	✕	✓

ACE, Addenbrooke's Cognitive Examination; ALP, Alkaline phosphatase; ALT, Alanine Aminotransferase; BMD, Bone Mineral Density; CAGE, Cut Down, Annoyed, Guilty, Eye-opener (in the context of the questionnaire); DEXA, Dual-Energy X-ray Absorptiometry; FEV1, Forced Expiratory Volume exhaled at the end of first second of forced expiration; ICIQ, International Consultation on Incontinence Questionnaire; IPSS, International Prostate Symptoms Score; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; MMSE, Mini–Mental State Examination; PASE, Physical Activity Score for the Elderly; PSA, Prostate-Specific Antigen; SF12, Short Form-12

Table 2.1 Information collected in CHAMP during the three assessment waves (continued)

Information	Method	Baseline	2-year follow-up	5-year follow-up
Examinations				
Anthropometry	Height and weight, hip, waist and neck circumference	✓	✓	✓
Balance	Sway metre, 6m narrow walk	✓	✓	✓ (No sway meter)
Bone	DEXA (hip and spine BMD), lateral vertebral morphometry, heel ultrasound	✓	✓	✓ (No heel ultrasound)
Cardiovascular system	Blood pressure (lying and standing), heart rate	✓	✓	✓
Cognitive function	ACE (79), MMSE (80), Trials B, Color Form, Sorting text, Logical Memory	✓	✓	✓
Gait	Walking speed (6-metre walk)	✓	✓	✓
Muscle strength	Grip strength, quad strength, repeated chair stands	✓	✓	✓(No quad strength)
Respiratory function	FEV1	✓	✓	✕
Sarcopenia	DEXA (lean body mass)	✓	✓	✓
Urinary function	Uroflow, post-void residual	✓	✓	✓
Vision	Acuity, contrast sensitivity, depth perception	✓	✓	✕
Blood tests				
Routine biochemistry and haematology	ALP, ALT, Albumin, bilirubin, calcium, cholesterol (total and HDL), creatinine, electrolytes, glucose, insulin, phosphate, PSA, triglycerides, urea, full blood count (haemoglobin, leucocytes, platelets)	✓	✓	✓ (Insulin only at five-year follow-up)

ACE, Addenbrooke's Cognitive Examination; ALP, Alkaline phosphatase; ALT, Alanine Aminotransferase; BMD, Bone Mineral Density; CAGE, Cut Down, Annoyed, Guilty, Eye-opener (in the context of the questionnaire); DEXA, Dual-Energy X-ray Absorptiometry; FEV1, Forced Expiratory Volume exhaled at the end of first second of forced expiration; ICIQ, International Consultation on Incontinence Questionnaire; IPSS, International Prostate Symptoms Score; IQCODE, Informant Questionnaire on Cognitive Decline in the Elderly; MMSE, Mini–Mental State Examination; PASE, Physical Activity Score for the Elderly; PSA, Prostate-Specific Antigen; SF12, Short Form-12

2.2.1. Self-completed questionnaire

For the three assessment time points, participants completed a questionnaire (**Appendix A**) at home before attending the study clinic at Concord Hospital. About half of the measures used in the CHAMP study are identical to those used in the Osteoporotic Fracture in Men study (MrOS) (2).The questionnaire included questions on socio-demographic information such as date of birth, country of birth, marital status, education, living arrangements, income, physical activity, lifestyle and depression. Some of the questions allowed for a large number of answers (e.g. country of birth) which resulted in some responses with very small number of participants, for this reason, some responses were grouped for analyses.

Country of birth was grouped as Australia/New Zealand, Italy/Greece, and other. Marital status was grouped as currently married/de facto, widowed, divorced/separated, never married and other. Living arrangements were dichotomised as lives alone versus other living arrangements. Post-school qualification listed categories were Bachelor degree or higher, trade/apprenticeship, certificate/diploma and no qualifications. Main lifetime occupation was grouped into nine categories (manager, professional/para-professional, tradesperson, personal-service worker, clerk, salesperson, plant and machine operator, labourer and inadequately stated/unknown) based on the Australian and New Zealand Classification of Occupations (ANZSCO), first edition (81). Source of income was dichotomised as age pension only versus other (repatriation pension, veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination). We used source of income as a proxy of personal income, assuming that age pensioners had the lowest income. House ownership was dichotomised as owning house outright versus other housing arrangements.

The questionnaire also included question on the following medically diagnosed health conditions: diabetes, thyroid problems, osteoporosis, Paget's disease, stroke, Parkinson's disease, kidney stones, dementia, depression, epilepsy, hypertension, myocardial infarction, angina, heart failure, intermittent claudication, chronic obstructive lung disease, liver disease, chronic kidney disease, arthritis, and cancer (excluding non-melanotic skin cancer and benign tumours such as bowel polyps). Multi-morbidity was defined as having two or more of these conditions (82). Depressive symptoms were measured using the shortened (15 items) Geriatric Depression Scale (GDS) (83). A cut-off of five or more symptoms was used to define clinically significant depressive symptoms, which is how GDS results are commonly reported in the literature (84).

Self-rated health was obtained through response to the question "compared to other people of your own age, how would you rate your own health?" which is part of the Short Form-12 (SF12) (QualityMetric inc., Lincoln, Rhode Island) and responses were categorised as excellent/good, fair and poor/very poor. Instrumental Activities of Daily Living (IADL) such as ability to shop for food and prepare own meals were assessed using the Older American Resource Scale (OARS) (85).

Measures of lifestyle-related health risk factors included cigarette smoking and alcohol use. Smoking status was grouped as former smoker/ never smoked and current smoker. In regards to alcohol consumption, men who had consumed at least 12 alcoholic drinks in the past year were asked about their frequency and quantity of alcohol consumption. This enabled grouping of men into categories of non-drinkers, safe-drinkers (≤14 drinks/week) and harmful drinkers

(>14 drinks/week) (86). Physical activity was assessed using the Physical Activity Scale for the Elderly (PASE) and grouped into tertiles: low (≤76), median (77-160) and high (≥161).

2.2.2. Clinic assessment

All subjects attended a three-hour clinic visit where they were seen by trained staff. Participants also had their fasting blood collected either at the clinic (if clinic was in the morning) or at home (if clinic was in the afternoon). Data were collected from participants using a standardised form **(Appendix B)**.

A range of information was obtained through clinical assessment such as anthropomorphic measures, cognitive tests, functional and neuromuscular tests, DXA scans and blood measures (**Table 2.1**).

Height and weight were measured according to a standardised protocol using Wedderburn digital scales and a Harpenden portable stadiometer. BMI was calculated as kg/m^2 and categorised as underweight (below $22kg/m^2$), normal ($22\text{-}27kg/m^2$) and obesity (above $27kg/m^2$ in accordance with recent studies in older people (65 years and over) that have shown that there is an increased risk of mortality in the lowest and highest cut-offs (79, 80, 82, 137-139). Cognitive function was assessed using a battery of cognitive tests including the Mini-Mental State Examination (MMSE) (80) and Addenbrooke's Cognitive Examination (ACE) (79). Muscle strength was measured by timed grip strength and chair stands. Walking speed was assessed on a six-metre course at usual pace. Activities of Daily Living (ADL) were measured using a modified version of the Katz index of ADL (87).

2.2.3. Dietary assessment

Dietary assessment was introduced in the five-year CHAMP follow-up. Usual dietary intake was determined through collection of diet histories (88) which was conducted by a research dietitian at participants' residences using a standardised diet history method. All dietitians involved in the administration were Accredited Practicing Dietitians (APD). DHQ admiration is part of the Bachelor of Nutrition and Master of Nutrition and Dietetics course curriculum. Analysis of data was performed by this thesis author (RW) who completed a number of statistical courses and is also an APD.

The diet history interview method was chosen as it is a reliable approach (89, 90) that does not limit the variability of response - as it is the case with FFQs (90). It is indicated for older people because their diets tend to be consistent over long periods of time and, even though it is a retrospective method, it does not rely on short-term memory and uses a much more interactive approach than other methods (30, 91-93). Furthermore, diet histories have low respondent burden, which may improve response rates among older people and they require no literacy or numeracy skills from participants (89, 94, 95), making them suitable for participants of culturally and linguistically diverse backgrounds. Diet history interviews took an average of 45 minutes to complete.

The diet history questionnaire form (DHQ) **(Appendix C)** contained open-ended questions on food consumption at different meal times and was adapted from the Sydney South West Area Health Service outpatient's diet history form. Participants were asked questions about their usual dietary intake during the previous three months, and quantities of foods consumed were ascertained by means of food models, photos (96), and household measures e.g. cup size. A

checklist of foods commonly forgotten was included at the end of the diet history questionnaire. As part of the dietary assessment, questions related to food habits, food access and factors influencing dietary intake were also asked. Participants' wives, carers and/or family members were encouraged to be present during interview as this has been found to assist participants' recall (30).

The Australian nutrient database (AUSNUT 2007) which contains 37 nutrient values of 4,425 foods (97) was selected in FoodWorks 7 Professional for Windows (Xyris Software [Australia] Pty Ltd, Brisbane, 2012) to convert participants daily dietary intakes into nutrients. Nutrient values for vitamin B6 and B12 were not assessed as they are not included in AUSNUT 2007.

A manual for nutritional data entry **(Appendix D)** was developed to ensure consistent data entry of the diet history questionnaire, where 869 food items were identified and standardised. Standardising food coding involved looking for described food items in FoodWorks, selecting the closest possible options and recording respective entries used in FoodWorks for future reference. Recipes of infrequently consumed dishes were entered using specific ingredients and amounts described by participants. Recipes of commonly consumed foods were entered as the closest possible option. Takeaways and pre-prepared (e.g. meals on wheels) dishes were identified and entered according to information provided on restaurant menu/package/website. Food items that were not found in FoodWorks and that had no similar equivalent were created using a different database (e.g. AusFood2012) and added to the Manual for nutritional data entry **(Appendix D)**. Only dietary supplements consumed as meal replacement or snacks (e.g. TwoCal HN) were entered accordingly.

Validity of this dietary record was assessed by comparing it with a 4-day weighed food record collected in a subgroup of 56 CHAMP men (see CHAPTER 4).

The median daily dietary intakes of energy, fat, protein, carbohydrates, alcohol, dietary fibre, calcium, magnesium, iron, zinc, sodium, phosphorus, phosphate, vitamins A, C, D, E, thiamin, riboflavin, and folate were calculated for each participant. Energy requirements were calculated using basal metabolic rate (BMR) (98) multiplied by the PAL of 1.6 (light activity) for older men (99). Percentage of energy (%E) derived from fat, protein, carbohydrates and alcohol was calculated. Intake of protein was also expressed as gram per kg of body weight (g/kg).

Misreporting (under or over-reporting) was addressed by excluding data of participants reported energy intakes above or below 2 standard deviations from the median overall energy intake (n=33). The final sample contained 761 men aged 75 years or older.

2.3. Statistical analyses

All data collected for this thesis were in hard copy. The data were subsequently entered into Microsoft Access Databases. These databases were then imported into Microsoft excel and subsequently imported into statistical analyses packages (SPSS Statistics for Windows, Version 21.0 (IBM Corp. Released 2012. Armonk, NY: IBM Corp.) SAS version 9.3 (SAS Institute Inc., Cary, North Carolina) or R version 3.1.2 (R: A language and environment for statistical computing, Core Team (2013), R Foundation for Statistical Computing, Vienna, Austria). Multiple regression analysis and multiple logistic models were adjusted for confounders. All potential confounders were identified in the literature and retained in the

final model rather than finding the most parsimonious model. The approach of retaining all potential confounders is a common one in epidemiology. Evidence against null hypotheses was considered statistically significant if p-values were less than 0.05 and no p-value correction was applied to account for multiple hypothesis tests (100, 101).

A number of different methods were used for statistical analyses and these are described in detail in the relevant research findings chapters. Below is a list of the statistical analyses method applied in this thesis:

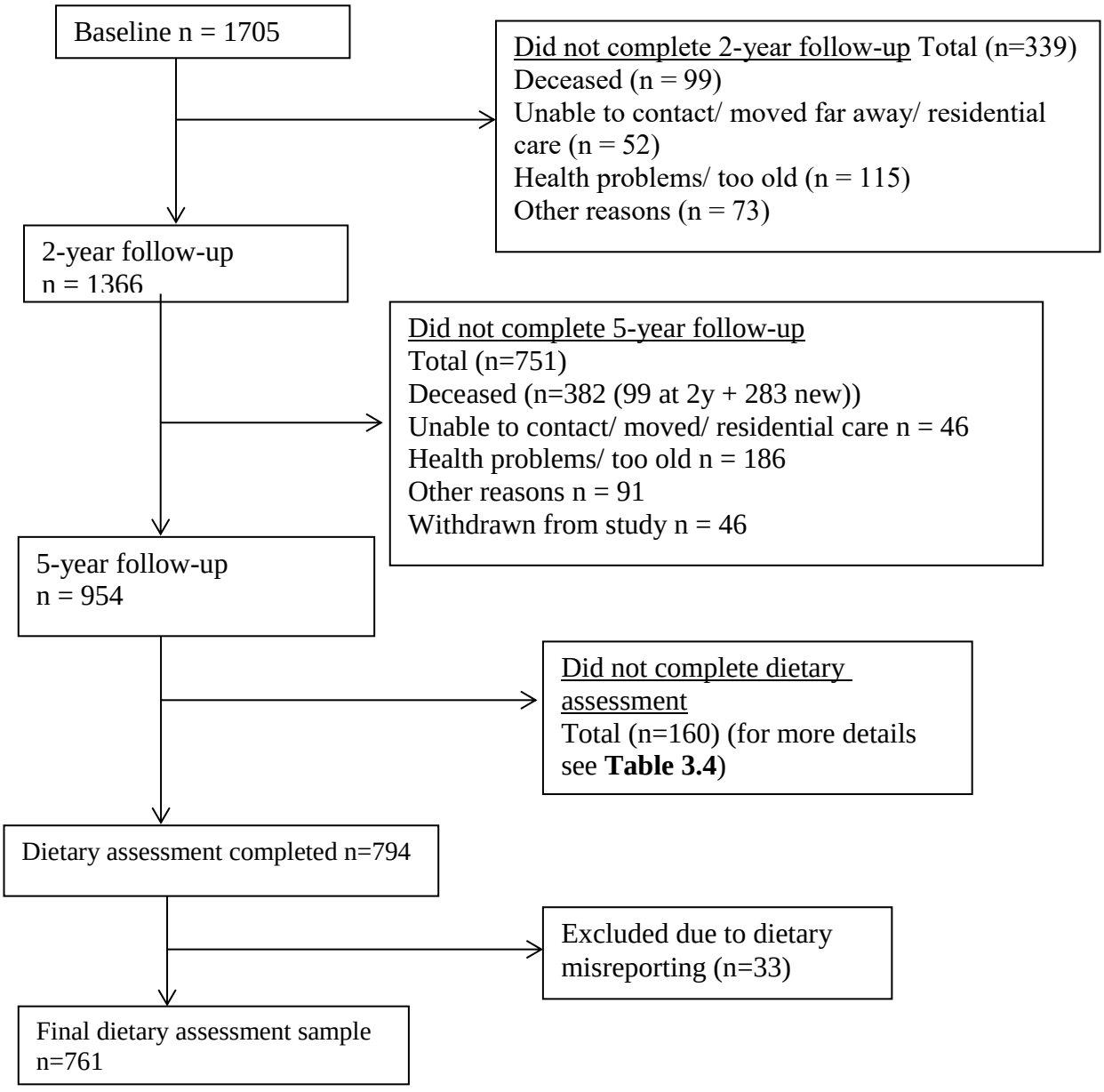
- Bland-Altman plots and limits of agreement (LOA) in CHAPTER 4;
- Chi-square analysis to investigate differences between categorical variables in CHAPTER 3 and 5;
- Correlation Coefficients (Pearson's and Spearman's) in CHAPTER 4;
- Descriptive statistics: mean, median, standard deviation (SD), range, confidence interval (CI), proportions in CHAPTERS 4, 5 and 6;
- Generalised additive model (GAM) in CHAPTER 6;
- Generalised additive model (GAM) smoothing splines in CHAPTER 4;
- Logistic regression in CHAPTER 5;
- Mann-Whitney U test to investigate difference between continuous skewed-distributed data in CHAPTER 3 and 5;
- Multiple regression analysis in CHAPTER 6;
- Shapiro-Wilk test to assess normality of continuous data in CHAPTER 4, 5 and 6;
- Standard major axis (SMA) regression in CHAPTER 4.

CHAPTER 3. STUDY PARTICIPANTS

3.1. Participants' characteristics

The following flow chart (**Figure 3.1)** displays the sample size transition from baseline (n=1705) to the final sample used in this thesis (n=761) with information on reasons for non-participation in each wave.

Figure 3.1 Flow chart showing sample size at baseline, two-year follow-up and five-year follow-up with reasons for non-participation in each wave



Sociodemographic, economic and lifestyle characteristics data of CHAMP participants considered in this thesis (761 men) are presented in **Table 3.1**. Health status measures for these men are shown in **Table 3.2**. factors related to food access and consumption are shown in **Table 3.3**.

Participants' ages ranged from 75 to 98 years (mean=81 years). The majority of men were married, house-owners with post high school education. Most men were born in Australia (54%), with 20% born in Italy. Most participants tended to have a normal BMI, consume safe amounts of alcohol and were non-smokers.

Compared to the data from the recent AHS of Australian male population in a similar age range (75 years and over), CHAMP had equivalent rates of men living alone (20% in both) (102) and smoking (3% in CHAMP and 4% in AHS) (103). Similarly, compared to the men of similar age who participated in the national Men in Australia Telephone Survey (MATeS) (104) - a study that involved 915 men aged 70 years and over and had a participation rate of 78% - many of the characteristics of CHAMP's participants were similar. For example, 55% of CHAMP's participants reported to have hypertension compared to 47% of MATeS' participants; stroke or cerebrovascular disease was reported by 9% of CHAMP's participants versus 11% of MATeS' participants; 7% of MATeS' participants were current smokers compared to 3% in of CHAMP; marital status distribution and education level were virtually the same in both studies: 73% of participants were married in MATeS versus 75% in CHAMP, 17% were widowed in MATeS versus 15% in CHAMP, 43% have pursued further education (non-tertiary) after high school in both studies. In terms of age distribution, of men aged 75 years and over,

43% of CHAMP men were aged 75-79 years compared to 41% of men aged 75-79 years in the study area (Burwood, Canada bay and Strathfield) in the 2013 census; 36% of CHAMP men were aged 80-84 years compared to 33% in the study area; and 21% of CHAMP men were aged 85 years and over compared to 25% in the study area (105). Additionally, CHAMP participants' nutritional intakes (discussed in CHAPTER 5) were comparable to the latest nationally representative Australian Heath Survey (AHS) (106) despite the use of different dietary methodologies in the two studies (AHS used 24-hour recall).

Dryness of the mouth (36%) was the most common symptom related to food consumption affecting participants, followed by heartburn (22%) and some type of mouth discomfort (13%). Upper dentures (partial or full) were used by the majority of participants (56%), but most men had natural lower dentition (57%). Participants were more likely to consider their dietary patterns healthy (68%) mostly due to the variety of foods they consumed; the majority of the men considered nutrition very important (51%) and were likely to have kept the same dietary habits for the past 5 years (77%). The vast majority (99%) of men reported no financial issues that prevented them from affording food. The majority of participants were involved in grocery shopping (70%) but were much less involved in food preparation (40%).

Table 3.1 Socio-economic, demographic and lifestyle characteristics of 761 men who completed dietary assessment

Characteristic	% (n)
Sociodemographic	
Age (years) (n=761)	
75-79	43 (327)
80-84	36 (277)
85+	21 (157)
Mean (SD)	81 (4)
Marital status (n=759)	
Married/de facto	75 (574)
Widowed	15 (114)
Divorced/separated	5 (34)
Never married	4 (33)
Other	1 (4)
Living arrangements (n=761)	
Live alone	20 (152)
Live with others	80 (607)
Level of education (n=757)	
Bachelor degree or higher	16 (119)
Trade/Apprenticeship	24 (182)
Certificate/diploma	19 (147)
High school or below	41 (309)
Country of birth (n=761)	
Australia/New Zealand	54 (410)
Italy/Greece	23 (178)
Other	23 (173)
Socio-economic	
Source of income (n=758)	
Pension only	39 (296)
Other*	61 (462)

PASE, physical activity scale for the elderly; * Repatriation pension/veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination

Table 3.1 Socio-economic, demographic and lifestyle characteristics of 761 men who completed dietary assessment (continued)

Characteristic	% (n)
House ownership	
Outright owner	89 (680)
Other housing arrangement	11 (79)
Occupational history (n=757)	
Managers	14 (109)
Professionals	22 (166)
Paraprofessionals	4 (29)
Tradespersons	24 (182)
Clerks	6 (48)
Salespersons & personal service workers	3 (22)
Plant & machine operators/drivers	8 (58)
Labourers	9 (67)
Inadequately stated/unknown	10 (76)
Lifestyle	
PASE (n=759)	
Low activity (≤76)	33 (250)
Median activity (77-160)	34 (255)
High activity (≥161)	33 (254)
Mean (SD)	120.2 (62)
Alcohol consumption (n=761)	
>14 drinks/week	15 (114)
≤14 drinks/week	62 (470)
Non-drinker	23 (177)
Cigarette smoking (n=753)	
Current smoker	3 (24)
Former smoker/never smoked	97 (729)

PASE, physical activity scale for the elderly; * Repatriation pension/veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination

Table 3.2 Health status of 761 men who completed dietary assessment

Health status measure	% (n)
Diabetes (n=759)	22 (165)
Thyroid issues (n=759)	3 (21)
Osteoporosis (n=758)	12 (92)
Paget's disease (n=759)	2 (13)
Stroke (n=759)	9 (71)
Parkinson's disease (n=759)	3 (21)
Kidney stone (n=759)	12 (89)
Epilepsy (n=759)	1 (10)
Hypertension (n=759)	55 (416)
Heart attack (n=759)	19 (144)
Angina (n=759)	14 (104)
Congestive heart failure (n=758)	4 (28)
Claudication (n=758)	7 (54)
Chronic obstructive lung disease (n=759)	11 (84)
Liver disease (n=759)	1 (7)
Chronic kidney disease (n=759)	4 (32)
Arthritis or gout (n=759)	55 (415)
Depression (n=758)*	12 (89)
Cognitive declined (n=226) †	8 (62)
Body mass index (kg/m^2) (n=738)	
Underweight (<22.0kg/m^2)	6 (44)
Normal (22-30.0kg/m^2)	67 (502)
Obese (>30.0kg/m^2)	27 (199)
Mean (SD)	27.7 (4)
Multi-morbidity (n=759)	
<2	28 (214)
≥2	72 (545)
Self-rated health (n=759)	
Excellent/good	75 (567)
Fair/poor/very poor	25 (192)

*Depression symptoms as per geriatric depression scale score (69); †English speakers only as per mini mental state examination score (80)

Table 3.3 Factors related to food access and consumption in the 761 men who completed dietary assessment

Factor	% (n)
Month and dental health	
Upper dentition (n=759)	
Teeth	43 (328)
Partial denture	28 (213)
Full denture	28 (215)
None	0 (3)
Lower dentition (n=759)	
Teeth	57 (435)
Partial denture	24 (184)
Full denture	18 (137)
None	0 (3)
Mouth discomfort* (n=758)	
Yes	13 (97)
Chewing problems (n=758)	
Yes	6 (42)
Swallowing problems (n=758)	
Yes	6 (45)
Nausea (n=758)	
Yes	4 (29)
Heartburn (n=758)	
Yes	22 (167)
Mouth dryness (n=758)	
Yes	36 (275)
Food access	
Grocery shopping (n=758)	
Self	32 (244)
Wife	24 (180)
Both	38 (291)
Other	6 (44)

*Pain in the mouth, teeth or gums; percentages do not add up to 100 due to rounding

Table 3.3 Factors related to food access and consumption in the 761 men who completed dietary assessment (continued)

Factor	% (n)
Grocery shopping (n=758)	
Self	32 (244)
Wife	24 (180)
Both	38 (291)
Other	6 (44)
Cooking (n=760)	
Self	27 (208)
Wife	53 (405)
Both	13 (100)
Other	6 (47)
Special food requirements (n=760)	
Yes	17 (127)
Financial issues affecting food access (n=758)	
Yes	0 (1)
No	99(755)
Don't know	0 (1)
Refused	0 (1)
Attitude towards nutrition	
Self-rated nutrition (n=758)	
Very healthy	29 (220)
Healthy	68 (514)
Not so healthy	14 (2)
Don’t know	1 (10)
Eating patterns compared to 5 years ago (n=758)	
Healthier	18 (138)
Same	77 (587)
Less healthy	4 (31)
Don’t know	0 (1)

*Pain in the mouth, teeth or gums; percentages do not add up to 100 due to rounding

Table 3.3 Factors related to food access and consumption in the 761 men who completed dietary assessment (continued)

Factor	% (n)
Importance given to nutrition (n=758)	
Very important	51 (387)
Important	40 (300)
Somewhat important	4 (31)
Not at all important	1 (10)
Don't know	4 (29)

*Pain in the mouth, teeth or gums; percentages do not add up to 100 due to rounding

3.2. Respondents versus non-respondents

Of the 954 men who completed the main CHAMP five-year follow-up assessment (self-completed and clinic assessments), 794 completed dietary assessment (83.2% of five-year follow-up sample) and 160 did not complete dietary assessment. Lack of time or interest was the main reason given by participants for not completing dietary assessment, followed by death (19%) and illness (16%) (**Table 3.4**).

Table 3.4 Participants reasons for not completing dietary assessment (n=160)

Reason	% (n)
Too busy/ not interested	49 (79)
Deceased	19 (30)
Too ill	16 (26)
Language problems/CALD	5 (8)
Moved or travelling out of the area	4 (7)
Unable to contact	4 (7)
Withdrawn from study	2 (3)

CALD, culturally and linguistically diverse; percentages do not add up to 100 due to rounding

Those who attended CHAMP five-year follow-up dietary assessment (n=794) were younger, more likely to be married, more likely to have higher education level and more physically active (as per PASE) than those who did not complete the five-year follow-up dietary assessment (n=160) (**Table 3.5**).

Table 3.5 CHAMP dietary assessment respondents (n=794) versus non-respondents (n=160)

	Diet assessment		
	Respondents (n=794)	Non-respondents (n=160)	p-value*
Age (n=954)			
Years, median (range)	80.0 (75 - 98)	82.0 (75 - 98)	<0.001
BMI (n=931)			
kg/m^2, median (range)	27.5 (15 - 43)	26.9 (18 - 40)	0.07
PASE (n=951)			
Points, median (range)	120.8 (0 - 507)	107.5 (0 - 365)	0.01
Marital status (n=950)			
Married/de facto, % (n)	75 (596)	60 (95)	<0.001
Widowed, % (n)	15 (121)	25 (40)	
Divorced/separated, % (n)	4 (35)	9 (15)	
Never married, % (n)	4 (35)	4 (6)	
Other, % (n)	1 (4)	2 (3)	
Income (n=950)			
Pension only, % (n)	40 (315)	45 (71)	0.26
Other, % (n)	60 (476)	55 (88)	
Country of birth (n=954)			
Australia/NZ, % (n)	54 (427)	49 (79)	0.39
Italy/Greece, % (n)	24 (188)	23 (37)	
Other, % (n)	22 (179)	28 (44)	
Education (n=945)			
Bachelor degree or higher, % (n)	15 (120)	6 (10)	0.04
Trade/Apprenticeship, % (n)	24 (187)	26 (41)	

CHAMP, Concord Health and Ageing in Men project; BMI, body mass index; PASE, physical activity scale for the elderly; Age, BMI and PASE scores were skewed distributed;* Chi-square used to compare proportions and Wilcoxon-Mann-Whitney test used to compare means of continuous data..

Table 3.5 CHAMP dietary assessment respondents (n=794) versus non-respondents (n=160) (continued)

	Diet assessment		
	Respondents (n=794)	Non-respondents (n=160)	p-value*
Certificate/Diploma, % (n)	20 (156)	23 (36)	
High school or below, % (n)	41 (327)	44 (68)	
Cigarette smoking (n=943)			
Current smoker, % (n)	4 (28)	4 (7)	0.59
Former smoker/never smoked, % (n)	96 (758)	96 (150)	
Self-rated health (n=951)			
Excellent/good, % (n)	74 (588)	71 (113)	0.41
Fair/poor/very poor, % (n)	26 (204)	29 (46)	
Multi-morbidity (n=951)			
<2, % (n)	29 (228)	32 (51)	0.41
≥2, % (n)	71 (564)	68 (108)	

CHAMP, Concord Health and Ageing in Men project; BMI, body mass index; PASE, physical activity scale for the elderly; Age, BMI and PASE scores were skewed distributed; *Chi-square used to compare proportions and Wilcoxon-Mann-Whitney test used to compare means of continuous data..

Baseline CHAMP data were used to compare characteristics of living men who did not participate at all in the CHAMP five-year follow-up (n=369) and those who completed the dietary assessment (n=794). Participants who completed the dietary assessment were younger, more physically active (as per PASE), more likely to be Australian or New Zealand born, had better education and self-rated health and were less likely to be receiving age pension as sole source of income than living CHAMP men who did not complete any of the five-year follow-up assessments (**Table 3.6**).

Table 3.6 Baseline characteristics of CHAMP dietary assessment respondents (n=794) versus five-year follow-up non-respondents* (n=369)

	Diet history respondents (n=794)	5-year follow-up non-respondents (n=369)	p-value †
Age (n=1163)			
Years, median (range)	75	76	<0.001
BMI (n=1149)			
kg/m^2, median (range)	28.0	27.9	0.79
PASE (n=1148)			
Points, median (range)	137.4	112.6	<0.001
Marital status (n=1163)			
Married/de facto, % (n)	81 (644)	76 (282)	0.31
Widowed, % (n)	10 (79)	12 (45)	
Divorced/separated, % (n)	4 (33)	6 (21)	
Never married, % (n)	5 (38)	6 (21)	
Income (n=1149)			
Pension only, % (n)	34 (265)	47 (169)	<0.001
Other, % (n)	66 (524)	53 (191)	
Country of birth (n=1163)			
Australia/NZ, % (n)	53 (418)	40 (147)	<0.001
Italy/Greece, % (n)	25 (197)	28 (103)	
Other, % (n)	23 (179)	32 (119)	
Education (n=1157)			
Bachelor degree or higher, % (n)	15 (120)	13 (46)	0.05
Trade/Apprenticeship, % (n)	24 (187)	21 (76)	
Certificate/Diploma, % (n)	20 (156)	16 (60)	
High school or below, % (n)	41 (328)	50 (184)	
Cigarette smoking (n=1163)			
Current smoker, % (n)	5 (43)	5 (19)	0.85
Former smoker/never smoked, % (n)	95 (751)	95 (350)	

CHAMP, Concord Health and Ageing in Men project; *Only includes participants who were alive at five-year-follow-up but refused participation; † Chi-square used to compare proportions and Wilcoxon-Mann-Whitney test used to compare means of continuous data

Table 3.6 CHAMP dietary assessment respondents (n=794) versus five-year follow-up non-respondents[1] (n=369) (continued)

	Diet history respondents (n=794)	5-year follow-up non-respondents (n=369)	p-value[2]
Self-rated health (n=1147)			
Excellent/good, % (n)	76 (599)	65 (232)	<0.001
Fair/poor/very poor, % (n)	24 (190)	35 (126)	
Multi-morbidity (n=1150)			
<2, % (n)	35 (274)	28 (102)	0.03
≥2, % (n)	65 (514)	72 (260)	

CHAMP, Concord Health and Ageing in Men project; *Only includes participants who were alive at five-year-follow-up but refused participation; † Chi-square used to compare proportions and Wilcoxon-Mann-Whitney test used to compare means of continuous data

In summary, participants who completed the dietary component of the CHAMP study (n=794) tended to be younger, more physically active and had a higher education level than those who did not complete the dietary assessment (n=529 [369+160]). Men who did not attend the five-year follow-up (n=369) - and consequently the dietary assessment - were less likely to be Australian or New Zealand born, were less active, had a lower income (age pension only), had a lower education level and poorer overall health.

Nevertheless, in spite of the differences between CHAMP respondents and non-respondents, CHAMP's final sample of participants with completed dietary assessment had similar age distribution, smoking and marital status, education level and dietary intake to the target population, making this sample a reasonable representation of the general population, and therefore, it is likely that nutritional-related findings are generalizable to the Australian population of older men (70+ years old).

PART TWO: RESEARCH FINDINGS

CHAPTER 4. RELATIVE VALIDITY OF A DIET HISTORY QUESTIONNAIRE AGAINST A FOUR-DAY WEIGHED FOOD RECORD AMONG OLDER MEN IN AUSTRALIA: THE CONCORD HEALTH AND AGEING IN MEN PROJECT (CHAMP).

As published in the Journal of Nutrition, Health and Aging. 2015;19(6):603-10

Abstract

Objectives: To evaluate the relative validity of the diet history questionnaire (DHQ) used in the Concord Health and Ageing in Men Project (CHAMP) against a four-day weighed food record (4dWFR) as the reference method. *Design and measurements:* Detailed DHQ followed by a 4dWFR were completed between July 2012 and October of 2013. *Setting:* Burwood, Canada Bay and Strathfield in Sydney, Australia. *Participants:* Fifty-six community-dwelling men aged 75 years and over (mean=79 years). *Results:* DHQ estimates of intakes were generally higher than estimates from 4dWFR. Differences between the two methods were generally less than 20% with the exception of β-carotene (37%). Fixed and proportional biases were only present for retinol, β-carotene, magnesium, phosphorus and percentage of energy from protein; however, 95% limits of agreement were in some cases wide. Pearson's correlation coefficient of log-transformed unadjusted values ranged from 0.15 (zinc) to 0.70 (alcohol), and from 0.06 (iron) to 0.63 (thiamine) after energy-adjustment. Spearman correlation coefficients ranged from 0.16 (zinc) to 0.80 (alcohol) before energy adjustment, and from 0.15 (zinc) to 0.81 (alcohol) after energy adjustment. *Conclusion:* Our findings suggest that the DHQ used in CHAMP to measure the nutritional intake of its participants is appropriate to this age group and provides reasonably similar results to the 4dWFR for the majority of nutrients analysed.

4.1 Introduction

The population is ageing rapidly in Australia and in the rest of the world (107); however, there is very little known about the dietary habits of older people. Dietary habits are one of the important modifiable factors that can affect the maintenance of health in old age (14) and therefore diet should be a key component of epidemiological studies involving older people.

Although a comprehensive understanding of older peoples' dietary habits is essential, collection of dietary intake data from older subjects can be a challenging task, particularly when it involves reliance on short-term memory (108). It is important that data are obtained through appropriate methodology to avoid misleading conclusions and potentially ineffective interventions (89, 109). However, in reviewing the literature, only a small number of validation studies of dietary intake among people aged 70 years and over were identified (93, 110, 111), moreover some studies have investigated diet-disease relationships utilising methods that were not validated.

Absolute validity of a dietary method cannot be measured because absolute intake is impossible to determine (90). Typically, the tested method is compared to a method that has a greater degree of validity, and relative validity is assessed. The weighed food record is a prospective method that does not rely on participants' memory and is considered the "gold standard" for comparisons with less detailed and demanding methods.

There are three main methods for dietary measurement available to epidemiological research: Diet history questionnaire, food frequency questionnaire (FFQ) and 24-hour recall. All have advantages and disadvantages (112, 113), and it is accepted that there is no ideal method valid in all situations. The best choice depends on the objectives and design of the study (111). To assess typical dietary intake, the diet history interview is thought to be a reliable approach (89, 90) that does not limit the variability of response as it is the case with FFQs (90). Diet history is particularly indicated for older people because their diets tend to be consistent over long periods of time and, although this is a retrospective technique, it does not rely on short-term memory and uses a much more interactive approach than other methods (30, 91-93). Moreover, diet histories have low respondent burden, which may improve response rates among older people and they require no literacy or numeracy skills from participants (89, 94, 95), making them suitable for participants of culturally and linguistically diverse backgrounds.

The Concord Health and Ageing in Men Project (CHAMP) is a longitudinal cohort study of the health of older men based in Sydney, Australia, that has followed up men aged 70 years and over since 2005 (63). In 2012, collection of nutritional data using the diet history method was added to the third wave of CHAMP data collection (five-year follow-up).

Despite the clear advantages of using the diet history method to collect dietary data in our study, it was important to evaluate the validity of this method (90). Therefore, the aim of the study reported in this paper was to evaluate the relative validity of the DHQ used in CHAMP compared with a 4dWFR. This is the very first paper to describe this evaluation in men aged

75 and over and it provides insights into the challenges of collecting dietary information in this age group.

4.2 Materials and Methods

Participants

The selection of CHAMP subjects has been described in detail elsewhere (63). Briefly, 3005 men aged 70 years and over living in the suburbs of Burwood, Canada Bay and Strathfield in Sydney, Australia who were on the electoral roll were invited to participate in CHAMP. A total of 1705 men participated in the project in the baseline data collection phase in 2005-2007. The only exclusion condition was living in a residential aged care facility. Participants completed a questionnaire at home and then attended a clinic where further data were collected through interview and examination. A total of 954 participants took part in the five-year follow-up. Out of those, 794 (83%) agreed to the diet history interview and 62 agreed to participate in the present validation study. All participants gave written informed consent. The study was approved by the Sydney South West Area Health Service Human Research Ethics Committee, Concord Repatriation General Hospital, Sydney, Australia.

Diet History

Usual dietary intake was determined through collection of diet histories (88), conducted by a trained dietitian at the participant's residence using a standardised interview method. Diet history interview took on average 45 minutes to be administered. Upon completion of five-year CHAMP follow up clinic visit, participants were contacted and invited to complete a diet

history questionnaire (DHQ). Participants were asked questions about their dietary intake during the previous three months, and quantities of foods consumed were ascertained by means of food models, photos (96), and household measures e.g. cup size. The diet history questionnaire (open-ended questions on foods consumption at different meal times) used in CHAMP was adapted from the Sydney South West Area Health Service outpatient's diet history form. Participants' wives, carers and/or family members were encouraged to be present during interview as it has been suggested to assist in participants' recall (30).

Weighed Food Record (WFR)

At the end of the diet history interview, participants were invited to take part in the validation study. At that time, an invitation letter containing a summary of tasks involved was given to potential participants. Contact was then made within a week to arrange participants' training. All the training and 4dWFR were completed within 5 weeks after diet history interview.

Participants in the validation study were required to weigh and record their dietary intake for four consecutive days (including a weekend day) giving as much detail about food consumed as possible. This included brands, preparation technique, leftovers (bones, skin and core), recipes and food consumed outside of home. An electronic scale (Salter SpaceSaver Electronic Kitchen Scale) was provided along with photographic and written instructions, weighed food record booklet and diary to record food eaten away from home. A trained dietitian demonstrated the procedure to participants. The CHAMP 4dWFR and eating out diary were adapted from Henderson et al (114). Participants were asked not to change their dietary habits during the study period, and encouraged to contact the dietitian if they had any

difficulties. The dietitian contacted the participant by telephone on day 3 of the validation study to ensure that records were completed correctly and to address any problems. Upon completion of the 4dWFR, the dietitian returned to participants' residences to collect and check diaries for accuracy and clarification. Participants were given a nutritional assessment of their diet based on the four days of the study, as a token of appreciation for their participation.

We have not reported the analysis for water, vitamin and mineral supplements, as these were not specified in the 4dWFR (i.e. arbitrarily reported).

Misreporting (both under- and over-reporting) is common in dietary studies and there are a number of exclusion methods to address this issue (115-118). One of these methods utilises estimates of an individual's basal metabolic rate (BMR) and physical activity level (PAL) to estimate total energy expenditure (TEE) and compare this with reported energy intake, and implausible data are then excluded. CHAMP participants' activity levels were measured using the Physical Activity Scale for the Elderly (PASE) (67) which uses a different scoring system to PAL. Participants' PASE scores varied greatly (0 to 507) and it was not feasible to adjust to the standard PAL ranges (1.2 bed rest to 2.2 elite athletes). Instead, data of participants who reported energy intake above or below 2 standard deviations from the median were excluded because of probable misreporting.

Dietary data analysis

Participants' daily dietary intakes were converted into nutrients using FoodWorks 7 Professional for Windows (Xyris Software (Australia) Pty Ltd, Brisbane, 2012) based upon the Australian nutrient database (AUSNUT 2007)(97), which contains the complete dataset for each food (119). A total of 27 nutrients as well as energy intake were analysed. A standardised manual was developed to assist with data entry of the diet history questionnaire, where 869 food items were identified and standardised. Recipes were entered using specific amounts as described by participants, and in cases where a food item was not available in FoodWorks, a similar food item was selected.

Data transformation

Normality of each nutrient was assessed by the Shapiro-Wilk test (120). The majority of nutrients had a skewed distribution. Consequently, data of each nutrient was log-transformed and energy adjusted (nutrient values/ total energy intake (kJ) = nutrient per kJ) prior to analysis to also evaluate nutrient density of diets(90). Alcohol intakes of 0g were replaced with values of 1g before log-transformation (as log of 1=0). Analyses were performed using the R statistical environment, version 3.0.2 for windows (121). Confidence intervals were generated at the 95% level, and evidence against null hypotheses was considered statistically significant if the resulting p-values were less than 0.05.

Bland-Altman method and GAM smoothing splines

Bland-Altman plots are widely used in comparison analyses to evaluate the agreement between a tested and a standard method (122). The mean percentage difference between methods (DHQ-4dWFR/4dWFR) was plotted against the mean by the two methods of energy (kJ) and all nutrients ((DHQ-4dWFR/2)). The 95% limits of agreement (LOA) were calculated (mean % difference ±1.96*(SD of difference (%)). Additionally, using mcgv package(123) for generalized additive models (GAMs), smoothing spline of the percentage difference between methods of each individual as a function of the mean nutrient intakes was also produced. Essentially, these lines show the moving (increase or decrease) difference between methods as a function of the mean nutrient intake values of both methods (124).

Proportional and fixed bias detection

Fixed and proportional biases are the two potential sources of systematic disagreement between methods. Fixed bias occurs when a method provides values that are consistently different (higher or lower) by a fixed amount to those provided by the compared method; proportional bias occurs when the difference is proportional to the level of the measured variable (125). To differentiate the two we utilised the standard major axis (SMA) regression analysis (126, 127). Average of 4dWFR intakes were regressed on DHQ intakes, then regression estimates of the intercept and slope were used to determine if the 95% confidence interval (CI) of the intercept did not include 0 (indicating presence of fixed bias), and if the 95% CI of the slope excluded 1 (interpreted as evidence of proportional bias).

Correlation

Pearson and Spearman correlation coefficients for crude, log-transformed and log-transformed energy-adjusted nutrient values from the DHQ and 4dWFR methods were calculated for comparison with other published validation studies.

4.3 Results

Participants

Participants interviewed by DHQ between July 2012 and October of 2013 were invited to take part in the validation study. From the eligible 361 men, 62 (17%) agreed to participate. Prior to statistical analysis, data were checked to detect potential data entry errors. Two men declined to participate after explanation of the tasks involved, two had incomplete 4dWFRs and two men were excluded from analysis due to misreporting. The final sample therefore contained 56 men aged 75 to 86 years (mean 79 years, SD 2.96), 82% of participants were born in Australia, 32% had university education and 87% were married (**Table 4.1**).

Table 4.1 Validation study participant characteristics (N=56)

Characteristic	N=56
Age (mean), years	79.2
(range)	(75 – 86)
BMI (mean), kg/m^2	27.15
(range)	(19 – 39)
Weight (mean), kg	80
(range)	(153 – 103)
PASE (mean), score	147
(range)	(36 – 397)
MMSE (mean), score	28.7
(range)	(22 – 30)
Level of education*, %	
Bachelor degree or higher	32% (n=18)
Trade/apprenticeship	18% (n=10)
Certificate/diploma	25% (n=14)
No education	23% (n=13)
Source of income, %	
Age pension	43% (n=24)
Other †	57% (n=32)
Country of birth, %	
Australia	82% (n=46)
Other ‡	18% (n=10)
Marital status, %	
Married	87% (n=49)
Widowed	9% (n=5)
Never married/divorced	4% (n=2)

MMSE, mini-mental state assessment; PASE, physical activity scale for the elderly; *One missing response; †Repatriation pension, veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary; ‡China, England, India, Indonesia, Ireland, Italy, Malta, United States of America, Yugoslavia

Bland-Altman, GAM smoothing splines and Bias

The mean and SD of each method by nutrient, the mean difference between methods with their 95% limits of agreement, and presence of fixed and proportional bias are shown in **Table 4.2**. Mean difference between methods ranged from -18% (alcohol) to 37% (β-carotene). The 95% limits of agreement ranged from -40% to 327%. With the exception of carbohydrate (g and percentage of energy), alcohol, thiamin, retinol, sodium and percentage of energy from alcohol, diet history tended to yield higher estimates of nutrients intakes. Individual data points generally fell within the 95% limits of agreement for most nutrients. The smoothing splines showed little evidence of trends in mean differences as a function of average in selected cases (vitamin A equivalent, retinol, β-carotene, calcium, phosphorus, iron and percentage of energy from carbohydrate) that contained outliers towards the extreme intakes.

The **Figure 4.1** shows the Bland-Altman plots (percentage difference between DHQ and 4dWFR against mean intakes) with the 95% limits of agreement and GAM spline of total energy (representing most nutrients) and retinol intakes (representing unusual cases).

Figure 4.1 Bland–Altman plots of the difference between total energy (kJ) and retinol (µg) intake estimated from the diet history questionnaire (DHQ) and the four-day weighed food record (4dWFR) plotted against means from the two methods for total energy (kJ) and retinol (µg).

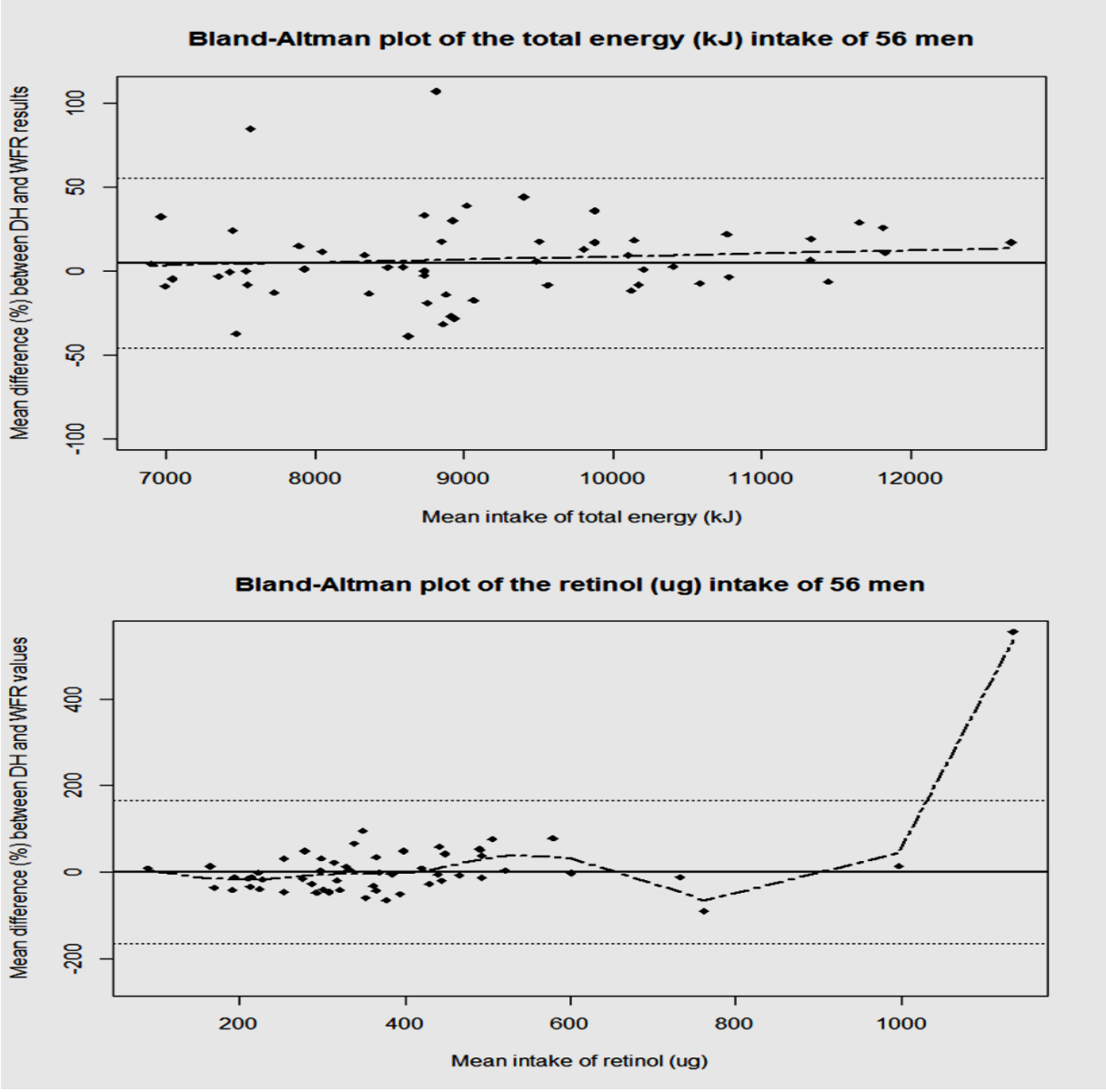


Table 4.2 Agreement between DHQ and 4dWFR using Bland-Altman method and SMA regression analysis to determine fixed and proportional bias (n=56)

	4dWFR		DHQ				SMA regression	
Nutrient	**Mean**	**SD**	**Mean**	**SD**	**Mean difference (%)**	**95% LOA (%)**	**Intercept 95% CI†**	**Slope 95% CI‡**
Energy (kJ)	8932.2	1555.5	9370.7	1895.8	5	-46.4 - 56.3	-1.55-2.72	0.70-1.16
Protein (g)	104.1	24.7	112.3	28.4	8	-67.8 - 83.7	-2.00-0.66	0.84-1.41
Carbohydrate (g)	223.5	57.6	215.5	60.1	-4	-58.7 - 51.6	-0.36-1.72	0.69-1.08
Total fat (g)	75.9	18.9	89.4	27.9	18	-71.4 - 107.1	-0.49-1.45	0.64-1.08
Alcohol (g)*	13.1	8.5	10.8	10.3	-18	-146.7 - 111.8	-1.04-0.70	0.78-1.29
Dietary fibre (g)	29.8	12.8	31.5	11.6	6	-87.7 - 99.1	-0.53-0.09	1.01-1.37
Thiamin (mg)	2.1	1	2	0.9	-2	-93.3 - 89.5	-0.23-0.08	0.89-1.38
Riboflavin (mg)	2.5	1.2	2.8	1.4	13	-94.1 - 121.0	-0.23-0.13	0.74-1.13

LOA, limits of agreement= mean difference (%) ± 1.96 x SD ; DHQ, diet history questionnaire; 4dWFR, four-day weighed food records ; SMA, standard major axis; SD, standard deviation; %E, percentage energy; * Alcohol intakes of 0g or 0% were replaced with values of 1g or 1% before analyses; †Significant fixed bias exists when the 95% CI of the intercept does not contain 0; ‡Significant proportional bias exists when the 95% CI of slope does not contain 1.

Table 4.2 Agreement between DHQ and 4dWFR using Bland-Altman method and SMA regression analysis to determine fixed and proportional bias (n=56) (continued)

Nutrient	4dWFR		DHQ		Mean difference (%)	95% LOA (%)	SMA regression	
	Mean	SD	Mean	SD			Intercept 95% CI†	Slope 95% CI‡
Niacin equivalents (mg)	53.1	13.9	57.2	14.2	8	-65.1 - 80.3	-2.15-0.26	0.92-1.51
Vitamin C (mg)	142.2	87.8	159.4	100.6	12	-159.9 - 184.1	-1.62-0.88	0.80-1.30
Vitamin D (µg)	5.2	3.2	5.3	3.2	1	-182.9 - 185.8	-0.56-0.26	0.81-1.35
Vitamin E (µg)	9.3	3.2	11.6	4.7	25	-102.7 - 152.3	-0.61-0.50	0.71-1.17
Total folate (µg)	445.6	168	465.3	208.9	4	-91.9 - 100.7	-0.86-1.71	0.71-1.14
Vitamin A (µg)	1125.9	387	1396.2	830.1	24	-135.0 - 183.0	-2.90-1.66	0.77-1.31
Retinol (µg)	386	199.3	383	284.2	-1	-169.3 - 167.8	-1.12-1.46	0.74-1.18
β-carotene (µg)	4437.7	2193.4	6076	4513.6	37	-259.5 - 333.3	-0.88-1.74	0.72-1.14
Sodium (mg)	2424.7	764.9	2184.8	840.8	-10	-110.7 - 91.0	0.27-3.00	0.56-0.94

LOA, limits of agreement= mean difference (%) ± 1.96 x SD ; DHQ, diet history questionnaire; 4dWFR, four-day weighed food records ; SMA, standard major axis; SD, standard deviation; %E, percentage energy; * Alcohol intakes of 0g or 0% were replaced with values of 1g or 1% before analyses; †Significant fixed bias exists when the 95% CI of the intercept does not contain 0; ‡Significant proportional bias exists when the 95% CI of slope does not contain 1.

Table 4.2 Agreement between DHQ and 4dWFR using Bland-Altman method and SMA regression analysis to determine fixed and proportional bias (n=56) (continued)

	4dWFR		DHQ				SMA regression	
Nutrient	**Mean**	**SD**	**Mean**	**SD**	**Mean difference (%)**	**95% LOA (%)**	**Intercept 95% CI†**	**Slope 95% CI‡**
Potassium (mg)	3716.8	821.1	4111.8	1404.6	11	-72.4 - 93.7	0.12-2.37	0.60-0.99
Magnesium (mg)	410.1	94	430.7	130.9	5	-69.4 - 79.5	-2.90-1.66	0.77-1.31
Calcium (mg)	928.7	318.4	1064.7	549.2	15	-113.6 - 142.9	-0.88-2.50	0.69-1.13
Phosphorus (mg)	1712	384.8	1881.3	594.9	10	-68.3 - 88.1	0.05-3.34	0.59-0.98
Iron (mg)	15	4.7	15.2	4.5	1	-66.2 - 68.8	-0.30-2.20	0.63-1.04
Zinc (mg)	14	4.2	15.7	4.7	13	-72.3 - 97.4	0.28-2.73	0.59-0.95
Iodine (µg)	131.1	53.5	141.3	76.7	8	-107.5 - 123.0	-0.55-2.50	0.66-1.06
%E from protein	19.8	3.4	20.6	4	4	-45.6 - 53.2	-0.81-0.56	0.79-1.30
%E from fat	31.4	5.4	35	6.7	12	-40.6 - 63.7	-0.99-0.49	0.78-1.32

LOA, limits of agreement= mean difference (%) ± 1.96 x SD ; DHQ, diet history questionnaire; 4dWFR, four-day weighed food records ; SMA, standard major axis; SD, standard deviation; %E, percentage energy; * Alcohol intakes of 0g or 0% were replaced with values of 1g or 1% before analyses; †Significant fixed bias exists when the 95% CI of the intercept does not contain 0; ‡Significant proportional bias exists when the 95% CI of slope does not contain 1.

Table 4.2 Agreement between DHQ and 4dWFR using Bland-Altman method and SMA regression analysis to determine fixed and proportional bias (n=56) (continued)

	4dWFR		DHQ				SMA regression	
Nutrient	**Mean**	**SD**	**Mean**	**SD**	**Mean difference (%)**	**95% LOA (%)**	**Intercept 95% CI†**	**Slope 95% CI‡**
%E from carbohydrate	40.4	6.7	36.9	6.6	-9	-40.9 - 23.5	0.79-2.16	0.55-0.84
%E from alcohol*	4.4	4.5	3.6	4.2	-18	-134.8 - 99.9	-0.65-0.82	0.72-1.20

LOA, limits of agreement= mean difference (%) ± 1.96 x SD ; DHQ, diet history questionnaire; 4dWFR, four-day weighed food records ; SMA, standard major axis; SD, standard deviation; %E, percentage energy; * Alcohol intakes of 0g or 0% were replaced with values of 1g or 1% before analyses; †Significant fixed bias exists when the 95% CI of the intercept does not contain 0; ‡Significant proportional bias exists when the 95% CI of slope does not contain 1.

Correlation coefficients

Pearson's and Spearman's correlation coefficients were calculated for each energy-adjusted, log-transformed and/or crude nutrient intake to determine the strength of relationship between the DHQ and 4dWFR (**Table 4.3**). Pearson's correlation coefficient of log-transformed values without energy-adjustment ranged from 0.15 (zinc) to 0.70 (alcohol). After energy adjustment and log transformation, iron had the weakest correlation (r=0.06) and thiamin the strongest (r=0.63). Spearman correlation coefficients were used to compare ranks as most values had skewed distributions before log-transformation. Spearman correlation coefficients ranged from 0.16 (zinc) to 0.80 (alcohol) before energy adjustment, and from 0.15 (zinc) to 0.81 (alcohol) after energy adjustment.

Table 4.3 Pearson's and Spearman's rank correlation coefficients (CCs) between intakes of energy, macro- and micronutrients measured with 4dWFR and DHQ in 56 men

	Pearson's CCs		**Spearman's CCs**	
Nutrient	**Log-transformed**	**Log-transformed energy adjusted**	**Crude**	**Energy adjusted**
Energy (kJ)	0.31*	-	0.37**	-
Protein (g)	0.30*	0.53***	0.36**	0.23
Carbohydrate (g)	0.56***	0.35**	0.50**	0.54**
Total fat (g)	0.27*	0.34*	0.26*	0.28*
Alcohol (g)	0.70**	0.41***	0.80**	0.81**
Dietary fibre (g)	0.37**	0.48***	0.43**	0.45**
Thiamin (mg)	0.57***	0.63***	0.59**	0.48**
Riboflavin (mg)	0.64***	0.27*	0.61**	0.58**
Niacin (mg)	0.37**	0.44***	0.42**	0.25

4dWFR, four-day weighed food records; DHQ, diet history questionnaire; %E, percentage energy*** P≤ 0.001; ** P≤0.01; * P≤0.05

Table 4.3 Pearson's and Spearman's rank correlation coefficients (CCs) between intakes of energy, macro- and micronutrients measured with 4dWFR and DHQ in 56 men (continued)

Nutrient	Pearson's CCs		Spearman's CCs	
	Log-transformed	Log-transformed energy adjusted	Crude	Energy adjusted
Vitamin C (mg)	0.41***	0.33**	0.38**	0.40**
Vitamin D (µg)	0.35**	0.48***	0.30*	0.28*
Vitamin E (µg)	0.34*	0.45***	0.31*	0.45**
Total folate(µg)	0.51***	0.32*	0.54**	0.42**
Vitamin A (µg)	0.24	0.29*	0.21	0.30*
Retinol (µg)	0.39***	0.28*	0.42**	0.34**
β-carotene (µg)	0.23	0.36**	0.24	0.23
Sodium (mg)	0.38***	0.32*	0.47**	0.42**
Potassium (mg)	0.28*	0.39***	0.34**	0.29*
Magnesium (mg)	0.34**	0.50***	0.38**	0.42**
Calcium (mg)	0.48***	0.50***	0.49**	0.47**
Phosphorus (mg)	0.45***	0.36**	0.54**	0.47**
Iron (mg)	0.37***	0.06	0.35**	0.32*
Zinc (mg)	0.15	0.57***	0.16	0.15
Iodine (µg)	0.64***	0.30*	0.62**	0.57**
%E from protein	0.28*	0.42***	0.23	0.24
%E from fat	0.35**	0.23	0.28*	0.50**
%E from carbohydrate	0.53***	0.37**	0.56**	0.26*
%E from alcohol	0.70***	0.28*	0.81**	0.80**

4dWFR, four-day weighed food records; DHQ, diet history questionnaire; %E, percentage energy *** P≤ 0.001; ** P≤0.01; * P≤0.05

4.4 Discussion

To our knowledge, this study is the first to validate a diet history questionnaire against a four-day weighed food record in a group of community-dwelling men aged 75 years or older. Overall, diet history estimates of intakes tended to be higher than estimates from weighed food records. Differences between the two methods were generally less than 20% with the exception of β-carotene (37%). Fixed and proportional biases were only present for retinol, β-carotene, magnesium, phosphorus and percentage of energy from protein; however, 95% limits of agreement were in some cases wide, possibly due to the modest sample size of this study.

There is very limited literature on validation of dietary methods against food records (excluding those investigating dietary patterns or one specific nutrient) in people aged 70 years and over, and no other study has focused on this topic utilising exclusively male participants' data. Previous studies (93, 94, 110, 111, 128-130) have focused on correlation coefficients, cross-classification and/or difference between the reference and tested method, without investigating the presence of systematic bias - a unique methodological aspect of our study.

Correlation coefficients are widely used in validation studies to measure the degree of association between methods. Non-significant (unadjusted zinc, $r=0.15$, $p>0.05$) to very strong (unadjusted percentage of energy from alcohol, $r=0.70$, $p<0.001$) correlations were found in the present study with lowest correlation coefficients found for retinol and vitamin A equivalents, nutrients that have high day-to-day variation (90, 131).

Other studies in older people have found a similar range of correlations when validating dietary methods against food records (93, 110, 130). However, Pedersen et al found better correlation coefficients (r=0.42-0.88) when comparing a diet history to a 3-day estimated food record (111). In their study, estimated food records were completed before diet history and that may have improved the correlation results given that DHQ can be influenced by participants' diet awareness and precision (111) when food records are completed first (89, 129). Shahar et al, on the other hand, found weaker associations between a DHQ and 7-day weighed food record in a small group of rural elderly Malays (94). The weaker associations observed in that study could be related to the small sample size, the education level of its participants or the extended length of food recording. However, it is important to remember that there are some limitations with the use of correlation coefficients when comparing diet history to food records: diet histories assess 'typical' intakes, whereas weighed food records captures dietary intake for a limited period of time, the null hypothesis of correlation is that there is no association between two measures, which is not the case of two methods that measure dietary intake and, factors related to how successfully participants complete both methods may vary (89, 132).

In our study, the DHQ estimations were consistently higher than 4dWFR, and mean differences between methods were similar to those found in other studies (93, 94, 110) despite the differences in length of food recording in other studies.

Vitamin C, which has its main dietary sources in fruit and vegetables, may have been overestimated in the diet history due to participants' attempt to convey a desirable image or gain approval from interviewer/researcher (132) as these foods are considered "healthy".

Bland-Altman plots are commonly used in comparison studies, as they allow visual investigation of associations between mean difference of nutrient intake between two methods and mean intakes of the same nutrient. With the addition of the 95% limits of agreement, one can visually demonstrate how different (or similar) values from the two methods are, and then decide whether one method can be considered "equivalent" to another. The addition of splines to these plots further assists this visual analysis by showing how difference behaves according to mean intake of the investigated nutrient.

Biases of any kind are undesirable in validation studies; however, proportional bias is particularly problematic when evaluating a dietary assessment method as it is very difficult to correct, especially when its direction varies according to nutrients (131). Many of the validation studies conducted in older populations using food recording as the standard method have failed to formally determine whether proportional bias was present (93, 94, 110, 111, 128-130). In the current study, proportional as well as fixed bias were investigated and only found in five nutrients (retinol, β-carotene, magnesium, phosphorus and %E (percentage of energy) from protein), this means that the variability of intake did not influence the difference between the two methods for the great majority of nutrients analysed.

Weighed food records are considered a "gold standard" as they can provide relatively accurate quantitative information on consumption(95), but despite their extensive use, WFR like all subjective measures of dietary intake have their limitations, especially when used in the older population. Older men may find it difficult to keep records of what they consume as meal planning, preparation and serving are often performed by their wives (30);they may change their eating habits to make recording easier; not record their intake of extra, small or "negligible" foods (129); or like their younger counterparts, change their eating habits to convey a desirable image or approval from interviewer (132). On the other hand, older people tend to follow an establish diet (30, 93), are less time-constrained and, if able to keep food records with accuracy, can provide data for precise comparisons. While 7-day weighed food records are considered ideal when validating a dietary method that is less detailed and demanding, prolonged food recording can be tedious, and resulting data recorded of substandard quality. Furthermore, collection of data for seven days requires motivated participants and can be expensive to administer in large samples, thus 4dWFR has been chosen as it is commonly used in practice settings.

The main strength of our study was the standardized methodology - yet tailored to its participants - applied in the study. We have also investigated systematic biases, which have not been assessed in previous diet validation studies in older people. There are some limitations in the present study. First, we acknowledge that the sample size is smaller than ideal (95, 133-135)**;** however, recruiting large numbers of community-dwelling older men for a nutrition validation study is a very difficult task. In the case of our study, several invited men refused to take part because of the perceived difficulties involved. Factors related to motivation were minimised by providing thorough assistance to participants. We also

provided participants with detailed diet assessment as an incentive to their participation. Second, the majority of participants involved in the present study were married, well-educated, Australian-born men who were assisted by or relied on their wives to keep the 4dWFR, which made the sample non-representative of the study population. Thirdly, we acknowledge that ideally a reference method should be independent from the tested method, however 4dWFR has similar limitations with DHQ, and this may have affected the correlation between the two methods. The use of reliable biomarkers (for example doubly labelled water) would further validate our study; however, its feasibility is questionable in an older population. Furthermore, this method is costly, time consuming, and requires technical skills and trained staff (90, 95).

In conclusion, we found that the diet history questionnaire used in CHAMP is appropriate for most nutrients analysed in our population group, as it provides similar results to the four-day weighed food record with limited evidence of systematic bias.

CHAPTER 5. ADEQUACY OF NUTRITIONAL INTAKE AMONG OLDER MEN LIVING IN SYDNEY, AUSTRALIA - FINDINGS FROM THE CONCORD HEALTH AND AGEING IN MEN PROJECT (CHAMP)

As published in the British Journal of Nutrition. 2015; 114 (05):812-21

Abstract

Previous research shows that older men tend to have lower nutritional intakes and higher risk of under-nutrition compared to younger men. The objectives of this study were to describe energy and nutrient intakes, assess nutritional risk, and investigate factors associated with poor intake of energy and key nutrients in community-dwelling men aged ≥75 years participating in the Concord Health and Ageing in Men Project - a longitudinal cohort study on older men in Sydney, Australia. A total of 794 men (mean age 81.4 years) had a detailed diet history interview collected by a dietitian. Dietary adequacy was assessed by comparing median intakes to Nutrient Reference Values (NRVs): Estimated Average Requirement, Adequate Intake or Upper Level of intake. Attainment of NRVs of total energy and key nutrients in older age (protein, iron, zinc, riboflavin, calcium and vitamin D) was incorporated into a "key nutrients" variable dichotomised as "good" (≥5) or "poor" (≤4). Using logistic regression modelling we examined associations between key nutrients with factors known to affect food intake. Median energy intake was 8728kJ (P5=5762kJ, P95=12303kJ) and mean BMI was 27.7 kg/m^2 (SD4.0). Men met their NRVs for most nutrients. However, only 1% of men met their NRV for vitamin D, only 19% for calcium, only 30% for potassium, and only 33% for dietary fibre. Multivariate logistic regression analysis showed that only country of birth was significantly associated with poor nutritional intake. Dietary intakes were adequate for most nutrients, however only half of the participants met NRVs of ≥5 key nutrients.

5.1 Introduction

Population ageing is a global phenomenon influencing health patterns in nearly all countries (136). In Australia, the population aged 65 years and over is increasing rapidly as a result of the ageing of the large post-war baby-boom cohort and increasing life expectancy at age 65 years (3). Furthermore, the composition of the older population has been shifting with increasing proportions of men reaching advanced old age as well as the ageing of migrants including many who had arrived from Europe during the 1950s and 1960s. From 2012 to 2061, it is projected that the proportion of people aged 65 and over will increase from 14% to 25% and the proportion of people aged 85 and over will rise 4.2% with a notable increase in the proportion of men in this age group (from 35% to up to 46%) (107).

It is well known that diet is an important modifiable factor affecting the maintenance of health in old age (14). Adequate nutritional intake is associated with reduced morbidity and mortality as well as improved quality of life in older age (15). An Australian longitudinal survey recently reported that nutrition at baseline was an independent predictor of older people's 'ageing well' defined as continuing to live in the community with independence in daily living, and good self-rated health and psychological well-being (16). Nutritional requirements of older people are the same, if not greater, than younger adults (17). However, older people tend to have lower dietary intakes compared to their younger counterparts (17-20).

Decline in dietary intake is related to physiological, social-economical and psychological changes observed in older people, and may increase risk of nutritional inadequacy (20-25). Factors such as country of origin (28), living conditions (25, 26) and physical disability (29) increase the likelihood

of nutritional inadequacy. Older men are at even higher risk of nutritional inadequacy than women due to their limited involvement in the planning and preparation of meals (30).

While dietary habits have been reported for older men in Europe and North America there have been limited studies of the dietary intake of older men in Australia (35, 137). This is of concern when considering the predicted increase in the numbers of older men living in Australia.

The primary aim of the present study was to describe and assess the risk of not meeting the requirements for energy and nutrient intakes among community-dwelling men aged 75 years and over living in Sydney, Australia. The secondary aim was to investigate factors associated with having a poor intake of key nutrients in older age.

5.2 Materials and Methods

Participants

The Concord Health and Ageing in Men Project (CHAMP) is a longitudinal cohort study of the health of older men based in Sydney, Australia, that has followed up men aged 70 years and over since 2005 (63). In 2012, collection of nutritional data using a diet history methodology was added to the third wave of CHAMP data collection (five-year follow-up).

The original selection of CHAMP subjects has been described in detail elsewhere (63). Briefly, 3005 men aged 70 years and over living in the suburbs of Burwood, Canada Bay and Strathfield in Sydney, Australia who were on the electoral roll were invited to participate in CHAMP. A total of 1705 men participated in the project in the baseline data collection phase in 2005-2007. The only

exclusion condition was living in a residential aged care facility. Participants completed a questionnaire at home (~45min to complete) and then attended a clinic (~3 hours to complete) where further data were collected through interview and examination.

A total of 954 participants took part in the five-year follow-up assessment. Of the 751 men who did not complete five-year follow-up, the majority were either deceased (51%) or too ill (23%) to attend the study clinic. For the nutritional component of the study, 794 (83%) agreed to participate. Of the 160 (17%) non-respondents, 49 % stated they were too busy or not interested, 19% were deceased, 16% were too ill/not able, 5% were un-contactable, 5% had limited English literacy, 4% had moved away from the study area and 2% had withdrawn completely from the study. Respondents were significantly younger, more likely to be married, more likely to have a higher education level and more physically active than non-respondents, but did not significantly differ in age, country of birth, occupation history, income or self-rated health.

Diet History

Usual dietary intake was determined through collection of diet histories (88), conducted by a research dietitian at the participant's residence using a standardised diet history method between August 2010 and August 2013, covering all the seasonal variation. The diet history questionnaire form (open-ended questions on food consumption at different meal times) used in CHAMP was adapted from the Sydney South West Area Health Service outpatient's diet history form. Participants were asked questions about their usual dietary intake during the previous three months, and quantities of foods consumed were ascertained by means of food models, photos (96), and household measures e.g. cup size. A checklist of common foods was included to verify those foods often forgotten. Validity of this dietary record has previously been reported by comparison with a 4-

day weighed food record collected in a subgroup of 56 CHAMP men (138). The diet history interview took an average of 45 minutes to complete. Participants' wives, carers and/or family members were encouraged to be present during interview as this has been found to assist participants' recall (30).

Misreporting

CHAMP participants' activity levels were measured using the Physical Activity Scale for the Elderly (PASE) (67) which uses a different scoring system to Physical Activity Level (PAL). It was not feasible to convert PASE scores to PAL; instead, data of participants who reported energy intakes above or below 2 standard deviations from the median energy intake (n=33) were excluded because of probable under- and over-reporting. The final sample therefore contained 761 men aged 75 years or older.

Data handling

Participants' daily dietary intakes were converted into nutrient intakes using FoodWorks 7 Professional for Windows (Xyris Software [Australia] Pty Ltd, Brisbane, 2012) which uses the Australian food, supplement and nutrient database 2007 (AUSNUT 2007) that contains 37 nutrient values for 4,425 foods (97). Nutrient values for vitamin B6 and B12 are not included in this database, and therefore were not assessed. Vitamin D values from AUSNUT 2007 are to be interpreted with caution as data derives from a small set of analyses and values were based on a number of assumptions (139). Sodium intakes reported in this study include sodium naturally present in foods as well sodium added during processing, but excludes the 'discretionary salt' added by participants in home prepared foods or 'at the table'. A coding manual was developed to assure consistent data entry of the diet history questionnaire, where 869 food items were identified and

standardised. Standardising food coding involved looking for described food items in the FoodWorks' database (AUSNUT 2007), selecting the closest possible options and recording respective entries used in FoodWorks for future reference. Recipes of uncommonly consumed dishes were entered separately using specific ingredients and amounts described by participants. Recipes of commonly consumed foods were entered as the closest possible option. Takeaways and pre-prepared (e.g. meals on wheels) dishes were identified and entered according to information provided on restaurant menu/package/website. Consumed leftovers were entered according to participants' descriptions of amounts and frequency. Dietary supplements consumed as meal replacement or snacks (e.g. TwoCal HN, Abbott Nutrition) were entered accordingly. Foods consumed in different seasons (outside the 3 month cut off) were not taken into consideration, as they would not reflect usual intake of the past 3 months. The median daily dietary intakes of energy, fat, protein, carbohydrates, alcohol, dietary fibre, thiamin, riboflavin, niacin and dietary folate equivalents, vitamins A, C, D, E, calcium, iron, zinc, magnesium, phosphorus, potassium, iodine and sodium were calculated for each participant. Estimated energy requirements (EER) were calculated using basal metabolic rate (BMR) (98) multiplied by the PAL of 1.6 (light activity) for older men (99). Percentage of energy derived from fat, protein, carbohydrates and alcohol was calculated. Intake of protein was also expressed per kg of body weight.

The Australian Nutrient Reference Values (NRVs) consist of a set of evidence-based nutritional recommendations. The median dietary intake of each nutrient in the CHAMP data set was compared to the NRVs for males aged 70 years and over as follows: Estimated Average Requirement (EAR) or Adequate Intake (AI) when Recommended Dietary Intake (RDI) - and consequently EAR – had not been established; Upper Level (UL) of intake to assess excessive sodium intake. Acceptable Macronutrient Distribution Range (AMDR) - amount of macronutrients (as a percentage of contribution to energy) was used to assess appropriate intake of macronutrients (99). To measure

acceptable percentage contribution to energy (%E) from alcohol, we used the recommendations from the Australian dietary guidelines (ADG) (6). Prevalence of inadequate intakes was calculated by comparing the group's usual intake and corresponding NRVs (140).

Total energy is not a nutrient but it is necessary for a number of essential activities in the body (99). From this point onwards we will refer to energy as a dietary component. Total energy and six nutrients have been identified as of particular importance in older age, they are: protein, iron, zinc, riboflavin, calcium and vitamin D (15). To investigate the proportion of men meeting the requirements for these dietary components, and to determine some of the factors associated with their poor nutritional intake, a composite key nutrients intake variable was created. This variable was dichotomised as "poor" (meets the requirements of 4 or fewer nutrients) and "good" (meets the requirements of 5 or more nutrients).

Foods included in the AUSNUT 2007 (97) have an assigned name, food description, inclusions, exclusions and an 8-digit code; these 8-digit food codes are grouped into major, sub-major and minor groups (139). The sub-major food group was used to identify the 3 main food sources of each nutrient for all men included in the analysis.

Measurements

Information on socio-demographic and economic factors, smoking status, alcohol consumption, physical activity and other factors known to affect food intake were obtained through a self-completed questionnaire. Height and weight were measured according to a standardised protocol and BMI was calculated as kg/m^2. BMI was categorised as underweight (below $22kg/m^2$), normal

(22-30kg/m^2) and overweight/obese (above 30kg/m^2) in accordance with recent studies in older people (65 years and over) that have shown that there is an increased risk of mortality in the lowest and highest cut-offs (141-146). Country of birth was grouped as Australia and New Zealand, Italy and Greece, and other. Source of income was categorised as age pension only and other (repatriation pension, veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination). We used source of income as a proxy of personal income, assuming that age pensioners had the lowest income. Self-rated health was obtained through response to the question "compared to other people of your own age, how would you rate your own health?" and data was dichotomised into excellent/good versus fair/poor/very poor. Participants were asked about change in their eating patterns in the past five years and whether they had any financial issues in the last 12 months that prevented them from buying food.

Data on medical conditions were obtained from a self-reported questionnaire in which participants reported whether a doctor or a health care provider had told them that they had any of the following diseases: diabetes, thyroid problems, osteoporosis, Paget's disease, stroke, Parkinson's disease, kidney stones, dementia, depression, epilepsy, hypertension, myocardial infarction, angina, heart failure, intermittent claudication, chronic obstructive lung disease, liver disease, chronic kidney disease, arthritis, and cancer (excluding non-melanotic skin cancer and benign tumours such as bowel polyps and meningioma). Multi-morbidity was defined as having two or more of these conditions (147).

Statistical analysis

Nutritional adequacy was assessed by comparing participants' median intakes to the Nutrient

Reference Values (NRV) recommended for males aged 71 years or older. A secondary analysis of the data was performed using the composite dichotomised key nutrients intake variable. The dichotomised key nutrients intake variable (poor or good) was used in a logistic regression model to examine associations with socio-demographic, economic, health, lifestyle and meal related activities of daily living factors.

Data were analysed using SAS version 9.3 (SAS Institute Inc., Cary, North Carolina). A number of statistical methods (e.g. Shapiro-Wilk) were used to examine data distribution and we found that all the nutrients analysed (except carbohydrate [%E]) were not normally distributed, therefore subjects' characteristics and energy and nutrient intakes were reported as medians and 5^{th} (P5) and 95^{th} (P95) percentiles when numerical values, and percentages when categorical values. Evidence against null hypotheses was considered statistically significant if p-values were less than 0.05. The goodness of fit of the final adjusted logistic regression model was assessed using the Hosmer-Lemeshow statistic.

The data presented on vitamin and mineral intakes refer to food consumption only; intake through nutritional supplements was not assessed as data are unavailable at present.

5.3 Results

Participants' characteristics

Socio-demographic, economic, health risk and meal habit related information are presented in **Table 5.1**. Participants' mean age was 81±4.4 years and a total of 57% were 80 years or older. Mean body mass index (BMI) was 27.7 kg/m^2 (SD 4.0) with a total of 27% of the men categorised

as overweight/obese, 67% as normal and 6% as underweight. The majority of men were married (75%), lived with someone (80%), received other than just age pension as source of income (61%) and were born in Australia or New Zealand (54%). Most men considered their health excellent or good (75%) in spite of living with 2 or more morbidities (72%). Few men were unable to shop for groceries (2%) or prepare their own meals (4%), and only 3% had received some kind of meal service in the previous year. Alcohol consumption was most likely to be at a safe level (62%) and very few men were current smokers (3%).

When asked about changes in their dietary intake over the past 5 years, 77% of participants reported no change in their diet. Only 1% of participants responded yes when asked the question “in the past 12 months, was there any time when you could not afford to buy food”.

Table 5.1 Participants' descriptive characteristics

SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	n (%)
Age (years) (n=761)	
75-79	327 (43%)
80-84	277 (36%)
85+	157 (21%)
Mean (SD)	81 (4.4)
Source of income (n=758)	
Pension only	296 (39%)
Other*	462 (61%)
Occupational history (n=757)	
Non-physical work †	632 (84%)
Plant and machine operator/labourer	125 (16%)
Marital status (n=761)	
Divorced/separated/widowed/never married/other	187 (25%)
Married/de facto	574 (75%)
Living arrangements (n=761)	
Lives alone	152 (20%)
Live with others	607 (80%)
Post-school qualifications (n=757)	
Bachelor degree or higher	119 (16%)
Other ‡	638 (84%)

PASE, physical activity scale for the elderly; MOW, meals on wheels; *Repatriation pension/veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination; †Manager/professional/para-professional/Tradesperson/clerk/salesperson/personal-service worker/inadequately stated/unknown; ‡Trade/apprenticeship/Certificate/diploma/No qualifications

Table 5.1 Participants' descriptive characteristics (continued)

SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	n (%)
Country of birth (n=761)	
Australia/New Zealand	410 (54%)
Italy/Greece	178 (23%)
Other	173 (23%)
HEALTH AND LIFESTYLE FACTORS	
PASE (n=759)	
Low activity (≤76)	250 (33%)
Median activity (77-160)	255 (34%)
High activity (≥161)	254 (33%)
Mean (SD)	120.2 (62.0)
Body mass index (kg/m^2) (n=738)	
Underweight (<22.0kg/m^2)	44 (6%)
Normal (22.0-30.0kg/m^2)	502 (67%)
Overweight/Obese (>30.0kg/m^2)	199 (27%)
Mean (SD)	27.7 (4.0)
Alcohol consumption (n=761)	
>14 drinks/week	114 (15%)
≤14 drinks/week	470 (62%)
Non-drinker	177 (23%)
Cigarette smoking (n=753)	
Current smoker	24 (3%)
Former smoker/never smoked	729 (97%)
Self-rated health (n=761)	
Fair/poor/very poor	194 (25%)
Excellent/good	567 (75%)
Multi-morbidity (n=759)	
≥2	545 (72%)
OTHER FACTORS	
Able to grocery shop (n=759)	
No	14 (2%)
Yes	745 (98%)

PASE, physical activity scale for the elderly; MOW, meals on wheels; *Repatriation pension/veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination; †Manager/professional/para professional/Tradesperson/clerk/salesperson/personal-service worker/inadequately stated/unknown; ‡Trade/apprenticeship/Certificate/diploma/No qualifications

Table 5.1 Participants' descriptive characteristics (continued)

SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	n (%)
No	32 (4%)
Yes	727 (96%)
Meal service (e.g. MOW) (n=759)	
Yes	24 (3%)
No	735 (97%)

PASE, physical activity scale for the elderly; MOW, meals on wheels; *Repatriation pension/veteran's pension, superannuation or other private income, own business/farm/partnership, wage or salary, other or any source of income combination; †Manager/professional/para-professional/Tradesperson/clerk/salesperson/personal-service worker/inadequately stated/unknown; ‡Trade/apprenticeship/Certificate/diploma/No qualifications

Dietary intake

Table 5.2 shows the median (P5/P95) intake of each studied nutrient, the proportion of participants not meeting recommended intake and the three main food sources of each nutrient.

Participants' median daily intake of total energy was 8728kJ (P5=5762kJ, P95=12303kJ) and there was no significant difference in intakes between age groups (data not shown). Median macronutrient distribution is presented in **Figure 5.1**. Participants' median percentage contribution of protein to energy was within the NRVs; participants' median carbohydrate contribution to energy was below the AMDR, while their median total and saturated fat intakes were above their respective AMDR. Most participants' median micronutrient intakes reached their respective NRVs with only calcium, potassium, vitamin D and E intakes below their respective NRVs. Participants' vitamin D median intake (32.5% of NRV) was the lowest compared to its NRV, followed by calcium (73% of NRV) and potassium (87% of NRV). Although participants' median intakes of nutrients such as iron, phosphorus, niacin and vitamin C were more than double what is recommended, median intakes did not exceed ULs of intake.

Table 5.2 Median daily intake of energy and nutrients, proportion of participants not meeting recommended intake, and main food sources of each nutrient

	Recommended intake (male, ≥70 years old)	Median (P5/P95)	% (n) not meeting recommended intake	Main food sources
Energy and macronutrients				
Total energy (kJ/day) -EER† *	-	8728.0 (5762.3/12303.0)	28 (211)	Olive oil, milk, cheese
Protein (g/kg/day) – EAR *	0.86	1.3 (0.78/2.05)	9 (74)	
Protein (g/day)	-	99.3 (63.3/146.6)	-	Beef, chicken, milk
Protein (%E/day) – AMDR	15-25	19.4 (13.8/26.7)	16 (125) **	
Carbohydrate (g/day)	-	199.0 (119.7/303.9)	-	Banana, rice, pasta
Carbohydrate (%E/day) – AMDR	45-65	37.7 (24.9/50.6)	82 (626) ††	
Total fat (g/day)	-	82.3 (42.2/142.6)	-	Olive oil, cheese, milk
Total fat (%E/day) – AMDR	20-35	35.0 (23.3/49.6)	48 (369) ‡‡	

EAR, estimated average requirement; AI, adequate intake; AMDR, accepted macronutrient distribution range; ADG, Australian dietary guideline; %E, percentage contribution to energy; ; * Eight missing, 1 refusal and 2 unable to weigh ; †Estimated energy requirements will vary according to height, weight and physical activity level of each individual; ‡ Retinol equivalent; § α-tocopherol equivalents; ‖ Vitamin D data should be interpreted with caution ; ¶ Includes sodium naturally present in foods as well sodium added during processing, but excludes the 'discretionary salt' added by participants in home prepared foods or 'at the table'; inadequate intake refers to proportion of participants who consumed amounts above the UL.; ** Of the 16% of participants not meeting the AMDR for protein (%E), 46% (n=58) had an average intake below the AMDR and 54% (n=67) above the AMDR; †† All the participants (n=626) not meeting the AMDR for carbohydrate (%E) had an average intake below the AMDR ; ‡‡ Of the 48% of participants not meeting the AMDR for total fat (%E), 3% (10) had an average intake below the AMDR and 97% (359) above the AMDR

Table 5.2 Median daily intake of energy and nutrients, proportion of participants not meeting recommended intake, and main food sources of each nutrient (continued)

	Recommended intake (male, ≥70 years old)	Median (P5/P95)	% (n) not meeting recommended intake	Main food sources
Dietary fibre (g/day) – AI	30	26.0 (14.2/45.5)	67 (511)	Peas, banana, carrot
Alcohol (g/day)	-	4.8 (0/37.2)	-	Beer, red wine, white wine
Alcohol (%E/day) – ADG	<5	1.7 (0/14.0)	-	
Vitamins				
Thiamin (mg/day) – EAR	1	1.6 (0.8/3.4)	12 (91)	Breakfast cereals, yeast vegetable extracts, wholegrain bread
Riboflavin (mg/day) – EAR	1.3	2.2 (1.1/4.3)	11 (84)	Milk, yeast vegetable extracts, breakfast cereal
Niacin equivalent (mg/day) – EAR	12	50.0 (31.5/78.1)	0 (1)	Chicken, beef, breakfast cereal
Dietary folate equivalent (µg/day) – EAR	320	415.7 (206.5/850.2)	29 (223)	Yeast vegetable extracts, breakfast cereal, tea
Vitamin A (µg/day) – EAR ‡	625	976.8 (430.0/2112.8)	17 (126)	Carrot, sweet potato, milk

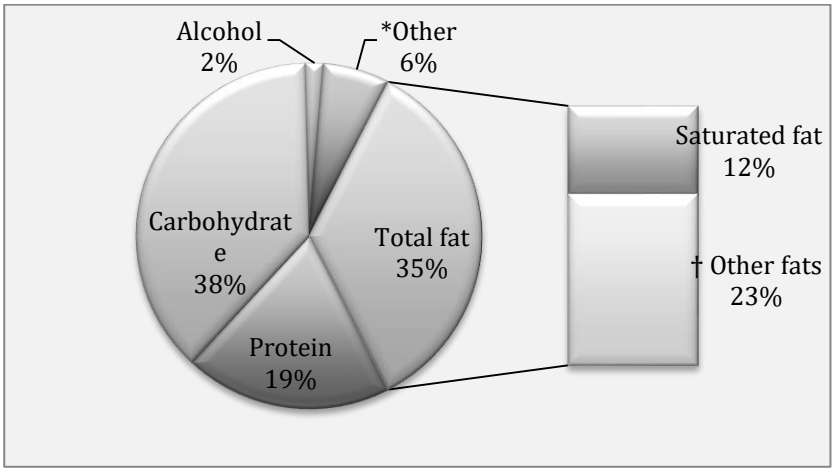
EAR, estimated average requirement; AI, adequate intake; AMDR, accepted macronutrient distribution range; ADG, Australian dietary guideline; %E, percentage contribution to energy; ; * Eight missing, 1 refusal and 2 unable to weigh ; †Estimated energy requirements will vary according to height, weight and physical activity level of each individual; ‡ Retinol equivalent; § α-tocopherol equivalents; ‖ Vitamin D data should be interpreted with caution ; ¶ Includes sodium naturally present in foods as well sodium added during processing, but excludes the 'discretionary salt' added by participants in home prepared foods or 'at the table'; inadequate intake refers to proportion of participants who consumed amounts above the UL.; ** Of the 16% of participants not meeting the AMDR for protein (%E), 46% (n=58) had an average intake below the AMDR and 54% (n=67) above the AMDR; †† All the participants (n=626) not meeting the AMDR for carbohydrate (%E) had an average intake below the AMDR ; ‡‡ Of the 48% of participants not meeting the AMDR for total fat (%E), 3% (10) had an average intake below the AMDR and 97% (359) above the AMDR

Table 5.2 Median daily intake of energy and nutrients, proportion of participants not meeting recommended intake, and main food sources of each nutrient (continued)

	Recommended intake (male, ≥70 years old)	Median (P5/P95)	% (n) not meeting recommended intake	Main food sources
Vitamin D (µg/day) – AI ‖	15	4.5 (1.9/9.6)	99 (752)	Fish, milk, cheese
Vitamin E (mg/day) – AI §	10	9.7 (4.3/21.0)	53 (403)	Olive oil, canola oil, egg
Minerals				
Calcium (mg/day) – EAR	1,100	800.7 (390.8/1540.9)	80 (610)	Milk, cheese, rolled oats
Iron (mg/day) – EAR	6	12.8 (7.6/22.3)	1 (7)	Breakfast cereals, beef, wholegrain bread
Zinc (mg/day) – EAR	12	13.3 (7.9/21.2)	35 (270)	Beef, Breakfast cereal, cheese
Magnesium (mg/day) – EAR	350	350.4 (214.3/543.4)	50 (380)	Banana, milk, breakfast cereals
Phosphorus (mg/day) – EAR	580	1583.3 (975.0/2376.7)	0 (1)	Milk, beef, cheese
Potassium (mg/day) – AI	3,800	3323.3 (2101.1/5052.1)	70 (533)	Milk, banana, potato
Iodine (µg/day) – AI	100	110.5 (49.8/233.9)	40 (306)	Milk, egg, fish
Sodium (mg/day) – UL ¶	2,300	1945.7 (1033.2/3422.8)	31 (237)	Ham, cheese, wholemeal bread

EAR, estimated average requirement; AI, adequate intake; AMDR, accepted macronutrient distribution range; ADG, Australian dietary guideline; %E, percentage contribution to energy; ; * Eight missing, 1 refusal and 2 unable to weigh ; †Estimated energy requirements will vary according to height, weight and physical activity level of each individual; ‡ Retinol equivalent; § α-tocopherol equivalents; ‖ Vitamin D data should be interpreted with caution ; ¶ Includes sodium naturally present in foods as well sodium added during processing, but excludes the 'discretionary salt' added by participants in home prepared foods or 'at the table'; inadequate intake refers to proportion of participants who consumed amounts above the UL.; ** Of the 16% of participants not meeting the AMDR for protein (%E), 46% (n=58) had an average intake below the AMDR and 54% (n=67) above the AMDR; †† All the participants (n=626) not meeting the AMDR for carbohydrate (%E) had an average intake below the AMDR ; ‡‡ Of the 48% of participants not meeting the AMDR for total fat (%E), 3% (10) had an average intake below the AMDR and 97% (359) above the AMDR.

Figure 5.1 Macronutrient (%) distribution of total energy intake of 761 men aged 75 years and over



* Other, sugar alcohol and dietary fibre; † Monounsaturated and polyunsaturated fats

Dietary adequacy and food sources

The majority of participants met the NRVs for energy, protein per kg of body weight, thiamin, riboflavin, niacin, folate, vitamin A, C, iron, zinc, phosphorus and iodine (**Table 5.2**). Nutrients of particular concern were vitamin D, calcium, potassium and dietary fibre, for which less than half met their requirements. Although the median intake of sodium was below the UL of intake, 31% of participants were consuming amounts considered harmful i.e. above UL. Two thirds of participants were consuming saturated fat amounts above the recommended intakes.

Milk was amongst the main food sources of many nutrients such as protein, calcium, vitamin D and phosphorus. Breakfast cereal was the second most predominant food source and provided participants with nutrients such as thiamin, folate and iron.

Factors associated with poor intakes of key nutrients

A total of 48% (n=362) of participants were considered to have a poor nutritional intake, based on meeting recommendations for four or fewer of the seven key nutrients of interest for older adults

(total energy, protein, iron, zinc, riboflavin, calcium and vitamin D). At the univariate level (**Table 5.3**), country of birth (p>0.0001), source of income (p=0.002) and occupational history (p=0.02) were significantly associated with nutritional intake. Italian/Greek-born men had an overall lower dietary intake of all the key nutrients. Although not reaching statistical significance, we found that current smokers (p=0.06) and those who were unable to prepare their own meals (p=0.09) had slightly higher risk of having a poor intake of key nutrients, while men with a university education had a slightly higher nutritional intake of key nutrients (p=0.06).

Table 5.3 Univariate analyses for nutritional intake of key nutrients for older adults and socio-demographic and economic, health and lifestyle and meal related activities of daily living factors

	Nutritional intake			
SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	**Meet**	**Not meet**	**Crude OR***	**p-value**
Age (years) (n=761)				
75-79 (reference)	172 (53%)	155 (47%)	1.00	1.00
80-84	145 (52%)	132 (48%)	1.01 (0.73 - 1.39)	
85+	82 (52%)	75 (48%)	1.01 (0.69 - 1.49)	
Source of income (n=758)				
Pension (reference)	135 (46%)	161 (54%)	1	0.002
Other	263 (57%)	199 (43%)	0.63 (0.47 – 0.85)	
Occupational history (n=757)				
Other (reference)	345 (55%)	287 (45%)	1.00	0.02
Plant and machine operator/labourer	54 (43%)	71 (57%)	1.58 (1.07 - 2.33)	
Marital status (n=761)				
Married/de facto (reference)	296 (52%)	278 (48%)	1.00	0.40
Divorced/separated/widowed/never married/other	103 (55%)	84 (45%)	0.87 (0.62 - 1.21)	
Living arrangements (n=759)				
Live with others (reference)	317 (52%)	290 (48%)	1.00	0.70
Lives alone	82 (54%)	70 (46%)	1.07 (0.75 - 1.53)	

OR, odds ratios; PASE, physical activity scale for the elderly; ADL, activity of daily living; MOW, meals on wheels; * Odds ratios of having a poor nutritional intake of key nutrients for older adults i.e. meeting the recommendations of four or less key nutrients

Table 5.3 Univariate analyses for nutritional intake of key nutrients for older adults and socio-demographic and economic, health and lifestyle and meal related activities of daily living factors (continued)

	Nutritional intake			
SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	**Meet**	**Not meet**	**Crude OR***	**p-value**
Post-school qualifications (n=757)				
Bachelor degree or higher (reference)	72 (60%)	47 (40%)	1.00	0.06
Non-university educated	325 (51%)	313 (49%)	1.48 (0.99 - 2.20)	
Country of birth (n=754)				
Australia/New Zealand (reference)	238 (58%)	172 (42%)	1.00	<0.0001
Italy/Greece	67 (38%)	111 (62%)	2.29 (1.60 - 3.29)	
Other	94 (54%)	79 (46%)	1.16 (0.81 - 1.66)	
PASE (points) (759)				
Low activity (≤76) (reference)	123 (47%)	127 (52%)	1.00	0.43
Median activity (77-160)	139 (53%)	116 (48%)	0.81 (0.57 - 1.15)	
High activity (≥161)	137 (53%)	117 (48%)	0.83 (0.58 - 1.17)	
Body mass index (kg/m^2) (n=745)				
Underweight (<22.0kg/m^2) (reference)	24 (55%)	20 (45%)	1.00	0.45
Normal (22.0-30.0kg/m^2)	259 (52%)	243 (48%)	1.12 (0.61 - 2.09)	
Overweight/Obese (>30.0kg/m^2)	113 (57%)	86 (43%)	0.91 (0.47 - 1.76)	

OR, odds ratios; PASE, physical activity scale for the elderly; ADL, activity of daily living; MOW, meals on wheels; * Odds ratios of having a poor nutritional intake of key nutrients for older adults i.e. meeting the recommendations of four or less key nutrients

Table 5.3 Univariate analyses for nutritional intake of key nutrients for older adults and socio-demographic and economic, health and lifestyle and meal related activities of daily living factors (continued)

	Nutritional intake			
SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	**Meet**	**Not meet**	**Crude OR***	**p-value**
Alcohol consumption (n=761)				
Non-drinker (reference)	89 (50%)	88 (50%)	1.00	0.80
≤14 drinks/week	250 (53%)	220 (47%)	0.89 (0.63 - 1.26)	
>14 drinks/week	60 (53%)	54 (47%)	0.91 (0.57 - 1.46)	
Cigarette smoking (n=753)				
Former smoker/never smoked (reference)	387 (53%)	342 (47%)	1.00	0.06
Current smokers	8 (33%)	16 (67%)	2.26 (0.96 - 5.35)	
Self-rated health (n=761)				
Excellent/good (reference)	305 (54%)	262 (46%)	1.00	0.20
Fair/poor/very poor	94 (48%)	100 (52%)	1.24 (0.89 - 1.72)	
Multi-morbidity (n=759)				
<2 (reference)	105 (49%)	109 (51%)	1.00	0.23
2+	294 (54%)	251 (46%)	0.82 (0.60 - 1.13)	
MEAL RELATED ADLs				
Able to grocery shop (n=759)				0.73
Yes (reference)	391 (52%)	354 (48%)	1.00	
No	8 (57%)	6 (43%)	0.83 (0.29 - 2.41)	

OR, odds ratios; PASE, physical activity scale for the elderly; ADL, activity of daily living; MOW, meals of wheels; * Odds ratios of having a poor nutritional intake of key nutrients for older adults i.e. meeting the recommendations of four or less key nutrients

Table 5.3 Univariate analyses for nutritional intake of key nutrients for older adults and socio-demographic and economic, health and lifestyle and meal related activities of daily living factors (continued)

	Nutritional intake			
SOCIO-DEMOGRAPHIC AND ECONOMIC FACTORS	**Meet**	**Not meet**	**Crude OR***	**p-value**
Able to prepare own meals (n=759)				
Yes (reference)	387 (53%)	340 (47%)	1.00	0.09
No	12 (37%)	20 (63%)	1.90 (0.91 - 3.94)	
Meal service (e.g. MOW) (n=759)				
No (reference)	389 (53%)	346 (47%)	1.00	0.28
Yes	10 (42%)	14 (58%)	1.57 (0.69 - 3.59)	

OR, odds ratios; PASE, physical activity scale for the elderly; ADL, activity of daily living; MOW, meals on wheels; * Odds ratios of having a poor nutritional intake of key nutrients for older adults i.e. meeting the recommendations of four or less key nutrients.

A multivariate logistic regression analysis showed that only the association between country of birth and nutritional intake remained significant after adjustment for occupational history and source of income (**Table 5.4**). Participants born in Italy/Greece were more likely to have poor nutritional intake of key nutrients (OR=1.94, 95%CI=1.32-2.87, p=0.0008).

Table 5.4 Final logistic regression model with adjusted odds ratios for poor nutritional intake (4 or less) of key nutrients of interest for older adults

Variables	Adjusted OR †	95% Confidence Interval	p-value
Source of income			0.08
Pension (reference)	1.00	-	-
Other	0.75	0.55 - 1.03	0.08
Occupational history			0.41
Other (reference) *	1.00	-	-
Plant and machine operator/labourer	1.19	0.79- 1.79	0.41
Country of birth			0.003
Australia/New Zealand (reference)	1.00	-	-
Italy/Greece	1.94	1.32 - 2.87	0.0008
Other	1.07	0.74 - 1.55	0.74

* Trade/apprenticeship/Certificate/diploma/No qualifications; † Odds ratios of having a poor nutrional intake of key nutrients for older adults i.e. meeting the recommendations of four or less key nutrients.

Age group, BMI classification, PASE classification, marital status, living arrangement, education, alcohol consumption, self-rated health and multi-morbidity were not associated with poor nutritional intake. Very few participants were unable to prepare their own meals, to shop for food or received meal service assistance in the previous year, therefore conclusions cannot be made in relation to associations between these factors and dietary intake.

5.4 Discussion

In this study we provide the nutritional intake information of the largest and oldest sample of older men ever recruited in Australia. Our findings were comparable to the latest nationally representative Australian Heath Survey (AHS) (137) despite the use of different dietary methodologies in the two studies (AHS used 24-hour recall). The similarity of results suggests that nutrition-related findings from CHAMP can be generalised to the Australian population of older men in the very old age group. However, in assessing the findings it is important to take into account important 'survival effects'; i.e. men with poor nutrition are relatively less likely to live to the advanced ages as examined in our study (16).

While we found that the majority of participants met or exceeded NRVs for most nutrients, it was alarming how low the intakes of vitamin D and calcium were amongst our sample. Being born in Italy or Greece was associated with a poor nutritional intake of key nutrients for older men, as was income and occupational history, with pensioners and participants with a history of physically demanding jobs being at higher risk.

The findings suggest a number of areas for targeted interventions. Macronutrient-unbalanced diets may lead to obesity, malnutrition, poor micronutrient intakes and nutritional deficiencies (e.g. anaemia) (99). We observed high total and saturated fat intakes (%E) and below the recommended intake of carbohydrate (%E) among CHAMP participants. Other studies have found similar total fat intakes amongst older men (21, 35, 148); one study has found higher intakes (149) and several have found lower intakes (17, 137, 150, 151) compared to ours.

Carbohydrate intakes in our study, both as a proportion of energy and as absolute intake, tended to be lower than in most other studies among older men (21, 148-151). However, CHAMP data for carbohydrate intakes are similar to those from older men in the AHS (137).

While 72% of participants were meeting their total energy requirements, it was notable that nearly a third of the participants were at risk in this respect. Assessment of total energy requirements is determined by calculating individuals' basal metabolic rate (BMR) – which varies according to body weight, sex and age – and physical activity level (PAL). CHAMP participants' activity levels were measured using the PASE (67) which could not be converted to PAL. Since there is no set PAL cut-off for older men, and studies have reported ranges from 1.54 to 1.75 (152), we chose the mid-point of the range (1.6; light activity) to calculate CHAMP participants' energy requirements.

Sun exposure is the main source of vitamin D for all age groups; however, older people may have insufficient sunlight exposure and so nutritional intake of vitamin D becomes more important. Dietary requirements of vitamin D increase from 5mcg for males up to 50 years old to 15mcg for males aged 71 years and older (99). Very few men in CHAMP achieved their vitamin D requirements; however, adults may find it difficult to obtain more than 5%–10% of their vitamin D requirement from dietary sources in Australia, and if sun exposure is insufficient, vitamin D supplementation is recommended for older individuals (153).

Calcium intake was also very low among men in CHAMP, with only 19% reaching the recommendations for this nutrient. Combined, calcium and vitamin D are two of the most important nutrients for bone health maintenance (154), and their deficiency is associated with

adverse outcomes such as increased incidence of osteoporosis, bone fractures and poor quality of life (154). Low vitamin D and calcium intakes have been raised as a concern in several other studies of older people (150, 151, 155).

We found that although the median intake of sodium was not above the UL of intake, 31% of participants were consuming potentially harmful amounts of sodium. It is important to highlight that participants' sodium intake may be higher when considering the extra salt potentially added to food at the time of consumption which was not measured in the present study. High dietary consumption of sodium can be particularly detrimental to cardiovascular health for adults; cardiovascular disease is amongst the leading causes of death worldwide (156-158).

Breakfast cereal was the main source for many nutrients. In Australia, cereal and cereal products such as wheat flour used in bread are mandatorily fortified with thiamin and folic acid, iodised salt is used to make bread, and some other nutrients may be voluntarily added to specific foods (159).

Among the many factors that we assessed, only country of birth and source of income were related to quality of dietary intake, as measured by meeting the NRVs for five or more of seven key nutrients (total energy, protein, iron, zinc, riboflavin, calcium and vitamin D).

A large proportion of CHAMP's participants were born in Italy or Greece (23%); however, their macronutrient intake distribution was not very different from participants born in Australia and other countries with the exception of alcohol intake (2.3% vs. 1.2%E). Overall,

Italian/Greek-born participants were more likely to have a poor dietary intake of total energy (with a higher proportion of energy coming from alcohol) and virtually all nutrients of interest than participants born elsewhere.

Men who received other sources of income (i.e. superannuation, business owners, on a salary, combination of age pension and other sources or other) tended to have a better nutritional intake compared with men on the Age pension only. The elevated risk for those on a pension only indicated the importance of income adequacy for purchasing food. An earlier study of older people in NSW found that food insecurity was a significant issue for a small proportion of older men and women (160). However when asked the question "in the past 12 months, was there any time when you could not afford to buy food" only 1% of our participants said yes, suggesting that food insecurity was not perceived to be an issue in the overall group, and perhaps nutritional education rather than affordability is a concern in this age group.

A strength of our study was that we used a validated diet history method to assess the nutritional intake of our study population (138). Diet histories taken by dietitians are a reliable (89, 90) approach to capture the dietary intake of individuals over a longer period of time (past 3 months in the present study). Diet histories do not limit the variability of response (90) and have less systematic errors than food frequency questionnaires, making them more suited to estimating usual nutrient intake. Diet histories are particularly indicated for older people because their diets tend to be consistent over long periods of time and, although it is a retrospective technique, it does not rely on short-term memory and uses a much more interactive approach than other methods (30, 91-93). Moreover, diet histories have low respondent burden, which may improve response rates among older people and

require no literacy or numeracy skills from participants (89, 94, 95), making them suitable for participants of culturally and linguistically diverse backgrounds. The high response rate to the dietary component of our study (83%) confirmed that the diet history method is well suited for older men, regardless of country of birth, occupational history, source of income or self-rated health. As with most dietary assessment studies, this study's findings are based on estimation of intake and should be considered as such. There will always be limitations with food composition data as nutrient content of food is variable and depends on a range of factors (161). In particular, we acknowledge that vitamin D data reported in this study may be less accurate than the data of other nutrients as they derive from a small set of analyses and values were based on a number of assumptions (139). However, given that they are the most up-to-date data available on vitamin D concentration in foods in Australia (162), we feel that it is important to report participants' intakes through Australian food sources.

In summary, our study of a large population sample of men living in the community in Sydney, Australia found that the dietary intake of older Australian men is adequate for most of the nutrients analysed (except vitamin D and calcium intakes, which were far below the recommended intakes). However, about half of the participants in this study had a poor nutritional intake of the combined key nutrients for older people. Being born in Italy or Greece was associated with poor nutritional intake of key nutrients for older men, suggesting the need for nutritional education targeted at older men from culturally and linguistically diverse backgrounds. Men on the Age pension had the worst intake of key nutrients for older men, even though the vast majority of men reported no financial issues that prevented them from affording food, which highlights that education and behavioural change – rather than affordability – may be the issue in this age group.

The findings suggest a number of avenues for further research and policy action. It seems likely that the nutritional patterns described here arise from complex cultural and socio-economic factors that arise earlier in life and persist or change with transitions into later life. The mechanisms leading to nutritional adequacy or risk require further investigation in CHAMP and other longitudinal surveys. Findings on the small but significant number of individuals at nutritional risk indicate the importance of targeted health promotion for ageing and older people as well as examination of the value of meals services and nutritional interventions for clinical populations.

CHAPTER 6. THE GEOMETRIC FRAMEWORK, NUTRITION AND HEALTH IN OLDER MEN

(This chapter may result in two or more papers)

6.1 Introduction

The aim of this chapter was to investigate the associations between macronutrient intakes (dependent variables) and the following health outcomes (independent variables) using the geometric framework: total energy intake, body mass index (BMI), percentage body fat, waist-to-hip ratio, insulin, total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, homeostatic model assessment for insulin resistance (HOMA-IR), number of medical conditions, SF12 (MCS and PCF), GDS and frailty score. Geometric framework surfaces not discussed in this chapter are presented in Appendix F.

An introduction and literature review of protein leverage and the geometric framework are found on Chapter 1 of this thesis. The statistical R script used to develop the geometric framework surfaces requires data in a continuous form, therefore the health outcomes discussed in this chapter were chosen on this basis as well as relevance of macronutrient intake to health outcome of interest e.g. it is well known that high fat intake is associated with high cholesterol.

6.2 Materials and Methods

Participants

Detailed information on CHAMP participants' characteristics can be found in Chapter 3. In summary, participants who responded to the nutritional component of the CHAMP study had a mean age of 81 years (SD 4.4 years), were likely to be married (75%), receiving other than just age pension as source of income (61%) and born in Australia or New Zealand (54%). In

this chapter, descriptive information of outcomes investigated in this chapter are presented at the beginning of results. Some discrepancy between participants' characteristics presented in Chapter 3 and this chapter may occur due to missing data of variables included in the models used to assess associations between macronutrients and health outcomes. A substantial number of participants did not have all their blood measures analysed due to an administrative error; this was not related to participants' characteristics and so excluding these subjects should not lead to selection bias.

Dietary intake

Detailed information on participants' dietary intake and comparison of diet history questionnaire to a four-day weighed food record can be found on Chapters 2, 4 and 5. In summary, usual dietary intake was determined through standardised collection of diet histories (88), conducted by a research dietitian at participant's residence between August 2010 and August 2013. Participants were questioned about their intake during the previous three months and the diet history interview took on average 45 minutes to complete.

Macronutrient intakes are presented as kilojoules per kilo of body weight (kJ/kg) and also in grams per kilo of body weight (g/kg) for comparison with other studies and current dietary recommendations. Adjustment for weight was also used to address the total energy intake effect on the relationship between health outcomes and macronutrient intake. Total energy intake presented in this chapter is the sum of energy deriving from macronutrients (protein, carbohydrate and fat) only i.e. energy from alcohol and fibre are not considered as they have a very small impact to total energy.

Health outcomes

Frailty scores

Frailty scores used in this thesis were determined using the five frailty components used in the Cardiovascular Health Study (CHS) - a prospective, observational study based in the U.S. designed to investigate risk factors for cardiovascular diseases in adults aged 65 years and over. Each component contributes with one point towards the final score and they are: weight loss, weakness/reduced muscular strength, slow walking speed, exhaustion, and low activity level (163). Weakness and slowness components were determined using the same criteria and the same cut-off points as in the CHS (163). Weight loss, exhaustion, and low activity criteria were adapted in the CHAMP study, as the exact measurements used in the CHS were not available. Frailty scores (0-5 points in increments of 1) were used for plotting response surfaces using the Geometric Framework (GF), for Generalised Additive Models (GAM), and multiple regression analyses. Frailty status was also used in multiple regression models to account for its influence on the relationship between macronutrient intake and various other health outcomes. For these analyses, participants were classified as frail if their score was ≥3 and non-frail (robust[0]/pre-frail[1-2]) if they scored 0-2 (163). Analysis of frailty was restricted to those with complete data on frailty and all frailty components (except exhaustion as all participants had a 0 score for exhaustion i.e. the exhaustion component did not contribute to overall frailty score).

Blood measures

All blood tests were performed at the Diagnostic Pathology Unit of Concord RG Hospital, which is a National Australian Testing Authority (NATA) accredited pathology service, using a MODULAR Analytics system (Roche Diagnostics, Castle Hill, Australia). Fasting blood

samples for cholesterol and high-density lipoprotein (HDL) cholesterol analysis were performed on a Roche Cobas 8000 analyser using a standard automated enzymatic methodology. Fasting blood samples for glucose measurement were taken into fluoride-oxalate (anticoagulant) tubes. Plasma glucose was measured using the Hexokinase method. Only fasting blood results were considered in this thesis, therefore there was a substantial amount of missing data for blood LDL cholesterol, HDL cholesterol, glucose, insulin and consequently HOMA IR (Homeostasis Model Assessment - Insulin Resistance) as some participants were not fasting at the time of blood collection. HOMA IR was calculated using HOMA calculator v 2.2.3 (© Diabetes Trials Unit, University of Oxford).

Body composition measures

a) Body mass index (BMI)

Height and weight were measured according to a standardised protocol (164) using Wedderburn digital scales and Harpenden portable stadiometer. Weight and height were measured in light clothing and no shoes to the closest 0.1kg and height in centimetres. BMI was calculated and categorised as underweight (below 22kg/m^2), normal (22-30kg/m^2) and overweight/obese (above 30kg/m^2) as per recent studies in older people (65 years and over) that have shown that there is an increased risk of mortality in the lowest and highest cut-offs (141-146). BMI was used in its continuous form in the GF, GAM and multiple regression analyses that investigated its association with macronutrient intake.

Since all macronutrient intakes were adjusted for body weight, we have not adjusted any of the models for BMI as its calculation includes body weight and its inclusion would cause collinearity problems.

b) Percentage body fat

Whole-body DXA scans were acquired using a fan beam Discovery-W scanner (Hologic Inc., Bedford, MA). Percentage body fat was calculated using subtotal (excluding head weight) body fat and body mass.

c) Waist-to hip ratio

Waist circumference was measured around the narrowest point between ribs and hips when viewed from the front after exhaling. Hip circumference was measured at the point where the buttocks extended the maximum, when viewed from the side. Two consecutive recordings were made for each site to the nearest 1 cm using a metal tape on a horizontal plane without compression of skin. The mean of two sets of values was used to calculate waist-to-hip ratio$\left(\frac{Waist(cm)}{Hip(cm}\right)$. Values above 0.9 (for men) indicate an increased health risk due to abdominal obesity (165).

Other measures

a) Physical Activity Scale for the Elderly (PASE)

The Physical Activity Scale for the Elderly score is computed from responses to questions that assess the frequency of activities of varying levels of exertion in several areas of daily life (recreational sport, leisure activities, home and work activities) over a 1-week recall period (67). The final PASE score in its continuous form was used in the GF, GAM and multiple regression analyses that investigated its relationship with macronutrient intakes. PASE scores were also included in multiple regression models to account for the physical activity level influence on the relationships between macronutrient intake and other health

outcomes. For frailty scores, participants were considered to have low activity level if they were in the lowest quintile of the PASE (cut-off score< 73).

b) Multi-morbidity

The self-completed questionnaire included questions on the following medically diagnosed health conditions: diabetes, thyroid problems, osteoporosis, Paget's disease, stroke, Parkinson's disease, kidney stones, dementia, depression, epilepsy, hypertension, myocardial infarction, angina, heart failure, intermittent claudication, chronic obstructive lung disease, liver disease, chronic kidney disease, arthritis, and cancer (excluding non-melanotic skin cancer and benign tumours such as bowel polyps); multi-morbidity was defined as having two or more of these conditions (82). The total number of morbidities was used in the GF, GAM and multiple regression analyses that investigated its association with macronutrient intakes. Number of morbidities was also included as a covariate in multiple regression models of the association between macronutrient intake and various health outcomes.

c) Geriatric Depression Scale (GDS)

Depressive symptoms were measured using the shortened (15 items) GDS (83). A cut-off of five or more symptoms was used to define clinically significant depressive symptoms, which is how GDS results are commonly reported in the literature (84).

d) 12-item short form survey (SF12)

To calculate the Physical (PCS) and Mental Health Composite Scores (MCS) of the SF12 we used the QualityMetric Health Outcomes Scoring Software (QualityMetric Inc., Lincoln, Rhode Island). The software uses all the 12 items to produce scores for the SF12-PCS and the

SF12-MCS and applies a norm-based scoring algorithm empirically derived from the data of a US general population survey (166). Physical health (PCS) encompasses information on physical functioning, role-physical, bodily pain and general health; mental health (MCS) includes information on vitality, social functioning, role-emotional and mental health (167). Scores for the SF12-PCS and the SF12-MCS can range from 0 (very poor) to 100 (very good).

Statistical analyses

Statistical analyses were performed using GAM, GF and multiple linear regression models. Firstly, GAM and GF analyses were performed, and then, based on GAM results where p-values <0.10 were considered, further investigation was conducted using multiple linear regression analyses that accounted for confounders.

GF analyses involved visualising response surfaces mapped onto arrays of macronutrient intakes using thin-plate spline procedures in R (see *Solon-Biet et al. 2014*) (39), with statistical support for surface interpretation coming from GAM.

GAM are semi-parametric extensions of generalized linear models (GLMs) except that the underlying assumption made is that the functions are additive and that the components are smooth, in other words, instead of a single coefficient for each variable (additive term) in the model, in additive models an unspecified (non-parametric) function is estimated for each predictor, to achieve the best prediction of the dependent variable values (168). GAMs allow us to deal with highly non-linear and monotonic relationships between the response and the set of explanatory variables (169). The following values are provided for each GAM:

EDF – estimated degrees of freedom; a EDF close to 1 indicates that the association between response variable and the predictor variables is linear, a EDF close to 2 indicates that the association response variable and the predictor variables is quadratic.

Ref. DF – reference degrees of freedom

F – It tests for a significant relationship between the response variable and the predictor variables.

P-value – p-value for the F-test on the model.

For presentation of surfaces (which are 4-dimensional, comprising the three macronutrient dimensions and the response dimension), three 2D slices are given to show all combinations of the three macronutrient dimensions (protein, P; carbohydrate, C; fat, F). For each 2D slice, the third nutrient is at its median (shown below the x axis in parentheses). In all surfaces, red indicates the highest value, while dark blue indicates the lowest value, with the colours standardised to the height of the full surface across the three slices.

For multiple regression analyses all dependant variables were checked for normality; variables that were skewed in their distribution were log transformed; zero values were changed to 0.01 before log-transformation. Independent variables (macronutrient intakes) were grouped into quintiles to determine whether their association with dependent variables (health outcomes) was linear; if an association was linear, the independent variable was then entered in the multiple linear regression model in its continuous form; if the association was nonlinear, the independent variable was entered in the multiple regression model as quintiles. Most multiple regression models were adjusted for the following factors: age (years, continuous), physical activity level as measured by PASE (continuous), number of

morbidities (continuous), marital status (married vs. not married), income (pension only vs. other), education (Bachelor degree and higher vs. other) and frailty status (frail or non-frail). Frailty was used as a measure of overall health and source of income as a proxy of personal income, assuming frail individual had poorest health and age pensioners had the lowest income. This study uses cross-sectional data, therefore, terms expressing variations in individuals' average intake (e.g. increase vs. decrease) refers to comparison between participants and not changes in their intakes over time.

The factors cited above are commonly associated with macronutrient intake and/or health in older individuals; therefore, they were entered into regression models regardless of statistical significance. The association between macronutrient intake and triglycerides were also adjusted for alcohol (g/kg), carbohydrate and total fat intake (kJ/kg) as these are known risk factors for hypertriglyceridemia (170). Ratios of macronutrients (ratio of nutrients that collectively comprise total energy i.e. the sum of these thee macronutrient reflects total energy intake) were entered into the regression models as interaction terms, assuming that their relationship with health outcomes were linear.

Confidence intervals were generated at the 95% level, and evidence against null hypotheses was considered statistically significant if the resulting p-values were less than 0.05.

6.3 Results

6.3.1 Total energy intake

Energy intake ranged from 3.8 to 12.7MJ (median=8.1MJ) in the 761 participants with complete data on energy and macronutrient intakes. GAM results showed that all

macronutrients (%E) were independently associated with energy intake (all P≤0.01, **Table 6.1**), but there were no interactions between macronutrients. GF graphs showed that energy intakes were highest when the diet contained a reduced percentage of protein; the majority of the remaining energy was as fat rather than carbohydrates - as indicated by the most intensely red region of the surface being at the top left of the middle panel in Figure 6.1, in which % fat is plotted against % protein.

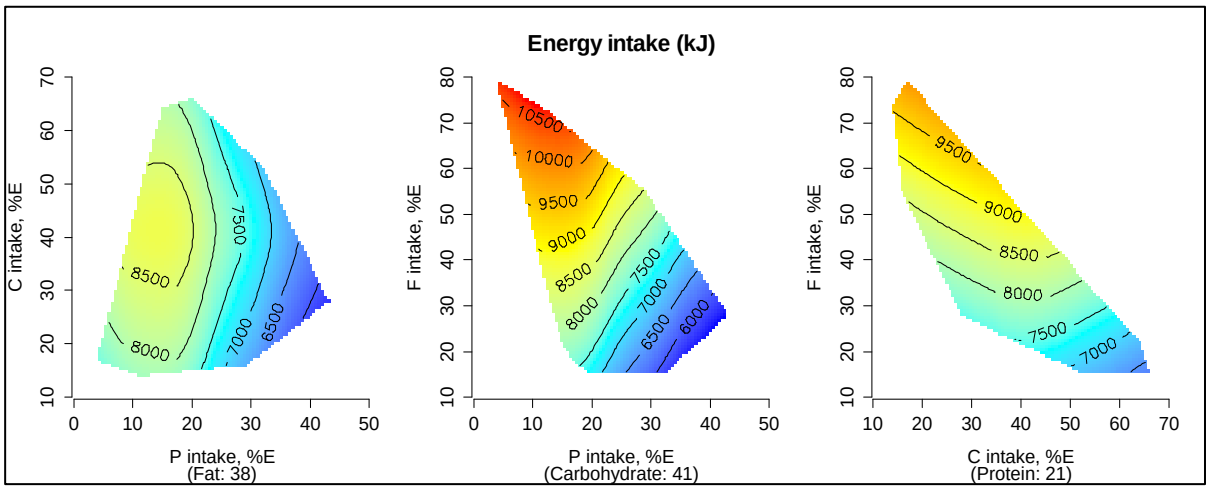
The relationships between total energy and each of the macronutrients were linear; therefore, these macronutrients were entered into regression models as continuous variables. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple regression model, the association between protein intake and total energy intake remained statistically significant: a 1% increase in energy derived from protein was associated with a 2% decrease in total energy intake (β=-0.02, CI=-0.022/-0.015, p<0.001, **Table 6.2);** a 1% increase in energy derived from carbohydrate was associated with a 0.5% decrease in total energy intake (β=-0.005, CI=-0.007/-0.003, p<0.001, **Table 6.2);** and a 1% increase in energy derived from fat was associated with a 1% increase in total energy intake (β=0.01, CI=0.008/0.012, p<0.001, **Table 6.2).**

Table 6.1 Coefficients from GAMs for total energy intake (kJ) in 761 participants

Nutrient (s) (%E)	EDF	Ref. DF	F	p-value
Protein	2.675	8	1.998	<0.001
Carbohydrate	1.688	8	0.747	0.01
Total fat	0.825	8	0.575	<0.001
Protein, Total fat	0.000	3	0.000	0.98
Carbohydrate, Total fat	0.000	3	0.000	0.81
Protein, Carbohydrate, Total fat	0.034	10	0.003	0.27

Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.1 Surface plots showing the relationship between macronutrient intakes (as percentage of total energy intakes, %E) and total energy intake in 761 participants



C, carbohydrate; P, protein; F, total fat; %E, percentage contribution to energy

Table 6.2 Multiple linear regression analysis of the association between total energy intake (kJ)* and macronutrient intakes (%E) in 746 participants

Dietary variable	Coefficient	95% CI		p value†
Protein (%E)	-0.02	-0.022	-0.015	<0.001
Carbohydrate (%E)	-0.005	-0.007	-0.003	<0.001
Total fat (%E)	0.01	0.008	0.012	<0.001

%E, percentage contribution to energy; *Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status; Total energy and macronutrient intake associations were investigated in separate models.

6.3.2 Body composition

a) Body mass index (BMI)

BMI ranged from 15.2 kg/m^2 to 43.0 kg/m^2 (median=27.5kg/m^2) in the 745 participants who had complete data on body weight, height and macronutrient intakes. GAM results showed that all macronutrients were statistically significantly associated with BMIs (all P<0.001, **Table 6.3**). GF graphs indicated that participants who had the highest BMIs consumed, on average, ≤18kJ/kg (≤1.1g/kg) of protein a day, >28kJ/kg (>1.6g/kg) of carbohydrate or between 10 and 90 kJ/kg (0.3 and 2.4g/kg) of fat a day (**Figure 6.2**). Based on the GAM and the GF graphs, protein, carbohydrate and fat had independent associations with BMI, but there were no interactions between them.

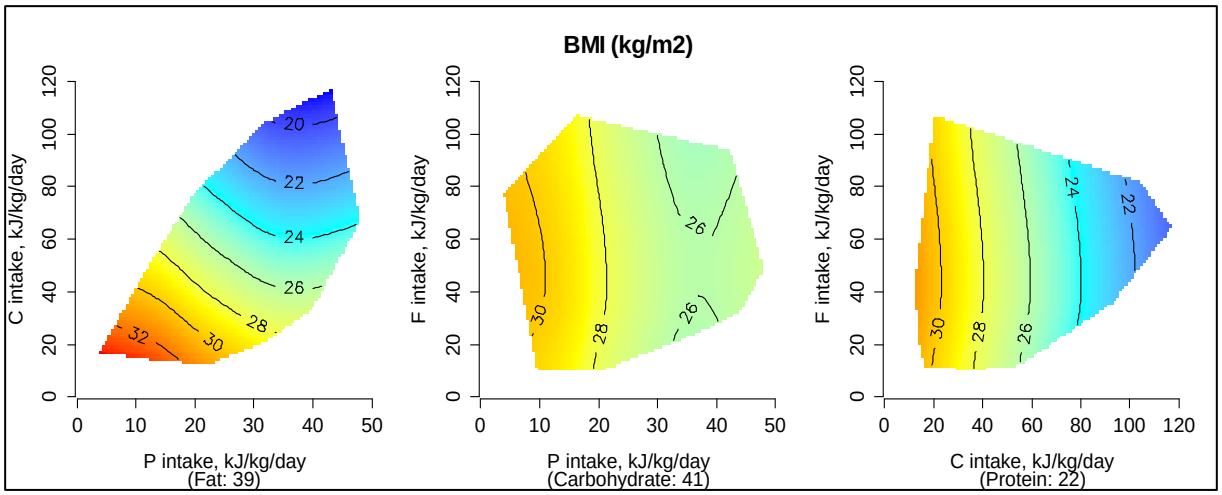
The relationships between BMI, protein, carbohydrate and fat were linear; therefore, these macronutrients were entered into the regression model as continuous variables. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple regression model, all the associations between macronutrient and BMI remained significant: for every 1kJ/kg of protein intake there was an associated 1% decrease in BMI (β=-0.01, CI=-0.011/-0.009, p<0.001, **Table 6.4),** a 1kJ/kg increase in carbohydrate was associated with a 0.5% decrease in BMI (β=-0.005, CI= -0.006/-0.005, p<0.001, **Table 6.4)** and a 1kJ/kg increase in fat was associated with a 0.2% decrease in BMI (β=-0.002, CI= -0.003/-0.002, p<0.001, **Table 6.4)**.

Table 6.3 Coefficients from GAMs for BMI (kg/m^2) in 745 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.675	8	1.998	<0.001
Carbohydrate	1.688	8	0.747	0.009
Total fat	0.825	8	0.575	<0.001
Protein, Carbohydrate	0.001	3	0.000	0.27
Protein, Total fat	0.000	3	0.000	0.98
Carbohydrate, Total fat	0.000	3	0.000	0.81
Protein, Carbohydrate, Total fat	0.003	10	0.000	0.33

BMI, body mass index; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.2 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and BMI (kg/m2) in 745 participants



BMI, body mass index; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.4 Multiple linear regression analyses of the association between BMI (kg/m2)*, protein and carbohydrate intake of 739 participants

Dietary variable	Coefficient	95% CI		p value†
Protein (kJ/kg)	-0.010	-0.011	-0.009	<0.001
Carbohydrate (kJ/kg)	-0.005	-0.006	-0.005	<0.001
Fat (kJ/kg)	-0.002	-0.003	-0.002	<0.001

BMI, body mass index; *Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status; BMI and macronutrient intake associations were investigated in separate models.

b) Percentage body fat

Participants' body fat ranged from 12.1% to 45.4% (median=30.2%) in the 732 participants with complete data on body weight, body fat (%) and macronutrient intakes. GAM results showed that protein and carbohydrate intake (kJ/kg) were statistically significantly associated with body fat percentages (both p<0.001, **Table 6.5**) as was the ratio of intake of all macronutrients (P*C*F) combined (p=0.01, **Table 6.5**). GF graphs revealed that participants who consumed ≤10kJ/kg (≤0.6g/kg) of protein a day and/or ≤30kJ/kg (1.8g/kg) of carbohydrate a day had the highest body fat percentages (**Figure 6.3**).

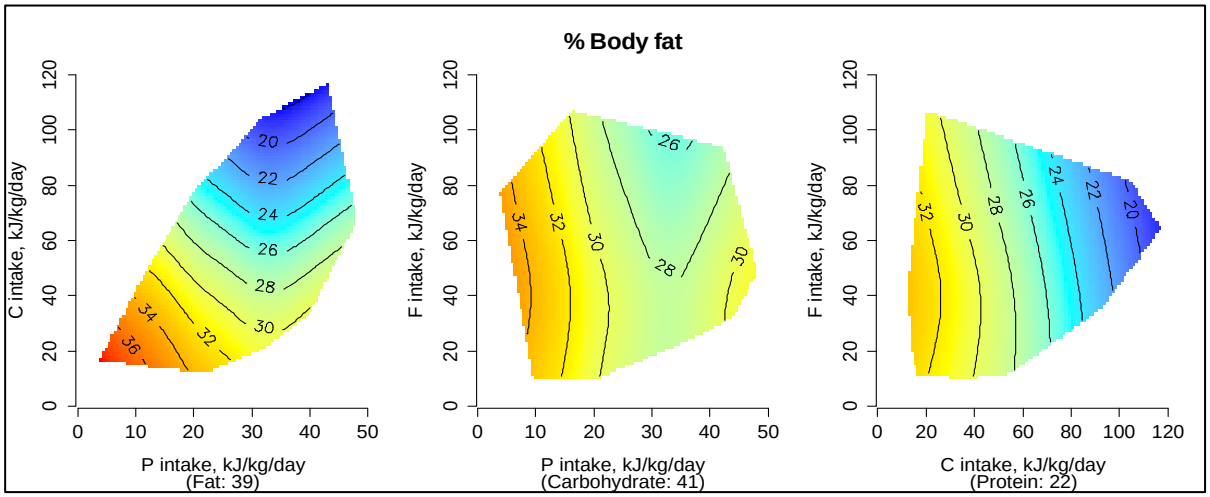
The association between percentage body fat and protein and carbohydrate intake (kJ/kg) was linear, therefore these macronutrients were entered into the regression model as continuous variables. The ratio of all three nutrients (P*C*F) was entered in the regression model as an interaction term, assuming that their relationship with percentage body fat was linear. After adjustment for protein (kJ/kg), carbohydrate (kJ/kg), fat (kJ/kg), age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple linear regression model, only the association between protein and percentage body fat and carbohydrate intake and percentage body fat remained significant (both p<0.001, **Table 6.6**): a 1 kJ/kg increase in protein was associated with a 1% decrease in percentage body fat (β=-0.01, CI=-0.015/-0.011, p<0.0001) and a 1kJ/kg increase in carbohydrate was associated with a 0.7% decrease in percentage body fat (β=-0.007, CI=-0.008/-0.006, p<0.0001). The ratio of all macronutrients (P*C*F) combined were no longer statistically significantly associated with percentage fat after adjustments.

Table 6.5 Coefficients from GAMs for body fat (%) of 732 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	3.109	8	5.891	<0.001
Carbohydrate	0.970	8	3.938	<0.001
Total fat	0.000	8	0.000	0.52
Protein, Carbohydrate	0.000	3	0.000	0.44
Protein, Total fat	0.000	3	0.000	0.46
Carbohydrate, Total fat	0.479	3	0.217	0.21
Protein, Carbohydrate, Total fat	0.781	10	0.357	0.01

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.3 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and body fat (%) in 732 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.6 Multiple linear regression analyses of the association between body fat (%)* and intake of protein, carbohydrate and P:C:F ratio of 723 participants

Dietary variable	Parameter	95% CI		p value†
Protein (kJ/kg)	-0.013	-0.015	-0.011	<0.001
Carbohydrate (kJ/kg)	-0.007	-0.008	-0.006	<0.001
P:C:F ratio ‡	0.000	0.000	0.000	0.17

P:C:F, ratio of protein, carbohydrate and fat; *Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status; ‡Also adjusted for protein (kJ/kg), carbohydrate (kJ/kg) and fat (kJ/kg); macronutrient/ratio of macronutrients intake and their associations with percentage body fat were investigated in separate models.

c) Waist-to-hip ratio

Waist-to-hip ratio ranged from 0.8 to 1.5 (median=1.0) in the sample of 739 participants with complete data on body weight, macronutrient intake, and waist and hip measurements. GAM results showed that waist-to-hip ratios were only statistically significantly associated with protein (p=0.006), carbohydrate (p<0.001) and the ratio of carbohydrate to fat intake (p=0.002) (**Table 6.7**). GF graphs revealed that consumption of ≤25kJ/kg (1.5g/kg) of protein a day and/or ≤40kJ/kg (2.3g/kg) of carbohydrate was associated with higher waist-to-hip ratios. Furthermore, participants who consumed ≤20kJ/kg (1.2g/kg) of carbohydrate while consuming ≥30kJ/kg (0.8g/kg) of fat a day, tended to have higher waist-to-hip ratios (**Figure 6.4**).

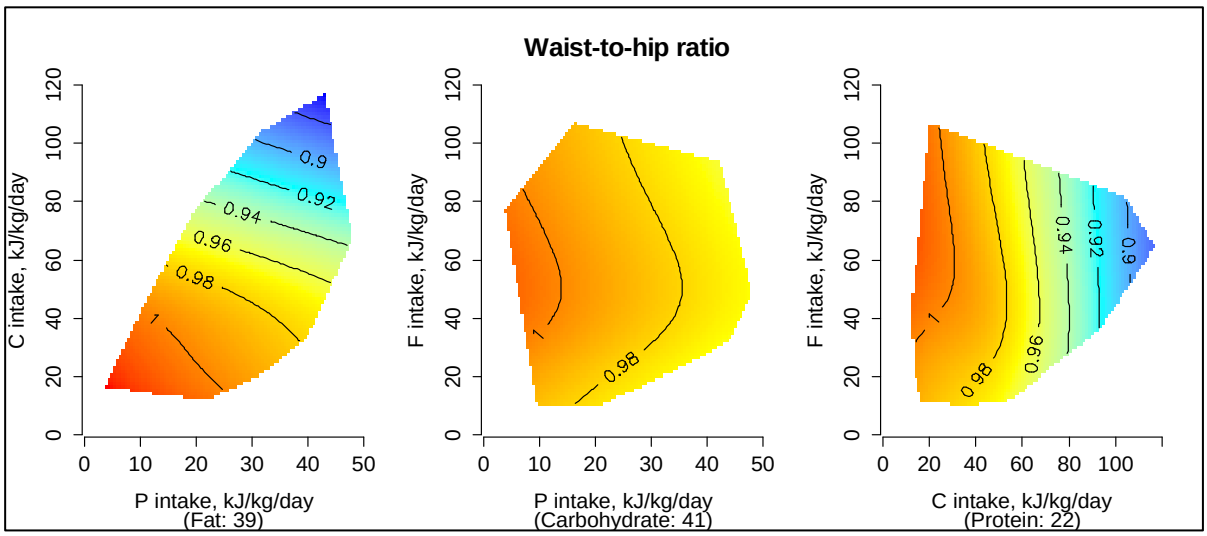
The association between waist-to-hip ratio and protein and carbohydrate was linear, therefore these macronutrients were entered into the regression model as continuous variables. The ratio of carbohydrate to fat (C:F) was entered in the regression model as an interaction term (C*F), assuming that their relationship with waist-to-hip ratio was also linear. After adjustment for carbohydrate (kJ/kg), fat (kJ/kg), age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple linear regression model, all the associations remained statistically significant (all with p≤0.002, **Table 6.8**); a 1 kJ/kg increase in protein intake was associated with a 0.2% decrease in waist-to-hip ratio (β=-0.002, CI=-0.002/-0.001, p<0.0001), a 1kJ/kg increase in carbohydrate intake was associated with a 0.1% decrease in waist-to-hip ratio (β=-0.001, CI=-0.0014/-0.0008, p<0.0001) and 1 unit increase in C:F ratio was associated with a 0.003% decrease in waist-to-hip ratio (β=-0.00003, CI=-0.00004/-0.00001 p=0.002) (**Table 6.8)**.

Table 6.7 Coefficients from GAMs for waist-to-hip ratio of 739 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.863	8	0.790	0.006
Carbohydrate	0.961	8	3.059	<0.001
Total fat	0.478	8	0.114	0.12
Protein, Carbohydrate	0.000	3	0.000	0.98
Protein, Total fat	0.000	3	0.000	0.70
Carbohydrate, Total fat	2.059	3	3.172	0.002
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.45

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.4 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and waist-to-hip ratio in 739 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day.

Table 6.8 Multiple linear regression analyses of the association between waist-to-hip ratio* and intake of protein, carbohydrate and C:F ratio of 739 participants

Dietary variable	Parameter	95% CI		p value†
Protein (kJ/kg)	-0.002	-0.002	-0.001	<0.001
Carbohydrate (kJ/kg)	-0.001	-0.0014	-0.0008	<0.001
C:F ‡	-0.00003	-0.00004	-0.00001	0.002

CF, ratio of carbohydrate to fat; *Log-transformed; †Derived by multiple linear regression analyses, adjusted for carbohydrate (kJ/kg), fat (kJ/kg), age, physical activity level, number of morbidities, marital status, income, education and frailty status; ‡Also adjusted for carbohydrate (kJ/kg) and fat (kJ/kg); macronutrient and ratio of carbohydrate to fat and its association with waist-to-hip ratio was investigated in separate models.

6.3.2 Metabolic health

a) Insulin

Insulin levels ranged from 8.0 to 682.0 pmol/L (median=44.0 pmol/L) in the sample of participants with complete data on body weight, macronutrient intake and fasting insulin levels (n=626). GAM results revealed that protein intake was statistically significantly associated with fasting insulin levels irrespective of intake of other macronutrients (p=0.007, **Table 6.9**). GF graphs indicated that the relationship between protein intake and insulin was monotonic, increasing progressively as protein intake declined (**Figure 6.5**).

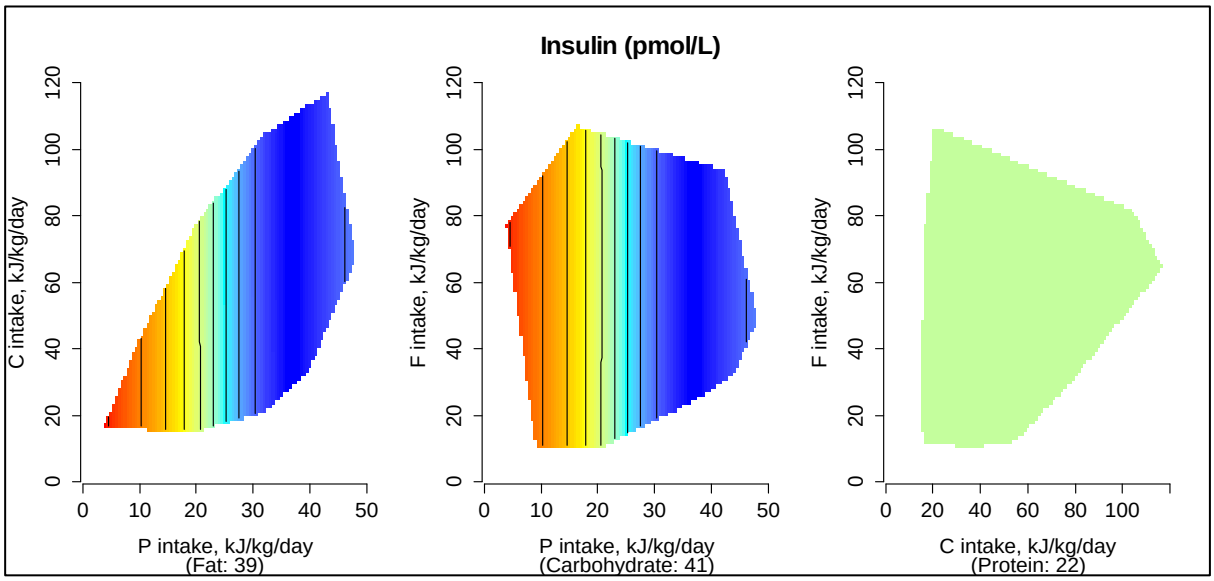
The relationship between protein and fasting insulin levels was linear; therefore, data on protein intake was entered in the regression model in its continuous form. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status, protein intake remained significant associated with fasting insulin levels; for every 1 kJ/kg increase in protein intake, a 1% decrease in insulin would be expected (β=-0.01, CI=-0.020/-0.008, p<0.0001, **Table 6.10**).

Table 6.9 Coefficients from GAMs for fasting insulin levels (pmol/L) of 626 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.4778	8	0.9026	0.007
Carbohydrate	0.0012	8	0.0001	0.56
Total fat	0.0008	8	0.0000	0.88
Protein, Carbohydrate	0.0004	3	0.0001	0.46
Protein, Total fat	0.0002	3	0.0000	1.00
Carbohydrate, Total fat	0.0003	3	0.0001	0.46
Protein, Carbohydrate, Total fat	0.0001	10	0.0000	0.84

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.5 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and insulin levels (pmol/L) in 626 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.10 Multiple linear regression analysis of the association between fasting insulin levels* and protein intake of 621 participants

Dietary variable	Parameter	95% CI		p value†
Protein (kJ/kg)	-0.01	-0.020	-0.008	<0.001

*Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status

b) Homeostasis Model Assessment- Insulin Resistance (HOMA-IR)

HOMA IR ranged from 0.15 to 13.3 (median=0.84) in the 623 participants who had complete data on body weight, macronutrient intakes and HOMA-IR scores. GAM results showed that protein intake was statistically significantly associated with HOMA-IR scores (p=0.008) (**Table 6.11**), with HOMA-IR scores rising progressively as protein intake declined (**Figure 6.7**).

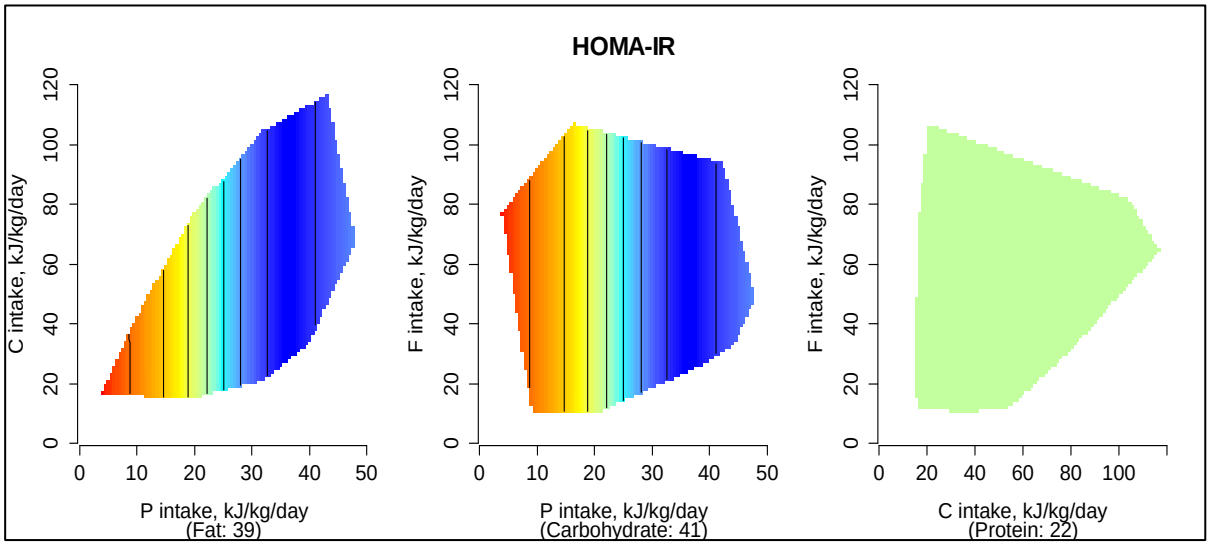
The relationships between HOMA-IR scores and protein intake was linear, therefore protein intake was entered into the regression model in its continuous form. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple regression model, the association between HOMA-IR scores and protein intake remained statistically significant; for every increase of 1kJ/kg of protein, HOMA-IR score would be expected to decrease by 1% (β=-0.01, CI=-0.021/-0.008, p<0.001, **Table 6.12)**.

Table 6.11 Coefficients from GAMs for HOMA-IR of 623 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.490	8	0.878	0.008
Carbohydrate	0.000	8	0.000	0.60
Total fat	0.000	8	0.000	0.84
Protein, Carbohydrate	0.000	3	0.000	0.48
Protein, Total fat	0.000	3	0.000	1.00
Carbohydrate, Total fat	0.000	3	0.000	0.51
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.89

HOMA-IR, Homeostasis Model Assessment - Insulin Resistance; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.6 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and HOMA-IR in 623 participants



HOMA-IR, Homeostasis Model Assessment - Insulin Resistance; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.12 Multiple linear regression analysis of the association between HOMA-IR* and protein intake of 618 participants

Dietary variable	Parameter	95% CI		p value†
Protein (kJ/kg)	-0.01	-0.021	-0.008	<0.001

HOMA-IR, Homeostasis Model Assessment - Insulin Resistance; *Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status

6.3.3 Cardiovascular health

a) Cholesterol

Cholesterol levels ranged from 2 to 8 mmol/L (median=4.5) in the 631 participants who had complete data on body weight, fasting blood cholesterol levels and macronutrient intakes. GAM results showed no statistically significant association between fasting blood cholesterol levels and macronutrient intakes (**Table 6.13**) and therefore no further investigation using multiple regression modelling was performed. However, GF graphs showed a tendency

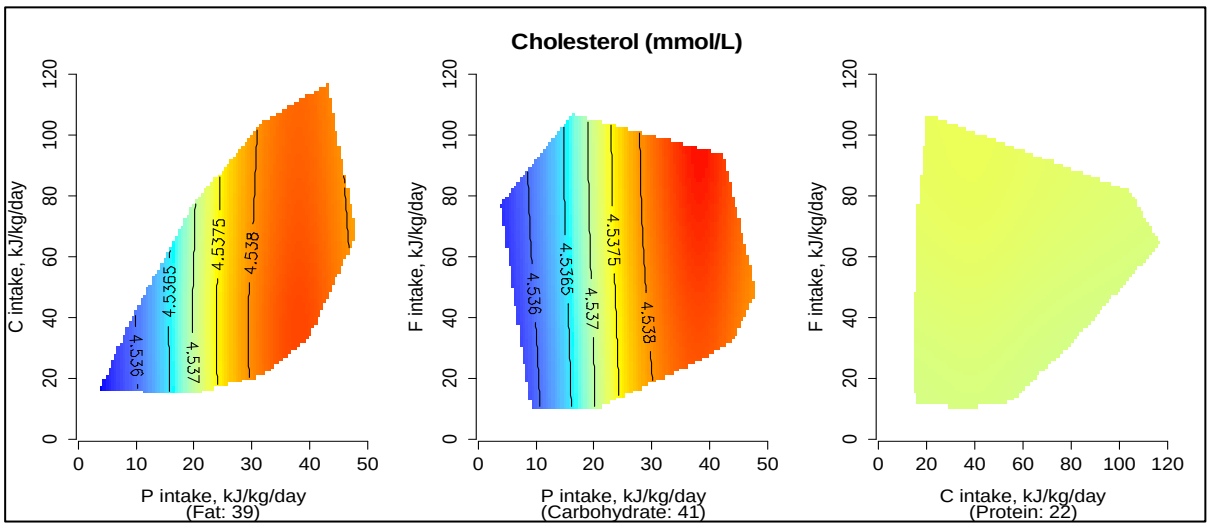
towards higher cholesterol levels in participants who consumed ≥30kJ/kg (1.8g/kg) of protein (**Figure 6.8**).

Table 6.13 Coefficients from GAMs for fasting blood cholesterol (mmol/L) of 631 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.019	8	0.002	0.32
Carbohydrate	0.000	8	0.000	0.64
Total fat	0.001	8	0.000	0.39
Protein, Carbohydrate	0.000	3	0.000	0.46
Protein, Total fat	0.000	3	0.000	0.68
Carbohydrate, Total fat	0.000	3	0.000	0.74
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.67

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.7 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and fasting blood cholesterol (mmol/L) in 631 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

b) Low-density lipoprotein cholesterol (LDLc)

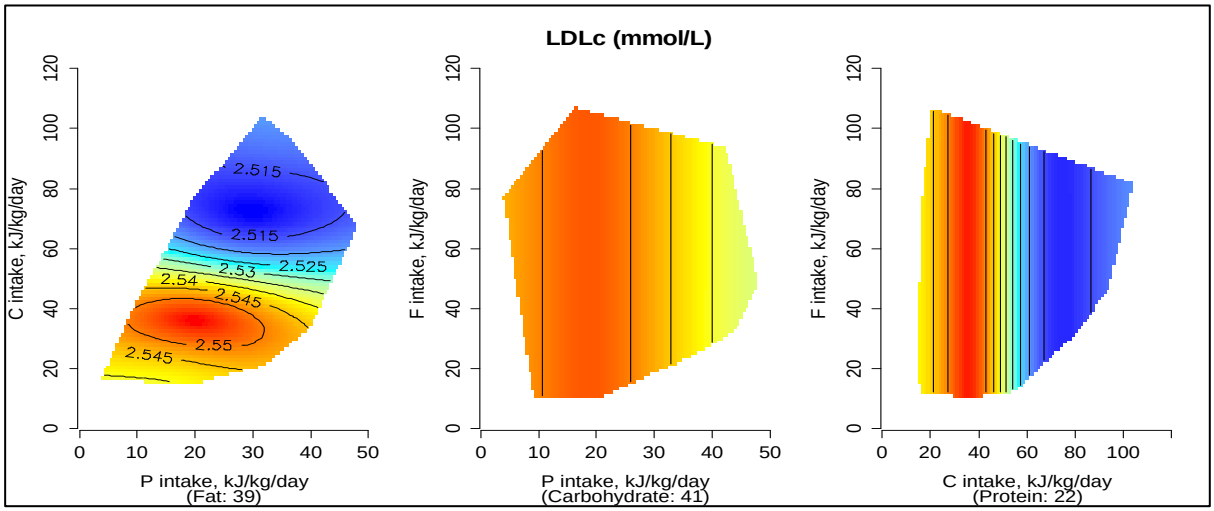
In the 621 participants for whom complete data on body weight, LDLc levels and macronutrients intake was available, LDLc levels ranged from 1.0 to 6.0 mmol/L (median=2.4 mmol/L). GAM results showed no statistically significant association between fasting LDLc levels and macronutrient intakes (**Table 6.14**), therefore no further investigation using multiple regression modelling was performed. GF graphs, however, suggested that participants who consumed between 30 and 45kJ/kg (1.8 and 2.6g/kg) of carbohydrate tended to have higher fasting LDLc levels (**Figure 6.9**).

Table 6.14 Coefficients from GAMs for LDLc (mmol/L) of 621 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	0.92
Carbohydrate	0.000	8	0.000	0.45
Total fat	0.000	8	0.000	0.96
Protein, Carbohydrate	0.392	3	0.178	0.25
Protein, Total fat	0.000	3	0.000	0.85
Carbohydrate, Total fat	0.000	3	0.000	1.00
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.99

GAMs, generalised additive models; LDLc, low-density lipoprotein cholesterol; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.8 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and fasting LDLc (mmol/L) in 621 participants



LDLc, low-density lipoprotein cholesterol; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

c) High-density lipoprotein cholesterol (HDLc)

HDLc levels ranged from 0.5 to 3.3mmol/L (median=1.4) in the 631 participants who had complete data on body weight, fasting HDLc levels and macronutrient intakes. GAM results showed a significant association between protein intake and fasting HDLc levels, as well as between the ratio of all macronutrients and fasting HDLc levels (**Table 6.15**). GF graphs indicated that highest fasting HDLc levels were found in subjects consuming high amounts of protein coupled with high carbohydrate intake (**Figure 6.10)**.

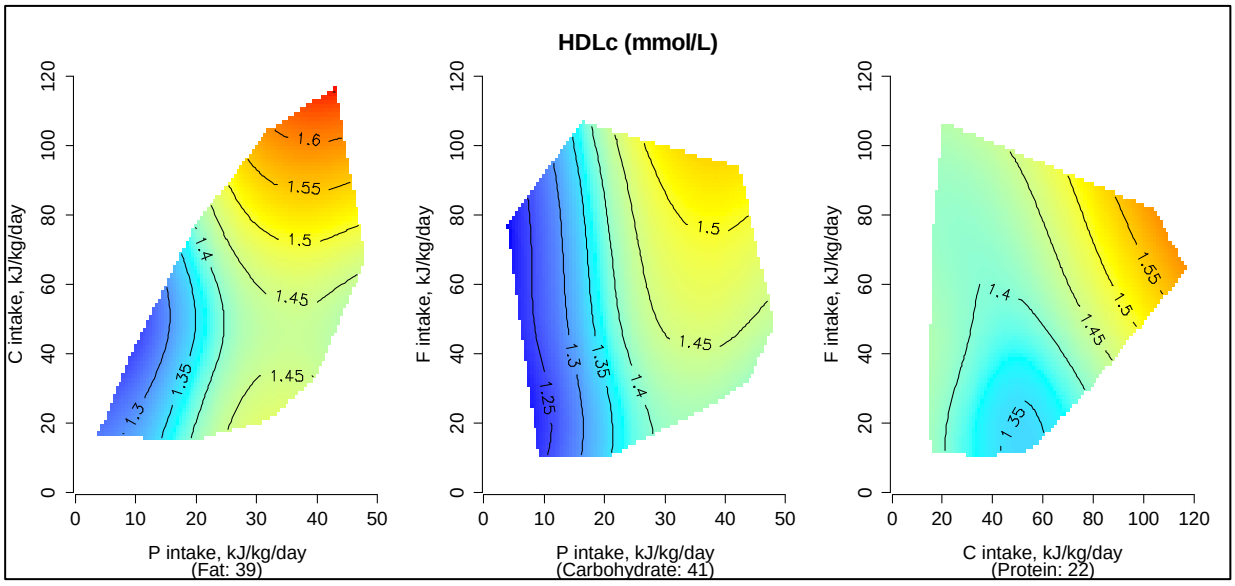
The relationships between fasting HDLc levels and protein was linear, therefore protein was entered into the regression model in its continuous form. After adjustment for age, physical activity level, number of morbidities, marital status, income, education, frailty status, carbohydrate and fat intake in a multiple regression model, the association between fasting HDLc levels and protein intake and the ratio of all macronutrients (P*C*F) were no longer statistically significant (**Table 6.16)**.

Table 6.15 Coefficients from GAMs for HDLc (mmol/L) of 631 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.816	8	1.518	0.003
Carbohydrate	0.000	8	0.000	0.55
Total fat	0.000	8	0.000	0.45
Protein, Carbohydrate	0.000	3	0.000	0.83
Protein, Total fat	0.168	3	0.060	0.28
Carbohydrate, Total fat	0.848	3	0.548	0.11
Protein, Carbohydrate, Total fat	0.755	10	0.308	0.01

GAMs, generalised additive models; HDLc, high-density lipoprotein cholesterol; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.9 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and fasting HDLc (mmol/L) in 631 participants



HDLc, high-density lipoprotein cholesterol; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.16 Multiple linear regression analyses of the association between HDLc*, protein and ratio of all macronutrients of 626 participants

Dietary variable	Parameter	95% CI		p value†
Protein (kJ/kg)	0.006	-0.0003	0.008	0.07
P:C:F	0.00	0.000	0.000	0.26

HDLc, high-density lipoprotein cholesterol; P:C:F, ratio of protein, carbohydrate and fat, *Log-transformed; † Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status; ‡ Also adjusted for protein (kJ/kg), carbohydrate (kJ/kg), fat (kJ/kg); macronutrient and ratio of macronutrients and their association with HDL-c were investigated in separate models.

d) Triglycerides

Fasting triglycerides levels ranged from 0.3 to 5.9mmol/L (median=1.1mmol/L) in the 631 participants who had complete data on body weight, fasting triglycerides levels and macronutrient intakes. GAM results showed that protein intake was significantly associated with blood triglycerides (p=0.01, **Table 6.17)**, rising progressively as protein intake declined (**Figure 6.11**).

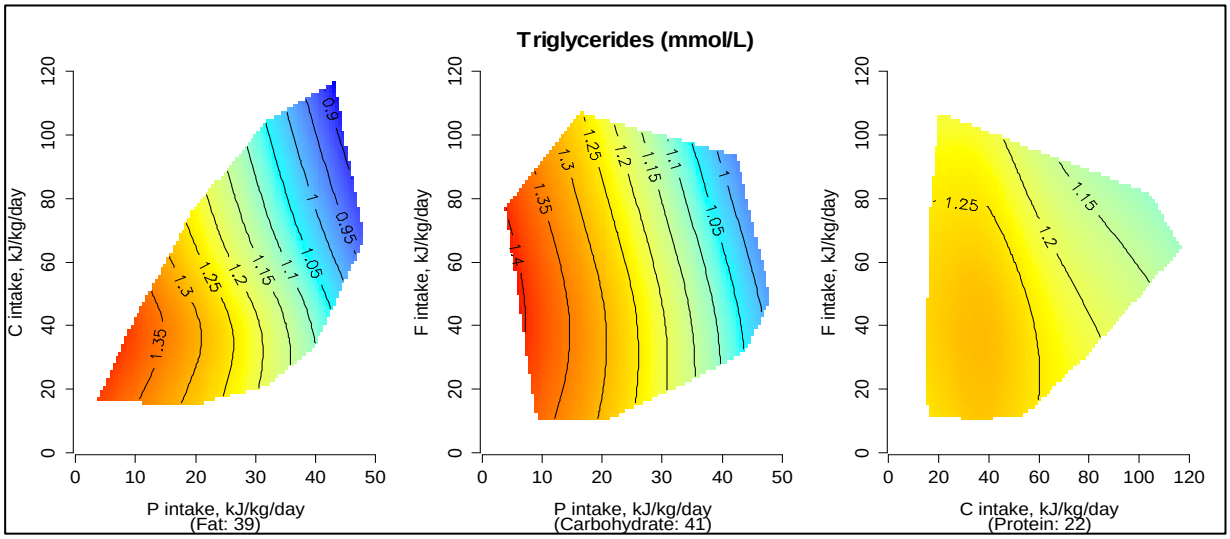
The relationships between fasting triglycerides levels and protein was linear, therefore protein was entered into the regression model in its continuous form. After adjustment for age, physical activity level, number of morbidities, marital status, income, education, frailty status, carbohydrate, total fat and alcohol intake in a multiple regression model, the association between fasting triglycerides levels and protein intake was very close to statistical significance (p=0.06, **Table 6.18)**. The relationship between the ratio of all macronutrients (P*C*F) and fasting triglycerides levels were no longer statistically significant after adjustment for protein (kJ/kg), carbohydrate (kJ/kg), fat (kJ/kg), alcohol (g/kg), age, physical activity level, number of morbidities, marital status, income, education and frailty status.

Table 6.17 Coefficients from GAMs for triglycerides (mmol/L) of 631 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.854	8	0.694	0.01
Carbohydrate	0.001	8	0.000	0.31
Total fat	0.000	8	0.000	0.96
Protein, Carbohydrate	0.426	3	0.191	0.22
Protein, Total fat	0.000	3	0.000	0.77
Carbohydrate, Total fat	0.000	3	0.000	0.54
Protein, Carbohydrate, Total fat	0.601	10	0.151	0.09

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.10 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and fasting triglycerides (mmol/L) in 631 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.18 Multiple linear regression analysis of the association between triglycerides* and protein intake of 626 participants

Dietary variable	Parameter	95% CI		p-value†
Protein (kJ/kg)	-0.006	-0.0130	-0.0002	0.06
P:C:F ‡	0.000	0.0000	0.0000	0.71

Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education, frailty status, carbohydrate (kJ/kg) and alcohol (g/kg); ‡Also adjusted for protein (kJ/kg), carbohydrate (kJ/kg), fat (kJ/kg); macronutrient and ratio of macronutrients and their association with triglycerides were investigated in separate models.

6.3.4 Mental and general health

a) Multi-morbidity

Multi-morbidity (2 or more morbidities) was present in 72% (536/748) of participants with complete data on body weight, number of morbidities and macronutrient intakes. GAM results showed no statistically significant association between number of morbidities and macronutrient intake (**Table 6.19**). However, GF results suggest a tendency for higher number of morbidities in participants who consumed ≤10kJ/kg (0.6g/kg) of protein (**Figure 6.12**).

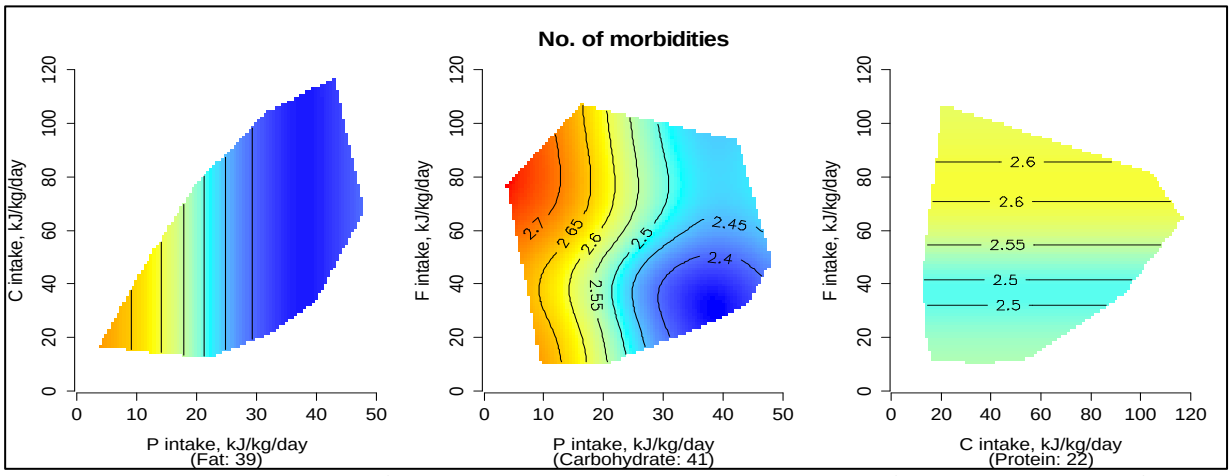
As GAM results showed that the association between protein intake and number of morbidities was close to statistical significance (p=0.07, **Table 6.20**), multiple regression analyses was carried out to further investigate this finding. The relationship between protein intake and number of morbidities was nonlinear; therefore, protein intake was entered in the regression model as quintiles. After adjustment for age, physical activity level, marital status, income, education and frailty status, this association remained non-statistically significant (**Table 6.22**).

Table 6.19 Coefficients from GAMs for number of morbidities of 748 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.903	8	0.287	0.07
Carbohydrate	0.000	8	0.000	0.91
Total fat	0.000	8	0.000	0.81
Protein, Carbohydrate	0.000	3	0.000	0.50
Protein, Total fat	0.555	3	0.274	0.21
Carbohydrate, Total fat	0.000	3	0.000	0.71
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.99

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.11 Response surfaces showing the relationship between macronutrient intake (kJ/kg) and number of morbidities in 748 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.20 Multiple linear regression analysis of the association between number of morbidities*† and protein intake of 743 participants

Dietary variable	Parameter	95% CI		p value‡
Protein quintiles				
Q1 (<16.6kJ/kg) (reference)	-	-	-	-
Q2 (16.6 to 19.9kJ/kg)	-0.266	-0.642	0.110	0.16
Q3 (20.0 to 23.4kJ/kg)	-0.022	-0.395	0.351	0.91
Q4 (23.5 to 28.1kJ/kg)	-0.291	-0.669	0.086	0.13
Q5 (≥28.2kJ/)	-0.306	-0.679	0.067	0.11

Q, quintile; *Log-transformed; †Zero values were changed to 0.01 before log-transformation; ‡Derived by multiple linear regression analyses, adjusted for age, physical activity level, marital status, income, education and frailty status

b) Short-form 12 - Mental Health Composite Scale (SF12-MCS)

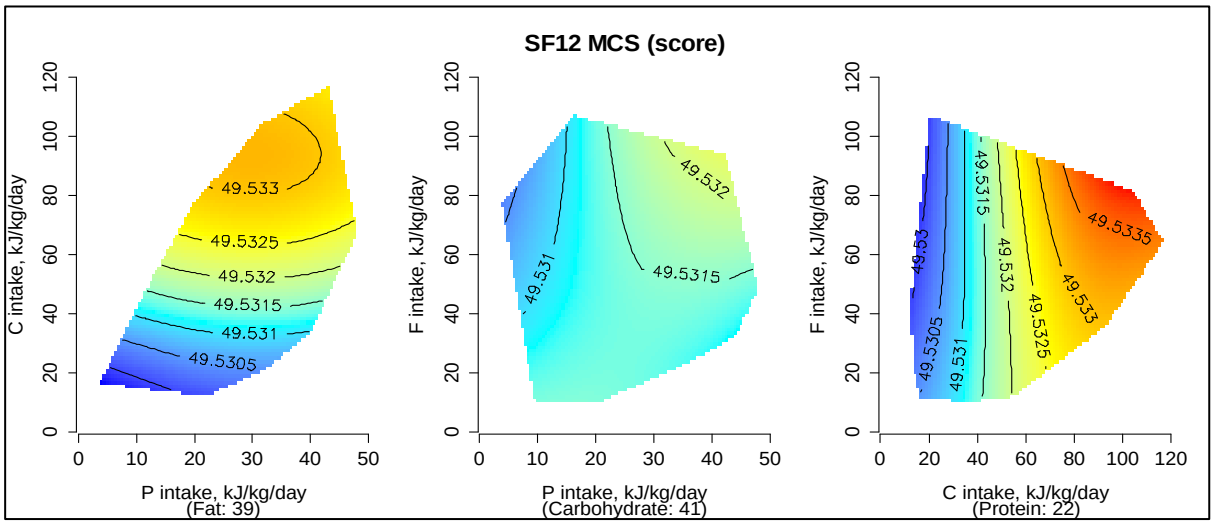
SF12-MCS scores ranged from 22.2 to 63.5 (median=51) in participants with complete data on body weight, SF12-MCS scores and macronutrient intakes (n=747). GAM results showed no significant association between macronutrient intakes and SF12-MCS scores (**Table 6.21)**. However, GF graphs indicated a tendency to higher SF12-MCS scores in participants who consumed ≥80kJ/kg (4.7g/kg) of carbohydrate (**Figure 6.13**).

Table 6.21 Coefficients from GAMs for SF12-MSC of 747 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.001	8	0.000	0.67
Carbohydrate	0.003	8	0.000	0.38
Total fat	0.000	8	0.000	1.00
Protein, Carbohydrate	0.000	3	0.000	0.60
Protein, Total fat	0.000	3	0.000	0.95
Carbohydrate, Total fat	0.000	3	0.000	0.87
Protein, Carbohydrate, Total fat	0.002	10	0.000	0.45

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.12 Response surfaces showing the relationship between macronutrient intake (kJ/kg) and SF12-MCS in 747 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

c) Short-form 12 - Physical Health Composite Scale (SF12-PCS)

SF12-PCS scores ranged from 15 to 65 (median=50) in the 747 participants who had complete data on body weight, SF12-PCS scores and macronutrient intakes. GAM results showed that protein was significantly associated with SF12-PCS scores (p=0.05, **Table 6.22)**. The relationship was quadratic (as indicated by an EDF value approaching 2), and as indicated in the GF graphs, participants who consumed between 22 and 32kJ/kg (1.3 to 1.9g/kg) of protein a day had the highest SF12-PCS scores i.e. better physical health, with values falling at both higher and lower protein intakes (**Figure 6.14**).

The relationship between protein and SF12-PCS scores was nonlinear; therefore, protein was entered in the regression model as quintiles. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status in a multiple regression model the association between SF12-PCS scores and protein intake was no longer

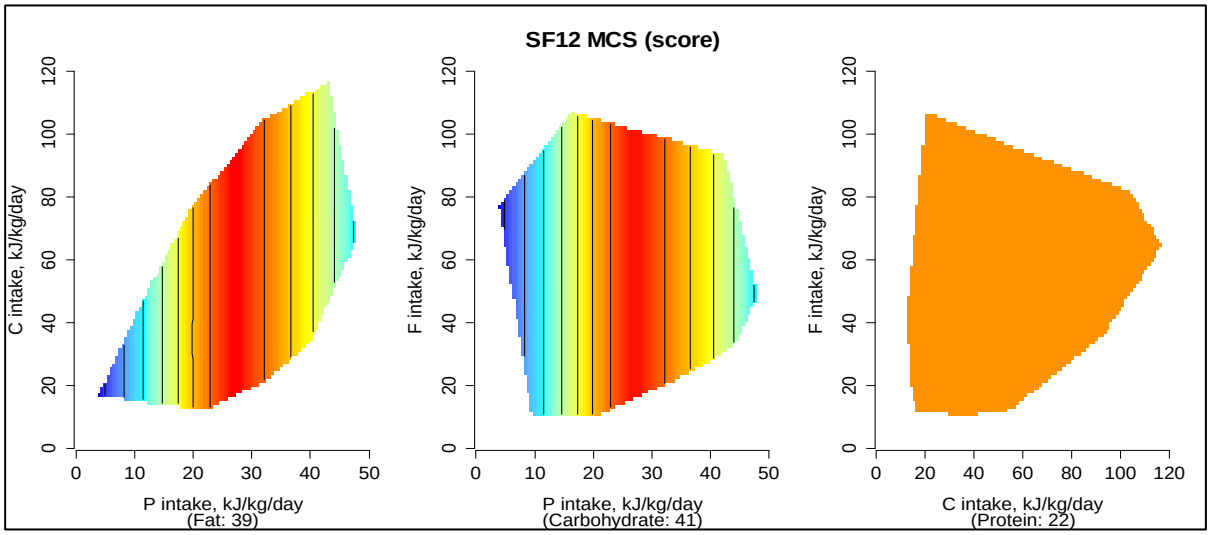
statistically significant, however Q3 (20.0 to 23.4kJ/kg) was very close to statistical significance (**Table 6.23**).

Table 6.22 Coefficients from GAMs for SF12-PSC of 747 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.684	8	0.594	0.05
Carbohydrate	0.001	8	0.000	0.78
Total fat	0.000	8	0.000	1.00
Protein, Carbohydrate	0.001	3	0.000	0.79
Protein, Total fat	0.000	3	0.000	0.73
Carbohydrate, Total fat	0.000	3	0.000	0.59
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.87

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.13 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and SF12-PCS in 747 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Table 6.23 Multiple linear regression analysis of the association between SF12-PSC* and protein intake of 742 participants

Dietary variable	Parameter	95% CI		p value*
Protein quintiles				
Q1 (<16.6kJ/kg) (reference)	-	-	-	-
Q2 (16.6 to 19.9kJ/kg)	-0.020	-0.069	0.029	0.42
Q3 (20.0 to 23.4kJ/kg)	0.047	-0.002	0.096	0.06
Q4 (23.5 to 28.1kJ/kg)	0.020	-0.029	-0.070	0.42
Q5 (≥28.2kJ/)	-0.007	-0.042	0.056	0.79

*Log-transformed; †Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status

d) Geriatric Depression Score (GDS)

The median GDS score was 2 in participants with complete data on body weight, GDS scores and macronutrient intakes (n=747); 12% (89/747) of participants were classified as depressed (GDS score ≥5). GAM results showed no statistically significant association between GDS scores and macronutrient intakes (**Table 6.24**); however, GF graphs showed that participants who consumed very low protein intakes tended to have the highest GDS scores i.e. more depressive symptoms (**Figure 6.15**).

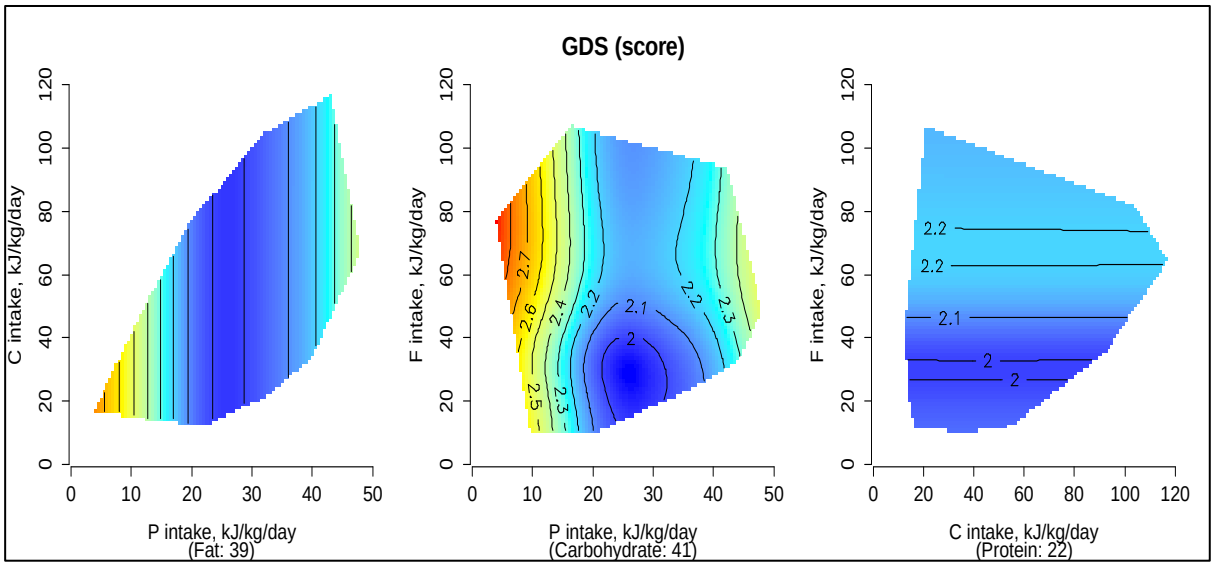
Multiple regression analyses was carried out to further investigate the association between protein intake and GDS as GAM results showed that this association was close to statistical significance (p=0.07, **Table 6.24**). The association between protein intake and GDS scores was nonlinear; therefore, protein intake was entered in the regression model as quintiles. After adjustment for age, physical activity level, number of morbidities, marital status, income, education and frailty status, this association remained non-statistically significant (**Table 6.25**).

Table 6.24 Coefficients from GAMs for GDS of 747 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.566	8	0.468	0.07
Carbohydrate	0.000	8	0.000	0.71
Total fat	0.012	8	0.001	0.25
Protein, Carbohydrate	0.000	3	0.000	1.00
Protein, Total fat	0.689	3	0.405	0.16
Carbohydrate, Total fat	0.000	3	0.000	0.65
Protein, Carbohydrate, Total fat	0.002	10	0.000	0.36

GDS, Geriatric Depression Scale; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6.14 Response surfaces showing the relationship between macronutrient intake (kJ/kg) and GDS scores in 747 participants



GDS, geriatric depression scale; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day; participants with scores of ≥5 are classified as depressed.

Table 6.25 Multiple linear regression analysis of the association between fasting GDS scores*† and protein intake of 747 participants

Dietary variable	Parameter	95% CI		p value‡
Protein quintiles				
Q1 (<16.6kJ/kg) (reference)	-	-	-	-
Q2 (16.6 to 19.9kJ/kg)	0.21	-0.314	0.728	0.44
Q3 (20.0 to 23.4kJ/kg)	-0.27	-0.793	0.243	0.30
Q4 (23.5 to 28.1kJ/kg)	-0.03	-0.558	0.490	0.90
Q5 (≥28.2kJ/)	-0.14	-0.659	0.376	0.59

Q, quintile; *Log-transformed; †Zero values were changed to 0.01 before log-transformation; ‡Derived by multiple linear regression analyses, adjusted for age, physical activity level, number of morbidities, marital status, income, education and frailty status

6.35 Frailty score

The median frailty score was 1 in the 701 participants with complete data on grip strength, physical activity level, walking speed, weight loss, body weight, frailty scores and macronutrient intake. A total of 7% (51) of the participants were frail (frailty score ≥3); 12% (82) had lost more than 15% of their heaviest weight; 15% (103) had slow walking speed; 21% (148) had a low physical activity level; 38% (265) had weak grip strength; and none (687, 5 missing) of the participants were classified as exhausted. GAM results showed that protein (p=0.05, **Table 6.26**) and the ratio of protein to fat (P:F) (p=0.03, **Table 6.26**) were associated with frailty scores. GF graphs showed strikingly that participants who consumed 20kJ/kg of protein while consuming 50kJ/kg of fat had the lowest frailty scores (robust), with this region forming a bull's eye on the surface plot, and frailty scores rising in any direction of intake away from this region (**Figure 6.16**).

The relationship between protein and frailty scores was nonlinear; therefore, protein was entered in the regression model as quintiles. Frailty score is a ordinal variable and was not log-transformed even though it had a skewed distribution. After adjustment for age, number

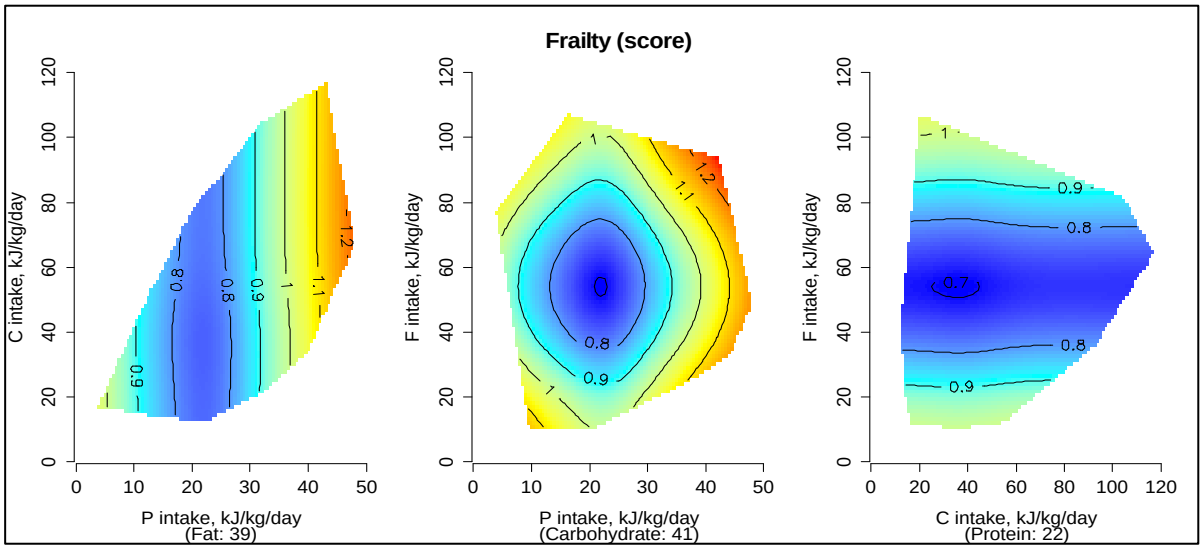
of morbidities, marital status, income and education in a multiple regression model, the association between frailty scores and protein intake was only statistically significant in Q3 (20.0 to 23.4kJ/kg; β=-0.232, CI=-0.432 to -0.032, p=0.02, **Table 6.27**) meaning that, as long as the other variables were kept constant, a reduction of 0.2 in the frailty score would be expected when protein intake went from Q1 (≤16.5kJ/kg) to Q3 (20.0 to 23.4kJ/kg).

Table 6.26 Coefficients from GAMs for frailty scores of 701 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.772	8	0.555	0.05
Carbohydrate	0.000	8	0.000	0.87
Total fat	0.001	8	0.000	0.28
Protein, Carbohydrate	0.168	3	0.062	0.30
Protein, Total fat	1.615	3	1.734	0.03
Carbohydrate, Total fat	0.003	3	0.001	0.25
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.41

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom;

Figure 6.15 Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and frailty scores in 701 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day; frailty score used for frailty classification: scores ≥3 classified as frail, 1-2 as pre-frail and 0 as robust (163)

Table 6.27 Multiple linear regression analysis of the association between frailty score and protein intake of 697 participants

Dietary variable	Parameter	95% CI		p value*
Protein quintiles				
Q1 (<16.6kJ/kg) (reference)	-	-	-	-
Q2 (16.6 to 19.9kJ/kg)	-0.110	-0.314	0.094	0.29
Q3 (20.0 to 23.4kJ/kg)	-0.232	-0.432	-0.032	0.02
Q4 (23.5 to 28.1kJ/kg)	-0.172	-0.379	0.034	0.10
Q5 (≥28.2kJ/)	0.048	-0.153	0.248	0.64
P:F	0.0001	-0.0005	0.0006	0.75

P:F, protein to fat ratio; Q, quintile; *Derived by multiple linear regression analyses, adjusted for age, number of morbidities, marital status, income and education; Frailty score and protein intake, and frailty score and protein to fat ratio associations were investigated in two separate models.

6.4 Discussion

Key findings

Table 6.28 summarises the associations that were found between macronutrient intakes and energy intake and health outcomes after adjustment for different confounding factors.

Out of all the macronutrients studied, protein stood out because of its association with most health outcomes (**Table 6.28**). Low protein intake was associated with higher total energy intake, higher BMI, higher percentage body fat, higher waist-to-hip ratios, higher insulin levels, and higher HOMA-IR. High protein intake was associated with higher HDLc and triglycerides levels. However, previous research has shown that a low protein intake was associated with longevity and better health outcomes in both humans (171) and animal models (39). Source of protein has also been shown to influence health outcomes such as bone and body composition (172, 173), body weight and cardiovascular health (174, 175). Similarly, the distribution of protein intake throughout the day has also been associated with

outcomes relevant to older individuals such as frailty (176). Furthermore, the impact of protein intake has been shown to be different in different age groups where older individuals may have difficulties in obtaining sufficient protein due to cost of nutrient dense foods, intolerance to certain food groups or difficulty chewing fibrous foods which in return may compromise their functional capacity and immune system (177).

Table 6.28 Summary of results showing associations between macronutrient intakes and energy intake and health outcomes after adjustment for confounders

	Macronutrients						
Energy intake and health outcomes	**P**	**C**	**F**	**P:C**	**P:F**	**C:F**	**P:C:F**
↑ Total energy	↓	↔	↑	-	-	-	-
↑ BMI	↓	↓	-	-	-	-	-
↑ Body fat (%)	↓	↓	-	-	-	-	↓
↑ W-H ratio	↓	↓	-	-	-	**↓C↑F**	-
↑ Insulin	↓	-	-	-	-	-	-
↑ HOMA-IR	↓	-	-	-	-	-	-
↑ Cholesterol	-	-	-	-	-	-	-
↑ LDL-c	-	-	-	-	-	-	-
↑ HDL-c	↑	-	-	-	-	-	**↑P↑C↔F**
↑ Triglycerides	↑	-	-	-	-	-	-
No. of medical conditions	-	-	-	-	-	-	-
↑ SF12-MCS	-	-	-	-	-	-	-
↑ SF12-PCS	↔	-	-	-	-	-	-
GDS	-	-	-	-	-	-	-
↓ Frailty score	↔	-	-	-	-	-	**↔P↔F**

↓=low intake, ↔= medium intake, ↑= high intake, - = no association found; associations found with GAM but no longer significant after adjustment for confounders are presented in grey colour; P, protein; C, carbohydrate; F, fat; P:C protein to carbohydrate ratio; P:F, protein to fat ratio; C:F, carbohydrate to fat ratio; P:C:F, ratio of protein, carbohydrate and fat; BMI, body mass index; W-H ratio, waist-to-hip ratio; HOMA-IR, Homeostasis Model Assessment-Insulin Resistance; LDLc, low density lipoprotein cholesterol, HDLc, High density lipoprotein cholesterol; SF12-MCS, 12-Item Short Form Health Survey - Mental Health Composite Scores, SF12-PCS, 12-Item Short Form Health Survey - Physical Health Composite Scores; GDS, Geriatric Depression Scale.

Protein leverage

Results from the current study show that low protein intake (%E) is associated with higher total energy intake, a phenomenon known as protein leverage (53). As discussed in detail in Chapter 1, protein leverage is the physiological and behavioural response that occurs when a protein target (individual protein requirement) is not reached. As a result of low protein intake

(%E), individuals tend to increase their food intake in an attempt to reach their protein goal, but also over-ingest fats, carbohydrate and total energy in the process (53). This increase in overall intake may lead to weight gain and obesity which in turn increases the risk of a number of adverse health outcomes such as cardiovascular diseases, diabetes and cancer (178).

To date there has been no other studies investigating protein leverage in community-dwelling older men. However, one population-based study investigated protein leverage in women (n=2031 (median age 28.5 years [1983] and 48 years [2005]) from the Cebu Longitudinal Health and Nutrition Survey (CLHNS) and found that calorie consumption derived from protein during a period of more than 20 years (from 1983 to 2005) stayed more constant than the energy consumption derived from carbohydrate or fat, regardless of absolute intake of individual macronutrient (62). This is consistent with the existence of personal protein targets (53).

Gosby et al conducted a randomised controlled experimental study involving subjects (n=26) aged 18 to 51 years (54). For four days, these subjects were provided with *ad libitum* food containing 10%, 15% or 25% of energy derived from protein. The study found a statistically significant increase in overall energy intake through snacking between meals when percentage of protein dropped from 15% to 10% (54). Participants in this study tended to prefer savoury snacks over sweet ones, which, as suggested by the author, could also be a protein leverage response, given that protein-rich foods are more likely to be savoury-flavoured. Unfortunately, the effect of fat on protein leverage and energy intake was not investigated in this study as the proportion of fat in all diets was kept constant at 30% (54).

Humans' prioritisation of protein was shown by *Gosby et al* in a review of 38 publications of experimental studies measuring *ad libitum* intake of subjects (aged 17 to 80 years) consuming diets varying in macronutrient composition: as the proportion of dietary protein decreased from 20% to 10%, total energy intake tended to increase considerably. In the same review, it was also found that carbohydrate feedbacks were slightly more evident than those of fat, which suggests that carbohydrate is better regulated than fat (47).

In an experiment involving 858 mice fed *ad libitum* over a lifetime on one of 25 diets differing in macronutrient content, regulatory feeding effects were evident for protein and, to a less extent, for carbohydrate but not for fat (39). High-protein-low-carbohydrate intake was associated with low food intake and adiposity, poor metabolic heath and diminished lifespan, whereas low-protein-high-carbohydrate intake increased food intake and adiposity, improved metabolic health and prolonged lifespan (39). In a similar experiment involving mated female flies fed *ad libitum* on one of 28 diets (differing in carbohydrate and protein content), flies lived longer on low protein diet but produced more eggs on a high protein diet. These studies illustrate that, in animal models, priority is given to one nutrient over others accordingly to its physiological requirement for a particular stage of life (48).

In younger adults, protein foods are commonly interchanged with carbohydrate (179); however, we found that CHAMP participants tended to increase the proportion of fat in their diet when the proportion of energy derived from protein was low, and since fat contains more than double the energy found in carbohydrate, and is the least satiating macronutrient (180), these individuals were more likely to have a high energy intake. One potential reason for this increase in the proportion of fat in the diet could be related to the savoury characteristics

shared between protein-rich and fat-rich foods which could indicate a behavioural response to low protein intake i.e. seeking protein in fat-rich food.

As in animal models, humans may also have different physiological priorities at different stages of their lives. For instance, protein demand may increase with age due to factors such as changes in metabolism, hormone levels and immunity, as well as frailty progression (181). Increased incidence of medical conditions experienced in older age (181), combined with inadequate intake and reduced ability to use available protein, may also affect protein requirements of older adults (182).

Altogether, studies have found that prioritisation of protein - or protein leverage - occurs in both humans (47, 61, 62) and animals (41, 55-60). Similarly, CHAMP participants regulated their protein and - to a certain extent - their carbohydrate, however, when seeking protein, these men over-consume fat (as percentage of energy in the diet) and increased their overall energy intake. It is also worth noting that, contrary to the above mentioned studies, CHAMP is a population-based epidemiological study involving exclusively community-dwelling older people whose dietary intakes have not been manipulated in any form prior to dietary data collection. Furthermore, the dietary assessment method used in CHAMP (i.e. DHQ) captured food variety, composition, timing and volume because of its open nature. Therefore, while we cannot draw any final conclusions from our study, the results suggest that in a free-living environment, older healthy men will prioritise protein over other macronutrients.

Body composition and dietary intake

In this thesis, the relationship between macronutrient intake and three widely used measures of body composition (namely BMI, percentage body fat and waist-to-hip ratio) were investigated. The association between macronutrient intake and these measures were consistent with each other: low protein and low carbohydrate intakes were associated with increased adiposity; however, we acknowledge that given that data of this is a cross-sectional study, the directions of association cannot be determined.

Amongst the many methods used to measure adiposity, BMI is one of the most commonly used because of its practicality; it uses individuals' weight and height to determine their weight status (183). The World Health Organisation (WHO) classifies adults aged 18 and older as overweight if their BMI is ≥25-29.9kg/m^2 and obese if their BMI ≥30kg/m^2 (183), however, these classifications do not differ by age (183).

Consensus has not been reached with regards to BMI classification for older individuals (65 years and older) as studies have presented conflicting findings; table 6.29 summarises studies that have investigated the association between BMI and morbidity and/or mortality risk in older individuals. For example, a recent meta-analysis involving 60000 individuals (mean age 63.2) showed that higher BMI in older age has a protective effect against all types of fractures in older age (184); on the other hand, a study involving 2917 individuals aged 70 years or over showed that higher BMI and higher body fat may be associated with increased risk of mobility-related functional limitations in older age (185). Therefore, there is some indication that higher adiposity may be protective against mortality in older age, but being overweight or obese may have a negative impact on the quality of life of older adults. Additionally, an

inverse relationship between lean mass and mortality risk has been found in older age (186, 187) possibly because lean mass may act as a nutritional reserve during prolonged periods of illness and disease commonly experienced in older age (188).

A recent meta-analysis investigating the relationship between BMI and all causes of mortality in older individuals (65 years and over) involved 32 studies and 197,940 individuals, and found that higher BMI was not associated with increased mortality risk in older individuals, instead, lower BMI (<23kg/m^2) was concerning as it increased their mortality risk (146). These was consistent with a number of studies that found that overweight BMI range was associated with lower risk of mortality (188, 189).

Table 6.29 Studies that have investigated the association between BMI and mortality in older individuals

Author, year	Participants, location	Aims	Results
Meta-analysis and reviews			
De Laet et al, 2005 (184)	60000 men and women from 12 prospective population-based cohorts, mean overall age 63.2 years	Explore the relationship between BMI and fracture risk (any fracture, any osteoporotic fracture and hip fracture alone)	Low BMI associated with increased risk of all fractures independent of age and sex, but dependent on bone mineral density; high BMI had a protective effect on fracture risk
Flegal et al, 2013 (189)	97 articles were identified through systematic search procedures with a combined sample >2.88 million individuals and >270 000 deaths.	To systematically review reported hazard of all cause mortality for overweight and obesity relative to normal weight in the general population	Relative to normal weight, both obesity (all grades) and grades 2 and 3 obesity were associated with significantly higher all-cause mortality
Janssen, Mark, 2007 (188)	Finding of 32 observational studies were included in this review and meta-analysis where participants were 65 years or older.	To perform a systematic review and meta-analysis of the studies and examine the impact of BMI on mortality risk in individuals aged ≥65 years	BMI in the overweight range was not associated with increased risk of mortality; BMI in the moderately obese range only associated with modest increase in mortality risk regardless of sex, disease status and smoking status.
Winter, 2014 (146)	32 prospective cohort studies in community-dwelling adults aged 65 and over (n=197,940)	To determine all-cause mortality risk associated with BMI in those aged 65 year or older living in the community.	Mortality risk was increased in those at the lower end of recommended BMI (<23kg/m^2) but not for those who were Overweight.
Dietary survey			
Davison et al, 2002 (185)	2917 individuals (1566 women and 1,391 men) aged 70 and older in the United States.	Investigate the association between functional limitations and body composition indices (% body fat, muscle mass and BMI)	Functional limitations associated with increased body fat and BMI (BMI<18.5 and ≥30 kg/m^2 for women and a BMI ≥to 35 kg/m^2 for men associated with approximately twice the likelihood of functional limitations) but not with sarcopenia alone or sarcopenic-obesity.

BMI, body mass index;

The results from this thesis suggest that a diet low in carbohydrate and protein and high in fat is associated with higher waist-to-hip ratios. It is likely that abdominal obesity (as measured by waist-to-hip ratio) was a result of protein leverage (47, 53) since low protein was associated with overall increase in energy intake via fat (that provide more than double of energy of carbohydrate and protein - 37kJ vs 17kJ) when carbohydrate intakes were also low.

A number of studies have shown that high protein intakes increase satiation, increase thermogenesis and maintain or increase fat-free mass compared with low protein intakes (190, 191). The findings on high protein intake are conflicting; for example, some studies have shown that high protein intake is linked to better weight management (192, 193), however high protein intake has also been linked to weight gain and increased risk of overweight and obesity (194).

In a meta-regression involving 87 human studies (165 intervention groups) investigating the effect of protein and carbohydrate intake on body mass and body composition (fat-free mass, percentage body fat and fat mass) during energy restriction, it was found that protein intakes of 1.06g/kg to 1.20g/kg were associated with greater loss of body fat percentage (195). The same study found that lower carbohydrate intakes (35 – 41.4% of energy) were associated with greater loss of body mass and fat percentage even after controlling for energy intake (195).

Similarly, in a large population-based study involving 23,876 participants (aged ≥19 years) who completed a 24-h dietary recall in the dietary interview component of the NHANES, 2001–2010, higher-protein diets were associated with lower BMI and waist circumference,

however these effects of higher-protein diets seemed to be more evident in overweight individuals (BMI: 25.0–29.9 kg/m^2) than in normal weight (BMI: 18.5–24.9 kg/m^2) and obese individuals (BMI: >30 kg/m^2) (196).

However, in a population-based randomised trial involving 645 individuals (38% males; baseline age 52±9 years) investigating the effect of different diet compositions (low-fat-average-protein vs low-fat-high-protein vs high-fat-average-protein vs high-fat-high-protein) for two years, it was found that the diets were equally effective in promoting clinically meaningful weight loss and the maintenance of weight loss over the 2-year period (197).

Meanwhile, the results of the European Prospective Investigation into Cancer and Nutrition (EPIC) - a multi-centre, prospective cohort - showed an association between high protein intake and weight gain. In this study involving 373,803 subjects aged 25-70 years recruited from 10 European countries between 1992 and 2000, whose dietary data were obtained through self-administered quantitative dietary questionnaires, semi-quantitative food frequency questionnaires or interviewer-administered dietary questionnaires, it was observed that replacing carbohydrate (%E) with protein (%E) was associated with weight gain after 5 years. Among participants who were normal weight or overweight at baseline, the risk of becoming overweight or obese was increased by more than 20% for those consuming diets high in protein (>22%) compared to those who consumed a diet low protein (≤14%) (194).

In a study using data from the EPIC study, the association between the amount and type of dietary protein, and changes in weight and waist circumference were investigated (198). The study involved 89,432 participants from 5 countries (Denmark, Germany, Italy, Netherlands

and UK) who were followed up for a mean of 6.5 years and had their dietary data obtained through either country-specific food frequency questionnaires (FFQs) or standardized 24-h recall (used to minimize the differences between national FFQs and potential measurement error introduced by the FFQs). The results showed no association between higher overall protein intake and lower weight or waist gain was found, instead, that higher intake of animal protein was positively associated with long-term weight gain (45).

A number of reasons can be attributed to the differences between the above mentioned studies and our findings with regards to protein. Firstly, CHAMP participants were older than the participants involved in other studies. Secondly, with the exception of NHANES, other studies investigated changes in body composition measurements, whereas in the CHAMP study the association between macronutrient intake and body composition was investigated at one point in time. Finally, difference in dietary assessment methods may also affect these results since they are not exactly equivalent to one another and different bias and misreporting may be present depending on method applied to gather dietary data.

While protein intake appeared particularly important among CHAMP men, there were also an association between low carbohydrate intake and high body composition values. This is consistent with what was found in a recent review, where a number of studies showed an inverse relationship between carbohydrate consumption and BMI, body weight and percentage body fat (199). However, it is worth noting that factors such as quality and source of carbohydrate also play an important role in the relationship between carbohydrate consumption and body composition; for example, high fibre and wholegrain intake has been inversely associated with total energy intake and body weight (200-202).

As far as the association between fat intake and waist-to-hip ratio goes, the results from this thesis suggest that fat (%E) intake is dependent on carbohydrate (%E) intake i.e. when carbohydrate intake is low, fat intake increases and that results in an increase in waist-to-hip ratio. This is consistent with the results of a recent review that included 32 randomised controlled trials (~54,000 participants) and 30 sets of analyses of 25 cohorts where it was shown that decreases in fat intakes were associated with decreases in body weight, BMI and waist circumference (203).

Protein intake, insulin levels and insulin resistance

Low protein intake was associated with higher fasting insulin levels as well as HOMA-IR in CHAMP participants. Our results are not consistent with previous research which shows that higher protein intakes are associated with higher fasting insulin levels since dietary proteins stimulate insulin secretion (204). In the current study, low protein intakes were associated with higher overall energy intake, higher BMI, higher percentage body fat and higher waist-to-hip ratios, all of which are associated with insulin resistance and increased insulin levels (205, 206). Furthermore, low protein intakes were compensated with higher fat intakes, which has also been linked with insulin resistance (204). Further analysis of the relationship between unadjusted macronutrient (kJ) intake and fasting insulin levels (appendix F) indicated that higher fat intakes were associated with higher fasting insulin levels, regardless of body weight. Therefore, a possible mechanism to explain the association between low protein intake and higher fasting insulin levels is that low protein intake increased overall energy intake, particularly from fat, which in return increased adiposity and insulin levels.

HDLc and protein intake

HDLc is considered the "good" cholesterol due to its role in removing cholesterol from plaques and transporting it back to the liver for excretion or re-use. Replacement of saturated fats to mono- or poly-unsaturated fats, low to moderate consumption of alcohol and regular physical activity are examples of modifiable factors that may increase HDLc levels.

In the current study it was found that high intake of protein was associated with high levels of HDLc. Some of the commonly known factors associated with HDLc levels such as physical activity level, body weight and fat intake were included in the multiple regression analysis performed to investigate the association between protein intake and HDLc levels, however, the association remained significant, indicating that the association is not confounded by any of these factors.

Pasiakos et al also found an association between high-protein intake and high HDLc levels in a study of 23,876 adults aged ≥19 years who took part in the NHANES 2001-2010. As part of their analyses, the authors included multiple physiological factors, total energy, carbohydrate and fat intake, and concluded that it may be the intrinsic properties of protein that affects HDLc levels (196).

However, in a randomised control trial involving 43 men aged 25 to 75 years of age, no difference in HDLc levels were found between low (0.8g/kg/day or ~15% of energy from protein) and high protein intake (1.4g/kg/day or ~25% of energy from protein) after 12 weeks (207).

Triglycerides and protein intake

About 95% of dietary and body fats are in the form of triglycerides (TGs) (208). Once digested, TGs are used as a source of energy or stored in adipose tissues and used as the primary source of energy when food intake is limited (208, 209).

In this thesis it was found that high protein intake was associated with higher fasting blood triglycerides, even after adjustment for weight, dietary intake of total fat, carbohydrate and alcohol as well as a number of health, demographic and lifestyle factors. It was also observed that individuals consuming high amounts of protein had a lower overall energy intake, which may have triggered the release of triglycerides to be used as a source of energy. Also likely is the possibility that the elevated protein intake may have prompted an increase in gluconeogenesis - a process in which amino acid carbons are diverted to triglycerides production. Triglyceride production outcompetes gluconeogenesis when carbohydrate is high (210), and given that CHAMP participants did not have a particularly high carbohydrate intake, it is likely that the high amino acid availability (through high protein intake) increased triglycerides production.

On the other hand, the OmniHeart trial, an American study involving 164 individuals aged 30 years or older (mean=53.6) , found that a diet high in protein (25% of total energy) substantially reduced serum triglycerides compared to a diet high in carbohydrate (58% of energy) or high in unsaturated fat (37% of total energy), with some suggestions that protein have a direct reducing effect on triglycerides (211). This study involved a much younger sample than CHAMP, and this may explain, at least in part, the differences between studies, given that older adults are more likely to have a reduced energy intake (17, 19, 212).

Another important factor to be considered when interpreting findings related to protein intake and triglyceride levels is the source of protein. For example, in OmniHeart trial, half the protein in the 'high-protein diet' came from plant sources (211), which has been shown to be associated with a decrease in serum triglycerides (175). Other factors such as vegetable, fruit and grain intake as well as dietary fibre content may also play a role in reducing blood triglycerides (213).

Total and LDL cholesterol and dietary intake

Increased serum lipids are a significant risk factor for cardiovascular diseases (214) and increased intake of fat, in particular saturated fat, is associated with hyperlipidaemia (215). In the current research no association was found between any macronutrient intake and total or LDL cholesterol. Further research is required to determine the influence of different types of fat on blood lipids levels (which goes beyond the scope of this thesis which was to investigate the associations between the main macro-nutrient [protein, fat and carbohydrate] intake and health outcomes).

Mental health and dietary intake

In the current study, although not statistically significant, there was some indication that low protein intake was associated with higher GDS scores. There was no association between GDS scores and carbohydrate or fat intakes. Studies have shown that both fat (more specifically Omega 3 polyunsaturated fatty acids [n3-PUFA]) (216, 217) and protein intakes (more specifically tryptophan amino acid) (218, 219) are associated with depression in humans. The mechanism by which protein intake may affect mood and behaviour is believed to be related to brain tryptophan concentration - a precursor of serotonin- and large neutral

amino acids (LNAAs) (220). PUFAs are important components of neuronal cell membrane that, with some exception, can only be obtained through diet. Alteration in PUFA composition can affect membrane microstructure, affect signal transduction and immunologic dysregulation, and may increase the risk of depression (221).

The literature investigating the association between protein intake and depressive symptoms in older subjects is scarce. One study involving 1,947 men and 2,909 women aged 25–74 years who participated in the National Health and Nutrition Examination Follow-Up Study (NHANES I) found that men who had higher protein intake were less likely to present severe depressed mood (222).

Frailty and dietary intake

In the present research it was found that men with protein intakes between 1.2 and 1.4g/kg were less likely to be frail and protein intakes outside of these range was associated with frailty i.e. having dietary protein intakes below or above these ranges was associated with frailty.

Frailty, as defined by Fried and colleagues, is a syndrome that occurs in old age characterised by slowness, exhaustion, low physical activity and unintentional weight loss (163). As a consequence of frailty, older individuals are at higher risk of disability, falls, hospitalisation and death (163, 181). Frailty significantly increases with age; it is estimated that the prevalence of frailty in people aged 80-84 is 15.7%, whereas for those aged 85 and over it is estimated that 26.1% are frail (223).

Inadequate dietary intake is an important factor that may lead to frailty (224), however, dietary intake per se is not a component of Fried and colleagues definition of frailty (163). Instead, they used unintentional weight loss as a proxy of nutritional status, which may not be a sensitive measure of inadequate diet as one can have sufficient energy intake to maintain body weight while consuming a nutritionally poor diet (224).

Several studies have investigated associations between protein intake and frailty. One study have found that low intake of protein is independently associated with frailty (224), while other studies have found no association between protein intake and frailty (225). Other studies have found that some other dietary factors are associated with frailty (e.g. meal patterns) (176, 226).

Bartali et al investigated the association of nutrient intake and frailty in a cohort of 802 individuals aged 65 years or older participating in the InCHIANTI (Invecchiare in Chianti, aging in the Chianti area) study and found that lower protein intake was associated with frailty after adjustment for energy intake and some other major confounders (224). Other studies involving older individuals have found an inverse relationship between Mediterranean diet (MD) and frailty risk (227-229). This, however, may be related to some of the MD qualities, such as nutrient-richness, which may provide sufficient micronutrient and protein to prevent the development of frailty (228).

On the other hand, some studies have shown no association between protein intake and frailty (176, 225, 226). A study involving 5,925 men aged ≥65 years who were enrolled in the Osteoporotic Fractures in Men (MrOS) study found that diet quality, rather than specific

macronutrient intake, was associated with frailty (226). Another study involving 4,731 aged 60 years and over who participated in the Third National Health and Nutrition Examination Survey (NHANES III) found that protein intake (g and %E) did not differ between frail and non-frail people (225). Similarly, in a study involving a sample of 194 (68 men and 127 women) healthy individuals aged ≥75 years, it was found that distribution of protein intake, but not amount of protein, was associated with frailty. The study found that frail subjects had a more irregular protein intake, with a high consumption of protein at lunch but low consumption breakfast (176).

One possible explanation for the association between frailty and protein intake is that protein intakes ranging from 1.0-1.4g/kg may improve muscle strength (182) and physical performance (182, 230) in older individuals, and since these are major components of frailty, an association between protein intake and frailty is to be expected. The findings of the current study were in line with this theory as higher protein intakes were associated with greater walking speed and grip strength (**APPENDIX F)**.

Some of the differences between studies may be due to differences in study design, location, dietary intake assessment method, participants' sex and age and even frailty definition as some studies have used different adaptations of the original *Fried et al* frailty criteria (InCHIANTI study used four domains excluding weight loss).

Conclusion

Data from this large cross-sectional study of older men show that protein intake is inversely associated with most measured outcomes and that a higher protein intake is likely to assist

with the maintenance of health in older age. Further studies are required to determine optimal protein intake for older individuals.

CHAPTER 7. CONCLUSION

This chapter starts with an overview of the findings of this thesis, then addresses its strengths and limitations and ends with relevant public health implications and suggestions for future research.

Overview of findings

An important part of this thesis was a validation study in which the DHQ used to obtain the data used in this thesis was compared to a four-day weighed food record (Chapter 4). Methods commonly used to collect dietary data have their limitations and this should be taken into consideration when deciding which method to use. Moreover, the information captured by the method of choice should be as accurate as possible. In this regard, the DHQ used in this thesis was appropriate for most nutrients analysed in the population group studied and it provided similar results to the four-day weighed food record, with limited evidence of systematic bias.

The interactive nature of the diet history interview was a good choice for this age group as it allowed for other family members to be involved (helping with participants' recall have similar limitations); it also captured a great deal of information on food preferences and cultural characteristics that other methods could not. Furthermore, it captured meal patterns and cooking methods with no heavy reliance on respondents' memory. This interaction with respondents made data collection more effective and food coding much simpler.

It was found that, in general, the men in this study were not at high risk of undernutrition. In Chapter 5 we compared their intake with reference values and only very few nutrients were

below the recommended level. It was also found that dietary intake was only associated with country of birth and not age or socio-economic background.

The best diet is the one that prevents the development and/or progression of diseases. This thesis (Chapter 6) provides evidence that there is no single "diet" associated with only positive outcomes in older age. However, it was found that protein is one of the most important macronutrients for older adults. The findings from this thesis add to the body of evidence that shows that a higher (compared to what is recommended for younger adults) protein intake in older age can be beneficial in many areas of health such as body composition, mobility and cardiovascular health (detailed information presented on Chapter 6).

This is the first time that the GF has been used to investigate the relationship between nutritional intake and health outcomes in older individuals living in the community. The GF technique, previously used in studies involving animal models, proved useful in humans, providing a simple and objective way to look into the associations between nutritional intake and health outcomes.

Strengths

The main strengths of this thesis were that dietary intake and a wide range of health outcomes pertinent in older age were investigated in a large sample of older men recruited from the community. Furthermore, the majority of health outcome measures as well as the dietary assessment method were either validated in older people or were developed to be used in older people. The diet history method used to assess nutrition intake was conducted in

personal interviews and were compared to a 4-day weighed food record (138). Generalisability of the study funding's is supported by the fact that participants' dietary intakes were very similar to those of the Australian population of the same sex and age group (133).

The GF is a novel technique that has been used in animal models, however this is the very first time that it is been used in free-living older humans. This new methodology provides another dimension of nutrient intake exploration and health outcomes by allowing for interrelationships between nutrients observed. Moreover, the associations between nutrient intake and health outcomes found with the GF were very similar to those found with more traditional statistical methods (namely multiple regression models), the difference being that traditional methods masked the interrelationship between nutrients.

The study in this thesis was embedded in the CHAMP study. CHAMP is a comprehensive study of the health of older men, with a wide range of information collected from its participants. This allowed for the adjustment of a number of confounders when investigating the relationships between nutrient intake and health outcomes. Another strength of using CHAMP for this study of nutrition is that CHAMP involves men from many different ethnic groups.

Limitations

The present study used a cross-sectional observational design, which precludes the investigation of causal mechanisms. In particular, reverse causality is a possibility, poor health may have resulted in the men changing their diet. A potential problem with any observational study is that some unmeasured confounders may have affected the findings. A

randomised trial is the best study design to overcome these limitations, but such a study is probably impractical for investigation of diet as a risk factor for disease in older people.

As in most studies on nutritional epidemiology, diet was self-reported and measurement bias may be present. However, measurement bias is likely to have been non-differential with regards to outcomes and so will have led to underestimation of associations, rather than causing spurious associations.

In this thesis, we have used data on nutrient intake of older men to investigate the associations between nutrient intake and health outcomes. Nutrient data was obtained through conversion of food intake into nutrient intake and some limitations arise from this process. Firstly, the database used was from 2007 (97), and a new up-to-date database only became available as this thesis was being completed. Secondly, determination of portion sizes can be subjective and may vary from participant to participant. Thirdly, although data entry has been conducted in a systematic manner and revised several times, it is still possible that some errors may have occurred.

It is also worth noting that dietary supplementation was not investigated in this thesis, and as such, associated nutritional risks of deficiency particularly of calcium and vitamin D may have been overestimated. However, also worth noting, the latest AHS has shown that even with supplementation of calcium, men aged 71 years and over were unable to meet recommendations for calcium (231) and although vitamin D supplements are more commonly used among older people, 20% of people aged 75 and over were had some level of vitamin D deficiency (232).

Although the geometric framework is a novel and effective tool to investigate associations between macronutrient intake and health outcomes, challenges regarding adjustment for confounders were faced as the currently available statistical method (GAM) used in conjunction with GF does not allow for control of multiple confounders. To address this, more traditional statistical methods were used (e.g. multiple regression analyses) that provided very similar results to those from the geometric framework technique.

The participation rate is a potential limitation of this study. At baseline, CHAMP was composed of 1,705 participants, representing 47% of men aged 70 years and over living in the community in the study geographic area. At the five-year follow-up in which nutritional data was collected and used in this thesis, there were 1,163 participants who still alive, of whom 68% (n=794) completed the DHQ. Nevertheless, CHAMP participants dietary intakes were very similar to the dietary intake of the Australian population of similar age and sex, as found in the AHS 2011-12 (137) .

The validation study had some specific limitations. Firstly, the sample size of the validation study was smaller than ideal (95, 133-135)**;** however, recruitment of older men living in the community is an extremely difficult task. Secondly, the validation study participants were different from the DHQ study population as they were more likely to be married, well-educated, Australian-born men who were assisted by their wives to keep the 4dWFR. Thirdly, the two methods showed a mean difference of more than 20% for β-carotene, vitamin E and vitamin A, however, this may be explained by the day-to-day variation of intake that is common for these nutrients; therefore, a different method (e.g. multiple 24-hour recall) may better capture this variation and may be a better option to investigate the intake of these

nutrients. Finally, ideally the reference (4dWFR in this case) method used to validate a dietary method (in this case DHQ) should be independent from each other, however, the 4dWFR has similar limitations and correlated errors to the DHQ, and this may have affected the correlations between the two methods. The use of reliable biomarkers (for example doubly labelled water) would further validate our study; however, its feasibility is questionable in an older population. Furthermore, this method is costly, time consuming, and requires technical skills and trained staff (90, 95).

Implications

The Australian population is growing rapidly, in particular, the older male population (4). Furthermore, Australia is a multicultural country and many of the post-war immigrants are now reaching older age (233). Therefore, it is important that research focus on better understanding the relationship between nutrition and ageing. The findings from this research have translational implications in several areas, including but not limited to, research methodology, nutrition policy and practical advice for older individuals.

The thesis uses a novel approach, the geometric framework, to assess the relationship between nutrient intake and health outcomes in free-living humans. This framework approach can be readily applied in all nutritional studies to answer questions related to human nutrition intake, and although in this thesis macronutrients were investigated, other interactions such as dietary fat (mono-, polyunsaturated and saturated fatty acids) or types of protein (animal vs vegetable) in relation to health outcomes can also be explored. However, some technical and statistical points are to be kept in mind when using the GF: 1-studies where participants are not on a specific diet and environment (i.e. controlled trials), confounding factors must be

considered as they may affect participants' intake and/or development of health outcomes. 2- continuous data are best when using the GF, as this allows the visualisation of ranges where intake is worse/optimal in relation to health outcome prevention/development.

One of the main findings from this thesis was that one diet cannot possibly prevent or cause all the different health issues older individuals are prone to. With that being said, focus must be directed to preventative nutritional measures rather than treatment. It is important to remember that older individuals are more likely to have followed the same dietary habits for a great part of their lives and for this reason they may be more resistant to changes; therefore, rather than a complete change of diet, positive behaviors should be encouraged.

As was discussed in this thesis, Australia is a multicultural nation; one in three of the people aged 65 or older living in Australia come from a culturally and linguistic diverse background. Each of these cultures have slightly different nutritional practices, therefore the "meat and three vegetables" guideline established to support health and be followed by the whole population may not be appropriate across all the different cultures. Therefore, nutrition policies must better reflect the diversity we have in Australia, and indeed, could potentially help to inform inclusive nutritional guidelines for healthy eating across the diverse communities.

The different methods for dietary measurement have their own advantages and disadvantages (112, 113). There is no standard method valid in all situations, and the choice of method will

depend study objectives and design (111). The findings from this thesis support the body of research that shows that the diet history interview method is a reliable approach (89, 90) that is particularly relevant for older people because of the low variability of their diet, low reliance of short-term memory, its interactive methodology (30, 91-93) and low respondent burden. The DHQ is also likely to be a good choice for studies with participants from culturally and linguistically diverse backgrounds, as it requires no particular language or numeracy skills from participants (89, 94, 95). However, to measure usual intake of nutrients such as, for example, vitamin A equivalent or retinol, an even more comprehensive dietary assessment method (e.g. multiple 24-hour recall or weighed food records) may be a better option as these nutrients have high day-to-day variation (88, 127).

Nutrition is an important modifiable factor associated with healthy ageing (14). However, it's alarming that in Australia only very few studies have investigated older individuals' dietary intakes, particularly given the speed in which the ageing population is growing. The results of this thesis have indicated that older men living in the community are not at high risk of dietary inadequacies and the findings regarding dietary inadequacy in Italian/Greek born men point to a gap in the research about culturally and linguistic diverse population dietary habits.

Further research is needed to investigate the benefit (and/or detrimental effects) of protein intake in older individuals. Much of what is known regarding optimal protein intake in older age derives from studies investigating the benefits of protein intake to treat health conditions in older age and there is a gap in the literature regarding optimal intake for healthy older individuals. Future research should include older healthy participants and investigate their

protein intake, distribution of protein consumption (meal pattern) and food sources (animal vs vegetable).

The results from this thesis may help identify men at risk of dietary inadequacies as well as assist in development of dietary interventions to prevent the development of health issues experienced in older age. Protein is an important nutrient associated with a number of health outcomes experienced in older age, therefore, it is important that its intake is at an optimal level later in life.

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APPENDICES

Appendix A- Self-completed questionnaire

CHAMP

CONCORD HEALTH AND AGEING IN MEN PROJECT

Self-Completed Questionnaire

Chief Investigators

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Dr Cindy Kok

Dr Tamara Ribaric

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Ms Maggie Hayes

Mrs Sue Todd

Thank you for assisting us with our research and taking the time to complete this questionnaire. The information you provide will help us understand many important issues about older men's health.

We would like to assure you the answers you provide will remain strictly confidential.

Instructions

1. In general we would like you to complete this questionnaire on your own. If you find that you need assistance please call Maggie Hayes or Melisa Litchfield on freecall 1800 174 287 and they will assist you. If your spouse or partner assist you, please indicate this on the front cover of the questionnaire.
2. Please answer every question (unless you are asked to skip questions because they don't apply to you). Please be as accurate as you can and choose the response that best describes your situation.
3. If you are unsure how to answer a question please give the best answer you can and make a comment in the left margin.
4. Answer every question by ticking (✓) the appropriate box. Some questions also require a written response.
5.

Statement of confidentiality

Information that would permit the identification of any person completing this questionnaire will be regarded as strictly confidential. All information provided will be used only for the CHAMP Study and will not be disclosed or released for any other purpose without your consent.

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Section 1 - General Information

1. **What is today's date?** _____/_____/_____
   day month year

2. **How old are you?** _____ years old

3. **What is your date of birth?** _____/_____/_____
   day month year

4. **What is your current marital status?**

   - ☐ Married
   - ☐ Living with a partner/de facto
   - ☐ Widowed
   - ☐ Divorced
   - ☐ Separated
   - ☐ Never married
   - ☐ Other *(Please specify)*_____

5. **For how many children are you the natural father?**

   _____ number

6. **Who else lives in your home?** *(Mark all that apply)*

   - ☐ No one, I live alone
   - ☐ Wife/partner
   - ☐ Daughter(s)
   - ☐ Son(s)
   - ☐ Brother(s)
   - ☐ Sister(s)
   - ☐ Grandchildren
   - ☐ Other *(Please specify)*_____

7. What is your housing arrangement? Are you:

- ☐ The outright owner of your home
- ☐ Paying off your home
- ☐ Leasing, purchasing (or other financial plan) in a retirement village
- ☐ Paying rent or board to a private landlord
- ☐ Paying rent to the government for public housing
- ☐ Living rent or board free
- ☐ Other *(Please specify)*_____

8. In which country were you born?

- ☐ Australia ➔ *Go to question 9*
- ☐ Other *(Please specify)*_____

↓

8a. If you were born in another country, how old were you when you first arrived in Australia?

_____ years old

9. In which country was your natural mother born?

- ☐ Australia
- ☐ Other *(Please specify)*_____

10. In which country was your natural father born?

- ☐ Australia
- ☐ Other *(Please specify)*_____

11. When did you first learn to speak English?

☐ Before 12 years of age ☐ After or equal to 12 years of age

12. What language do you usually speak at home?

- ☐ English
- ☐ Other *(Please specify)*_____

13. How old were you when you left school?

_____ years old ☐ Didn't go to school

14. Since leaving school have you obtained a trade qualification, certificate, diploma or any other qualification?

☐ Yes ☐ No ➔ *Go to question 15*

14a. If yes, what is your highest qualification?

- ☐ Bachelor degree or higher
- ☐ Trade/apprenticeship
- ☐ Certificate/diploma
- ☐ Other *(Please specify)*_____

15. Are you currently in paid employment?

☐ Yes➔ *Go to question 16* ☐ No

15a. If no, how old were you when you retired completely?

_____ years old

16. Thinking of all the paid jobs that you ever had, what kind of work did you do the longest?

_____

17. Which of the following are sources of income for you?
(Mark all that apply)

- ☐ Age pension
- ☐ Repatriation pension, Veteran's pension
- ☐ Superannuation or other private income
- ☐ Own business/farm/partnership
- ☐ Wage or salary
- ☐ Other *(Please specify)*_____

18. Are you currently driving at least once in a while?

☐ Yes ➔ *Go to section 2, question 1* ☐ No

18a. If no, have you ever driven a car or have you given up driving?

☐ Never drove ➔ *Go to section 2, question 1* ☐ Gave up driving

18b. If you gave up driving, how old were you when you stopped driving?

_____years old

Section 2 - Medical History

1. Has a doctor or other health care provider ever told you that you had or have:

Diabetes?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
High thyroid, Grave's disease or an overactive thyroid gland?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Low thyroid or an under active thyroid gland?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Osteoporosis, sometimes called thin or brittle bones?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Paget's disease?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
A stroke, blood clot in the brain or bleeding in the brain?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Parkinson's disease?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Kidney stones?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Dementia?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Depression?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Epilepsy or fits?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Hypertension or high blood pressure?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Heart attack, coronary or myocardial infarction?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Angina (chest pain)?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Congestive heart failure or enlarged heart?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Intermittent claudication or pain in your legs from a blockage of the arteries?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Chronic obstructive lung disease, chronic bronchitis, asthma, emphysema or COPD?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Liver disease?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No
Chronic kidney (renal) disease or kidney (renal) failure?	□ Yes ➔ □ No	If yes, are you currently being treated for this condition by a doctor?	□ Yes □ No

2. Have you ever had heart, or coronary, bypass surgery?

☐ Yes ☐ No ➔ *Go to question 3*

2a. If yes, how old were you when you had this surgery?

_____years old

3. Have you ever had surgery to remove all or part of your stomach or intestines?

☐ Yes ☐ No ➔ *Go to question 4*

3a. If yes, how old were you when you had this surgery?

_____years old

4. Has a doctor or other health care provider told you that you have arthritis or gout?

☐ Yes ☐ No ➔ *Go to question 5*

4a. If yes, what type of arthritis did the health care provider say it was? *(Mark all that apply)*

- ☐ Rheumatoid arthritis
- ☐ Osteoarthritis or degenerative arthritis
- ☐ Gout
- ☐ Some other type of arthritis *(Please specify)* _____
- ☐ Don't know

4b. Which of your joints have arthritis? *(Mark all that apply)*

- ☐ Hip
- ☐ Hand/Fingers
- ☐ Back
- ☐ Shoulder
- ☐ Ankle
- ☐ Knee
- ☐ Wrist
- ☐ Neck
- ☐ Elbow
- ☐ Foot/Toes
- ☐ Other *(Please specify)* _____

5. Have you ever had a serious head injury with loss of consciousness for more than 15 minutes?

☐ Yes ☐ No

6. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?

☐ Yes ☐ No ➔ *Go to question 7*

6a. Do you get short of breath walking with other people of your own age on level ground?

☐ Yes ☐ No ➔ *Go to question 7*

6b. Do you have to stop for breath when walking at your own pace on level ground?

☐ Yes ☐ No ➔ *Go to question 7*

6c. Are you short of breath on washing or dressing?

☐ Yes ☐ No

7. Do you feel you have a hearing loss?

☐ Yes ☐ No

8. Compared to other people your age, how would you rate your memory?

☐ Better than most
☐ Average
☐ A little below average
☐ A lot below average

9. Do you sometimes have trouble with dizziness?

☐ Yes ☐ No ➔ *Go to question 10*

9a. If yes, how long have you had trouble with dizziness?

☐ Less than 1 month
☐ 1 month to 1 year
☐ More than 1 year

9b. Would you describe your dizziness as: *(Mark all that apply)*

☐ Feeling like you are about to faint or pass out?
☐ Feeling that you or the room are spinning around?
☐ Feeling that you are losing your balance?
☐ Other *(Please specify)*_____

9c. Is your dizziness troublesome enough to limit your activities, such as walking or other leisure activities?

☐ Yes ☐ No

10. During the past 12 months, have you fallen and landed on the floor or ground, or fallen and hit an object like a table or chair?

☐ Yes ☐ No ➔ *Go to question 11*

10a. If yes, how many times have you fallen in the past 12 months?

☐ Once
☐ Twice
☐ Three times
☐ Four times
☐ Five times
☐ Six or more times

10b. Which of the following injuries did you have? *(Mark all that apply)*

☐ I broke or fractured a bone
☐ I hit or injured my head
☐ I had a sprain or a strain
☐ I had a bruise or bleeding
☐ I had some other kind of injury
☐ I did not have any injuries from a fall in the past 12 months

11. How tall were you without shoes when you were about 25 years old? If you don't remember exactly, give your best estimate.

_____feet _____inches OR _____centimetres

12. What was your usual weight when you were about 25 years old?

If you don't remember exactly, give your best estimate.

_____stone _____pounds OR _____kilograms

13. What is the most you have ever weighed, and how old were you when you were at your heaviest weight?

_____stone _____pounds OR _____kilograms

at _____years old

Section 3 - Prostate Health

	Not at all	Less than 1 time in 5	Less than half the time	About half the time	More than half the time	Almost always
1. Over the PAST MONTH, how often have you had a sensation of not emptying your bladder completely after you finish urinating?	☐	☐	☐	☐	☐	☐
2. Over the PAST MONTH, how often have you had to urinate again less than two hours after you finished urinating?	☐	☐	☐	☐	☐	☐
3. Over the PAST MONTH, how often have you found you stopped and started again several times when you urinated?	☐	☐	☐	☐	☐	☐
4. Over the PAST MONTH, how often have you found it difficult to postpone urination?	☐	☐	☐	☐	☐	☐
5. Over the PAST MONTH, how often have you had a weak urinary stream?	☐	☐	☐	☐	☐	☐
6. Over the PAST MONTH, how often have you had to push or strain to begin urination?	☐	☐	☐	☐	☐	☐

7. Over the PAST MONTH, how many times did you most typically get up to urinate from the time you went to bed at night until the time you got up in the morning?

- ☐ None
- ☐ Once
- ☐ Twice
- ☐ Three times
- ☐ Four times
- ☐ Five or more times

8. If you were to spend the rest of your life with your urinary condition just the way it is now, how would you feel about that?

- ☐ Delighted
- ☐ Pleased
- ☐ Mostly satisfied
- ☐ Mixed, about equally satisfied and dissatisfied
- ☐ Mostly unsatisfied
- ☐ Unhappy
- ☐ Terrible

Many men leak urine some of the time. We are trying to find out how many men leak urine, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

9. How often do you leak urine?

- ☐ Never
- ☐ About once a week or less often
- ☐ Two or three times a week
- ☐ About once a day
- ☐ Several times a day
- ☐ All the time

We would like to know how much you think leaks.

10. How much urine do you usually leak (whether you wear protection or not)?

- ☐ *None*
- ☐ *A small amount*
- ☐ *A moderate amount*
- ☐ *A large amount*

11. Overall, how much does leaking urine interfere with your everyday life?
(Please circle a number between 0 (not at all) and 10 (a great deal))

0	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Not at all										*A great deal*

12. When does urine leak? (Mark all that apply)

- ☐ *Never – urine does not leak*
- ☐ *Leaks before you can get to the toilet*
- ☐ *Leaks when you cough or sneeze*

- ☐ *Leaks when you are asleep*
- ☐ *Leaks when you are physically active/exercising*
- ☐ *Leaks when you have finished urinating and are dressed*
- ☐ *Leaks for no obvious reason*
- ☐ *Leaks all the time*

13. Over the PAST MONTH, how many pads or other incontinence aids, if any, did you usually use to help with leaking or dripping?

- ☐ *No pads*
- ☐ *1 pad per day*
- ☐ *2 pads per day*
- ☐ *3 or more pads per day*

14. The Prostate Specific Antigen (PSA) test is a simple blood test that men are sometimes offered by their doctor, as a check for prostate disease. Have you ever had a PSA test?

☐ Yes ☐ No ➔ *Go to question 15*

14a. If yes, in the past TWO YEARS, have you had a PSA test?

☐ Yes ☐ No

15. A digital rectal exam is an exam in which a doctor, nurse, or other health professional places a gloved finger into the rectum to feel the size, shape, and hardness of the prostate gland. Have you ever had a digital rectal exam?

☐ Yes ☐ No ➔ *Go to question 16*

15a. If yes, in the past TWO YEARS, has a doctor or other health care provider checked your prostate by a digital rectal exam?

☐ Yes ☐ No

16. Has a doctor or other health care provider told you that you have or had an enlarged prostate, also known as benign prostatic hyperplasia (BPH)? This means an enlarged prostate that is NOT due to cancer.

☐ Yes ☐ No ➔ *Go to question 17*

16a. Treatments for BPH usually are to improve urinary symptoms and flow. Have you ever had treatment for BPH?

☐ Yes ☐ No ➔ *Go to question 17*

16b. If yes, what type of treatment have you received? *(Mark all that apply)*

☐ Surgery (laser surgery or transurethral resection of the prostate, sometimes called TURP or re-bore)

☐ Prescription medications

☐ Other *(Please specify)* _____

17. Has a doctor or other health care provider told you that you had or have prostatitis (inflammation or infection of the prostate)?

☐ Yes ☐ No ➔ *Go to question 18*

17a. If yes, are you currently being treated for this condition by a doctor?

☐ Yes ☐ No

18. Has a doctor or other health care provider ever told you that you have prostate cancer?

☐ Yes ☐ No ➔ *Go to question 19*

18a. If yes, how old were you at first diagnosis?

_____years old

18b. What type of treatment did you receive? *(Mark all that apply)*

☐ Radiation

☐ Surgery to remove prostate gland

☐ Surgery to remove testicles

☐ Hormone treatment

☐ No treatment or careful observation by a doctor

☐ Other *(Please specify)*_____

19. Has a doctor or other health care provider ever told you that you have any other cancer?

☐ Yes ☐ No ➔ *Go to section 4, question 1*

19a. If yes, what cancer(s) were you diagnosed with?

(List all the cancers you have had diagnosed. If you have been diagnosed with more than 3 cancers please list other cancers and the age at diagnosis in the blank space at the bottom of the page.)

Cancer: _____ Age at diagnosis: _____

Cancer: _____ Age at diagnosis: _____

Cancer: _____ Age at diagnosis: _____

Section 4 – Tobacco & Alcohol Use

1. Have you smoked at least 100 cigarettes (5 packs) in your entire life?

☐ Yes ☐ No ➔ *Go to question 2*

1a. If yes, how old were you when you first started smoking regularly?

_____years old.

1b. On the average of the entire time you smoked, how many cigarettes did you smoke per day?

_____cigarettes

1c. Do you smoke cigarettes now?

☐ Yes

1d. About how many cigarettes do you smoke per day?

_____cigarettes

☐ No

1e. How old were you when you stopped smoking?

_____years old

2. Have you ever smoked a pipe or cigars regularly?

☐ Yes ☐ No ➔ *Go to question 3*

2a. If yes, for how many years?

_____years.

2b. About how much did/do you smoke?

_____pipes or cigars per week.

3. Have you had at least 12 alcoholic drinks in your entire life?

☐ Yes ☐ No ➔ *Go to section 5, question 1*

3a. If yes, have you ever felt you should cut down on your drinking?

☐ Yes ☐ No

3b. Have people ever annoyed you by criticizing your drinking?

☐ Yes ☐ No

3c. Have you ever felt bad or guilty about your drinking?

☐ Yes ☐ No

3d. Have you ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover?

☐ Yes ☐ No

Section 5 - Sun Exposure

1. How often do you go outside into the street or garden?

☐ Never
☐ A few times a month
☐ Weekly
☐ Most days

2. Do you avoid direct sunshine?

☐ Always
☐ Usually
☐ Never

3. Have you had a suntan in the last 6 months?

☐ No
☐ Slight tan
☐ Obvious tan

Section 6 - Physical Activity

1. **Do you take walks for exercise, daily or almost everyday?**

☐ Yes ☐ No ➔ *Go to question 2*

1a. On the average, how many kilometres do you walk each day for exercise?

_____ kilometers

2. **Over the PAST YEAR, have you spent more than one week confined to a bed or a chair as a result of any injury, illness or surgery?**

☐ Yes ☐ No➔ *Go to question 3*

2a. How many weeks over this PAST YEAR were you confined to a bed or chair?

_____ weeks

The next few questions ask about your physical activity during the last 7 days. If the last 7 days have not been typical because of illness or bad weather, please estimate based on two or three weeks ago.

3. **Over the PAST 7 DAYS, how often did you participate in sitting activities such as reading, watching TV, computing or doing handcrafts?**

☐ Never ➔ *Go to question 4*
☐ Seldom (1-2 days)
☐ Sometimes (3-4 days)
☐ Often (5-7 days)

3a. What were these activities?_____

3b. On average, how many hours per day did you engage in these sitting activities?

☐ Less than 1 hour
☐ Between 1 and 2 hours
☐ 2-4 hours
☐ More than 4 hours

4. **Over the PAST 7 DAYS, how often did you take a walk outside your home or yard for any reason**? For example, for fun or exercise, walking to work, walking the dog, etc.?

☐ Never ➔ *Go to question 5*
☐ Seldom (1-2 days)

- ☐ Sometimes (3-4 days)
- ☐ Often (5-7 days)

4a. What were these activities?_____

4b. On average, how many hours per day did you spend walking?

- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ 2-4 hours
- ☐ More than 4 hours

5. Over the PAST 7 DAYS, how often did you engage in light sport or recreational activities such as bowling, golf with a buggy, fishing from a boat or pier, or other similar activities?

- ☐ Never ➔ *Go to question 6*
- ☐ Seldom (1-2 days)
- ☐ Sometimes (3-4 days)
- ☐ Often (5-7 days)

5a. What were these activities?_____

5b. On average, how many hours per day did you engage in these light sport or recreational activities?

- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ 2-4 hours
- ☐ More than 4 hours

6. Over the PAST 7 DAYS, how often did you engage in moderate sport and recreational activities such as doubles tennis, ballroom dancing, golf without a buggy, softball or other similar activities?

- ☐ Never ➔ *Go to question 7*
- ☐ Seldom (1-2 days)
- ☐ Sometimes (3-4 days)
- ☐ Often (5-7 days)

6a. What were these activities?_____

6b. On average, how many hours per day did you engage in these moderate sport or recreational activities?

- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ 2-4 hours
- ☐ More than 4 hours

7. Over the PAST 7 DAYS, how often did you engage in strenuous sport and recreational activities such as jogging, swimming, cycling, singles tennis, aerobic exercise, skiing (downhill or cross country) or other similar activities?

- ☐ Never ➔ *Go to question 8*
- ☐ Seldom (1-2 days)
- ☐ Sometimes (3-4 days)
- ☐ Often (5-7 days)

7a. What were these activities?_____

7b. On average, how many hours per day did you engage in these strenuous sport or recreational activities?

- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ 2-4 hours
- ☐ More than 4 hours

8. Over the PAST 7 DAYS, how often did you do any exercise specifically to increase muscle strength and endurance, such as lifting weights or pushups, etc.?

- ☐ Never ➔ *Go to question 9*
- ☐ Seldom (1-2 days)
- ☐ Sometimes (3-4 days)
- ☐ Often (5-7 days)

8a. What were these activities?_____

8b. On average, how many hours per day did you engage in exercise to increase muscle strength and endurance?

- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ 2-4 hours
- ☐ More than 4 hours

9. During the PAST 7 DAYS, have you done any light housework, such as dusting or washing dishes?

☐ Yes ☐ No

10. During the PAST 7 DAYS, have you done any heavy housework or duties, such as vacuuming, scrubbing floors, washing windows or carrying wood?

☐ Yes ☐ No

11. During the PAST 7 DAYS, did you engage in any of the following activities?

11a. Home repairs, like painting, wallpapering, electrical work, etc.?

☐ Yes ☐ No

11b. Lawn work or yard care, including leaf removal, wood chopping, etc.?

☐ Yes ☐ No

11c. Outdoor gardening?

☐ Yes ☐ No

11d. Caring for another person, such as children, dependent spouse, or another adult?

☐ Yes ☐ No

12. During the PAST 7 DAYS did you work, either for pay or as a volunteer?

☐ Yes ☐ No ➔ *Go to section 7, question 1*

12a. If yes, how many hours in the past week did you work for pay and/or as a volunteer?

_____hours

12b. Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work?

☐ Mainly sitting with slight arm movements
Examples: office worker, watchmaker, seated assembly line worker, bus driver

☐ Sitting or standing with some walking
Examples: cashier, general office worker, light tool and machinery worker

☐ Walking, with some handling of materials generally weighing less than 50 kgs
Examples: postman, waiter/waitress, construction worker, heavy tool and machinery worker

☐ Walking and heavy manual work often requiring handling materials weighing more than 50 kgs
Examples: stone mason, farm or general laborer

Section 7 - Lifestyle (SF12)

1. **Compared to other people your own age, how would you rate your overall health?**

   ☐ Excellent for my age
   ☐ Good for my age
   ☐ Fair for my age
   ☐ Poor for my age
   ☐ Very poor for my age

The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

2. **Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling or playing golf?**

   ☐ Yes, limited a lot
   ☐ Yes, limited a little
   ☐ No, not limited at all

3. **Climbing several flights of stairs?**

   ☐ Yes, limited a lot
   ☐ Yes, limited a little
   ☐ No, not limited at all

During the PAST 4 WEEKS, have you had any of the following problems with your work or other regular daily activities because of your physical health?

4. **Accomplished less than you would like**

   ☐ Yes ☐ No

5. **Were limited in the kind of work or other activities**

   ☐ Yes ☐ No

During the PAST 4 WEEKS, have you had any of the following problems with your work or other regular daily activities because of any emotional problems (such as feeling depressed or anxious)?

6. **Accomplished less than you would like**

☐ Yes ☐ No

7. **Didn't do work or other activities as carefully as usual**

☐ Yes ☐ No

8. **During the PAST 4 WEEKS, how much did pain interfere with your normal work (including both work outside the home and housework)?**

☐ Not at all
☐ A little bit
☐ Moderately
☐ Quite a bit
☐ Extremely

These questions are about how you feel and how things have been with you during the PAST 4 WEEKS. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the PAST 4 WEEKS . . .

9. **Have you felt calm and peaceful?**

☐ All of the time
☐ Most of the time
☐ A good bit of the time
☐ Some of the time
☐ A little of the time
☐ None of the time

10. **Did you have a lot of energy?**

☐ All of the time
☐ Most of the time
☐ A good bit of the time
☐ Some of the time
☐ A little of the time
☐ None of the time

11. **Have you felt downhearted and blue?**

☐ All of the time
☐ Most of the time
☐ A good bit of the time
☐ Some of the time

- ☐ A little of the time
- ☐ None of the time

12. During the PAST 4 WEEKS, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

- ☐ All of the time
- ☐ Most of the time
- ☐ A good bit of the time
- ☐ Some of the time
- ☐ A little of the time
- ☐ None of the time

The following questions are about your health and how you have been feeling in the LAST 4 WEEKS. In the LAST 4 WEEKS:

13. Have you felt keyed up or on edge?	☐ Yes	☐ No
14. Have you been worrying a lot?	☐ Yes	☐ No
15. Have you been irritable?	☐ Yes	☐ No
16. Have you had difficulty relaxing?	☐ Yes	☐ No
17. Have you been sleeping poorly?	☐ Yes	☐ No
18. Have you had headaches or neckaches?	☐ Yes	☐ No
19. Have you had any of the following: trembling, tingling, dizzy spells, sweating, diarrhoea or needing to pass water more often than usual?	☐ Yes	☐ No
20. Have you been worried about your health?	☐ Yes	☐ No
21. Have you had difficulty falling asleep?	☐ Yes	☐ No

Section 8 - Activities of Daily Living

We are interested to know about some of your activities of daily living, things that we all need to do as part of our daily lives. We would like to know if you can do these activities without any help at all, or if you need some help to do them, or if you can't do them at all.

1. Can you use the telephone?

- ☐ Without help, including looking up numbers and dialing
- ☐ With some help (can answer phone or dial operator in an emergency, but need a special phone or help in getting the number or dialing)
- ☐ Or are you completely unable to use the telephone

2. Can you get to places out of walking distance?

- ☐ Without help (can travel alone on buses, taxis, or drive your own car)
- ☐ With some help (need someone to help you or go with you when traveling)
- ☐ Or are you unable to travel unless emergency arrangements are made for a specialized vehicle like an ambulance?

3. Can you go shopping for groceries or clothes (if you have transportation)?

- ☐ Without help (taking care of all shopping needs yourself, assuming you had transportation)
- ☐ With some help (need someone to go with you on all shopping trips)
- ☐ Or are you completely unable to do any shopping?

4. Can you prepare you own meals?

- ☐ Without help (plan or cook full meals for yourself)
- ☐ With some help (can prepare some things but unable to cook full meals yourself)
- ☐ Or are you completely unable to prepare any meals?

5. Can you do your housework?

- ☐ Without help (can you scrub floors, etc)
- ☐ With some help (can do light housework but need help with heavy work)
- ☐ Or are you completely unable to do any housework?

6. Can you take your own medications?

- ☐ Without help (in the right doses at the right time)
- ☐ With some help (are able to take medications if someone prepares it for you and/or reminds you to take it)
- ☐ Or are you completely unable to take your medication?

7. Can you handle your own money?

- ☐ Without help (write cheques, pay bills etc)
- ☐ With some help (manage day-to-day purchases but need help with managing your chequebook and paying your bills)
- ☐ Or are you completely unable to handle money?

8. Are you able to do heavy work around the house, like washing windows, walls, or floors without help?

☐ Yes ☐ No

9. Are you able to walk up and down stairs to the first floor without help?

☐ Yes ☐ No

10. Are you able to walk half a mile (approximately one kilometre) without help?

☐ Yes ☐ No

Section 9 - Caring

1. **Do you have the main responsibility in caring for someone who has a long-term illness, disability, or other problem?** (i.e. a problem that would prevent them from managing their household tasks or personal care independently.)

☐ Yes ☐ No ➔ *Go to section 10, question 1*

1a. If yes, who do you care for? *(Mark all that apply)*

- ☐ Wife/partner
- ☐ Son
- ☐ Daughter
- ☐ Grandchild
- ☐ Friend
- ☐ Mother
- ☐ Father
- ☐ Other *(Please specify)*_____

Section 10 - Use of Health Services

1. **In the LAST 12 MONTHS, have you consulted a GP or local doctor about your health?**

☐ Yes ☐ No ➔ *Go to question 2*

1a. If yes, in the LAST 2 WEEKS, have you consulted a GP or local doctor about your health?

☐ Yes ☐ No

2. **In the LAST 12 MONTHS, have you visited or been visited by a community nurse or a private nursing service?**

☐ Yes ☐ No

3. **In the LAST 12 MONTHS, have you visited or been visited by a podiatrist or chiropodist?** A podiatrist/chiropodist is a person who is specially trained to provide foot care.

☐ Yes ☐ No

4. **In the LAST 12 MONTHS, have you visited or been visited by a physiotherapist?**

☐ Yes ☐ No

5. **In the LAST 12 MONTHS, have you spent at least one night in hospital?**

   ☐ Yes ☐ No

6. **In the LAST 12 MONTHS, have you spent at least one night in a hostel/nursing home?**

   ☐ Yes ☐ No

7. **In the LAST 12 MONTHS, have you spent at least one day in an Aged Care Day Centre?**

   ☐ Yes ☐ No

8. **In the LAST 12 MONTHS, have been visited by HomeCare to help with household or personal duties?**

   ☐ Yes ☐ No

9. **In the LAST 12 MONTHS, have you used the services of the Community Aged Care Packages (CACPs) to help with any duties?**

   ☐ Yes ☐ No

10. **In the LAST 12 MONTHS, did any service deliver or prepare your meals for you at home? For example, Meals-On-Wheels.**

    ☐ Yes ☐ No

Section 11 - Social Support

1. **How many times during the PAST WEEK did you spend some time with someone who does not live with you? For example, you went to see them or they came to visit you, or you went out together?**

   - ☐ None
   - ☐ Once
   - ☐ Twice
   - ☐ Three times
   - ☐ Four times
   - ☐ Five times
   - ☐ Six times
   - ☐ Seven or more times

2. **How many times did you talk to someone -- friends, relatives or others -- on the telephone in the PAST WEEK (either they called you, or you called them)?**

   - ☐ None
   - ☐ Once
   - ☐ Twice
   - ☐ Three times
   - ☐ Four times
   - ☐ Five times
   - ☐ Six times
   - ☐ Seven or more times

3. **About how often did you go to meetings of social clubs, religious meetings, or other groups that you belong to in the PAST WEEK?**

   - ☐ None
   - ☐ Once
   - ☐ Twice
   - ☐ Three times
   - ☐ Four times
   - ☐ Five times
   - ☐ Six times
   - ☐ Seven or more times

4. **Does it seem that your family and friends (i.e. people who are important to you) understand you most of the time, some of the time, or hardly ever?**

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

5. Do you feel useful to your family and friends (i.e. people who are important to you) most of the time, some of the time, or hardly ever?

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

6. Do you know what is going on with your family and friends most of the time, some of the time, or hardly ever?

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

7. When you are talking with your family and friends, do you feel you are being listened to most of the time, some of the time, or hardly ever?

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

8. Do you feel you have a definite role (place) in your family and among your friends most of the time, some of the time, or hardly ever?

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

9. Can you talk about your deepest problems with at least some of your family and friends most of the time, some of the time, or hardly ever?

- ☐ Hardly ever
- ☐ Some of the time
- ☐ Most of the time

10. How satisfied are you with the kinds of relationships you have with your family and friends very dissatisfied, somewhat dissatisfied, or satisfied.

- ☐ Very dissatisfied
- ☐ Somewhat dissatisfied
- ☐ Satisfied

11. How many persons in this area (within one hours travel of your home) do you feel you can depend on or feel very close to?

_____Number of family members

_____Number of people who are NOT family members

☐ None

Section 12 - Back and Joint Health

1. During the PAST 12 MONTHS, have you had any back pain?

☐ Yes ☐ No ➔ *Go to question 2*

1a. If yes, how often were you bothered by back pain in the PAST 12 MONTHS?

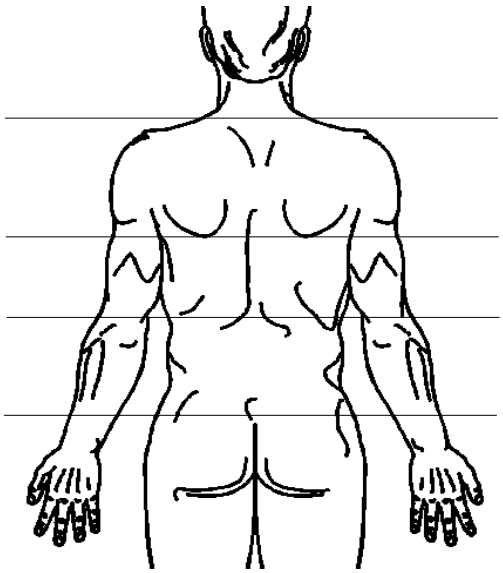
- ☐ All of the time
- ☐ Most of the time
- ☐ Some of the time
- ☐ Rarely
- ☐ Never

1b. When you have had back pain, how bad was it on average?

- ☐ Mild
- ☐ Moderate
- ☐ Severe

1c. In what part or parts of your back is the pain usually located?

(Mark all areas that apply with an X)



2. During the PAST 12 MONTHS, have you limited your activities because of back pain?

☐ Yes ☐ No ➔ *Go to question 3*

2a. If yes, how many days did you stay in bed (or lie down) at least half of the day because of your back?

_____days

2b. How many days did you limit or cut down on your usual activities because of back pain? Do not include days in bed.

_____days

3. In the PAST 12 MONTHS, have you had pain in or around either hip joint, including the buttock, groin, or either side of the upper thigh, on most days for at least one month? Do not include pain from the lower back.

☐ Yes ☐ No ➔ *Go to question 4*

3a. If yes, was this pain in the left hip, right hip or both hips?

☐ Left hip
☐ Right hip
☐ Both hips

4. In the PAST 12 MONTHS, have you had pain, aching or stiffness in either knee on most days for at least one month? Include pain, aching and stiffness in or around your knee, including the front, back and side of knee.

☐ Yes ☐ No ➔ *Go to section 13, question 1*

4a. If yes, was this pain in the left knee, right knee or both knees?

☐ Left knee
☐ Right knee
☐ Both knees

Section 13 - Geriatric Depression Scale

Choose the best answer for each of the following questions for how you felt over the LAST WEEK.

1. Are you basically satisfied with your life?	☐ Yes	☐ No
2. Have you dropped many of your activities and interests?	☐ Yes	☐ No
3. Do you feel that your life is empty?	☐ Yes	☐ No
4. Do you often get bored?	☐ Yes	☐ No
5. Are you in good spirits most of the time?	☐ Yes	☐ No
6. Are you afraid something bad is going to happen to you?	☐ Yes	☐ No
7. Do you feel happy most of the time?	☐ Yes	☐ No
8. Do you often feel helpless?	☐ Yes	☐ No
9. Do you prefer to stay at home, rather than going out and doing new things?	☐ Yes	☐ No
10. Do you feel you have more problems with memory than most?	☐ Yes	☐ No
11. Do you think it is wonderful to be alive now?	☐ Yes	☐ No
12. Do you feel pretty worthless the way you are now?	☐ Yes	☐ No
13. Do you feel full of energy?	☐ Yes	☐ No
14. Do you feel that your situation is hopeless?	☐ Yes	☐ No
15. Do you think that most people are better off than you are?	☐ Yes	☐ No

Section 14 - Family History

1. **Is your natural mother still living?**

☐ Yes ☐ No ☐ Don't know ➔ *Go to question 2*

1a. If yes, how old is your natural mother now? _____years old	1b. If no, how old was your natural mother when she died? _____years old

2. **Is your natural father still living?**

☐ Yes ☐ No ☐ Don't know ➔ *Go to question 3*

2a. If yes, how old is your natural father now? _____years old	2b. If no, how old was your natural father when he died? _____years old

Cognition

3. **Has anyone in your immediate family ever had dementia, Alzheimer's disease, severe memory loss or mental confusion?** Please include blood relatives only.

☐ Yes ☐ No ➔ *Go to question 4* ☐ Don't know ➔ *Go to question 4*

3a. If yes, please indicate their relationship to you? *(Mark all that apply)*

- ☐ Natural father
- ☐ Natural mother
- ☐ Full brother
- ☐ Full sister
- ☐ Half brother
- ☐ Half sister
- ☐ Mother's brother (maternal uncle)
- ☐ Mother's sister (maternal aunt)
- ☐ Father's brother (paternal uncle)
- ☐ Father's sister (paternal aunt)
- ☐ Son
- ☐ Daughter

Fractures

4. **Was your natural mother ever told by a doctor that she had osteoporosis, sometimes called thin or brittle bones?** Please answer for your natural mother--the mother who gave birth to you.

   ☐ Yes ☐ No ☐ Don't know

5. **Did your natural mother ever break or fracture a bone?** Please answer for your natural mother--the mother who gave birth to you.

   ☐ Yes ☐ No ➔ *Go to question 6* ☐ Don't know ➔ *Go to question 6*

   5a. Did your natural mother ever break or fracture her HIP?

   ☐ Yes ☐ No ☐ Don't know

   5b. Did your natural mother ever break or fracture her WRIST OR FOREARM?

   ☐ Yes ☐ No ☐ Don't know

   5c. Did your natural mother ever break or fracture her SPINE?

   ☐ Yes ☐ No ☐ Don't know

   5d. Did you natural mother ever break a bone not listed above?

   ☐ Yes ☐ No ☐ Don't know

   If yes, Please specify:_____

6. **Was your natural father ever told by a doctor that he had osteoporosis, sometimes called thin or brittle bones?**

   ☐ Yes ☐ No ☐ Don't know

7. Did your natural father ever break or fracture a bone?

☐ Yes ☐ No ➔ *Go to question 8* ☐ Don't know ➔ *Go to question 8*

7a. Did your natural father ever break or fracture his HIP?

☐ Yes ☐ No ☐ Don't know

7b. Did your natural father ever break or fracture his WRIST OR FOREARM?

☐ Yes ☐ No ☐ Don't know

7c. Did your natural father ever break or fracture his SPINE?

☐ Yes ☐ No ☐ Don't know

7d. Did you natural father ever break a bone not listed above?

☐ Yes ☐ No ☐ Don't know

If yes, Please specify:_____

Prostate Cancer

8. Has anyone in your immediate family ever had prostate cancer? Please include blood relatives only.

☐ Yes ☐ No ☐ Don't know

8a. If yes, please indicate their relationship to you: *(Mark all that apply)*

- ☐ Natural father
- ☐ Full brother
- ☐ Half brother
- ☐ Son
- ☐ Mother's brother (maternal uncle)
- ☐ Father's brother (paternal uncle)

Thank you for completing this questionnaire!

Please bring this questionnaire with you to the CHAMP clinic.

Appendix B- Clinic Questionnaire

CHAMP

CONCORD HEALTH AND AGEING IN MEN PROJECT

Clinic Questionnaire

Chief Investigators

Professor Robert Cumming

Professor David Handelsman

Professor Philip Sambrook

Professor Markus Seibel

Professor David Le Couteur

Dr Helen Creasey

Dr Louise Waite

Dr Vasi Naganathan

Project Manager

Ms Melisa Litchfield

Project Officers

Dr Cindy Kok

Dr Tamara Ribaric

Research Nurses

Ms Maggie Hayes

Mrs Sue Todd

Section 1 - Specimen Collection

1. Date of specimen collection

_____/_____/_____
day month year

2. Blood ID number

«PerBloodID»

3. What is the date and time you last ate or drank anything except water?

3a. Date of last meal _____ (dd/mm/yy)

3b. Time of last meal _____:_____ (hours:minutes) __am __pm

3c. How many hours has participant fasted? _____Hours

4. Do you bleed or bruise easily?

- ☐ Yes
- ☐ No
- ☐ Refused
- ☐ Don't Know

5. Have you ever been told you have a disorder relating to blood clotting or coagulation?

- ☐ Yes
- ☐ No
- ☐ Refused
- ☐ Don't Know

6. Have you ever experienced fainting spells while having blood drawn?

- ☐ Yes
- ☐ No
- ☐ Refused
- ☐ Don't Know

7. Have you ever had a shunt or port for kidney dialysis?

- ☐ Yes → 7a. Which side?
  - ☐ right *(draw blood on left)*
  - ☐ left *(draw blood on right)*
  - ☐ both *(Do NOT draw blood)*
- ☐ No
- ☐ Refused
- ☐ Don't Know

8. Start time of venipuncture (butterfly or needle into vein):

____:____(hours:minutes) __am __pm

9. Finish time of venipuncture:

____:____(hours:minutes) __am __pm

10. Total tourniquet time:
(If tourniquet was reapplied, enter total time tourniquet was on.)

_____Minutes

11. Was any blood drawn?

☐ Yes ☐ No

11a. If no, why not? _____

12. Which tubes were filled?

☐ Hormones (9mL red tube)	ANZAC label
☐ 1st Bone assay (9mL red tube)	ANZAC label
☐ 2nd Bone assay (9mL red tube)	ANZAC label
☐ Future parameters - EDTA (9mL purple tube)	ANZAC label
☐ Biochemistry & PSA (5mL yellow tube)	CSAHS label
☐ Hematology - FBC (4mL small purple tube)	CSAHS label
☐ Future parameters (9mL green tube)	ANZAC label
☐ 1st future parameters (9mL red tube)	ANZAC label
☐ 2nd future parameters (9mL red tube)	ANZAC label

13. If any of the above blood tubes were not filled, why not?

_____

14. Quality of venipuncture:

☐ Clean ☐ Traumatic

14a. If traumatic, *Mark all that apply*:

☐ Vein collapse
☐ Hematoma
☐ Vein hard to get
☐ Excessive duration of draw
☐ Leakage at venipuncture site
☐ Other *(Please specify)*_____

15. Comments of phlebotomy:

Section 2 - Alcohol Use

A show card that lists the measures of standard drinks should be shown while asking these questions.

1. **In the past 12 months, have you had at least 12 drinks of any kind of alcoholic beverage?**

   ☐ Yes
   ☐ No
   ☐ Don't Know
   ☐ Refused

   1a. In the past 12 months, on the average, how many days per week, month, or year did you drink any alcoholic beverage?

   _____days per ☐ Week ☐ Month ☐ Year

   1b. On the average, on the days that you drank alcohol, how many drinks did you have a day?

   _____drinks

   1c. In the past 12 months, how many days per week, month, or year did you have five or more drinks on a single day?
   Include all types.

   _____days per ☐ Week ☐ Month ☐ Year

   ☐ Participant did not have at least five drinks on any day

2. **Was there ever a time in your life when you drank 5 or more drinks of any kind of alcoholic beverage almost every day?**

   ☐ Yes
   ☐ No
   ☐ Don't Know
   ☐ Refused

Section 3 - Functional disability

Do you need help from another person or special equipment or device to do any of the following things?

	No, does not need help	Yes, needs help	Unable to do this
1. Walking across a small room?			
2. Bathing, either a sponge bath, tub bath, or shower?			
3. Personal grooming, like brushing hair, brushing teeth, or washing face?			
4. Dressing, like putting on a shirt, buttoning and zipping, or putting on shoes?			
5. Eating like holding a fork, cutting food, or drinking from a glass?			
6. Getting from a bed to a chair?			
7. Using the toilet?			

Section 4 - Pain

1. **In the last 6 months, have you experienced pain in any part of your body which has lasted for 3 months or more, that is pain experienced every day for at least 3 months?**

☐ Yes ☐ No

↓

1a. In which part(s) of your body have you experienced this pain?
(Mark all that apply)

☐ Hands	☐ Neck
☐ Wrist	☐ Hips
☐ Elbows	☐ Knees
☐ Shoulders	☐ Ankles
☐ Face	☐ Feet
☐ Jaw	☐ Back

☐ Other *(Please specify)*_____

Section 5 – Cognition

Say to participant ***"In the next section we're going to do some tasks which you may find challenging. That's normal, because some of them are difficult. We're doing these tasks to look at your memory and concentration…things like that. You won't get them all right – that's impossible. The important thing is that you try your best. To help me score the tests later, I'm going to record***

some of the sections – is that ok? Also, I will not tell you whether your answers are right or wrong during this session."

Logical Memory

Say to participant ***"I am going to read a short story to you. Listen carefully and try to remember it just the way I say it, as close to the same words as you can remember. When I am finished, I want you to tell me everything I read to you. You should tell me as much as you can remember even if you are not sure. You will not be able to remember the whole story but just remember as much as you can. Are you ready?"***

Read the following story in a steady, clear voice.

Robert / Miller / was driving / a ten-ton / truck /	/5
down a highway / at night / in the Hunter / Valley /,	/4
carrying eggs / to Newcastle /, when his axle / broke.	/4
His truck skidded / off the road /, into a ditch /.	/3
He was thrown / against the dashboard / and was badly shaken /.	/3
There was no traffic / and he doubted that help would come /.	/2
Just then his two-way radio / buzzed /. He quickly answered /,	/3
"This is Grasshopper /."	/1
1. Total for story Max = 25	

After reading the story, say **"Tell me everything you can remember about the story. Start at the beginning."**

As the participant repeats the words to you, place a tick above the word. Score one point for each section of words (separated by a "/"). If the participant says anything that is not part of the story, record what they say on the right hand side of the story box.

When the participant has finished ask them **"Is there anything else you can think of?"** as they often remember another couple of words**. "I want you to remember as much of this story as you can because I will ask you to tell me the story again later."**

2. Record the time this sentence was said to participant _____:_____

Trail Making Task B

Hand the participant the “Sample Response Sheet” and a pencil.

Say to the participant: **"On this page there are some numbers and letters. When I tell you to,**
please begin at number 1 *(point to 1)*
and draw a line from 1 to A *(point to A)***,**
then from A to 2 *(point to 2),*
from 2 to B *(point to B),*
B to 3 *(point to 3)***,**
3 to C *(point to C)*
and so on, in order, until you reach the end. *(Point to the circle marked end.)* **Remember, first, you have a number** *(point to 1),*
then a letter *(point to A)***,**
then a number *(point to 2)***,**
then a letter *(point to B)***. Work as fast and accurately as you can. Try not to lift your pencil from the page. Ready? Begin."**

If the participant makes a mistake, point out the error and explain it. For example, say **“That’s not quite right. Let me show you how it should be done.”** If necessary, guide the participant's hand through the trail, eraser end down. Then say, **"Now you try it,"** and repeat the directions starting, **"Begin at number 1 . . “** The participant is allowed 3 attempts at the Sample Response Sheet. If they do not complete the sample successfully, do not administer the test.

If the participant completes the sample sheet correctly and shows that he understands the task, say, **"Good! Let's try the next one,"** and continue on with the test.

1. Was the participant able to complete the Sample Response Sheet?

☐ Yes ☐ No

1a. If no, why not?

- ☐ Unable due to physical problems (hand tremor, cast, etc.)
- ☐ Participant did not understand directions
- ☐ Other
- ☐ Participant refused

Hand the participant the "Test Response Sheet."

Say to the participant: **"Here is another page with numbers and letters. Do this page the same way.**
Begin at number 1 *(point to 1)*
and draw a line from 1 to A *(point to A),*
A to 2 *(point to 2),*
2 to B *(point to B),*
and so on, in order, until you reach the end. *(Point to the circle marked end.)*
Work as fast and as accurately as you can. Try not to lift the pencil from the page. I will be watching you as you work so I can point out any problems as they occur. I'll be drawing a line across any incorrect lines as we go along. You will have five minutes to do as much of this as you can. Ready? Begin."

Start timing as soon as the instruction is given above. Allow a maximum of 300 seconds (5 minutes) for the task. WATCH CLOSELY IN ORDER TO CATCH ANY ERRORS AS SOON AS THEY ARE MADE. If the participant makes an error, identify it immediately by saying **"Excuse me, that's not quite right"**. Draw a perpendicular line through the incorrect line and tell him to proceed from the number or letter where the mistake occurred. Do not show him which circle to go to next and DO NOT STOP TIMING.

If the participant is having trouble, say **"Just do the best you can"**.

Record time in minutes and seconds and list the number of errors made. If the participant makes more than 5 errors or goes over 300 seconds, stop, and go on to the next test.

	2. Number of circles connected (max = 25) circles
:	3. Total time in minutes and seconds (max = 5 mins)
	4. Number of errors

Addenbrooke's Cognitive Examination (ACE)

Say to the participant **"Now we will move onto the next section."** Write the participants answer in the space provided in the response column.

1= Correct 0= Incorrect R=Refused

Question	Response	Score		
1. What is the year?	Year:	1	0	R
2. What is the season? *(Current season Or within 1 week of upcoming season Or within 2 weeks of previous season)*	Season:	1	0	R
3. What is the date? *(± 2 days)*	Date:	1	0	R
4. What is the day?	Day:	1	0	R
5. What is the month?	Month:	1	0	R
6. What is the country we are in?	Country:	1	0	R
7. What state are we in?	State:	1	0	R
8. What city are we in?	City:	1	0	R
9. What is the name *(or address)* **of this place?**	Name:	1	0	R
10. What floor of the building are we on?	Floor:	1	0	R
11. Listen carefully. I am going to say three words. After I have said them, I want you to repeat them. Remember what they are because I am going to ask you to name them again in a few minutes. Please repeat the names for me: **APPLE** **TABLE** **PENNY** *(Score first try (0-3), but keep saying all 3 until subject can repeat all 3, up to 6 trials. Record number of trials required.)*	Apple Table Penny No of trials necessary for the participant to repeat the sequence ☐	1 1 1	0 0 0	R R R
12. Now I'd like you to subtract 7 from 100. Then keep subtracting 7 from each answer until I ask you to stop. *(If subject cannot or will not perform this task, administer b, world)*	93 86 79 72 65	1 1 1 1 1	0 0 0 0 0	R R R R R

12b. ADMINISTER ONLY IF SUBJECT CANNOT DO 12. **Now I am going to give you a word and ask you to spell it forwards and backwards. The word is WORLD. First, can you spell it forwards? Now spell it backwards.** *(Repeat if necessary, and help subject spell world forward, if necessary. Score number of letters given in correct order.)*	D L R O W	/ 5 R
13. What are the three objects I asked you to remember?	Apple Table Penny	1 0 R 1 0 R 1 0 R
14. I am going to read a name and address: I want you to repeat it when I have finished. Wait until I finish telling you the complete address. *(Now read aloud the following name and address.)* **Peter Marshall** **42 Station Street** **Geelong** **Victoria** *Regardless of the score after the first trial, say* **"Now I'm going to read the name and address again and I want you to repeat it again when I am finished."** *Repeat this instruction and test twice. Record score for each of the three trials.*	*14a. Trial 1* Peter:_____ Marshall: _____ 42: ____ Station: _____ St: _____ Geelong: _____ Victoria: _____ *14b. Trial 2* Peter:_____ Marshall: _____ 42: ____ Station: _____ St: _____ Geelong: _____ Victoria: _____ *14c. Trial 3* Peter:_____ Marshall: _____ 42: ____ Station: _____ St: _____ Geelong: _____ Victoria: _____	/ 7 R / 7 R / 7 R
15. Tell me the name of the: • **the Prime Minister** • **the previous Prime Minister** • **the Leader of the Opposition** • **the President of the United States of America**	PM: Last PM: Opposition: USA President:	1 0 R 1 0 R 1 0 R 1 0 R

16. Tell me all the words you can think of beginning with the letter P, but don't tell me names of people or places. **Remember, no people or place names.** *(Time the patient for 60 seconds and list all the answers in the space provided. The score is the number of words they think of.* *If the person mentions a person or a place you may remind them of the rules once.)*			Total words Raw score Scaled score /7 Refused		
17. Now tell me names of all the animals you can think of (it doesn't matter what letter they start with). *(Time the patient for 60 seconds and list all the answers in the space provided. The score is the number of words they think of.* *If the person mentions a person or a place you may remind them of the rules once.)*			Total words Raw score Scaled score /7 Refused		
18. *(Show wrist watch)* **What is this called?**	Watch:		1	0	R
19. *(Show pencil)* **What is this called?**	Pencil:		1	0	R
20. Show 10 pictures. Ask patient to name the pictures. *Allow close synonyms.* Ask the patient: **What do you call this?**	Giraffe		1	0	R
	Kite		1	0	R
	Helicopter		1	0	R
	Pig		1	0	R
	Kangaroo		1	0	R
	Crown		1	0	R
	Windmill		1	0	R
	Goat		1	0	R
	Barrel		1	0	R
	Camel		1	0	R

21. Please obey the following simple commands: • **Point to the door** • **Point to the ceiling** • **Point to the ceiling then the door** • **Point to the door after touching the desk**	Point to the door: Point to the ceiling: Ceiling to door: Desk to door:	1 1 1 1	0 0 0 0	R R R R
22. Read the words on this page, then do what it says. *(The paper reads "CLOSE YOUR EYES". Correct if subject closes eyes.)*	Close your eyes	1	0	R
23. I'm going to give you a piece of paper. When I do, take the paper in your right hand, fold the paper in half with both hands, and put the paper down on your lap. *(Read the full statement, THEN hand over paper. Do not repeat instructions or coach. Score 1 point for each correct step.)*	Take in right hand Fold in half Put it on lap	1 1 1	0 0 0	R R R
24. Repeat each of these words after me. • **Brown** • **Conversation** • **Articulate**	Brown: Conversation: Articulate:	1 1 1	0 0 0	R R R
25. I would like you to repeat each of these phrases after me: **"NO IFS, ANDS OR BUTS"** **"The orchestra played and the audience applauded."** *(Allow only one trial.)*	No ifs, ands: Orchestra:	1 1	0 0	R R
26. Please read these words aloud: • **Shed** • **Wipe** • **Board** • **Flame** • **Bridge**	Shed: Wipe: Board: Flame: Bridge:	1	0	R

27. Please read these words aloud: • **Sew** • **Pint** • **Soot** • **Dough** • **Height**	Sew: Pint: Soot: Dough: Height:	1 1 1 1 1	0 0 0 0 0	R R R R R
28. Write any complete sentence on that piece of paper for me. (*If examinee needs a sentence ask them to write about the weather. Ask subject to write on the page they folded in half. Sentence must contain a subject and a verb and be sensible. Correct grammar and punctuation are not necessary.)*	Sentence:	1	0	R
29. Can you tell me the name and address that I told you before (the one you practiced 3 times).	*5 minute delay* Peter:_____ Marshall: _____ 42: ____ Station: _____ St: _____ Geelong: _____ Victoria: _____	/ 7 R		
30. Here are two drawings. Please copy the drawings on the same paper.	Pentagon Wire cube	1 1	0 0	R R
31. Can you please draw a clock-face with numbers and the hands at ten past five.	Correct circle: Numbering: Position of hands:	1 1 1	0 0 0	R R R
	32. Total score MMSE:	**/30**		
	33. Total score ACE:	**/100**		

34. Does the participant have any physical/functional disabilities or other problems that caused the participant difficulty in completing any of the tasks.

☐ Yes ☐ No

↓

34a. If yes, what is the most significant reason?

_____

Colour form sort

Spread the colour form pieces on the table in no apparent order. Say to the participant **"Sort the pieces into separate groups, so that the ones that are alike go together."**

If the participant asks for any advice, say **"It's completely up to you."**

Leave the pieces as they are and say to the participant **"Now sort the pieces into groups that go together in a *different* way.**

If they sort the pieces incorrectly say **"That's not different enough, sort them in a completely different way."**

1. ☐ Unable to do first sort
   ☐ Sorts one category spontaneously
   ☐ Sorts two categories spontaneously

If the participant failed and is unable to sort the pieces, ask them to name the colours.

2. Was the participant able to name the colours? ☐ Yes ☐ No

Logical Memory Recall

3. Record the time _____:_____

Say to participant **"Do you remember the story I read you a little while ago? I want you to tell me the story again. Tell me everything that you can remember about the story. Start at the beginning."**

If the participant does not recall any story, say **"The story was about a man who had trouble on the highway."**

4. Was the reminder sentence given? ☐ Yes ☐ No

Do not give any further help other than general encouragement. When they have finished say **"Is there anything else you can think of?"**

Robert / Miller / was driving / a ten-ton / truck /	*/5*
down a highway / at night / in the Hunter / Valley /,	/4
carrying eggs / to Newcastle /, when his axle / broke.	/4
His truck skidded / off the road /, into a ditch /.	/3
He was thrown / against the dashboard / and was badly shaken /.	/3
There was no traffic / and he doubted that help would come /.	/2
Just then his two-way radio / buzzed /. He quickly answered /,	/3
"This is Grasshopper /."	/1
5. Total for story Max = 25	

Section 6 - Fracture History

1. Has a doctor EVER told you that you broke or fractured a bone?

☐ Yes ☐ No

1a. If yes:
- which bones were they?
- how old were you?
- how did you break or fracture the bone?

Allow multiple breakages for the same bone. Record details for each breakage

	Yes	No	Age	How did you break the bone?
Spine				
Wrist				
Hip				
Arm				
Ankle				
Leg				
Other				

Other specify _____

Section 7 - Height, Weight & Pulse

1. Standing Height

Say to participant **"Please stand with your back against the board mounted on this wall. Your legs should be together and your heels, your buttocks and your back should be touching the wall-plate. Look straight ahead and stand tall.**

Bring the horizontal bar down firmly onto the top of the participant's head. Place the bean bag on the headboard to make sure the horizontal bar makes contact with the top of the scalp.

Ask the participant to **"Take a deep breath."** Record the reading on the stadiometer just before the participant exhales. Then say **"Breathe out."**

Ask the participant to **step away from the stadiometer, then step back into the measurement position.** Take the second measurement as before.

1a. Measurement 1 _____mm 1b. Measurement 2 _____mm

1c. Does measurement 1 and measurement 2 differ by 4 or more mm?

☐ Yes ☐ No

↓

If yes: Complete Measurements 3 & 4

1d. Measurement 3 _____mm 1e. Measurement 4 _____mm

1f. Is the participant standing sideways due to kyphosis?

☐ Yes ☐ No

2. Weight

Turn the scales on and do not touch the scales or support poles while the scales set themselves. The scales will beep when they are ready.

Say to participant **"In order to measure your weight, please remove your shoes and heavy jewellry, and empty your pockets. Please step forward onto the center of the scale."** If the participant needs support you can tell them they can use the bars of the scales to steady themselves.

Weight _____kg

2a. If weight was not measured, explain why _____

3. Circumferences

Neck

3a. Measure 1 _____mm 3b. Measure 2 _____mm 3c. Measure 3 _____mm

Waist

3d. Measure 1 _____mm 3e. Measure 2 _____mm 3f. Measure 3 _____mm

Hip

3g. Measure 1 _____mm 3h. Measure 2 _____mm 3i. Measure 3 _____mm

4. Measurement of foot size?

Right

4a. Measurement 1 _____ mm

4b. Measurement 2 _____ mm

Left

4c. Measurement 1 _____ mm

4d. Measurement 2 _____ mm

5. Radial Pulse

5a. Measurement 1

_____beats per 30 seconds x 2 ➔ Measurement 1 _____beats per minute

5b. Measurement 2

_____beats per 30 seconds x 2 ➔ Measurement 2 _____beats per minute

Total (Measurement 1 + Measurement 2) _____ ÷ 2 = _____ Average beats per minute

Blood Pressure

6. Exclusion criteria ➔ **If any of these are ticked, DO NOT TEST**

- ☐ Open wounds, ulcerations
- ☐ Bilateral amputation
- ☐ Unable to lie at <45 degree angle
- ☐ Participant refused

7. Cuff size

- ☐ Small
- ☐ Regular
- ☐ Large
- ☐ Thigh

8. Arm Used

- ☐ Right
- ☐ Left ➔8a. Why wasn't right arm was used:_____

9. Blood pressure while patient LYING DOWN

Blood Pressure 1

9a. Systolic Measurement 1

_____mmHg

9b. Diastolic Measurement 1

____mmHg

Blood Pressure 2

9c. Systolic Measurement 2

_____mmHg

9d. Diastolic Measurement 2

____mmHg

Make sure participant is alright after they stand upright.

10. Blood pressure while patient STANDING UPRIGHT

Blood Pressure 3	**Blood Pressure 4**
10a. Systolic Measurement 3 _____mmHg	10c. Systolic Measurement 4 _____mmHg
10b. Diastolic Measurement 3 _____mmHg	10d. Diastolic Measurement 4 _____mmHg

11. After standing blood pressure has been measured, ask participant **"Did you feel dizzy, woozy or lightheaded during any of the procedure?"**

☐ Yes ☐ No

Section 8 – Functional Vision

1. **Have you ever been told by your doctor or health professional that you have macular degeneration?**

   ☐ Yes ☐ No

   ↓

   1a. If yes, are you currently being treated for this condition by a doctor?

   ☐ Yes ☐ No

2. **Have you ever been told by your doctor or health professional that you have glaucoma?**

   ☐ Yes ☐ No

   ↓

   2a. If yes, are you currently being treated for this condition by a doctor?

   ☐ Yes ☐ No

3. **Have you ever been told by your doctor or health professional that you have cataracts?**

   ☐ Yes ☐ No

   ↓

   3a. If yes, have you had surgery for cataracts?

   ☐ Yes ☐ No

Letter literacy test

Administer the letter literacy test. Show participant letter literacy card.
Be sure they are wearing their reading glasses, if needed.

Script: **"Can you see these letters** *(point to card).* **Read me the letters one by one across the line."**

A B O S E R T H U P I V Z J Q

4. Letter literacy test score: Number of correct letters:_____

   Were 10 or more letters read correctly?

   ☐ Yes ➔ *administer all functional vision tests*
   ☐ No ➔ *administer Frisby stereo test only*

LOGMAR VISUAL ACUITY

5. **"Do you usually wear glasses or contact lenses to see things at a distance, like for driving or watching TV?"**

   ☐ Yes ☐ No ➔ *Go to question 6*

5a. Is the participant wearing glasses or contact lenses for the acuity test?

☐ Yes ☐ No ➔ *Go to question 6*

5b. What is the participant wearing – glasses and/or contact lenses?

☐ Glasses ☐ Contact lenses

5c. What type of glasses?

☐ Distance
☐ Bifocal
☐ No-line bifocal
☐ Multi-focal

5d. What type of contact lenses?

☐ Distance
☐ Bifocal
☐ Monovision (one eye corrected for near, one for distance)

6. Which distance was used?

☐ 8 feet
☐ 4 feet
☐ Participant unable to read chart at 4 feet

Say to participant **"I'm going to ask you to read me the letters on that chart. Can you read the highlighted top row using both eyes? Don't squint and don't lean forward."** If they correctly read the top line, continue. If they can't read the top line, move the participant to 4 feet and try again. If they still cannot read the top line, stop the test.

Then say **"Now keep reading down the chart. If you are not sure about a letter, please guess."** Don't tell the participant when they have made a mistake. If they hesitate, say **"Go ahead and guess. We need you to go as far as you can, guessing when you are not sure."**

Mark any incorrect letters on the table on the next page. If the participant gets three or more letters wrong in the one row, tell them to stop after they have finished the entire row. Say **" Okay, that's great. Now you can stop."**

Examiner Note: Make an "X" through each letter incorrectly identified. If the participant misses 3 or more letters on one row, stop administering the test and go to Question 8.

Chart	Letter Count	SNELLEN 8 feet	Equivalent 4 feet
H V Z D S	5	20/200	20/400
N C V K D	10	20/160	20/320
C Z S H N	15	20/125	20/250
O N V S R	20	20/100	20/200
K D N R O	25	20/80	20/160
Z K C S V	30	20/63	20/125
D V O H C	35	20/50	20/100
O H V C K	40	20/40	20/80
H Z C K O	45	20/32	20/63
N C K H D	50	20/25	20/50
Z H C S R	55	20/20	20/40
S Z R D N	60	20/16	20/32
H C D R O	65	20/12.5	20/25
R D O S N	70	20/10	20/20

7. Number of letters read correctly: _____letters

(Examiner Note: Starting with the Letter Count for the last line read without errors, add one for each additional letter correctly read on lines below it.)

8. Was the acuity test administered?

☐ Yes ☐ No

8a. If no, why not?
(Examiner Note: Check main reason test was not administered.)

- ☐ Did not pass letter literacy exam
- ☐ Participant fatigued
- ☐ Unable to see chart
- ☐ Did not understand
- ☐ Refused

PELLI-ROBSON TEST FOR CONTRAST SENSITIVITY

9. Is the participant wearing glasses and/or contact lenses for the Pelli-Robson test?

☐ Yes ☐ No ➔ *Go to question 10*

9a. What is the participant wearing – glasses and/or contact lenses?

☐ Glasses ☐ Contact lenses

9b. What type of glasses?

☐ Distance
☐ Bifocal
☐ No-line bifocal
☐ Multi-focal

9c. What type of contact lenses?

☐ Distance
☐ Bifocal
☐ Monovision (one eye corrected for near, one for distance)

10. Which chart was used?

☐ Chart 1 ☐ Chart 2

11. Which distance was used?

☐ 8 feet ☐ 4 feet

(Examiner Note: Use the same distance as for the acuity chart or if the participant cannot identify the darkest triplet correctly at 8 feet, move to 4 feet.)

Explain the task to the participant **"Now on this chart, the letters stay the same size, but get more faded as you read down the chart. Again, I want to encourage you to guess if you aren't sure of a letter, and sometimes it helps just to stare at the letter for a moment. I'd like you to start with the top line. Can you read that line?"**

If the participant can't read the first three letters, move them or the chart to 4 feet.

Say to the participant **"Now keep reading down the chart. If you are not sure about a letter, please guess."**

If they hesitate **"Go ahead and guess. We need you to go as far as you can, guessing when you are not sure. Do not lean forward. Keep looking, sometimes the letter appears even though it is invisible when you first look at it."**

When the participant gets all three letters in a triplet wrong say **"Okay, that's great. Now you can stop."**

(Examiner Note: Make an "X" through each letter incorrectly identified. When the participant misses all 3 letters in a triplet, stop administering the test and go to Question 13.)

Chart 1	Letter Count	Chart 2

H S Z	D S N	06	V R S	K D R
C K R	Z V R	12	N H C	S O K
N D C	O S K	18	S C N	O Z V
O Z K	V H Z	24	C N H	Z O K
N H O	N R D	30	N O D	V H R
V R C	O V H	36	C D N	Z S V
C D S	N D C	42	K C H	O D K
K V Z	O H R	48	R S Z	H V R

12. Number of letters read correctly: _____letters

(Examiner Note: Starting with the Letter Count for the last line read without errors, add one for each additional letter correctly read on lines below it.)

13. Was the Pelli-Robson test administered?

☐ Yes ☐ No

13a. If no, why not?
(Examiner Note: Check main reason test was not administered.)

☐ Did not pass letter literacy exam
☐ Participant fatigued
☐ Unable to see chart
☐ Did not understand
☐ Refused

FRISBY STEREO TEST—DEPTH PERCEPTION

14. Does the participant usually wear glasses and/or contact lenses for reading?

☐ Yes ☐ No

14a. Is the participant wearing glasses and/or contact lenses for the Frisby Stereo test?

☐ Glasses ☐ Contact lenses ☐ Not wearing either

14b. What type of glasses?

- ☐ Distance
- ☐ Bifocal
- ☐ No-line bifocal
- ☐ Multi-focal
- ☐ Reading

14c. What type of contact lenses?

- ☐ Distance
- ☐ Bifocal
- ☐ Monovision (one eye corrected for near, one for distance)

Show the participant the thickest plate. The circle should be sticking out towards the participant.

Script: **"This is a test of depth perception. One of the squares has a circular area of pattern standing out in front of it. Can you see which one it is?"**

If the participant correctly identifies the square with the circle in it, begin testing on the medium thickness plate.

If they guess incorrectly or cannot see the circle, ask them to guess. If they guess wrong, turn the plate onto a corner and twist the plate slightly back and forth. This should allow them to see the circle without affecting the test. If the participant still cannot identify the correct square, point to the square with the circle.

Once they can see the circle, remove the plate from their vision and rotate the plate so the circle is in a new position. Place the plate back on the table in the standard testing position and ask the participant to identify the circle again.

After the participant correctly identifies the first square, remove the plate under the table and rotate it one side and ask the question again. After they respond to the second plate position, remove the plate under the table again but this time do not rotate the plate. Present it in the same position.

15. Was the participant able to point out the depth cue without hesitation (either before or after a demonstration using monocular clues)?

☐ Yes ☐ No

If Yes:

Start here

Plate 2 (medium thickness)	**Plate 3 (thinnest)**
17. Trial	**18. Trial**
1. ☐ Correct ☐ Incorrect	1. ☐ Correct ☐ Incorrect
2. ☐ Correct ☐ Incorrect	2. ☐ Correct ☐ Incorrect
3. ☐ Correct ☐ Incorrect	3. ☐ Correct ☐ Incorrect
If 3 correct, record as "Pass" & go to Plate 3.	*If 3 correct, record as "Pass" & go to Question 19 on next page.*
4. ☐ Correct ☐ Incorrect	4. ☐ Correct ☐ Incorrect
5. ☐ Correct ☐ Incorrect	5. ☐ Correct ☐ Incorrect
6. ☐ Correct ☐ Incorrect	6. ☐ Correct ☐ Incorrect
Pass if 3/3 or at least 5/6 correct	***Pass if 3/3 or at least 5/6 correct***
17a. Plate 2	18a. Plate 3
☐ Pass (Go to plate 3)	☐ Pass (Go to question 19)
☐ Fail (Go to plate 1)	☐ Fail (Go to question 19)
☐ Did not test	☐ Did not test

If no:

Start here

Plate 1 (maximum thickness)

16. Trial

1. ☐ Correct ☐ Incorrect
2. ☐ Correct ☐ Incorrect
3. ☐ Correct ☐ Incorrect

If 3 correct, record as "Pass" & go to Plate 2.

4. ☐ Correct ☐ Incorrect
5. ☐ Correct ☐ Incorrect
6. ☐ Correct ☐ Incorrect

Pass if 3/3 or at least 5/6 correct

16a. Plate 1

- ☐ Pass (Go to plate 2, unless already completed.)
- ☐ Fail (STOP. Go to Question 19 on next page.)
- ☐ Did not test

19. Was a non-standard distance (other than 40 cm) used?

☐ Yes ☐ No

19a. If yes, specify distance used: _____cm

20. Was the Frisby Stereo test administered?

☐ Yes ☐ No

20a. If no, why not?
(Examiner Note: Check main reason test was not administered.)

- ☐ Participant fatigued
- ☐ Unable to see chart
- ☐ Did not understand
- ☐ Other *(Please specify)* _____
- ☐ Refused

Section 9 – Muscle Strength

Grip Strength

Say to participant "**This device measures your arm and upper body strength."**

1. **Do you have any pain or arthritis in your hands?**

☐ Yes ☐ No➔ *Go to question 2*

↓

1a. Has any of it gotten worse recently?

☐ Yes ⟶ **1b. If yes, which side?**
☐ No ☐ Left *(Do not test)*
☐ Don't Know ☐ Right *(Do not test)*
☐ Refused ☐ Both *(Do not test either side)*

2. **Have you had any surgery on your hands or wrists in the past 3 months (12 weeks)?**

☐ Yes ⟶ **2a. If yes, which side?**
☐ No ☐ Left *(Do not test)*
☐ Don't know ☐ Right *(Do not test)*
☐ Refused ☐ Both *(Do not test either side)*

Script: **"I'd like you to take your right/left arm, rest it on the table, and bend your elbow. Grip the bars in your hand, like this. Please slowly squeeze the bars as hard as you can."**

Hand the dynamometer to the participant. **"Does that feel like a comfortable grip?"** Adjust if needed.

Script: **"Now try it once just to get the feel of it. For this practice, just squeeze gently. It won't feel like the bars are moving, but your strength will be recorded. Are the bars the right distance apart for a comfortable grip?"**

Show dial to participant. Test twice on the right side, then twice on the left side.

Script: **"We'll do this two times. This time counts, so when I say squeeze, squeeze as hard as you can. Ready? Squeeze! Squeeze! Squeeze! Now, Stop!"**

Right side

3a. Trial 1 _____kg
☐ Refused
☐ Unable, did not attempt

3b. Trial 2 _____kg
☐ Refused
☐ Unable, did not attempt

Left side

3c. Trial 1 _____kg
☐ Refused
☐ Unable, did not attempt

3d. Trial 2 _____kg
☐ Refused
☐ Unable, did not attempt

Leg strength

Say to participant "**Now we are going to measure the strength in your quadriceps muscles."**

4. Do you have any pain or arthritis in your knees?

☐ Yes ☐ No

↓

4a. If yes, the test should not aggravate the pain but ask the participant to tell you if he is concerned, or excessively uncomfortable or in pain. Make sure they do not push too hard as it may aggravate the knee.

Script **"I need you to get up on this chair and move your bottom all the way back. I'm going to place a strap around your shin."**

Hang the spring gauge off the back rung of the chair. The participant's leg should be at an 80 degree angle so when they extend their leg it goes to a right angle. Fasten the Velcro around their leg, about 10cm up from the ankle. You can do the test over clothing and you should use the shoulder pads so that the strap does not dig into the skin.

Say **"Does that feel comfortable? Now, when we do the test, please hold onto the side of the chair for support. When I say Go I want you to push against the strap at a moderate pace but as hard as you can. Ready? Go! Push! Push! Push! Now stop! We will do this test 3 times on each leg."**

If the participant is very strong, the 40kg spring gauge will be too easy so use the 100kg spring gauge instead. You may only find this out after the first trial, that's fine, just swap the spring gauges. If they are strong and push really hard they may have some muscle soreness over the next couple of days. You may want to warn some people about this after the test is complete.

5. Which spring gauge was used?

☐ 40kg ☐ 100kg

Right side

6a. Best Trial _____kg

☐ 6b. Test not completed

6c. Why

Left side

7a. Best Trial _____kg

☐ 7b. Test not completed

7c. Why not?_____

Section 10 – Neuromuscular Function

INTRODUCTION/SCREENING QUESTIONS

Script**: "I'm going to ask you to try to do several different movements of your body. I will first describe and show each movement to you. Then I'd like you to try to do it. If you cannot do a particular movement or you feel it would be unsafe to try to do it, please tell me and we'll move on to the next one. Let me emphasize that I would like you to try each exercise. But I don't want you to try to do any exercise that you feel might be unsafe."**

1. Ask the participant**, "Do you have any problems from recent surgery, injury or other health conditions that might prevent you from standing straight up from a chair or walking up steps?"**

☐ Yes ☐ No

↓

If yes, Tell the participant, **"Before we do each test, I'll describe it to you. Please tell me if you think that you shouldn't attempt the test because of the problems you described."**

2. Ask the participant, **"Do you use any walking aids, such as a cane?"**

☐ No aids
☐ Cane or quad cane
☐ Walker, Wheelchair, leg brace, crutches

3. Does the participant have any of the following? *(Mark all that apply)*

☐ Orthosis
☐ Missing limbs
☐ Prothesis
☐ Paralysis of extremity or side of body

SINGLE CHAIR STAND

Have the participant sit in the chair, assuming the position from which he would normally stand up from a chair (but no more than half-way forward on the seat of the chair) with the feet resting on the floor and the arms folded across the chest.

Script: **"This is a test of strength in your legs in which you stand up from sitting without using your arms."**

Demonstrate the procedure. **"Fold your arms across your chest, like this, and stand, keeping your arms in this position. Do you understand?"** Ask the participant to stand. Script: **"Can you stand and sit one time for practice?"**

If the arms unfold, or the participant puts one or both hands down on the chair to push up, remind him to keep his arms folded snugly across his chest, and ask him to repeat the chair stand. It is OK for the participant to move part-way forward in the chair before standing, but knees and hips should be flexed to approximately 90 degrees before standing.

If the participant cannot rise without using arms, say: **"Ok. Try to stand up using your arms to push off."**

4. Could the participant stand up one time unassisted?

- ☐ Stands without using arms
- ☐ Unable to stand
- ☐ Rises using arms
- ☐ Did not attempt/Refused

If cannot stand without using arms then do not test the repeated chair stands. Go on to six meter usual pace, next page.

REPEATED CHAIR STAND

When the subject is properly seated after practicing, say, **"This time, I want you to stand up 5 times as quickly as you can, keeping your arms folded across your chest."**

Demonstrate the test. Script: **"First I will show you. When you stand up, come to a full standing position each time, and when you sit down, sit all the way down each time. I will demonstrate two chair stands to show you how it is done."** Rise two times quickly as you can, counting as you stand up each time.

Script: **"When I say 'Go,' stand five times in a row, as quickly as you can, without stopping. Stand all the way up and sit all the way down each time. Ready? GO!"** Count "1,2,3,4,5" as the participant stands up each time.

If the participant fatigues before completing 5 stand-ups, confirm that he can't do more by asking, **"Can you continue?"** If he says yes, keep timing. If he says no, record that he could not complete five stand-ups and DO NOT record a time for him.

5. Did the participant complete all 5 stands?

☐ Yes ↓

5a. Record time and arm use for chair stand.	
_____.___ seconds to complete 5 stands	
5b. Arm use:	
☐ 5 times without using arms	
☐ 5 times, uses arms part of time	
☐ 5 times, uses arms all of time	

☐ No ↓

5c. How many stands were completed?
_____ stands completed
5d. Why weren't 5 chair stands completed?
☐ Attempted, unable to stand up once
☐ Attempted, unable to finish 5 stands
☐ Did not attempt/Refused

SIX METER USUAL PACE

The video should be set up to record the walking. PRESS RECORD on the video before the first walk. Hold up the large CHAMP ID number (on the back of the clinic checklist) in front of the camera for identification of the participant.

The participant should be wearing comfortable walking shoes. He may use a walking aid, but should be encouraged to walk without one if he is comfortable doing so.

Script: **"This is a walking test that will also test your balance. First I want you to walk down the hall normally, at a comfortable pace, ignoring the coloured lines. For the second walk, I will ask you to walk keeping your feet inside the lines. Each test will be done at least twice."**

PRESS THE RED START BUTTON ON THE VIDEO REMOTE AND HOLD UPTHE PARTICIPANT'S CHAMP ID IN FRONT OF THE CAMERA.

Ask the subject to stand behind the line at one end of the course. Script: **"Place your feet with your toes behind, but touching the starting line. Wait until I say 'Go.' Remember, I want you to walk at a comfortable pace ignoring the coloured lines."** Demonstrate and return. "**Walk past the finish line each time. Any questions? Ready? Go?"**

Start the stopwatch at the first foot fall, and stop timing when the first footfall (complete or partial) crosses the finish line. Count the number of steps taken to cover the course (NOT ALOUD). One step is counted when either foot is placed down on the floor, including the first step and the step which a participant's foot crosses or touches the end line. Record time and number of steps below.

6. Trial 1 (6m usual pace)

6a. ____.___ seconds 6b. ____steps 6c. Trial 1 Aid used

- ☐ No aid
- ☐ Straight cane
- ☐ Quad cane
- ☐ Walker
- ☐ Crutch

6d.

- ☐ Trial 1 not attempted
- ☐ Trial 1 attempted but unable
- ☐ Unable to assess

When the participant crosses the end line, ask him to turn around and stand at the end line as before.

Script: **"Now, do the same thing in the other direction. Walk at your usual pace and go all the way, past the finish line, to the other end. Ready? Go"** Record time and number of steps below.

7. Trial 2 (6m usual pace)

7a. ____.___ seconds 7b. ____steps 7c. Trial 2 Aid used

- ☐ No aid
- ☐ Straight cane
- ☐ Quad cane
- ☐ Walker
- ☐ Crutch

7d.

- ☐ Trial 2 not attempted
- ☐ Trial 2 attempted but unable
- ☐ Unable to assess

20 cm NARROW WALK

Script: **"Now for this walk, I want you to keep your feet inside the lines. It is important that you do your best to keep your feet inside the lines"**

Script: **"I'll demonstrate. Keep your feet inside the lines. Be sure to walk past the finish line. Any questions? We will do this test 3 times."**

Note: Time walk as before, but do not count steps. Not staying within the lines is defined as stepping on, or going outside of the colored tape two or more times. Perform up to three trials to obtain 2 valid times.

8. Trial 1 (Narrow walk)

8a. ____.____seconds

8b. Did the participant stay within the lines?

- ☐ Yes, 2 or fewer deviations
- ☐ No, 3 or more deviations (Unable to assess time)
- ☐ Trial 1 Not Attempted
- ☐ Trial 1 Attempted but unable

8c. Trial 1 Aid used

- ☐ No aid
- ☐ Straight cane
- ☐ Quad cane
- ☐ Walker
- ☐ Crutch

9. Trial 2 (Narrow walk)

9a. ____.____seconds

9b. Did the participant stay within the lines?

- ☐ Yes, 2 or fewer deviations
- ☐ No, 3 or more deviations (Unable to assess time)
- ☐ Trial 2 Not Attempted
- ☐ Trial 2 Attempted but unable

9c. Trial 2 Aid used

- ☐ No aid
- ☐ Straight cane
- ☐ Quad cane
- ☐ Walker
- ☐ Crutch

Perform trial 3 only if Trial 1 or Trial 2 were labeled 'No, 3 or more deviations (Unable to assess time)'

10. Trial 3 (Narrow walk)

10a. ____.____seconds

10b. Did the participant stay within the lines?

- ☐ Yes, 2 or fewer deviations
- ☐ No, 3 or more deviations (Unable to assess time)
- ☐ Trial 3 Not Attempted
- ☐ Trial 3 Attempted but unable

10c. Trial 3 Aid used

- ☐ No aid
- ☐ Straight cane
- ☐ Quad cane
- ☐ Walker
- ☐ Crutch

60 second NARROW WALK

Script: **"For the next walk, I want you to walk back and forth at a comfortable pace, keeping your feet inside the lines. When I say go, walk until you pass the yellow line, turn around and come back again. Keep going until I tell you to stop. Remember, don't touch the lines. Any questions? Go."**

Note: The participant needs to walk for 60 seconds. This is a baseline walk for neuropsychological testing. You need to tell the participant to stop after 60 seconds, the other assessments will be completed by reviewing the recorded images.

11. Trial 1 (60 second Narrow walk)

_____deviations

DUAL TASK – walking and talking

Script: **"Now I would like you to walk at the same pace, keeping your feet inside the lines, but this time also name as many words you can think of starting with the letter C. Do not tell me names of people or places. Again, don't touch the lines and walk back and forth between the lines until I say stop. Any questions? Go."**

Note: The participant needs to walk for 60 seconds. This walk is for neuropsychological testing. You need to tell the participant to stop after 60 seconds, the other assessments will be completed by reviewing the recorded images.

12. Trial 1 (Talk and narrow walk)

12a. _____deviations 12b. _____words *(assessed from video)*

REMEMBER TO STOP THE VIDEO

Balance (sway meter)

Say to the participant **"This is a balance test. I'm going to put a strap around your waist. OK, now put your feet shoulder-width apart."** Do not tell the subject this is a sway test.

It is important that the subject's legs are the same distance apart for all three tests. Place the strap firmly around the waist (on the belt line of men). Adjust the table height so that the swaymeter rod is horizontal. Position the pen over the front half of the graph paper.

"Now I want you to stand as still as you can for 30 seconds with your eyes open. Look slightly down and do not talk."

1. Was the participant able to complete the floor sway test?

   ☐ Yes ☐ No➔ why not? _____

Place the foam at the participant's feet and say **"Now I want you to very carefully step onto the middle of this piece of foam."** Make sure his feet are again shoulder-width apart.

Reassure the participant that you will not let them fall whilst undertaking the test. **"Now stand as still as possible for 30 seconds. Again, look slightly down and do not talk. I am standing right here beside you and can support you if you lose balance."** Reposition table so that the pen is over the back half of the graph paper. Repeat the procedure as per the test done on the floor.

2. Was the participant able to complete the foam sway test?

   ☐ Yes ☐ No➔ why not? _____

Say **"Now we will do another test with this device. I'm going to put it on you the other way around – with the rod to the front."**

Position swaymeter with the rod at the front of the person. Place table with the 'race track' sheet in front of them and the pen positioned in the start position in the center of the sheet.

Say **"Keeping your feet still, I'd like you to move your body anyway you need so that you move the pen around the track without going outside the track. Go as slowly as you need to keep steady. Try your best to stay within the lines."**

Conduct a practice and a test. If the trial shows they can't reach the top and bottom of the track, move the paper to make it easier for them.

If a participant is having trouble you can say "slow down" or "take your time". You can also tell them to cut the corners if they need to rather than lifting their feet.

3. Was the participant able to complete the race track test?

   ☐ Yes ☐ No➔ why not? _____

Section 11 – Spirometry

Say to participant: **"This is a test of your lung function. To start with I need to ask you a few questions."**

1. **In the past three months have you have any surgery on your chest or abdomen?**

   ☐ Yes ☐ No

2. **Have you had a heart attack within the past three months?**

   ☐ Yes ☐ No

3. **Do you have a detached retina or have you had eye surgery within the past three months?**

   ☐ Yes ☐ No

4. **Have you been hospitalized for any other heart problem within the past month?**

   ☐ Yes ☐ No

5. **Does the participant have a resting pulse of greater than 120 beats per minute?**

   ☐ Yes ☐ No

If the participant answers YES to any of the above questions, do NOT proceed with the spirometry test. Answer question 8 – No, due to medical reasons.

6. **Have you had a respiratory infection (cold) in the last three weeks?**

   ☐ Yes ☐ No

7. **Have you used any medication for breathing in the last three hours?**

   ☐ Yes ☐ No

Place a new spirette into the spirometer making sure you keep the top of the spirette clean and away from your fingers. Turn the machine on by holding down the 'ON/OFF' button for at least 2 seconds. The machine will buzz and turn on. The screen will show a list of options, select the top option 'Perform test' by pressing the 'ENTER' key on the spirometer. Select 'Quick' using the arrow keys and press the 'ENTER' key again. The machine will show a screen with a list of tests, select the top test 'FVC (Expiration)' by pressing 'ENTER'. The spirometer will buzz and ask you to do the baseline setting. Cover the bottom of the spirette with your hand and select 'ENTER'. This should take a couple of seconds.

When the machine is ready it will say 'Blast out'. Hand the machine to the participant and say **"Take a big deep breath, then place your lips completely around the top of the mouthpiece. Then I want you to blow out as hard and fast as you can. Continue blowing until your lungs are completely empty. Ready? Go, deep breath."**

Repeat the test three times. When the result screen appears, record the FEV1 value below and press ‘Enter’. Use the arrow keys to select ‘Quit’, then select ‘Post’. The machine will start again and ask you to set the baseline measure. To start the final test, once you have recorded the result from the second test, select ‘Quit’, then ‘Quit’ again. This will take you back to the main screen where you select ‘Perform test’.

8. Was the spirometry test completed?

☐ **Yes**

8a. FEV1 Trial 1 _____

8b. FEV1 Trial 2 _____

8c. FEV1 Trial 3 _____

☐ ``

☐ Unable to perform adequate test

☐ Did not understand instructions

☐ Unable to attempt due to medical reasons

☐ Did not attempt/Refused

Section 12 – Urinary function

Uroflow

When the participant needs to urinate set up the uroflow meter in a men's bathroom. There must be a power point available to plug the machine in.

Once the machine is plugged in, press the 'on' button on the top of the machine. The light above the button will be orange in colour and the display screen will say "Not Ready for Recording". Press the button again and the light will flash orange and green; at the same time the spinning disk in the uroflow meter will start spinning. When the machine is ready for recording (about 5 seconds) the light will stay green and the screen will say "Ready for recording". The disk in the uroflow meter will be spinning.

Say to the participant **"This machine will measure various things about the way you wee. All you need to do is wee into the bowl and the machine will do the rest."**

Check the uroflow bowl is at the right height for the participant. **"Is the bowl at a comfortable height for you? It can be adjusted. I will be waiting outside to ensure no one comes in, just come out when you are finished. We need to keep a sample of your urine so please do not empty the jug."**

1. Was the test completed?

   ☐ Yes ☐ No

   ↓

   1a. If no, why not? _____ _____

1b. Did the participant have a natural urge to urinate?

☐ Yes ☐ No

2. Did the participant void at least 150 mls?

   ☐ Yes ☐ No

If no, proceed with other testing and give the participant some water to drink. Repeat the uroflow test when the participant needs to urinate again.

3. **Was urine collected?**

   ☐ Yes ☐ No 3a. Time of urine collection ____:____ (hours:mins)

4. **Can you please tell me how many times you have urinated this morning?**

   _____ times

5. **Can you tell me the time that you urinated last (prior to the test)?**

   Time of last urination ____:____ (hours:minutes)

Bladder ultrasound

The bladder ultrasound should be completed soon after the participant has urinated.

Say to the participant **"I now need to measure how much wee is left in your bladder. Can you please lie down on the bed and undo your trousers for me?"** Turn on the bladder machine and make sure the probe is connected. Pull the trousers out of the way and find the participant's pubic bone.

Place a small amount of ultrasound gel on their skin just above the pubic bone. Place the ultrasound probe on the gel and point the tip down towards the pubic region. Either press the button on the top of the probe or the button under the word 'scan' on the machine. Another screen will appear, make sure the figure on the screen has straight sides to indicate a man (the woman has a skirt).

To do the scan, press the 'scan' button either on the machine or the probe. Make sure the picture/black circle that appears in the circle with the cross in it is centred, as this is the bladder. Adjust the probe so the whole bladder fits within the circle.

When the scan is complete the probe noise will stop and the machine will show the total millilitres left in the bladder.

If there is more than 200mls left in the bladder ask the participant **"There is still quite a bit of wee in your bladder. Do you need to wee again?"** For the second scan it is best for them to get a natural urge and just go to the usual toilet. Do the second scan after they indicate they can urinate again.

6. Was the bladder scan completed?

☐ Yes ☐ No

6a. If yes, what were the total millilitres remaining? _____mL

6b. If no, why not?_____

7. Was a second scan required?

☐ Yes ☐ No ➔ *Go to section 13*

🡻

7a. If yes, what were the total millilitres remaining? _____mL

Section13 – Heel Ultrasound

Basic Rules:
1. Right heel preferred. (NOTE: machine defaults to LEFT so make sure this is changed)
2. Never scan a heel that has been broken.
3. Never scan with an open sore on heel or ankle.

1. Have you ever broken either heel or have hardware in either heel?

- ☐ No
- ☐ Yes, right heel *(Do not scan right heel)*
- ☐ Yes, left heel *(Do not scan left heel)*
- ☐ Yes, both heels *(Do not perform ultrasound)*

2. Does the participant have an open sore on either ankle or heel?

- ☐ No
- ☐ Yes, right side *(DO NOT scan right foot. If answered 'Yes, left heel' in Question 1, STOP.DO NOT PERFORM ULTRASOUND)*
- ☐ Yes, left side *(DO NOT scan left foot. If answered 'Yes, right heel' in Question 1, STOP. DO NOT PERFORM ULTRASOUND)*
- ☐ Yes, both sides *(STOP. DO NOT PERFORM ULTRASOUND)*

3. Have you ever broken any bone in either leg? (Do not include isolated toe fractures.)

☐ Yes ☐ No

↓

3a.If yes, which leg was most recently broken?

- ☐ Right leg *(Scan left foot, if eligible. Otherwise scan right. Go to question 5.)*
- ☐ Left leg *(Scan right foot, if eligible. Otherwise scan left. Go to question 5.)*
- ☐ Both legs/Don't know *(Go to question 4)*

4. Do you have any permanent weakness in your legs, ankles or feet from an old injury or stroke?

☐ Yes ☐ No

↓

4a. If yes, which side is weaker?

- ☐ Right side *(Scan left foot, if eligible. Otherwise scan right.)*
- ☐ Left side (*Scan right foot, if eligible. Otherwise scan left.)*
- ☐ Right and left same *(Scan right foot, if eligible. Otherwise scan left.)*

5. Measurement 1

5a. BUA _____ dB/MHz

6. Measurement 2

6a. BUA _____ dB/MHz

5b. VOS _____ m/s 6b. VOS _____ m/s

7. What is the difference between BUA measurement 1 and measurement 2?

_____units

7a. Was the difference between BUA measure 1 and BUA measure 2 > 10 units?

- ☐ Yes *(Repeat scan and record results in question 8.)*
- ☐ No *(Go to question 9)*

8. Measurement for repeat scan

8a. BUA _____ dB/MHz

8b. VOS _____ m/s

9. Which heel was scanned?

- ☐ Right
- ☐ Left → 9a. Why was the left foot scanned?
  - ☐ Fracture/Hardware on right
  - ☐ Permanent weakness on right
  - ☐ Open sore on right
  - ☐ Other *(Please specify)*_____
- ☐ Scan not attempted → 9b. Why wasn't the scan attempted?
  - ☐ Feet too big/edema
  - ☐ Equipment problem
  - ☐ Participant refused
  - ☐ Other *(Please specify)*_____
- ☐ Scan not completed → 9c. Why wasn't the scan completed?
  - ☐ Out of range reading
  - ☐ Invalid measurement
  - ☐ Other *(Please specify)*_____

Section 14 – DEXA

1. **Have you ever had a hip replacement surgery where all or part of your joint was replaced?**

☐ Yes → 1a. Which side did you have hip replacement surgery?
☐ Right *(Scan left hip)*
☐ Left *(Scan right hip)*
1b. Year of hip replacement _____

☐ No *(Scan right hip)*
☐ Don't know
☐ Refused

2. **Do you have any metal objects in your body, such as a pacemaker, staples, screws, plates, etc.?**

☐ Yes ☐ No ☐ Don't know ☐ Refused

↓

Indicate the location of the joint replacement, hardware or other artifacts.
(Sub regions are those defined by the whole body scan analysis.)

	Hardware?	Other Artifacts?
Head		
Left arm		
Right arm		
Left ribs		
Right ribs		
Thoracic		
Lumbar spine		
Pelvis		
Left Leg		
Right leg		

3. **Have you had any of the following in the past ten days?**
Examiner note: If 'Yes' to any responses below, reschedule bone density measurement so that at least 10 days will have passed since the tests were performed.

	Yes	No
Barium enema		
Upper GI X-ray series		
Lower GI X-ray series		
Nuclear medicine scan		
Other tests using contrast ('dye') or radioactive materials		

4. Was a bone density measurement obtained for:

	Yes	No	Last 2 characters of scan	Date of scan
Lumbar spine				
Hip				
Whole body				
Lateral spine				

5. Temperature of room during scan: _____degrees Celcius

Section 15 - Medication Use

1. **Do you have testosterone injections at least once a month?**

   ☐ Yes ☐ No

   1a. How many times a month do you receive testosterone injections? _____times

   1b. For how many months have you received this treatment? _____months

   1c. What was the date of your last testosterone injection?

   _____/_____/_____
   day month year

2. **Have you ever taken medicine to treat osteoporosis, Paget's disease or other bone diseases?**

   ☐ Yes ☐ No

3. **Have you ever taken Bisphosphonates?**

   ☐ Yes ☐ No *(Go t to question 4)*

   3a. If yes, when did you start and stop taking bisphosphonates?

Start date *(month/year)*	
Stop date *(month/year)*	

   3b. Which bisphosphonates have you ever taken?
   (Mark all that apply)

   ☐ Alendronate (Fosamax)
   ☐ Clodronate
   ☐ Etidronate (Didronel)
   ☐ Ibandronate
   ☐ Pamidronate (Aredia)
   ☐ Risedronate (Actonel)
   ☐ Tiludronate (Skelid)
   ☐ Other/don't know

4. Have you ever taken any of the following:?

			Start date *Month/Year*	Stop date *Month/Year*
Fluoride (or Sodium Fluoride)		Yes		
		No		
Calcitonin (or miacalcin)		Yes		
		No		
Vitamin D (Ostelin or cod liver oil)		Yes		
		No		
Calcium supplements (Caltrate, Sandocal, Citrical, etc.)		Yes		
		No		
Other medication for bone health		Yes		
		No		

Other specify_____

5. Have you ever taken steroids such as Cortisone or Prednisone for asthma, arthritis or other conditions for more than one month?

☐ Yes ☐ No ☐ Don't know

5a. If yes, were the steroids: *(Mark all that apply)*

- ☐ Oral
- ☐ Inhaled
- ☐ Nasal
- ☐ Injected
- ☐ Other *(please specify)*_____

Medication inventory

6. Does the participant take any medication, daily or almost daily, for at least the past month? This includes both prescription and non-prescription medication.

☐ Yes ☐ No

↓

Prescription

Name	Strength (mg) per tablet	No of tablets per day	Duration (months)

Non-Prescription

Name	Strength (mg) per tablet	No of tablets per day	Duration (months)

7. Are there any other medications that you take that you have not brought with you? *(This question is a prompt in case they have forgot anything. Enter medications in appropriate table above)*

Do you regularly take any medicines prescribed by a doctor?
Do you regularly take any medicines purchased over the counter?
Do you take any sleeping tablets?
Do you take any nerve tablets?
Do you take any fluid tablets?
Do you take any laxatives/bowel medicines?
Do you take any headache tablets/painkillers?
Do you take any antacid/indigestion medicines?

Appendix C- Nutrition questionnaire

CHAMP

CONCORD HEALTH AND AGEING IN MEN PROJECT

5 Year Follow-up

Nutrition Questionnaire

Location (circle)	Home/ Clinic
Respondent	☐ Self ☐ Self + family ☐ Self + friend/ carer ☐ Family only ☐ Friend/ carer only
Date	_____/ _____/ _____
Completed by	

Age (years)	
Weight (kg)	
Height (cm)	
BMI	

1. Do you live alone?

☐ Yes ☐ No 1a. How many other adults live with you?

2. Who mostly shops for food?

☐ Self
☐ Wife
☐ Both
☐ Other (please specify) _____

3. Who mostly does the cooking?

☐ Self
☐ Wife
☐ Both
☐ Other (please specify) _____

4. Any special food requirements? (e.g. diabetic, gluten free, low lactose, on warfarin) (please state) _____

5. Nutritional Supplements (vitamins, minerals, fish oil, etc)

TYPE/ BRAND	CONTENTS	HOW MUCH/ HOW OFTEN

6. Teeth/ Dentures

5a. Upper	5b. Lower
☐ Teeth	☐ Teeth
☐ Partial denture	☐ Partial denture
☐ Full denture	☐ Full denture
☐ None	☐ None

In the past 3 MONTHS (prompt with the names of the last 3 months) have you had:

	Yes	No	
7. Any soreness of the mouth/ teeth/ gums?	☐	☐	
7a. Any problems chewing?	☐	☐	
7b. Any problems swallowing?	☐	☐	
8. Any nausea?	☐	☐	
9. Any heart burn?	☐	☐	9a. If yes, do you take medication? ☐ Over-the-counter ☐ Prescription ☐ Nil
10. The feeling of dryness in your mouth?	☐	☐	
11. Any loss of appetite OR weight?	☐	☐	

What do you USUALLY eat and drink for your BREAKFAST? (in the past 3 months)	
Time_____	**Notes**
Cereal **Milk/ Soy** full/ light/ skim ___L/___days/ week **Sugar/ Sweetener** **Fruit/ Fruit juice** **Bread/ toast** white/w'meal/ multigr/ other _____ slices **Butter/ Margarine** **Spread** **Hot food** **Beverage** tea/ coffee/ other + milk + sweetener Fruit juice/ water **Mo** **Tu** **We** **Th** **Fr** **Sa** **Su**	

What do you USUALLY eat and drink for your LIGHT MEAL**?** **(in the past 3 months)**	
Time_____	**Notes**
Soup **Sandwich** **Hot food** **Salad** **Fruit** **Dairy dessert** **Cake/ biscuit/ nuts etc** **Beverage** tea/ coffee/ water/ fruit juice/ soft drink/ beer/ wine/ port/ sherry/ spirits/ other **Mo** **Tu** **We** **Th** **Fr** **Sa** **Su**	**Bread** white, w'meal, m'grain, other_____ _____ slices/ day **Butter/ marg** _____ _____ g/ _____ weeks **Cold meats** eg ham, devon, corned beef, salami **Fish** **Cheese** _____g/ _____ wks **Eggs** _____/ wk Size _____ g Baked beans Spaghetti Salad veges

What do you USUALLY eat and drink for your MAIN MEAL**?** **(in the past 3 months)**	
Time_____	**Notes**
Soup **Sandwich** **Hot food** **Salad** **Fruit** **Dairy/ Cake/ biscuit/ nuts etc** **Beverage** tea/ coffee/ water/ fruit juice/ soft drink/ beer/ wine/ port/ sherry/ spirits/ other **Mo** **Tu** **We** **Th** **Fr** **Sa** **Su**	**Meat** _____g = _____ serves Beef/ lamb/ pork/ chicken/ steak/ chops/ roast/ casserole/ curry/ mince/ sausages **Trim fat from meat** None/ some/ most/ all **Remove skin from chicken** Yes/ No **Fish** _____g = _____ serves Fry/ poach/ bake/ grill **Potato/ Pasta/ Rice/ Noodle** **Vegetables** **Sauces/ gravy/ dressings** **Desserts** Custard Ice cream Yoghurt Cheesecake Pies/ tarts Cream Jelly Other **OIL for cooking/ salads**

What do you USUALLY have for SNACKS? (in the past 3 months)	
Time of Day	**Food and Drinks (in past 3 months)**
Morning Biscuits, cheese, cakes, fruitcake, lollies, liquorice nuts, chocolate, fruit, potato crisps, olives, etc	Time _____ Time_____
Afternoon Tea Tea, coffee, cocoa, Milo, Ovaltine, Sustagen, Ensure etc Water, soft drink, beer, wine, sherry, port, whisky, scotch etc	Time _____ Time_____
Evening	Time _____ Time_____
Night	Time _____ Time_____

1. Would you say your eating patterns (what & how you eat) are:

☐ Very ☐ Healthy ☐ Not so healthy ☐ Don't ☐ Refused

↓ ↓ ↓ ↓ ↓

Go to Question1a Go to Question 1b Go to Question 2

1a. What things about your eating behaviours are HEALTHY?

1. _____
2. _____
3. _____

1b. What things about your eating behaviours are UNHEALTHY?

1. _____
2. _____
3. _____

2. Compared to 5 YEARS AGO, would you say that your eating habits are:
   - ☐ MORE healthy now
   - ☐ About the SAME now
   - ☐ LESS healthy now
   - ☐ Don't know
   - ☐ Refused

3. How important do you think eating patterns are, for the health and well-being of older people?
   - ☐ Very important
   - ☐ Important
   - ☐ Somewhat important
   - ☐ Not at all important
   - ☐ Don't know
   - ☐ Refused

4. In the LAST 12 MONTHS, were there any times that you ran out of food and couldn't afford to buy more?

☐ Yes ☐ No ☐ Don't know ☐ Refused

Appendix D- Manual for nutritional data entry

Nutritional data entry manual

Part 1- List of foods and its correspondent entry in FoodWorks

Food	FOODWORKS entry	Weight
Almond meal	Almond, with skin	n/a
Amaranth flour	Flour, rice	n/a
Antipasti nfs	Olives, green, black, drained	n/a
Custard apple	Apple, unpeeled, raw, nfs	n/a
Apple/fruit, stewed	Apple, peeled, stewed nfs	n/a
Apricot delight/slice nfs	Slice, muesli, w oats, apricots & sultanas, homemade	n/a
Apricot nectar	BERRI JUICE APRICOT NECTAR	n/a
Artichoke	Artichoke, globe, boiled	n/a
Asparagus	Asparagus, boiled, drained	n/a
Avocado nfs	Avocado, raw, nfs	n/a
Bacon, rasher	Bacon, breakfast rasher, grilled	n/a
Baked rice	Pudding, rice	n/a
Banana	Banana, cavendish, peeled, raw	n/a
Banana, dried	Banana, chip	n/a
Bar, Rice Crispie	Bar, chocolate & rice crisps, milk chocolate coated	n/a
Bean, baked	Baked beans, canned in tomato sauce	1 large can= 420g, small can=220g
Bean, black	Bean, black, boiled, drained	n/a
Bean, borlotti	Bean, red kidney, canned in brine, drained	n/a
Bean, broad	Bean, broad, fresh, boiled, drained	n/a
Bean, cannellini	Bean, cannellini, canned in brine, drained	n/a
Bean, dried nfs	Bean, butter, fresh, boiled, drained	n/a
Bean, green/string	Bean, green, fresh, boiled, drained	n/a
Bean, sprout	Sprout, bean, raw	n/a
Bean, sweet	Beans, cooked, nfs	n/a
Beans, nfs	Beans, cooked, nfs	1/2 cup =95g
Beef, blade	Beef, blade steak, lean grilled	n/a
Beef, chuck	Beef, chuck steak, untrimmed, grilled/bbq	n/a
Beef, corned	Beef, corned, canned	n/a
Beef, fillet	Beef, fillet, lean, grilled	n/a
Beef, minced nfs	Beef, mince, cooked, nfs	n/a
Beef, roasted	Beef, rump steak, lean, baked/roasted	n/a
Beef, roasted, cold	Beef, roast, deli-sliced, ready-to-eat	n/a

Beef, schnitzel	Meat, crumbed, fried, ns oil, nfs	n/a
Beef, shoulder	Meat, cooked, nfs	n/a
Beef, silverside	Beef, silverside, corned, lean & fat, boiled	n/a
Beef, steak	Beef, rump steak, lean, grilled	n/a
Beef, stew nfs	Beef, stewed, nfs	n/a
Beef, stew with vegetables	Beef, stew/casserole, tomato sauce & vegetables including potato	1 cup= 253g- based on beef curry, 1 cup
Beef, T-bone	Beef, t-bone steak, lean, grilled	n/a
Beef, topside	beef, topside steak, lean, grilled/BBQ	n/a
Beef, steak, new york	Beef, sirloin steak, lean, grilled	n/a
Beef/Red meat roast	Beef, rump steak, lean, baked/roasted	n/a
Beer nfs	beer, lager	n/a
Beer, light	Beer, reduced alcohol/light style	n/a
Beer/ale, ginger	Soft drink, ginger ale, creamy soda/other non-fruit flavours, intense sweetened	n/a
Beetroot nfs	Beetroot, canned, drained	n/a
Biscuit nfs	Biscuit, sweet, plain	n/a
Biscuit, almond	UNIBIC ALMOND BISCOTTI BISCUIT	n/a
Biscuit, ANZAC	Biscuit, sweet, Anzac/butternut style	n/a
Biscuit, arrowroot	ARNOTTS MILK ARROWROOT	n/a
Biscuit, biscottini/savoiardi	ITAL BISCUITS BISCOTTINI	n/a
Biscuit, butterscotch	PARADISE BISCUIT SHORTBREAD BUTTERSCOTCH	9g per biscuit
Biscuit, cherry slice	ARNOTTS CHERRY SLICE	n/a
Biscuit, chocolate	Biscuit, sweet, chocolate coated	n/a
Biscuit, chocolate chip	Biscuit, sweet, chocolate chip	n/a
Biscuit, chocolate cream (2 round biscuit (6cm dia)	Biscuit, sweet, chocolate coated, chocolate flavour, sandwiched w cream filling	n/a
Biscuit, coffee	Biscuit, sweet, chocolate coated, coffee flavour	n/a
Biscuit, cracker	Biscuit, savoury, cracker, nfs	n/a
Biscuit, cream (round biscuit- 6cm dia)	Biscuit, sweet, chocolate flavour, sandwiched w cream filling	n/a
Biscuit, digestive	MCVITIES DIGESTIVES	n/a
Biscuit, fruit	Biscuit, sweet, with dried fruit	n/a
Biscuit, ginger nut	HOME BRAND GINGER NUT	n/a
Biscuit, Monte Carlo	ARNOTTS MONTE CARLO	n/a

	ORIGINAL	
biscuit, peanut/nut	Biscuit, sweet, with nuts	n/a
Biscuit, rice cracker	Biscuit, savoury cracker, rice	n/a
Biscuit, Sakata, rice cracker	SAKATA RICE CRACKER PLAIN	n/a
Biscuit, savoury nfs	Biscuit,savoury,cracker,nfs	Biscuit 7x7
Biscuit, sesame and wheat	Biscuit,savoury,wholemeal wheat flour with sesame	n/a
Biscuit, shape	ARNOTTS SAVOURY SHAPES	1 shape= ~2.5g (based on one small packet =25g, with 10 biscuits in pack) or 1 box= 175g
Biscuit, shortbread	Biscuit,shortbread style	
Biscuit, shortbread cream	ARNOTTS SHORTBREAD CREAMS	n/a
Biscuit, vita wheat	ARNOTTS VITA WHEAT REGULAR	n/a
Biscuit, wafer	Biscuit,sweet,wafer layers,sandwiched w cream filling (other flavours)	n/a
Biscuit, wagon wheel	ARNOTTS WAGON WHEELS CHOCOLATE WHEATEN	n/a
Biscuit, wheaten	ARNOTTS CHOCOLATE WHEATEN MILK	n/a
Biscuit, wheatmeal, sweet	Biscuit,sweet,wheatmeal	n/a
Biscuit, wholemeal, savoury	Biscuit,savoury,wholemeal wheat flour	n/a
Bittermelon	Melon,bitter,boiled/steamed	n/a
Blueberry	Blueberry, fresh, raw	n/a
Bok choy nfs/Asian green/ gai choy	Cabbage,bok choy,stir-fried without oil	cup (cooked)
BONNOX	Spread,beef extract	1tb makes 1 cup
Bread loaf nfs	Bread,from white flour,dutch style fruit loaf,extra dried fruit	n/a
Bread nfs	Bread, fresh, nfs	n/a
Bread roll nfs	Bread roll, nfs	n/a
Bread roll, bacon and cheese	Bread/bread roll,from white flour,topped w cheese & bacon	n/a
Bread roll, coles bakery	COLES IN STORE BAKED WHITE ROLLS	n/a
Bread roll, multigrain	Bread roll,mixed grain,nfs	n/a
bread roll, wholemeal	Bread roll,from wholemeal flour	n/a
Bread, bakers delight white	BAKERS DELIGHT WHITE BLOCK	n/a
Bread, burgen	BURGEN MIXED GRAIN BREAD	n/a

Bread, continental	HELGAS CONTINENTAL TRADITIONAL WHITE BREAD	n/a
Bread, crisp nfs	HOME BRAND CRISP BREAD 97% FF	n/a
Bread, crisp, wholemeal	Biscuit,savoury crispbread,wholemeal wheat flour	n/a
bread, custard on the top	Bun,no dried fruit,iced,with custard	n/a
Bread, fruit nfs/ Panetonne	Bread,from white flour,dried fruit,nfs	n/a
Bread, garlic	Bread,garlic,made with butter	n/a
Bread, gluten freen, toasted, nfs	Bread,gluten free,commercial,toasted	n/a
Bread, Helgas, Rye	HELGAS BREAD LIGHT RYE	n/a
Bread, Helga's, Sandwich thin	HELGAS TRADITIONAL BREAD WHITE	1 thin = 42.5g
Bread, Italian loaf	Bread,from white flour,italian style e.g. ciabatta,pane di casa	Slice medium
Bread, lebanese nfs	Bread,flat (pita/lebanese style),wholemeal	n/a
Bread, Low GI	BUTTERCUP LOW GI BREAD	n/a
Bread, mixed grain, Helgas	HELGAS BREAD MIXED GRAIN OATS	n/a
Bread, multigrain	Bread,from wholemeal flour,grain & seeds	n/a
Bread, multigrain toasted	Bread,from wholemeal flour,grain & seeds,toasted	n/a
Bread, raisin toast nfs	TIP TOP RAISIN BREAD (TOASTED)	n/a
Bread, roll multigrain	Bread roll,mixed grain	n/a
Bread, rye or pumpernickel	Bread from rye flour, fresh, nfs	n/a
Bread, Rye, Light	Bread,from rye flour,light	n/a
Bread, sourdough	Bread,from white flour,sour dough	n/a
Bread, soy and linseed	Bread,from white/wholemeal flour,soy & linseed	n/a
Bread, stick , grissini	VITA VIGOR GRISSINI BREAD STICK	n/a
Bread, toasted, Rye & Soy nfs	Bread,from rye flour,light,soy & linseed,toasted	n/a
Bread, toasted, sourdough	Bread,from white flour,sour dough,toasted	n/a
Bread, toasted, white	Bread,from white flour,toasted	n/a
Bread, toasted, wholemeal	Bread,from wholemeal flour, toasted	n/a
Bread, Vienna	COLES WHITE ITALIAN VIENNA	n/a

Bread, white	Bread,from white flour	n/a
Bread, white added fibre	Bread,from white flour,added fibre	n/a
Bread, wholemeal	Bread,from wholemeal flour	n/a
Bread, wholemeal, helgas	HELGAS TRADITIONAL BREAD WHOLEMEAL	n/a
Bread, wrap	Bread,flat (pita/lebanese),white	1 pita
Broccoli	Broccoli,fresh,boiled,drained	n/a
Broth, beef	Soup,beef,broth style,condensed,canned	n/a
Broth, chicken	Soup, chicken, broth style, condensed, canned	n/a
Brownie	Brownie, chocolate with nuts, homemade	n/a
Brussel sprout	Brussels sprout,fresh,boiled,drained	n/a
Bulgur/crushed wheat	Barley,pearl,boiled without added salt/fat	n/a
Burger, chicken, nfs	MCDONALDS,BURGER,MCCHICKEN	n/a
Burger, fish	MCDONALDS,BURGER,FILET-O-FISH (137 G)	n/a
Burger, veggie	Vegetarian burger,vegetarian pattie & salad (lettuce,tomato,onion),takeaway style	n/a
Chicken,butter	Chicken, curry, butter, Indian restaurant style	n/a
Butter nfs	Butter,nfs	n/a
Butter, lurpak	LURPAK SLIGHTLY SALTED BUTTER	n/a
Buttermilk	Buttermilk,cultured,2% fat	n/a
Cabbage	Cabbage,white,boiled,drained	n/a
Cake, nfs	Cake,sponge,plain,unfilled,uniced,	Slice
Cake, carrot, nfs	Cake,carrot,iced,commercial	Slice
Cake, cheese cake french/fruit	Cake,cheesecake,other flavours,biscuit base,cream cheese topping	
Cake, cheeseceke	Cake,cheesecake,chocolate flavour,biscuit base,cream cheese topping	
Cake, chocolate	Cake,chocolate,standard style,uniced,homemade from basic ingredients	1 slice; 20cm cake, cut into 12 slices
Cake, date and walnut	BAKERS DELIGHT CAPE FRUIT & NUT LOAF	n/a
Cake, fruit/sultana, Cake	Cake,fruit,rich	n/a

	style,uniced,commercial	
Cake, lamington (small)	Cake,lamington,unfilled	n/a
Cake, mud cake	Cake,chocolate,rich/mud style,uniced,homemade	n/a
Cake, orange	Cake,almond & orange,uniced,homemade	n/a
Cake, Panettone	Cake,fruit,rich style,uniced,commercial	n/a
Cake, rock	Biscuit,sweet,chocolate chip	n/a
Cake, rollette/swiss roll	Cake,sponge,Swiss roll (jam & mock cream filling),commercial	n/a
Cake, vanilla/plain/madeira/buttercake	Cake,plain/buttercake,uniced,homemade from basic ingredients	n/a
Cake, walnut/nut nfs	Muffin,cake/American style,with nuts,homemade	n/a
Cake/Bread, banana	Cake,banana,uniced,homemade	1 slice of banana bread: 1 piece (1/10 of loaf)
Calamari	Squid/calamari,baked/grilled	n/a
Capsicum	Capsicum,raw,nfs	n/a
Caramel slice	Slice,caramel	n/a
Carrot	Carrot,mature,peeled,boiled,drained	n/a
Casserole nfs	Beef,stew/casserole,gravy	n/a
Casserole, beef	Beef,stew/casserole,gravy	n/a
Cauliflower	Cauliflower,boiled,drained	n/a
Celery	Celery,raw	1 bunch =~ 5 medium stalks
Cereal, All Bran	KELLOGGS ALL BRAN	g/cup/tb/tsp
Cereal, breakfast nfs	Breakfast cereal,mixed cereal (oat,corn,rice,barley),extruded,unfortified	n/a
Cereal, Just right	KELLOGGS JUST RIGHT ORIGINAL	n/a
Cereal, Kelloggs advantage	KELLOGGS BRAN FLAKES HIGH FIBRE	n/a
Cereal, uncle toby's oat crisp	UNCLE TOBYS OAT FLAKES	n/a
Cheese, mozzarella	Cheese, mozzarella	n/a
Cheese nfs	Cheese,cheddar (mild,tasty & vintage styles)	n/a
Cheese, blue vein / roquefort	Cheese,blue vein	n/a
Cheese, bocconcini	Cheese,Mozzarella	1 ball = 30g
Cheese, cheddar, reduced fat/light	Cheese,cheddar,reduced fat (~ 25%)	n/a
Cheese, cottage	Cheese,cottage,creamed,unflavoured	n/a

Cheese, cream, light/ reduced fat	Cheese,cream,light (~15% fat)	n/a
Cheese, cream, regular	Cheese,cream	n/a
Cheese, fetta	Cheese, feta (fetta),sheep & cow's milk	n/a
Cheese, fontina	Cheese, gouda	n/a
Cheese, goat	Cheese, goat	n/a
Cheese, gorgonzola	Cheese,blue vein	n/a
Cheese, haloumi	Cheese,haloumy	n/a
Cheese, jalsberg	Cheese,Swiss	n/a
Cheese, light	Cheese,cheddar,reduced fat (~ 15%)	n/a
Cheese, parmesan	Cheese,parmesan,shaved	1 tb = 6.8g
Cheese, provolone	Cheese,provolone style	n/a
Cheese, ricotta	Cheese,ricotta	n/a
Cheese, sweet	Cheese,nfs	n/a
Cheese, swiss	Cheese,Swiss	n/a
Cheese, tasty	Cheese,cheddar (mild,tasty & vintage styles)	n/a
Cherry	Cherry,fresh,raw	0.5 cup (nfs)
Chicken, cacciatore	Chicken,stew/casserole,tomato sauce,vegetables including potato	n/a
Chicken, nfs	Chicken,grilled/BBQ,nfs	n/a
Chicken, apricot	Chicken,stir fry,sweet & sour sauce,capsicum,carrot & onion	n/a
Chicken, breast nfs	Chicken,breast,lean,baked	n/a
Chicken, drumstick, baked	Chicken,drumstick,lean,baked	n/a
chicken, fried	Chicken,fried,ns oil,nfs	n/a
Chicken, kebab	Chicken,kebab,grilled/BBQ	n/a
Chicken, kiev	FARMLAND CHICKEN KIEV	n/a
Chicken, lemon, chinese style	Chicken,battered,w lemon/honey sauce,Chinese restaurant style	cup= 143g
Chicken, maryland	Chicken,maryland,lean,baked	n/a
Chicken, nugget	Chicken,nugget,frozen,cooked,nfs	n/a
Chicken, parmagiana	Chicken,baked w tomato,eggplant & cheese,parmigiana style	n/a
Chicken, rissole/meatball	chicken patty/meatball,plain,fried,ns oil	n/a
Chicken, roast	Chicken,baked/roasted,nfs	n/a
Chicken, satay / stir fry satay	Chicken,stir fry,satay sauce	n/a
Chicken, stew nfs	Chicken,stewed/braised,nfs	n/a
Chicken, stew with vegetable	Chicken,stew/casserole,tomato sauce,vegetables including potato	n/a
Chicken, tenderloin	Chicken,breast,lean,baked	n/a
Chicken, thigh, crumbed	Chicken,thigh,lean,crumbed,stir-fried	n/a

Chicken, thighs nfs	Chicken,thigh,lean,skin & fat,baked	n/a
Chicken, whole, bbq	Chicken,whole,lean,baked/roasted	n/a
Chicken, wing, nfs	Chicken,wing,lean,grilled/bbq	n/a
Chicken, wing, marinated	Chicken,wing,lean,marinated,grilled/BBQ	n/a
Chickpea	Chickpea,canned in brine,drained	n/a
Chicory	Chicory,boiled,drained	n/a
Chilli	Chili (chili),red,raw	n/a
Prawns, chilli	Prawn garlic, king, home made	n/a
Chinese prawn based dish, nfs	Omelette, w prawn & vegetables, Chinese restaurant style	2 egg omelette
Chinese steamed buns	Bun,no dried fruit,uniced	n/a
Chinese t/a nfs	Beef,stir fry,chow mein (beef & noodles),Chinese restaurant style	n/a
Chinese, fish and lemon sauce	Fish,stew/casserole,simmer sauce,with onion	1 cup= 253g - based on beef curry, 1 cup
Chips/ crisps	Crisp/chip,potato,nfs	1 cup = 20g - based on crisp/chip potato,unflavoured,salted
Chocolate bar nfs	Chocolate/chocolate bar,filled,nfs	1 small bar= 18g
Chocolate cover nut or dried fruit	Dried fruit & nut mix,milk chocolate-coated	n/a
Chocolate finger	HOME BRAND CHOCOLATE WAFER FINGERS	1 biscuit; 2-layers
Chocolate fruit and nut	Chocolate,milk,with dried fruit & nut	n/a
Chocolate or Dark chocolate nfs	Chocolate,dark,high cocoa solids	1 piece nfs or 1 block= 250g
Chocolate, milk	Chocolate,milk,with added milk solids	n/a
Chocolate, milk, freddo	Chocolate,milk,with added milk solids (then select freddo from quantity list)	n/a
Chocolate, snickers bar	Bar,nougat,caramel & peanut centre,milk chocolate-coated	n/a
Chocolate, with nuts	Chocolate,milk,with nuts	n/a
Choko	Choko,peeled,boiled,drained	n/a
Chop (meat) nfs	Lamb,loin chop,lean,grilled	n/a
Chorizo	Sausage,pork,cooked,nfs	n/a
Choy sam	Cabbage,bok choy,stir-fried without oil	n/a
Chutney, nfs	Chutney,fruit,commercial	n/a
Clam/Pippy/Cockle/shellfish	Clam,boiled un unsalted water	n/a
Club meal, roast of the day	Meat,baked,nfs	n/a
Coco pops	KELLOGGS COCO POPS	n/a

Coffee nfs	Coffee,from instant coffee powder,no milk	n/a
Coffee, cappucino	Coffee,from ground coffee beans,cappuccino,latte/flat white style,w regular fat milk	n/a
Coffee, espresso	Coffee,from ground coffee beans,espresso style,no milk	n/a
Coffee, iced	Coffee,from espresso coffee,regular fat milk,ice & sugar,iced coffee style	n/a
Coke (size ns)	MCDONALDS, SOFT DRINK, COCA COLA,MEDIUM	n/a
Cone, Ice cream	Cone,wafer style,for ice cream	n/a
Congee	Rice porridge (congee),cooked	n/a
Continetal pasta pack nfs	CONTINENTAL INSTANT CHEESE SAUCE (40G)	n/a
Cordial, nfs	Cordial base,25% citrus fruit juice	n/a
Cordial,diet	Cordial base,25% citrus fruit juice,intense sweetened	n/a
Corn	Sweetcorn,canned in brine,drained	1 can= 125g (small)
Corn chip	Corn chip,toasted,unflavoured,unsalted	n/a
Corn, cob	Sweetcorn,fresh on cob,boiled,drained	1 medium ear
Corn, creamed	sweetcorn, creamed, canned, heated	n/a
Cornetto ice cream	Ice cream,vanilla,regular fat,with wafer cone	Cone=122g
Cornflakes	COLES CORNFLAKES	n/a
Cottage pie	Pie,meat,with potato topping	n/a
Couscous nfs	Couscous, boiled without added salt	n/a
Crab, nfs	Crab,various types,fresh only,boiled/steamed	n/a
Cracker, premium	LANES CRACKER PREMIUM 98% FF	n/a
Craisin/Cranberry	Cranberry,dried,sweetened	1 cranberry= 1.4g - based on weight of a sultana
Cream nfs	Cream,regular thickened,35% fat	
Cream, sour	Cream,sour	n/a
Cream,whipped	Cream,whipped,aerosol,regular fat (~28%)	n/a
Creamed rice	HEINZ CREAMED RICE VANILLA	n/a
Creme brulee	DIVINE CLASSIC CARAMEL CREME (150G)	n/a
Crème caramel	DIVINE CLASSIC CARAMEL	n/a

	CREME (150G)	
Crepe, plain	Pancake,plain,homemade	n/a
Crumbed cutlet/meat	Meat,crumbed,fried,ns oil,nfs	n/a
Crumpets	Crumpet,from white flour,toasted	crumpet, round
Crunchy nut cornflakes	KELLOGGS CORN FLAKES CRUNCHY NUT	n/a
Cucumber	Cucumber,common,unpeeled,raw	whole=262g
Cupcake	Cake,cupcake,iced,commercial	n/a
Curry, nfs	Beef,curry,tandoori,home prepared	n/a
Curry, beef nfs	Beef,curry,prepared w curry powder,onions & stock	n/a
Curry, beef, Indian	Beef,curry,vindaloo,Indian restaurant style	n/a
Curry, chicken, homemade/nfs	Chicken,curry,korma,home prepared w purchased sauce	1 cup= 253g - based on beef curry, 1 cup
Curry, chickpea/lentils/legumes	Curry,legume (dhal),Indian restaurant style	n/a
Curry, fish	Fish,curry,made with curry powder	n/a
Curry, lamb	Lamb,curry,prepared w curry powder,onions & stock	n/a
Curry, vegetable	Curry,mixed vegetables (cauliflower & mushroom),Tandoori	n/a
Curry, vegetable, Thai	Curry,mixed vegetables,made w curry paste & coconut milk	n/a
Custard nfs	Custard,dairy,vanilla,regular fat,commercial	n/a
Custard, banana	DAIRY FARMERS TRIO FLAVOURED CUSTARD BANANA (100G)	n/a
Custard, low/reduced fat	Custard,dairy,vanilla,reduced fat,commercial	n/a
Custard, sago	Pudding, nfs	n/a
Dairy soft, devondale	DEVONDALE DAIRY SOFT	n/a
Danish pastry	Danish style pastry,custard & fruit filled	n/a
Date loaf	BAKERS DELIGHT COFFEE & DATE ROLL	n/a
Dessert, apple pie/streudel nfs	Pie,apple,commercial,family size,RTE	1 small (e.g. nanas mini= 125g)
Dessert, bavarian	Dessert,bavarian cream,vanilla flavoured	n/a
Dessert, nfs eg at club	Pie,apple,commercial,family size,RTE	n/a
Devon/luncheon	Devon/fritz,processed luncheon meat	n/a

Dhal	Curry,legume (dhal),Indian restaurant style	n/a
Dim sim	Dim sim,meat & vegetable filling,deep fried	n/a
Dinner Winner, nfs (frozen meal)	Pasta bolognese,Italian restaurant style	1 frozen meal
Dip, nfs	Dip,nfs	1 cup =260g (using hommus 1 cup)
Dip,Tzatziki	Dip,cucumber & yoghurt,Indian restaurant style	n/a
Doughnut nfs	Doughnut,iced (non-chocolate)	n/a
Dressing, french	Dressing,french,regular,homemade	n/a
Dressing, nfs	Dressing,commercial,nfs	n/a
Dried berries eg Gogi berry	Berries,mixed (strawberry,raspberry,blueberry,blackberry),dried	1 cup = 170g (Using sultanas 1 cup weight)
Duck, nfs	Duck,lean,stewed/casseroled	n/a
Easiyo yoghurt	Yoghurt,natural,regular fat (~4%)	n/a
Egg, nfs	Egg,chicken,whole,cooked,nfs	n/a
Egg, boiled	Egg,chicken,whole,hard-boiled	n/a
Egg, fried	Egg,chicken,whole,fried In peanut oil	n/a
Egg, scrambled	Egg,chicken,scrambled,cooked without fat	
Eggplant	Eggplant,grilled	1 cup= 101g
Endive	Endive,raw	n/a
Fennel	Fennel bulb, boiled, drained	n/a
Ferrero Rocher chocolate (piece)	Chocolate,milk,with nuts	n/a
Fish, barramundi	Barramundi,aquacultured fillets,baked/grilled	n/a
Fish, bassa nfs	Bassa (basa), baked/grilled	n/a
Fish, battered	Fish,battered,frozen,baked,nfs	n/a
Fish, bream	Bream,flesh,steamed	n/a
Fish, crumbed	Silver perch,aquacultured,crumbed,fried, olive oil	n/a
Fish, dory	Trevally,dory,ling,cod,flounder/sole,baked/grilled	n/a
Fish, finger nfs	Fish finger,crumbed,frozen,baked/roasted	n/a
Fish, flathead nfs	Flathead,flesh only,baked/grilled	n/a
Fish, frozen fillets	Fish,fillet,frozen,glazed & flavoured,baked	n/a
Fish, herring	Silver perch,aquacultured,baked/grilled	

Fish, hoki	Blue grenadier (hoki),baked	n/a
Fish, leather jacket	Silver perch,aquacultured,baked/grilled	n/a
Fish, marinara	Marinara mix,w fish & shellfish,fresh,poached/steamed	n/a
Fish, salmon nfs	Salmon,Atlantic,fillet,grilled	n/a
Fish, salmon patties/cake	Fish cake,contains salmon,crumbed,frozen,baked	n/a
Fish, salmon, crumbed	Salmon,Atlantic,crumbed,baked/grilled	n/a
Fish, salmon, fried	Salmon,Atlantic,fillet,fried,olive oil	n/a
Fish, salmon, smoked	Salmon,smoked,sliced	n/a
Fish, samon, canned	Salmon,canned,drained,nfs	n/a
Fish, sardines	Sardine,canned in tomato sauce,undrained	n/a
Fish, shark nfs	Shark (flake),skinless fillet,baked/grilled	n/a
Fish, snapper nfs	Snapper,flesh,steamed	n/a
Casserole / Stew, fish	Fish,stew/casserole,simmer sauce,with onion	1 cup= 253g - based on beef curry, 1 cup
Fish, whiting	Whiting,king george,flesh only,steamed	n/a
Fish/Tuna, canned	Tuna,canned in brine,drained	n/a
Fortune Cookie	Biscuit,sweet,plain	n/a
French dressing	Dressing,french,regular,commercial	n/a
French toast	French toast,plain	n/a
Fresh fruit nfs /bowl	Fruit,fresh,nfs	n/a
Fried rice/ Asian Meal, based on rice	Rice,fried,w meat,seafood,egg & vegetables,Chinese restaurant style	1 cup= 209g
Frittata nfs	Omelette,w prawn & vegetables,Chinese restaurant style	n/a
Frozen beef meal	Beef,stew/casserole,tomato sauce & vegetables including potato	n/a
Frozen chicken meal	Chicken,stew/casserole,tomato sauce,vegetables including potato	n/a
Frozen meal, nfs	LEAN CUISINE NZ HOKI MEAL (180G)	n/a
Fruit Roll	BAKERS DELIGHT CAPE FRUIT & NUT ROLL	87g=1 serve/roll
Fruit salad, fresh	Fruit salad,fresh,commercial,with melon	Large tin= 825g (Based on Goulbourn Valley Fruit salad tins)
Fruit salad/tinned fruit/ fruit	Fruit salad,canned in syrup	

nfs		
Fruit, apple	Apple,red skin,unpeeled,raw	1 medium (6-8cm dia)
Fruit, apricot, canned	Apricot,canned in light syrup,drained	n/a
Fruit, pie fruit nfs	Pie,apple,commercial,family size,RTE	
Fruit, puree tub	Fruit puree,apple & strawberry	1 tub =140g (Goulbour valley fruit tub)
Fruit, stoned nfs	Peach,fresh,unpeeled,raw	n/a
Gai lan (chinese broccoli)	Broccoli,fresh,boiled,drained	n/a
Garlic	Garlic,peeled,raw	n/a
Gatorade, sport drink (600ml)	GATORADE SPORT DRINK LEMON LIME	n/a
Gelato	Gelato,various flavours,commercial	n/a
Gherkin,pickled,drained,commercial	Pickled cucumber	n/a
Ginger	ginger, peeled, raw	n/a
Gnocchi	Gnocchi,potato,boiled	n/a
Goat	Meat, cooked, nfs	n/a
Goulash	Beef,stew/casserole,tomato sauce & vegetable including potato	1 cup= 253g - based on beef curry, 1 cup
Gow Gee/dumpling (Asian)	Dumpling,meat filled,Chinese style	n/a
Grain wave	Biscuit,savoury crispbread,white & wholemeal wheat flour w grains & seeds	n/a
Grape	Grape,raw,nfs	n/a
Grapefruit	Grapefruit,peeled,raw	n/a
Guava nectar	GOLDEN CIRCLE JUICE GUAVA NECTAR	n/a
Ham, cold	Ham,leg,non-canned,lean & fat	n/a
Hamburger, nfs	Hamburger,beef pattie w cheese,lettuce,onion & sauce,takeaway style	n/a
Hand roll	Sushi,California,roll,restaurant style	n/a
Hard candy (werthers orig)	Sugar confectionery,hard varieties	n/a
Herb, nfs	Mixed herbs, fresh	1 tb= 12.6g (Using parsley 1 tb)
Highland Oatcakes	Biscuit, sweet, oatmeal	n/a
Hommus	Dip,hommus (hoummous/hummous),Lebanese style	n/a

Chicken, honey	Chicken, battered w lemon/honey sauce, Chinese restaurant style	n/a
Hot chocolate nfs	Beverage,drinking chocolate,from chocolate powder & liquid,nfs	n/a
Hot cross bun	Bun/scroll,with dried fruit,iced	n/a
Ice block	Ice confection,stick,frozen,water-based,flavoured	1 stick
Ice cream, nfs	Ice cream,regular fat,neopolitan flavour (vanilla,strawberry & chocolate)	1L =550g, Using 'Ice cream,reduced fat,vanilla & other non-chocolate flavours'
Ice cream, choc coated	Ice cream,stick,vanilla,chocolate coated	n/a
Ice cream, light/reduced fat	Ice cream,reduced fat,neopolitan flavour (vanilla,strawberry & chocolate)	n/a
Ice cream, low fat/low sugar	Ice cream,reduced fat,vanilla,low carbohydrate (~5%)	n/a
Ice cream, vanilla, light/reduced fat	Ice cream,reduced fat,vanilla,low carbohydrate (~ 5%)	n/a
Ice cream, with cone	Ice cream,vanilla,regular fat,with wafer cone	n/a
Indian takeaway nfs	Chicken,curry,tandoori,Indian restaurant style	n/a
Italian takeaway nfs	Pasta bolognese,Italian restaurant style	n/a
Jam, nfs	Jam,all flavours,intense sweetened	n/a
Jam, unsweetened	Jam,all flavours,reduced sugar	n/a
Jelly prepared	Jelly,made up,all flavours,sugar sweetened	n/a
Juice , lemon	Juice,lemon,home squeezed,added water & sugar	n/a
Juice nfs	Juice,orange,home squeezed	n/a
Juice, apple	Juice,apple,home squeezed	n/a
Juice, apple & mango	Fruit drink, 20% apple & 5% mango juice	n/a
Juice, apple and blackcurrant	Juice,94% apple & 6% blackcurrant	n/a
Juice, apple and pear	BERRI JUICE APPLE PEAR	n/a
Juice, blackcurrant	Juice,blackcurrant	n/a
Juice, cranberry	Fruit drink,cranberry juice	n/a
Juice, mango nfs (enter half of serve recorded and half of water)	Mango,pulp,canned	n/a
Juice, orange & mango	COLES JUICE ORANGE & MANGO	n/a

Juice, orange nfs	Juice,orange,home squeezed	n/a
Juice, pineapple	Juice,pineapple,home squeezed,added water	n/a
Juice, tomato	Juice,tomato,salted	n/a
Juice, tropical	Juice,tropical (pineapple,orange,apple,pear & passionfruit juices)	n/a
Just Juice	JUST JUICE ORANGE 100% NAS	n/a
Kangaroo, nfs	Kangaroo,loin fillet,grilled	n/a
Kangaroo, sausage	Sausage,cooked,nfs	n/a
Kebab, doner /souvlaki	Doner kebab,chicken in flat white bread w lettuce,tomato,onion & sauce	n/a
Kelloggs cereal nfs	KELLOGGS CORN FLAKES	n/a
Kiwi	Kiwifruit,unpeeled,raw	n/a
Casserole, lamb	Lamb,stewed/casseroled,nfs	n/a
Lamb, nfs	Lamb,cooked,nfs	n/a
Lamb, rissole	meatballs,lamb,grilled/dry fried, nfs	n/a
Lamb, chop	Lamb,loin chop,lean,grilled	n/a
Lamb, chump chop	Lamb,chump chop,lean,grilled	n/a
Lamb, cutlet	Lamb,frenched cutlet/rack,lean,grilled	n/a
Lamb, fry	Lamb,trim lamb,stir-fry strips,lean,stir fried	n/a
Lamb, leg	Lamb,leg roast,lean,baked/roasted	n/a
Lamb, roasted	Lamb,trim lamb,mini roast,lean,baked/roasted	n/a
Lamb, semi-trimmed, cutlet	Lamb,frenched cutlet/rack,semi-trimmed,grilled	n/a
Lamb, shank	Lamb,easy carve shoulder,lean,baked/roasted	1= 94g (using lamb,forequarter chop,lean,grilled, large chop(94g, bone removed.
lamb, steak	Lamb,trim lamb,steaks,lean,grilled	n/a
Lamb, stewed	Lamb,stew/casserole,gravy & onion	n/a
Lamb, stir-fry, with vegetable	Lamb,stir fry,plum & oyster sauces,mixed vegetables	n/a
Lasagne nfs	Lasagne,beef,frozen,baked	n/a
Le Rice	Pudding,rice,vanilla flavoured	n/a
Lebanese takeaway	Lamb,sausage (kafta/kofta),w herbs,Lebanese restaurant style	n/a
Leek	Leek,raw	n/a

Legumes, nfs	Beans,cooked,nfs	n/a
Lemon sorbet	WEIS SORBET LEMON	n/a
lemon tart	Pie,lemon,baked	0.5 cup= 98.5g (using apple pie)
Lemon, lime and bitters	Soft drink, Lemon	n/a
Lemonade	Soft drink,lemonade	n/a
Lentils nfs	Lentil,dried,soaked,boiled,drained	n/a
Lettuce	Lettuce,raw,nfs	n/a
Licorice	Licorice,plain	1 piece (2cm long)
Light n tasty, macadamia	Breakfast cereal,mixed grain(wheat,corn,oat),clusters,nuts added vitamins,B1,B2 & folate & Fe	n/a
Liver, nfs	Chicken,liver,fried,butter	n/a
Macaroni & Cheese	Macaroni cheese,homemade from basic ingredients	n/a
Cake, madeira	Cake,plain/buttercake,uniced,homemade from basic ingredients	n/a
Magnum mini	STREETS MAGNUM CLASSIC MINI SIZE	n/a
Mandarin	Mandarin (imperial),peeled,raw	n/a
Mandarin canned	Mandarin, canned in syrup, drained	n/a
Mango	Mango,peeled,raw	n/a
Mango pudding	Pudding,rice,with mango	n/a
Margarine , logical	MEADOW LEA LOGICOL SPREAD	n/a
Margarine nfs	Margarine spread,nfs	n/a
Margarine, canola	HOMEBRAND MARG CANOLA	n/a
Margarine, canola (flora)	FLORA SPREAD CANOLA	n/a
Margarine, flora nfs	FLORA SPREAD ORIGINAL	n/a
Margarine, meadow lea, reduced fat	MEADOW LEA MARG LITE RED FAT	n/a
Margarine, meadowlea nfs	MEADOW LEA MARG	n/a
Margarine, olive nfs	OLIVE GROVE MARG OLIVE OIL	n/a
Margarine, polyunsaturated	Margarine spread,polyunsaturated,nfs	n/a
Margarine, pro active	FLORA PRO ACTIV MARG	n/a
Margarine, reduced salt	Margarine spread,reduced salt,nfs	n/a
Margarine, sunflower	FLORA MARG SUNFLOWER LIGHT	n/a
Marmalade, nfs	Marmalade,orange,preserve	n/a
Mars bar	Bar,nougat & caramel centre,milk chocolate-coated	n/a
Mayonnese nfs	Mayonnaise,commercial,nfs	n/a

Mayonnese, light/ reduced fat	Mayonnaise,low fat,commercial	n/a
McCain Apricot chicken	Chicken,breast,lean,casseroled + Vegetarian protein,stew/casserole,in tomato sauce,w vegetables (including potato) + Rice,white,boiled with added salt	Total= 350g ie 117g of each
McCain Steak diane	Beef,stew/casserole,gravy + Vegetarian protein,stew/casserole,in tomato sauce,w vegetables (including potato) + Rice,white,boiled with added salt	Total= 320g ie 107g of each
Meat bun (Asian)	Dumpling,meat filled,Chinese style	n/a
Meat, nfs	Meat, cooked, nfs	n/a
Meat with vegetables soup/chucky canned soup	Soup,meat (beef/lamb/pork),w vegetables,prepared w water	n/a
Meat, minced nfs	Meat (beef,chicken,lamb,pork),mince,cooked,nfs	n/a
Meat, red nfs	Beef,rump steak,lean,grilled	n/a
Meat, roast nfs	Meat,baked,nfs	n/a
Meatballs nfs	Meatballs,beef,fried,ns oil,nfs	2 meatball = 86g. Based on 2 meatball with sauce
Meatloaf nfs	Meatloaf,beef,with breadcrumbs & vegetables	
Melon, honey dew	Melon,honey dew,white skin,peeled,raw	1 wedge (1/8 of 13cm dia melon)
Melon, nfs	Melon,rockmelon (cantaloupe),peeled,raw	1 medium slice
Meringue, lemon	Pie,lemon meringue,baked	n/a
Milk, powder	Milk,powder,cow,regular	n/a
Milk, chocolate flavoured or flavoured nfs	Milk,cow,fluid,flavoured,chocolate,regular fat	n/a
Milk, condensed nfs	Milk,canned,sweetened,condensed,regular	n/a
Milk, dairy famers, light white	DAIRY FARMERS LITE WHITE FRESH	n/a
Milk, lactose free, nfs	ZYMIL LACTOSE FREE LOW FAT FRESH	n/a
Milk, light/reduced fat	Milk,cow,fluid,reduced fat (~1%)	n/a
Milk, regular	Milk,cow,fluid,regular fat (~3.5%)	n/a
Milk, semi skim	DEVONDALE SEMI SKIM 2% FAT FRESH	n/a

Milk, skim	Milk,cow,fluid,skim (~0.15% fat)	n/a
Milk, smart nfs	PAULS SMARTER WHITE MILK	n/a
Milk, soy, light/ reduced fat/skim	SOY LIFE FRESH SOY LOW FAT FRESH	n/a
Milk, soy, regular	SOY LIFE MILK FRESH NATURAL FRESH	n/a
milk,farmers best, omega 3	FARMERS BEST OMEGA 3 FRESH	n/a
Milkshake	Milkshake,home made,chocolate flavour,regular fat cow milk	1 serve = 300ml - based on Milkshake,cafe style,chocolate flavour,regular fat cow milk
Millet meal	Millet,raw	n/a
Milo	NESTLE MILO	n/a
Mince, curry	Meat (beef,chicken,lamb,pork),mince,cooked,nfs	n/a
Mince, reduced fat	Beef,mince,low fat,dry fried	n/a
Mineral water	Water,mineral,natural,unflavoured	n/a
Mint jelly	Sauce, mint	n/a
Mortadella nfs or bologna	Mortadella,processed meat	n/a
Mousse, chocolate	Mousse, choc, homemade	1 tub= 62g (Based on Nestle choc mouse 1 tub)
Muesli bar, choc flavour	Bar,muesli,chocolate chip	n/a
Muesli flakes	UNCLE TOBYS MUESLI FLAKES PLUS	n/a
Muesli nfs	Muesli,commercial,toasted,unfortified	n/a
Muesli, bar, nfs	Bar,muesli,uncoated,nfs	n/a
Muesli, bar, Uncle tobys	UNCLE TOBYS CRUNCHY MUESLI BAR ORIGINAL (20G)	n/a
Muesli, Morning sun nfs	MORNING SUN MUESLI NATURAL APRICOT ALMOND	n/a
Muesli, w dried fruit and nuts	Muesli,homemade,toasted,added nuts,seeds & dried fruit	n/a
Muffin nfs	Muffin,cake/American style,plain,homemade	n/a
Muffin, bran	Muffin,cake/American style,with bran,uniced	n/a
Muffin, cheese and bacon	Muffin,savoury,with cheese & ham,homemade	n/a
Muffin, choc chip	Muffin,cake/American style,w	n/a

	chocolate chips,uniced,homemade	
Fish, mullet	Mullet,yelloweye,baked/grilled	n/a
Fish, mulloway/jewfish	Mulloway,fried,ns butter	n/a
Mushroom	Mushroom,common,boiled/steamed	n/a
Mushroom, in breakfast dish	Mushroom,common,stir-fried without oil	n/a
Mussel	Mussel,green,steamed/boiled	n/a
Nectarine	Nectarine,unpeeled,raw	n/a
Nesquik, beverage base	NESTLE DAIRY NESQUIK CHOC MILK	n/a
Nestle drumstick	NESTLE DRUMSTICK VANILLA	n/a
Noodle nfs	Noodle,boiled,nfs	cup= 136g- besed on weight of 1 cup of Noodle,wheat,instant,boiled w flavour sachet,drained
Noodle, egg	Noodle,wheat,Asian style	n/a
Noodles nfs	Noodle,boiled,nfs	n/a
Noodles, crunchy, non flavoured	Noodle,wheat,instant,uncooked,no flavour sachet	n/a
Noodles, fried	Noodle,wheat,Asian style,fried in ns oil	n/a
Noodles, Instant	Noodle,wheat,instant,boiled w flavour sachet,drained	n/a
Nougat	Nougat,honey & almond	n/a
Nut, almond	Nut,almond,with skin,dry roasted	n/a
Nut, bar	WOOLWORTHS NATURA BAR NUT DELIGHT (50G)	n/a
Nut, Brazil	Nut,brazil,raw/blanched	n/a
Nut, cashew	Nut,cashew,roasted,salted	n/a
Nut, macadamia	nut, macadamia	n/a
Nut, mixed	nuts, mixed/peanut, cashew, hazelnut, brazil nut	1 packet nfs: 250g (based on a woolworths packet of nuts)
Nut, peanut nfs	Nut,peanut,no skin,roasted,with oil,unsalted	n/a
Nut, walnut	Nut,walnut,raw	n/a
NUTRI-GRAIN	KELLOGGS NUTRI-GRAIN	n/a
Nuts nfs	Nuts,mixed (peanut,cashew,hazelnut,brazil nut)	n/a
Nuttelex	NUTTELEX MARG	n/a

	POLYUNSAT 500G	
Oat bran	Oats,bran,unprocessed	n/a
Oat flakes	UNCLE TOBYS OAT FLAKES	n/a
Oats nfs	Porridge,rolled oats,nfs	1 tb = 7.6 g (raw)
Oats, Uncle tobys	UNCLE TOBYS TRADITIONAL OATS	40g makes 1c of porridge
Octopus	Squid/calamari,baked/grilled	n/a
Oil, nfs	Oil, nfs	n/a
Oil, olivel nfs	Oil,olive,pure	n/a
Oil, vegetable	Oil,blended,polyunsaturated vegetable oils	n/a
Oil, mustard seed	Oil,blended,polyunsaturated vegetable oils	n/a
Olives, nfs	Olive,green/black,drained	n/a
Omelette nfs or potato omelette	Omelette,chicken egg,cooked with fat	n/a
Onion	Onion,mature,white skinned,peeled,raw	n/a
Onion rings , fried	Onion,bhaji,deep-fried	n/a
Onion, red	Onion,mature,peeled,raw,nfs	n/a
Onion, spring	Onion,spring,raw	n/a
Orange	Orange,navel (all varieties),peeled,raw	n/a
Osso Bucco (veal)	Veal,leg steak,untrimmed,stewed/casseroled	n/a
Oyster, nfs	Oyster,baked/grilled	n/a
Paddle pop nfs	STREETS PADDLEPOP CHOCOLATE	
Pancake nfs	Pancake,plain,homemade	1 medium
Parsley nfs	Parsley,curly,raw	n/a
Parsnip	Parsnip, peeled, boiled, drained	82.5g=1/2cup as per potato
Pasta dish, nfs	Pasta bolognese,Italian restaurant style	n/a
Pasta nfs	Pasta, white wheat flour based, boiled from dry, w added salt	n/a
Pasta sauce, white	Sauce,pasta,cream-based,commercial	n/a
Pasta+ tomato sauce	Pasta, white wheat flour based, boiled from dry, w added salt + Sauce,pasta,tomato-based,commercial,heated	n/a
Pastie, nfs	Pastie,vegetable,baked	n/a
Pastizzi, spinach and cheese	Pastry,spinach & cheese filling (spanakopita),Greek style,RTE	n/a
Pastrami nfs	Beef,corned,canned	n/a

Pastry (savoury) nfs	Pastry,fillo (phyllo),baked	n/a
Pastry roll, spinach and cheese	Pastry. spinach & cheese filling,RTE	n/a
Pate, nfs	Pate,liverwurst	n/a
Pavlova	Pavlova,plain,cream-topped	n/a
Paw paw, nfs	Pawpaw (papaya),peeled,raw	1 slice= 37g - based on 1 medium slice of melon
Peache, canned	Peach,canned in light syrup,drained	1 can =825g (SPC)
Peanut butter	Peanut butter,smooth & crunchy,sweetened,salted	
Pear	Pear,unpeeled,raw,nfs	1 medium (6-7cm dia base)
Pear, stewed/canned	Pear,canned in syrup,drained	1 cup =240g
Peas/ frozen peas	Pea,green,fresh,boiled,drained	n/a
Perch / Fish nfs	Silver perch,aquacultured,baked/grilled	n/a
Persimmon	Persimmon,peeled,raw	n/a
Pickles	Gherkin,pickled,drained,commercial	n/a
Pie, fish	Pie,mixed seafood in creamy sauce,individual size	n/a
Pie, fruit mince pie	Pie,apple,commercial,family size,RTE	n/a
Pie, meat	Pie,meat	n/a
Pineapple	Pineapple (cayenne),fresh,peeled,raw	n/a
Pineapple, canned	Pineapple,canned in water,drained	n/a
Pistachio	Nut,pistachio,roasted,with oil,salted	n/a
Pizza nfs / pizza mini	Pizza,cheese topping,tomato sauce,homemade	n/a
Pizza, bacon	MCCAIN PIZZA SLICE CHEESE&BACON (100G)	n/a
Pizza, meat and veg	Pizza,meat & vegetable topping,tomato sauce,homemade	n/a
Pizza, meatlovers	Pizza,meat & cheese topping,BBQ sauce,homemade	n/a
Pizza, supreme	Pizza,supreme topping,tomato sauce,take away style	n/a
Pizza, vegetarian	Pizza,vegetarian topping,tomato sauce,homemade	n/a
Plum	Plum,unpeeled,raw,nfs	n/a
Polenta	Cornmeal (polenta),cooked in unsalted water without fat	n/a
Pork, belly	Pork,crackling,baked/roasted	n/a
Pork, fillet	Pork,fillets,lean,fried,olive oil	n/a

Pork, mince	Pork,mince,stir-fried without oil	n/a
Pork, nfs	Pork,cooked,nfs	n/a
Pork, rissole	Patty/meatball,pork,plain,fried,ns oil	n/a
Pork, roll	Pork,cooked,nfs	n/a
Pork, boiled	Pork leg,diced,lean,boiled/simmered	n/a
Casserole, pork	Pork,stewed/casseroled,nfs	n/a
Pork, chop	Pork, loin chop, lean,grilled	n/a
Pork, cutlet	Pork, loin chop, lean,grilled	n/a
Pork, medallion	Pork,medallion steak,lean,grilled	n/a
Pork, ribs	Pork,spare ribs,lean &fat,grilled/BBQ	n/a
Pork, roasted	Pork,leg roast,trimmed,roasted	n/a
Pork, satay	pork,kebab,marinated,satay sauce, grilled/BBQ	1 cup=253 g as per pork stirfry sweet & sour Chinese restaurant style
Pork, schnitzel	Pork,leg schnitzel,lean,dry fried	n/a
Pork, steak	Pork,leg,steak,lean,grilled	n/a
Pork, stir-fried	Pork,leg strips,lean,stir-fried	n/a
Pork, sweet & sour	Pork,stir fry,sweet & sour sauce,Chinese restaurant style	1 cup= 253g - based on beef curry, 1 cup
Porridge (variety pack/quick)	UNCLE TOBYS PORRIDGE QUICK OATS	n/a
Porridge nfs	Porridge,rolled oats,nfs	n/a
Porridge/oats raw	Oats,rolled,raw	n/a
Port nfs	Port (fortified wine)	n/a
Potato bake	Potato,scalloped/bake,nfs	n/a
Potato, fried, nfs	Potato,hash brown,fresh/frozen,fried,ns oil	
Potato, gem	Potato,other varieties (e.g. gems,smiles,nuggets),fresh/frozen ,baked without oil	48.5g =½ cup
Potato, nfs	Potato,boiled,drained,nfs	1/2 cup =82.5g
Potato, wedges	Potato,wedges,homemade - fresh/frozen,fried,ns oil,nfs	n/a
Potato, chips - take away /club	Potato,chips,homemade - fresh/frozen,fried,ns oil	n/a
Potato, hash brown	Potato,hash brown,fresh/frozen,cooked,nfs	n/a
Potato, mashed	Potato,peeled,boiled,mashed,nfs	n/a
Potato, roast, nfs	BIRDS EYE OVEN ROAST POTATO TRADITIONAL	n/a
Potato, scallop	Potato,scallop,battered,deep-fried,take-away outlet	n/a

Potato, sweet	Sweet potato,orange flesh,peeled,boiled,drained	n/a
Pototo mashed, with butter	Potato,peeled,boiled,mashed,ns butter,nfs	n/a
Prawns, nfs	Prawn,king (large size),baked/grilled	n/a
PROMITE	Spread,yeast,vegemite	n/a
Protein powder (whey)	Milk,powder,cow,whey	n/a
Prune	Prune (dried plum)	n/a
Pudding ,christmas	Pudding,nfs	n/a
Pudding nfs or pudding, ginger	Pudding,nfs	n/a
Pudding, bread and butter	Pudding,bread & butter,baked	n/a
Pudding, rice pudding/ creamed rice	Pudding,rice	n/a
Pudding, sticky date/caramel	Pudding,sticky date,homemade	n/a
Pumpkin, nfs	Pumpkin,peeled,cooked,nfs	n/a
Pureed fruit/blended fruit	Fruit, puree apple & blackberry	n/a
Quiche	Quiche,nfs	n/a
Radicchio	Chicory,boiled,drained	n/a
Radicchio/Chicory raw	Chicory,raw	0.5 cup= 72.5g- based on wt of boiled chicory
Radish	Radish,white skinned,peeled,raw	0.5 cup =87.5g- based on wt of white onion
Raisin	Currant,dried	1 raisin=1.4g- based on Foodworks sultana weight
Ranch, dressing	Dressing,thousand island,regular,commercial	n/a
Ravioli/angloti meat	Pasta,meat filled,boiled,no sauce	n/a
Ravioli/angloti veg+cheese	Pasta,cheese & vegetable filled,no sauce,fast food style	n/a
Rhubarb + berries stewed	Rhubarb,stalk,stewed,sugar sweetened + Berries,mixed (strawberry,raspberry,blueberry,blackberry,canned,drained)	n/a
Rhubarb, stewed	Rhubarb,stalk,stewed	n/a
Rice bran oil/spread	Margarine spread,rice bran oil based	n/a
Rice, bubbles	KELLOGGS RICE BUBBLES	n/a
Rice, cake	Biscuit,savoury cake,rice,salted	n/a
Rice, nfs	Rice, white, boiled with added salt	n/a
Noodle, rice	Noodle,rice,boiled without added salt	n/a

Rice, fried	Rice,fried,with mixed vegetables,ns oil	n/a
Risotto	Risotto,chicken,with parmesan cheese	1 cup =280g- Wt based on 1 c of Sauce,pasta,cream-based,added chicken
Rissoles	Hamburger patty,frozen,grilled	n/a
Ritz crackers	RITZ CRACKERS PLAIN (3G)	n/a
Rocket/ ruccola	Spinach,English,raw	n/a
Rockmelon/melon	Melon,rockmelon (cantaloupe),peeled,raw	n/a
Roti/naan bread	Bread,naan,Indian restaurant style	n/a
Rum, nfs	Rum,dark & light coloured	n/a
Rusk (biscuit)	Biscuit,savoury,melba toast	n/a
Ryvita, nfs	RYVITA CRISP BREAD ORIGINAL RYE	n/a
Salad dressing, reduced fat	Dressing,french,reduced fat,commercial	n/a
Salad dressing, vinigarete	Dressing,salad,oil & vinegar,homemade	n/a
Salad, caesar	Salad,caesar,with dressing	n/a
Salad, coleslaw	Salad,coleslaw,commercial	n/a
Salad, greek	Salad,greek,no dressing	1 cup = 169g (using tabouli 1 cup to estimate)
Salad, green nfs	Salad,green (lettuce,capsicum,snowpeas,cucumber,avocado), no dressing	0.5 cup = 84.5g- based on wt of Salad,tabouleh,Lebanese restaurant style
Salad, pasta	Pasta,salad,with vegetables	n/a
Salad, potato	Salad,potato,commercial	n/a
Salad, seafood,nfs	Seafood,mixed,poached,w creamy dressing & lettuce	n/a
Salami, nfs	Salami,nfs	n/a
Sandwich, ham and salad	Sandwich roll,white roll,ham w salad (lettuce,tomato,carrot,onion,capsicum),fast food	n/a
Sandwich, nfs	Sandwich,white bread,with cheese & tomato,toasted	n/a
Sandwich, cheese, tomato	Sandwich,white bread,with cheese & tomato,toasted	n/a
Sandwich, salad	Sandwich roll,white roll,salad (lettuce,tomato,carrot,cucumber,onion,capsicum,olive),fast food	n/a

Sanitarium Light n Tasty nfs	SANITARIUM LIGHT N TASTY BERRY	n/a
Sao	Arnotts sao original	n/a
Sara Lee Dessert, nfs	SARA LEE STICKY DATE PUDDING (85G)	n/a
Sara Lee Pie	SARA LEE RASPBERRY FLAN (1 SLICE = 80G)	n/a
Sashimi, nfs	Salmon,Atlantic,fillet,raw	n/a
Sauce simmer, chicken tonight	Sauce,simmer for chicken,commercial	n/a
Sauce, apple	Apple,peeled,stewed,nfs	n/a
Sauce, apricot	Apricot,fresh,stewed	n/a
Sauce, black bean	Sauce,black bean,Asian,commercial	n/a
Sauce, bolognaise	Beef, bolognaise pasta sauce, mince, tomato & olive oil, homemade	n/a
Sauce, carbonara	Sauce,pasta,cream-based,added beef & ham	n/a
Sauce, cheese	Sauce,cheese,made with butter & milk,home-prepared	n/a
Sauce, gravy/diane sauce	Gravy,commercial,prepared	n/a
Sauce, korma	TAYLORS ROYAL KORMA	n/a
Sauce, oyster	Sauce,oyster,Asian,commercial	n/a
Sauce, soy	Sauce,soy,commercial	n/a
Sauce, sweet and sour	Sauce,sweet & sour,Asian,commercial	n/a
Sauce, sweet chilli	Sauce,sweet & sour,Asian,commercial	n/a
Sauce, tomato	Sauce,tomato,commercial	n/a
Sauce, tomato (for pasta)	Sauce,pasta,tomato-based,commercial,heated	n/a
Sauce, white (eg. for pasta)	Sauce,white,home-prepared	n/a
Sauce, white creamy	Sauce,white,home-prepared	n/a
Sauce, worcestershire or holbrook	sauce,worcestershire,commercial	n/a
Sauerkraut	Sauerkraut,canned in brine,drained	n/a
Sausage, nfs	Sausage,cooked,nfs	n/a
Sausage, roll	Sausage roll,individual size,commercial,RTE	n/a
Sausage, beef	Sausage,beef,cooked,nfs	n/a
Sausage, chicken	Sausage,chicken,grilled/BBQ	n/a
Sausage, frankfurt	Frankfurt/cheerios,fresh,simmered	n/a
Sausage, Italian/chipolata	Sausage,pork,cooked,nfs	n/a
Sausage, kransky	Sausage,curry,made with curry powder	n/a

Sausage, Lamb	Lamb,sausage (kafta/kofta),w herbs,Lebanese restaurant style	1 thin= 44g- based on sausage cookned nfs (1 thin)
Sausage, pork	Sausage,pork,cooked,nfs	n/a
Scampi	Lobster,purchased,steamed/boiled	n/a
Schnitzel, nfs	INGHAMS CHICKEN SCHNITZELS (200G)	n/a
Chicken, scnitzels	INGHAMS CHICKEN SCHNITZELS (200G)	n/a
Scone, nfs	Scone,white flour,plain	n/a
Scotch finger	ARNOTTS SCOTCH FINGER (18g/biscuit)	n/a
Seafood in pasta	Sauce,pasta,tomato-based,added seafood	n/a
Seafood marinara	Marinara mix,w fish & shellfish,fresh,poached/steamedMarinara mix,w fish & shellfish,fresh,poached/steamed	n/a
Seafood, Scallop	Scallop,boiled,unsalted water	n/a
Seaweed	Seaweed,nori,poached	n/a
Seed, chia	Seed,linseed/flaxseed	1 tb = 11.2g (using seseme seeds 1tb)
Semolina	Semolina,made with water	n/a
Shallot	Shallot,peeled,cooked,nfs	n/a
Shepherds pie	Pie,meat,with potato topping	n/a
Sherry, nfs	Sherry (fortified wine),sweet style (approximately 11% sugars)	n/a
Silverbeet	Silverbeet,boiled,drained	n/a
Slice, apple	Pie,fruit (apple/apricot),commercial,family size,RTE	n/a
Slice, caramel/cherry/vanilla slice	Slice,sweet,nfs	n/a
Slice, coconut	Slice,coconut filling	n/a
Snowpea	Snowpea, raw	n/a
So Good, Frozen Yoghurt	SO GOOD BLISS CREAMY VANILLA	1 tb =26.8g- baed on wt of 1tb of regular frozen yoghurt
Soft candy/gummy lollies	Sugar confectionery,jelly varieties	
Soft drink, nfs	Soft drink,nfs	1= 375ML (NFS)
Soft drink, diet	MCDONALDS,SOFT DRINK,DIET COKE,MEDIUM	n/a
Solo/lift/soft drink lemon flavour	Soft drink,lemon flavour	n/a
Soup, bean/lentil	Soup,vegetable & lentil,homemade	n/a

Soup, beef noodle	Soup,meat (beef/lamb/pork,w vegetables & noodles,prepared w milk & water	n/a
Soup, canned nfs	Meat & vegetable,canned,RTE,heated	Large can = 430g, Small =290g- campbells soup
Soup, chicken	Soup,chicken & vegetable,homemade,prepared w water	n/a
Soup, chicken noodle or pasta	Soup,chicken noodle,made with water	n/a
Soup, chicken, canned	Soup,chicken,broth style,condensed,canned	n/a
Soup, chicken, creamy	Soup,cream of chicken,condensed,canned	n/a
Soup, chickpea	Soup,vegetable & lentil,homemade	n/a
Soup, creamy vegetable	Soup,cream of vegetables,condensed,canned	n/a
Soup, instant soup e.g cup a soup	Soup,cream variety,instant dry mix	1 serve = 200ml
Soup, laksa	Soup,chicken laksa	n/a
Soup, lentil	Soup,vegetable & lentil,homemade	n/a
Soup, meat and pasta	Soup,meat (beef/lamb/pork),w pasta,prepared w water	n/a
Soup, minestrone	Soup, minestrone, homemade	n/a
Soup, mushroom	Soup,mushroom,cream style,condensed,canned	n/a
Soup, nfs	Soup,vegetable,homemade	n/a
Soup, noodle, asian	Soup,Asian style,w noodles,instant dry mix,cup style,reconstituted w water	n/a
Soup, pea and ham	Soup,pea & ham,w vegetables,homemade,prepared w water	n/a
Soup, potato and leek	Soup, potato & leek, homemade	n/a
Soup, pumpkin	Soup,pumpkin,homemade	n/a
Soup, seafood	Soup,seafood/fish,w vegetables,made with water	n/a
Soup, short	Soup,wonton in chicken broth	n/a
Soup, tomato	Soup,tomato,condensed,canned,reconstituted w water	n/a
Soup, vegetable	Soup,vegetable,homemade	n/a
Soup, wonton	Soup,wonton in chicken broth	n/a
Souvlaki nfs	Lamb,kebab,grilled/BBQ	n/a
Spagetti, canned	Spaghetti in meat sauce,canned	1 CUP= 265G
Sparkling, apple juice	APPLEMAID JUICE APPLE	n/a

	SPARKLING	
Special K	KELLOGGS SPECIAL K	n/a
Spinach	Spinach, English, raw	n/a
Spinach, roll	Pastry. spinach & cheese filling, RTE	Size=1 pastry; Bakers Del Danish Square Spinach & Feta
Splice	Streets splice berry	n/a
Split pea	Pea, split, dried, soaked, boiled, drained	n/a
Cheese, spread	Cheese spread, cheddar cheese-based	n/a
Spreadable tuna/fish paste/fish dip	Fish paste/spread	n/a
Spring roll, Chinese t/a	Spring roll, deep fried, take away style	n/a
Squash	Squash, button, boiled, drained	1cup=222g
Steak, chuck nfs	Beef, chuck steak, trimmed, casseroled	n/a
steak, porterhouse	Beef, sirloin steak, lean, grilled	n/a
Steak, semi-trimmed	Beef, rump steak, semi-trimmed, grilled	n/a
Stir fry, beef or stir fry nfs	Beef, stir-fry strips, lean, fried, ns oil	n/a
Stir fry, beef with vegetable nfs	Beef, stir fry, mixed vegetables	1 cup = 253g (using beef, curry, prepared with curry powder, onions and stock)
Stir fry, chicken nfs	Chicken, breast, lean, stir-fried	n/a
Stir fry, chicken with vegetable	Chicken, stir fry, soy based sauce, mixed vegetables	n/a
Stir fry, Chinese	Chicken, stir fry, chop suey (chicken & vegetables),Chinese restaurant style	n/a
Stir fry, lamb	Lamb, trim lamb, stir-fry strips, lean, stir fried	n/a
Stir fry, Noodle, Asian meal based on noodles	Chicken, stir fry, chow mein (chicken & noodles),Chinese restaurant style	n/a
Stir fry, pork, takeaway	Pork stir fry, sweet & sour sauce, Chinese restaurant style	1 cup =253g (Using beef stir fry and veg to estimate)
Stir fry, prawns	Prawn, stir fry, soy based sauce, asparagus	n/a
Stirfry vegetables (mixed)	Stir-fry, mixed vegetable (capsicum, carrot, snow pea, bok choy & onion),w soy-based sauce, no oil	n/a

Stock nfs	Stock, liquid, commercial, nfs	n/a
Strawberry	Strawberry, fresh, raw	n/a
Stroganoff, beef	Beef, stroganoff (steak, mushroom & sour cream casserole)	n/a
Sugar, nfs	Sugar, white, granulated/lump	n/a
Sultana	Sultana, dried	n/a
SULTANA BRAN	KELLOGGS SULTANA BRAN	n/a
Sushi, tuna and avocado	Sushi, California roll, restaurant style	n/a
Sushi, nfs	Sushi, vegetarian	n/a
Sustagen RTD	Beverage, formulated supplementary, chocolate flavour, purchased RTD (Sustagen brand)	n/a
Sustagen, powder	Beverage base, chocolate flavour, added calcium, iron & vitamins A,B1,B2 & C (Milo brand)	n/a
Swede	Swede, peeled, boiled, drained	n/a
Sweet bread/tripe/other offal	Beef, kidney, simmered	n/a
Sweetcorn, creamed	Sweetcorn, creamed, canned, heated	n/a
Sweetener	Sweetener, powder, nfs	n/a
Syrup, Ribena/ blackcurrant	RIBENA BLACKCURRANT SYRUP	n/a
Tabouleh	Salad, tabouleh, Lebanese restaurant style	n/a
Taro	Taro, peeled, boiled, drained	1/2 c= 102g
Tart, sweet, nfs	Tart, jam	n/a
Tart, citrus	Slice, lemon/orange custard filling	n/a
Tarte Tatin	Cake, apple, uniced, homemade	n/a
Tea, green	Herbal tea	n/a
Tea, nfs	Tea, regular, no milk, brewed from leaf/teabags	n/a
Thai curry/takeaway nfs	Chicken, curry, green, Thai restaurant style	n/a
Tim Tam	ARNOTTS TIM TAM ORIGINAL	n/a
Tip top 9 grain nfs	TIP TOP BREAD 9 GRAIN MEDIUM	n/a
Tiramisu	Pudding, nfs	1 cup= 210g (using bread and butter pudding 1 cup)
Toffee	Sugar confectionery, hard varieties	n/a
Tofu, firm	Tofu (soy bean curd), firm, baked without oil	n/a
Tofu, fried	Tofu (soy bean curd), firm, stir-fried, no oil	n/a

Tofu, silken	Tofu (soy bean curd), silken/soft, as purchased	n/a
Tomato, canned	Tomato, canned in tomato juice, nfs	1 can = 400g
Tomato, nfs	Tomato, common, raw	n/a
Tomato, paste	Tomato paste, with added salt	n/a
Tortilla	Tortilla, from wheat flour	1 medium
Tuna, bake	Fish, pasta bake, tuna mornay w cheese & breadcrumbs	1 serve= 296
Turkey, leg	Turkey, hindquarter, lean,baked	n/a
Turkey, breast	Turkey, breast, lean,baked	n/a
Turkey, cold	Turkey, processed luncheon meat	n/a
Turkey, roast	Turkey, breast, lean, baked	n/a
Turkish Pide	BAZAAR TURKISH PIDE	n/a
Turnip	Turnip, white, peeled, boiled, drained	1cup=240g
Two fruits (pear and peach)	Mixed fruit, peach & pear, canned in light syrup, drained	n/a
Uncle Toby's plus range	UNCLE TOBYS PLUS FIBRE PLUS	n/a
Uncle Toby's, Oatbrits	UNCLE TOBYS VITA BRITS	n/a
Veal, chop	Veal, loin chop, lean, grilled	n/a
Veal, cutlet	Veal, loin chop, lean, grilled	n/a
Veal, nfs	Veal, cooked, nfs	n/a
Veal, pan fried	Veal, leg, steak, fried, ns oil	n/a
Veal, Schnitzel	Veal, leg steak, crumbed, fried, ns oil	n/a
Veal, stew nfs	Veal, leg steak, untrimmed, stewed/casseroled	n/a
Veal, steak	Veal, leg steak, lean, grilled	n/a
VEGE juice nfs	V8 JUICE VEGETABLE 100%	n/a
Vegemite	Spread, yeast, vegemite	n/a
Vegetable, mint	Mint, raw	n/a
Vegetable, mixed , frozen	Mixed vegetables, frozen, boiled/microwaved, drained	n/a
VITA BRITS	UNCLE TOBYS VITA BRITS	1 cup =60g
Waffle	Waffle, plain, homemade	Waffle, square
Watercress	Lettuce, raw, nfs	n/a
Watermelon	Melon, watermelon, peeled, raw	1 pc = 1 wedge (~1/16 whole)
Weaten, chocolate	HOME BRAND CHOCOLATE WHEATS	n/a
Weet-Bix	SANITARIUM WEET-BIX	Cup= 60g
Weet-bix mini/bites	SANITARIUM WEET-BIX FRUITY APRICOT	n/a
WEETIES	UNCLE TOBYS WEETIES VITA ORIGINAL	n/a

Weis bar	WEIS BARS MANGO	n/a
Wheat, bran	wheat bran, unprocessed	n/a
Wheat, germ	Wheat germ	n/a
Wheat, meal	ARNOTTS SHREDDED WHEATMEAL	n/a
Whisky, nfs	Whisky	n/a
Wine, nfs	Wine, nfs	n/a
Wine, red	Wine, red	n/a
Wine, white	Wine, white, medium dry style (approximately 1% sugars)	n/a
Wombok	Cabbage, bok choy, raw	n/a
Yoghurt, flavoured nfs	Yoghurt, flavoured, nfs	n/a
Yoghurt, frozen, nfs	Yoghurt, frozen, regular fat, fruit flavoured	n/a
Yoghurt, fruit	Yoghurt, regular fat (~3%),fruit pulp/juice, nfs	n/a
Yoghurt, Greek nfs	Yoghurt, Greek style, natural/plain, nfs	n/a
Yoghurt, Greek, low fat	Yoghurt, Greek style (~6% fat),plain/flavoured	n/a
Yoghurt, Jalna, nfs	JALNA WHOLE MILK NATURAL	n/a
Yoghurt, kafir	Yoghurt, Greek style, natural/plain, nfs	n/a
Yoghurt, lactose free	VAALIA NATURAL LACTOSE FREE	n/a
Yoghurt, light/ reduced fat	Yoghurt, natural, reduced fat (~2%)	n/a
Yoghurt, low fat/low sugar	Yoghurt, low fat/no fat (<0.5%),intense sweetened, nfs	n/a
Yoghurt, nfs	Yoghurt, natural, regular fat (~4%)	n/a
Yoghurt, no fat	Yoghurt, low fat/no fat (<0.5%),nfs	n/a
Yoghurt, no fat/diet varieties nfs	Yoghurt, low fat/no fat (<0.5%),nfs	n/a
Yoghurt, ski activ	SKI D/LITE FAVOURITES	n/a
Yoghurt, ski d'lite	SKI D/LITE FAVOURITES	n/a
Yoghurt, ski, nfs	SKI DIVINE VANILLA CREME	n/a
Yoghurt, soy	Soy yoghurt, regular fat (~3%),nfs	n/a
Yoghurt, Vaalia, nfs	VAALIA NATURAL LOW FAT	n/a
Yoplait for me nfs	YOPLAIT FRNCH VANILLA NO FAT	n/a
Zucchini flower nfs	Zucchini, green skin, boiled, drained	n/a
Zucchini nfs	Zucchini, green skin, boiled, drained	cup (nfs), 1 cup=190g

Part 2- List of food models and its correspondent weight

FOOD MODELS	**WEIGHT**
1 dsp	2 tsp
1cup (aus)	250ml/ 12.5tb
1tb (aus)	20ml/2ds/4ts
Apple	170g = 1 medium
Apple Sauce	1/2 cup (120mL)
Banana	170g= 1 medium
Beans, Baked	1/3 cup (80mL)
Beans, Green, Canned	1/2 cup (120mL)
Beef, Roast	1/2 cup (120mL)
Bologna/davon	30g
Bread roll	70g
Bread, White Spread W/ Peanut Butter	1 slice w/ 2 tbsp. (30mL) peanut butter
Broccoli	1/2 cup (120mL)
Cake	126g= 1 slice
Carrots, cooked or canned	1/2 cup (120mL)
Cereal, Bran Flakes	1/2 cup (120mL)
Cereal, Raisin Bran	1 cup (240mL)
Cheese	20g
Chicken Drumstick	85g
Chicken Thigh, Fried	85g
Cocoa mix	2 tbsp.
Corn Flakes, Dry Cereal	3/4 cup (180mL)
Corn, Whole Kernel, Canned	1/2 cup (120mL)
Cornetto	120g
Cucumber for sandwich	6 slices
Cup of coffee/tea	180ml or tea/coffee cup
Fish/Breast Chicken	85g
Grapes serve nfs	1/2 cup
Ham Slices Model	55g
Hamburger Large	115g

Hamburger Small	85g
Handful of nuts	30g
Herring	Silver perch, aquacultured, baked/grilled
Ice Cream	1 scoop/1/2 cup (120ml)
Loaf of bread	700g
Margarine/Jam/ spreads in general- Big Dab	1 tbsp./15mL
Meat Loaf/ cakes	85g = use slice/piece/1/8 of whole for cakes
Mixed veggies pack	1kg
Nfs sugar for coffee/tea	1 tsp.
Oil	1 tbsp./15mL
Onion	1/2 cup (120mL)
Orange Juice	120mL or 1 cup if NFS
Peas, Frozen	1/2 cup (120mL)
Pineapple Slices	80g
Pizza	210g= 1 slice
Potatoes, French Fried	1/2 cup (120mL)
Potatoes, Mashed	1/2 cup (120mL)
Rice, White Cooked	1/3 cup (80mL)
Rice, White, Cooked	1/2 cup (120mL)
Salad	2 cups
Spaghetti +Meatballs	240g (1/2 pasta +1/2 sauce)
Steak Strip/Steak	225g
Sweet Potatoes/Pumpkin	1/2 cup (120mL)
Tomato in sandwich nfs	1/2 cup
Whole chicken	1.2Kg= Whole spring chicken
Chop	225g
Fruit in general	Use medium size or one unit (e.g. mandarin)
Meals on Wheels serve	360g (with 1 cup of vegetable (142g) included)

Additional instructions:

- Use cup or cup nfs when referring to cup except for pasta, rice, porridge, beans in which case you should use cup (cooked)
- Use g (only) for beef, chicken, fish etc. - Don't use g (bone remover, raw) for example.

- Use small (95g) or large (100-120g) can when entry tuna/salmon cans (weight stated on cans are gross weights, not drained)
- Select the grilled option if available for meat, as we enter the amount of oil used separately.

Part 3 – Formula and calculations used in data entry

To calculate what is consumed from leftover:

1. Determine amount- same as dinner, 1/3 of serve of dinner, etc.
2. Determine how often leftover is being consumed- once a week, 5 days a week, etc.
3. Calculate frequency - 1 (week)/7(days)* number of days leftover is being consumed.

E.g.: Rosie eats chicken from leftovers 3 times a week, 1/3 of dinner serve
Chicken serve is 85g-> 85/3=28.3g

1/7*3= 0.428 ~0.43 -> this is equivalent to 3 days in a week.
0.43*28.3=12.13g of chicken in amount and 0.43W in frequency

Always multiply amount by how often food is being consumed to obtain total amount consumed.

To calculate frequency of consumption of food when participant consumes leftover from main meal on specific days but does not specify which food i.e. anything from a range of options:

1- Follow the same procedures as above, however at the end you will have to use formula bellow.

E.g.: Rosie consumes leftover from dinner 3 times a week and there are 7 options for dinner.
1/7*3=0.43 or 43% of the time-> here is how often Rosie consumes leftovers
So 0.43/7(options)= 0.06 a week
Rosie will consume each dinner leftover option 0.06 a week
The portion size will not change; only the frequency will change because the portion size is the same as dinner unless otherwise specified.

You can also calculate it as percentage, e.g.: if I have chicken 2/w, beef 3/w, pork 2/w but only have leftover 3 week. Determine % of the week I eat leftover (in this example ~43%) then you multiply the percentage by how often I consume each alternative i.e. chicken 2 x 0.43= 0.86/w

To determine how much is being consumed per day when several options are available follow the following example:

E.g.: 2 fruits per meal; 4 options provided; 3 times a week
2/4x3 = 1.5 (g/kg/cup/serves/fruit - as reported by participant) per week

To determine how much is being consumed per week (and to make sure above formulae is correct):
1 item (fruit in the above example) x 3 days of the week = weekly weight/ 7 days (week)= daily weight

Appendix E- WFR photographic instruction

How to weigh your food

Starting up the scales

Turn on scales by pressing ON-ZERO-OFF for 3 seconds;

Wait for 0g to appear;

Place plate/bowl on scales and record its weight;

Press ON-ZERO-OFF until 0g appears again.

Start weighing your food!

Example of how to weigh your coffee

Start off by weighing your cup/mug. Record its weight!

Press ON-ZERO-OFF button, add water and record its weight;

Add coffee granules and record its weight;

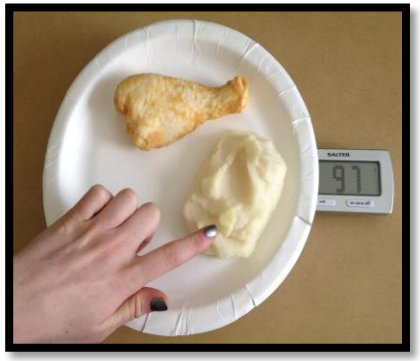
Add sugar and record its weight.

Add milk and record its weight.

How to weigh your food - Main meal

Plate first item (e.g. chicken) and record its weight;

Press ON-ZERO-OFF button, once 0g appears, plate 2nd item and record its weight;

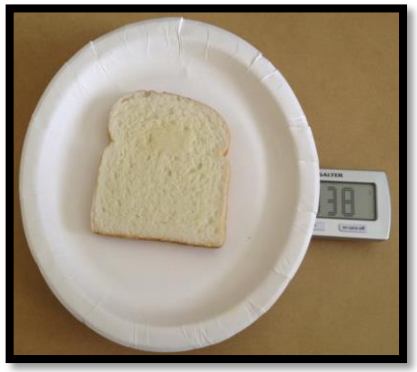


Repeat the process until all items have been weighed. Scales will turn itself off after a few seconds.

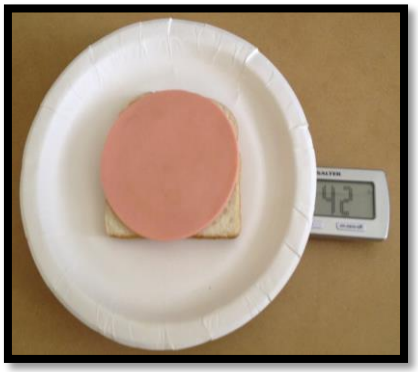
DO NOT FORGET TO PRESS ON-ZERO-OFF BEFORE WEIGHING FOOD ITEMS

How to weigh your food - Breakfast, lunch and snack

The same can be done with breakfast cereals.



Or with a sandwich for light meal



Or with a piece of fruit.

Appendix F- Geometric framework surface

Body composition, cognitive, metabolic, cardiovascular and general health

1) Waist circumference (cm)

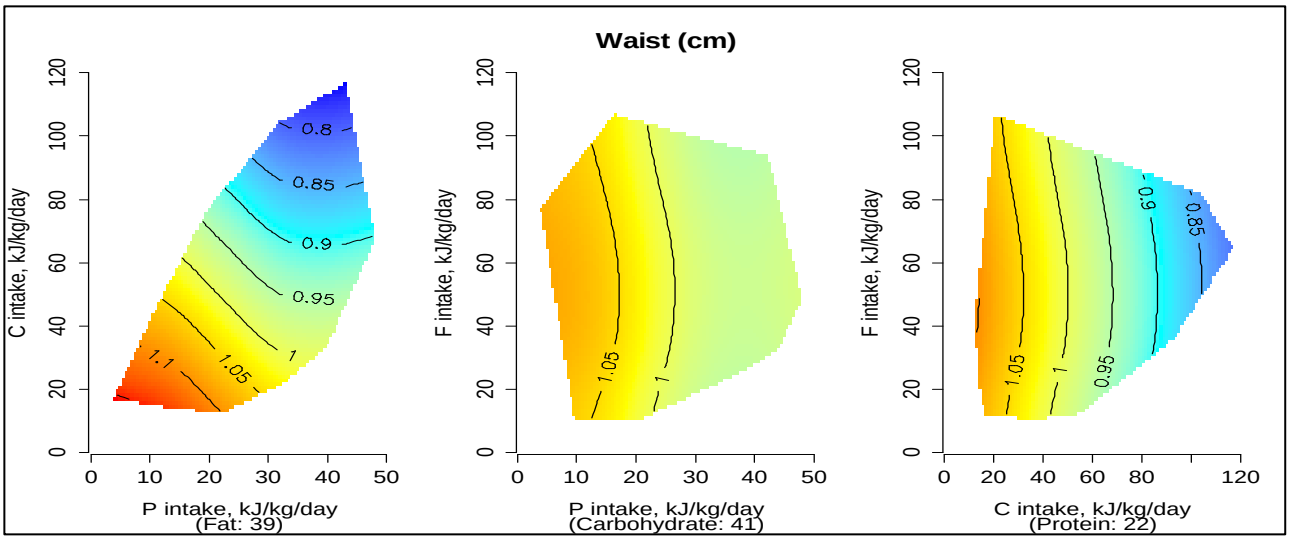
Waist circumference ranged from 0.7 to 1.5 cm (median=1cm) in participants with complete data on body weight, waist circumference and macronutrient intake (n=739). GAM results showed that protein and carbohydrate intakes were independently associated with waist circumference (**Table 1**). GF graphs indicated that wider waist circumferences were associated with low protein and carbohydrate intakes (**Figure 1**).

Table 1. Coefficients from GAMs for waist circumference (cm) of 739 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.5703	8	6.2443	0.0000
Carbohydrate	0.9896	8	11.9034	0.0000
Total fat	0.0000	8	0.0000	0.4215
Protein, Carbohydrate	0.0000	3	0.0000	0.8043
Protein, Total fat	1.4466	3	1.0785	0.0908
Carbohydrate, Total fat	0.0007	3	0.0001	0.4209
Protein, Carbohydrate, Total fat	0.0000	10	0.0000	0.6472

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 1. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and waist circumference (cm) in 739 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

2) Lean body mass (%)

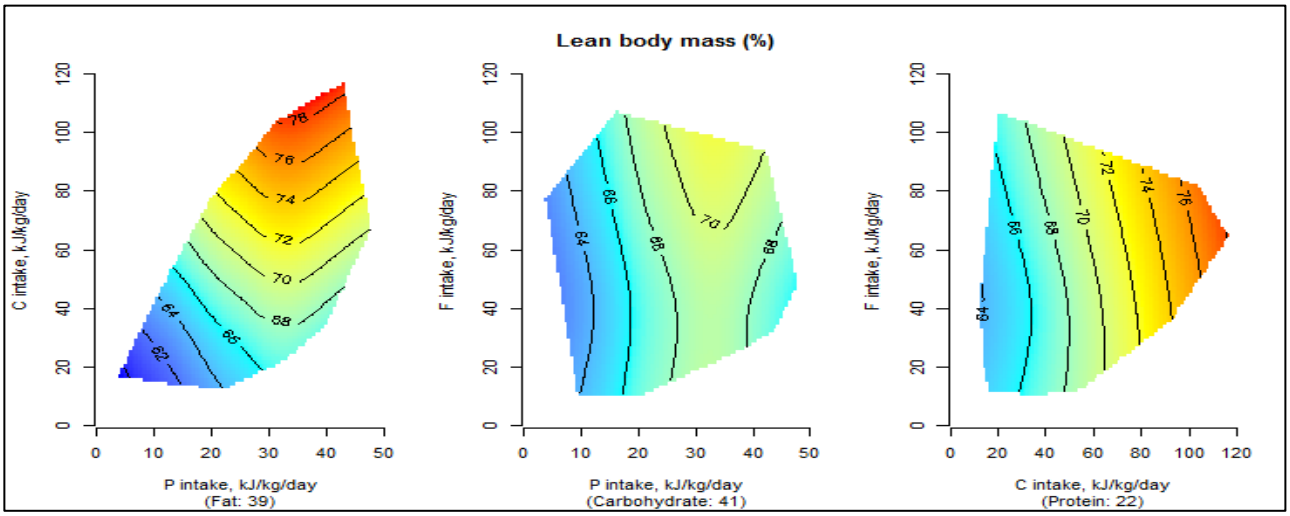
Percentage of lean body mass ranged from 52 to 85% (mean=67%, normally distributed) in participants with complete data on body weight, lean body mass (%) and macronutrient intake (n=732). GAM results showed that the ratio of intake of all macronutrients (as well as the independent intake of protein and carbohydrate) was associated with percentage of lean body mass (**Table 2**). GF graphs revealed that participants who consumed between ~25 and 40kJ/kg (1.5 and 2.35 g/kg) of protein, ≥100kJ/kg (≥6g/kg) of carbohydrate and ≥70kJ/kg (1.9g/kg) of fat had the highest percentage of lean body mass (**Figure 2**).

Table 2. Coefficients from GAMs for lean body mass (%) of 732 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	3.100	8	5.970	0.000
Carbohydrate	0.965	8	3.485	0.000
Total fat	0.000	8	0.000	0.505
Protein, Carbohydrate	0.040	3	0.013	0.337
Protein, Total fat	0.000	3	0.000	0.487
Carbohydrate, Total fat	0.532	3	0.251	0.195
Protein, Carbohydrate, Total fat	0.799	10	0.398	0.007

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 2. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and waist circumference (cm) in 732 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

3) Mini-mental state examination (MMSE)

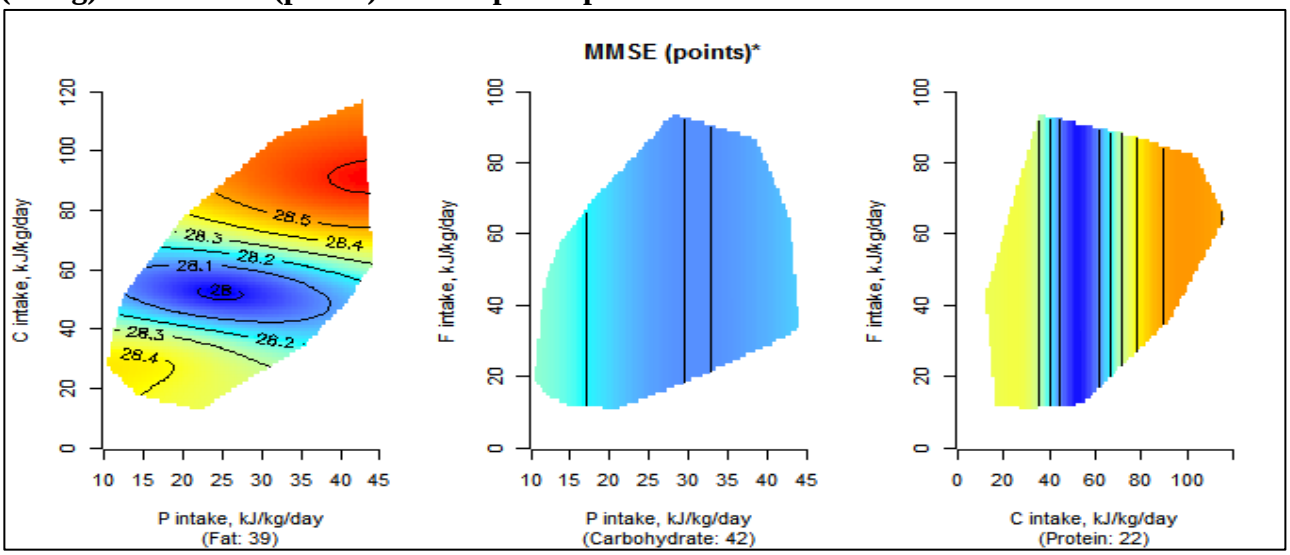
MMSE ranged from 17 to 30 points (median=29) in participants who had English as their first language or learned English before 12 years of age and had complete data on body weight, MMSE and macronutrient intake (n=485). GAM results showed that protein and carbohydrate intakes were associated with MMSE (**Table 3**). GF graphs revealed that participants who consumed ~50 to ~55kJ/kg (~2.9 to ~3.2g/kg) of carbohydrate or between 22kJ/kg and 25kJ/kg (1.3g/kg and 1.6g/kg) of protein, had better MMSE scores (**Figure 3**).

Table 3. Coefficients from GAMs for MMSE (points)* of 485 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.0002	8	0.000	0.75
Carbohydrate	0.0001	8	0.000	0.94
Total fat	0.0003	8	0.000	0.49
Protein, Carbohydrate	1.4678	3	1.442	0.05
Protein, Total fat	0.0001	3	0.000	0.49
Carbohydrate, Total fat	0.0001	3	0.000	0.46
Protein, Carbohydrate, Total fat	0.0000	10	0.000	0.51

* Mini-mental examination state test of participants who had English as their first language or learned English before 12 years of age.

Figure 3. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and MMSE (points)* in 485 participants

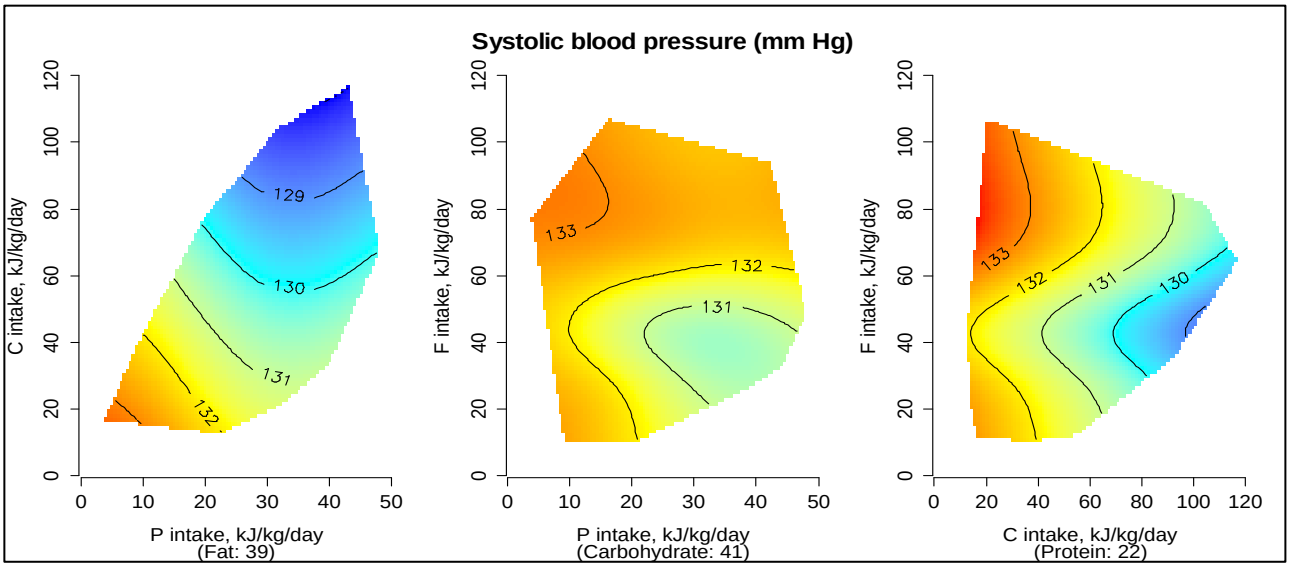


C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day; * Mini-mental examination state test of participants who had English as their first language or learned English before 12 years of age

4) Systolic blood pressure

Standing systolic blood pressure ranged from 70 to 207.5 (median=130) in participants (n=734) with complete data on body weight, standing systolic blood pressure and macronutrient intakes. GAM results showed no statistically significant association between standing systolic blood pressure and macronutrient intakes (**Table 4**). GF graphs showed that there was a tendency for higher standing systolic blood pressure in participants who consumed less carbohydrate (**Figure 4**).

Figure 4. Response surfaces showing the relationship between macronutrient intake (kJ/kg) and systolic blood pressure (mmHg)* in 734 participants



*Systolic blood pressure measure in a standing position; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day.

Table 4. Coefficients from GAMs for systolic blood pressure (mmHg)* of 734 participants

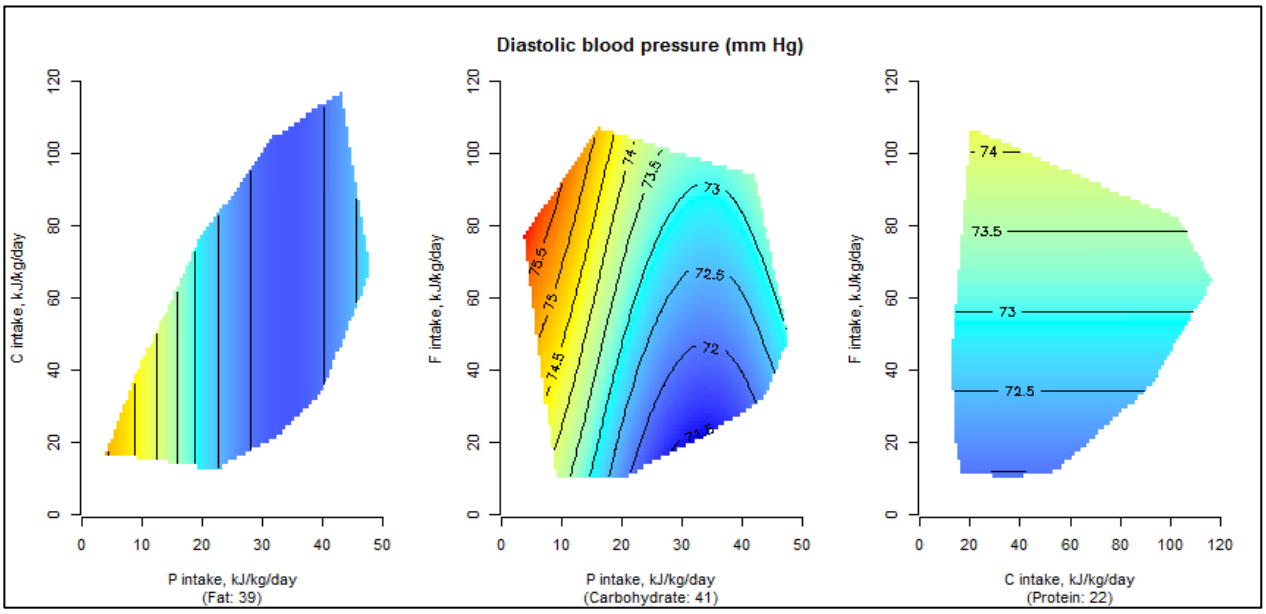
Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.398	8	0.067	0.207
Carbohydrate	0.508	8	0.129	0.135
Total fat	0.000	8	0.000	0.368
Protein, Carbohydrate	0.001	3	0.000	0.478
Protein, Total fat	0.910	3	0.508	0.172
Carbohydrate, Total fat	0.000	3	0.000	0.306
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.773

*Systolic blood pressure measured in a standing position; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

5) Diastolic blood pressure

Standing diastolic blood pressure ranged from 30 to 103 (median=71) in participants (n=733) with complete data on body weight, standing diastolic blood pressure and macronutrient intakes. GAM results showed that protein intake was statistically significant association between standing diastolic blood pressure and protein intake (**Table 5**). GF graphs showed that highest standing diastolic blood pressure was found in participants who consumed low amounts of protein (**Figure 5).**

Figure 5. Response surfaces showing the relationship between macronutrient intake (kJ/kg) and diastolic blood pressure (mmHg)* in 734 participants



*Diastolic blood pressure measure in a standing position; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day.

Table 5. Coefficients from GAMs for diastolic blood pressure (mmHg)* of 733 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Saturated	1.419	8	0.634	0.022
Polyunsaturated	0.000	8	0.000	0.604
Monounsaturated	0.616	8	0.200	0.101
Saturated, Polyunsaturated	0.000	3	0.000	0.752
Saturated, Monounsaturated	0.004	3	0.001	0.414
Polyunsaturated, Monounsaturated	0.000	3	0.000	0.544
Saturated fat, Polyunsaturated, Monounsaturated	0.001	10	0.000	0.420

*Diastolic blood pressure measured in a standing position; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

6) Self-rated health (SRH)

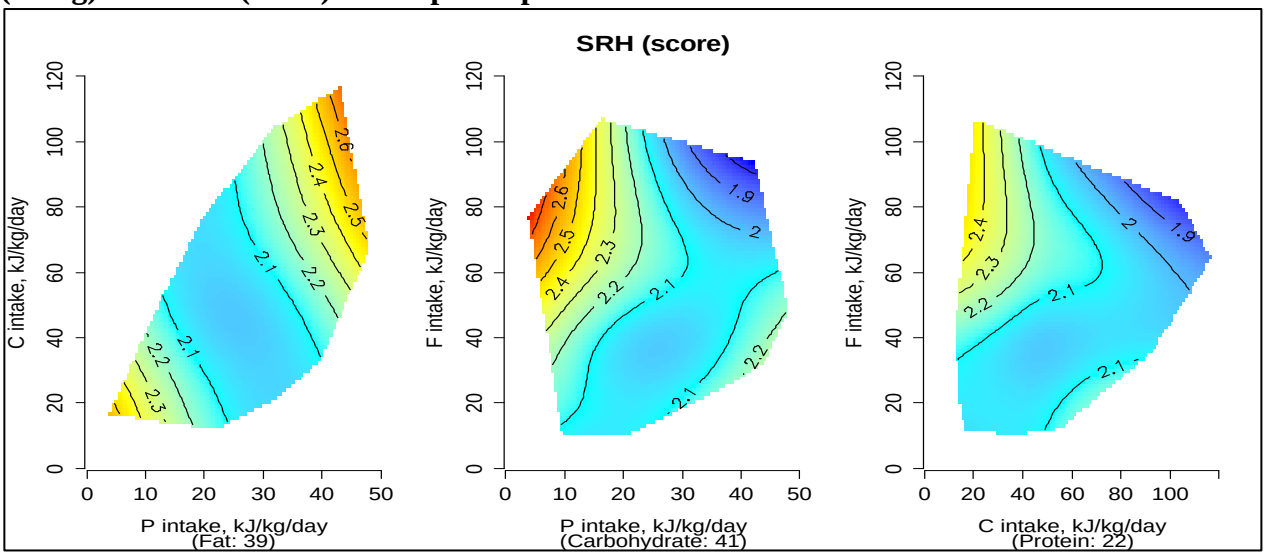
Of the 748 participants with complete data on body weight, SRH and macronutrient intake, 75% (n=561) considered that health to be good/excellent (1-2 SRH score). GAM results showed that protein and fat intakes, as well as the ratio of intake of all macronutrients was associated with SRH (**Table 6**). GF graphs revealed that participants who consumed between ~25 and ~40kJ/kg (~1.5 to ~2.6g/kg) of protein, ≥90kJ/kg (5.3g/kg) of carbohydrate, and between 70 and 100kJ/kg of fat had better self-rated health scores (**Figure 6**).

Table 6. Coefficients from GAMs for SRH (score) of 748 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.0029	8	0.000	0.1030
Carbohydrate	0.0003	8	0.000	0.1541
Total fat	0.0002	8	0.000	0.6440
Protein, Carbohydrate	0.6029	3	0.277	0.1637
Protein, Total fat	1.1969	3	1.131	0.0187
Carbohydrate, Total fat	0.0001	3	0.000	0.3187
Protein, Carbohydrate, Total fat	4.8065	10	1.461	0.0007

SRH, self-rated health; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 6. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and SRH (score) in 748 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Demographical factors

7) Education level

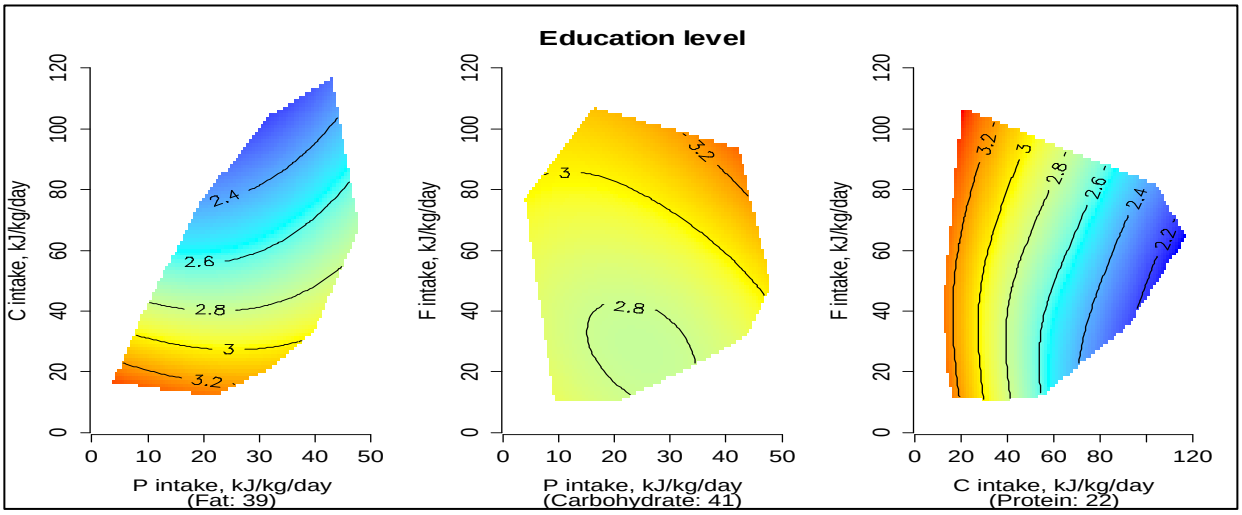
Of the 743 participants with complete data on body weight, education level and macronutrient intake, 16% (n=119) had a bachelor degree or higher, 24% (n=180) had a trade/apprenticeship, 20% (n=147) had a certificate/diploma and 40% (n=297) have completed high school or below. GAM results showed that carbohydrate intake as well as the ratio of intake of all macronutrients was associated with education level (**Table 7**). GF graphs revealed that participants with a lower level of education tended to have a lower carbohydrate intake (**Figure 7**).

Table 7. Coefficients from GAMs for education level (cm) of 743 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.0001	8	0.0000	0.5713
Carbohydrate	0.9531	8	2.5397	0.0000
Total fat	0.0011	8	0.0001	0.4657
Protein, Carbohydrate	0.0000	3	0.0000	1.0000
Protein, Total fat	0.0000	3	0.0000	0.7203
Carbohydrate, Total fat	0.0000	3	0.0000	0.9969
Protein, Carbohydrate, Total fat	0.8401	10	0.5253	0.0116

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 7. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and education level* in 743 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day; *Education level = 1- Bachelor degree or higher, 2- Trade/Apprenticeship, 3- Certificate/diploma, 4- High school or below

8) Age (years)

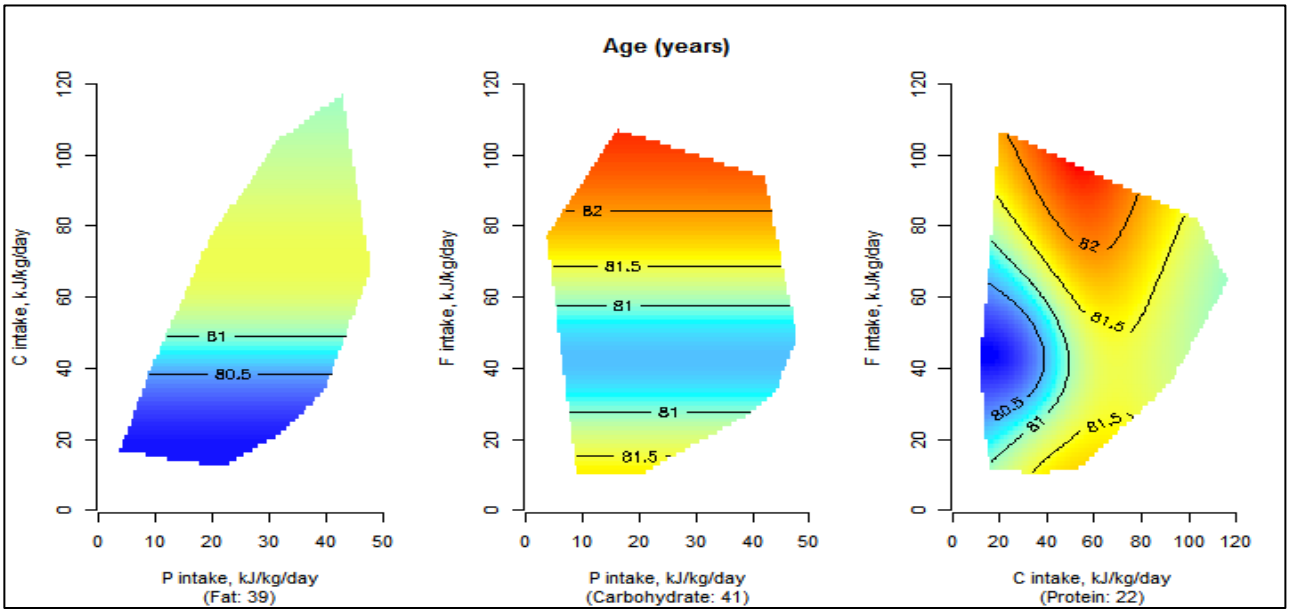
The mean age of participants with complete data on body weight, macronutrient intake and age (n=750) was 81 years. GAM results showed that the ratio of carbohydrate to fat intake was associated with age (**Table 8**). GF graphs revealed that older participants tended to consume between ~25 and ~65kJ/kg (~0.7g/kg and 1.8g/kg) of fat while consuming ≤40 kJ/kg (≤2.35g/kg) of carbohydrate (**Figure 8**).

Table 8. Coefficients from GAMs for age (years) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	1.000
Carbohydrate	0.002	8	0.000	0.391
Total fat	0.000	8	0.000	1.000
Protein, Carbohydrate	0.000	3	0.000	0.457
Protein, Total fat	0.000	3	0.000	1.000
Carbohydrate, Total fat	1.654	3	3.485	0.002
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.742

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 8. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and age (years) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Frailty components

Analyses of frailty components were restricted to those with complete data on frailty and all frailty components (except exhaustion as all participants had a 0 score for exhaustion i.e. the exhaustion component did not contribute to overall frailty score).

9) Physical activity scale for the elderly (PASE)

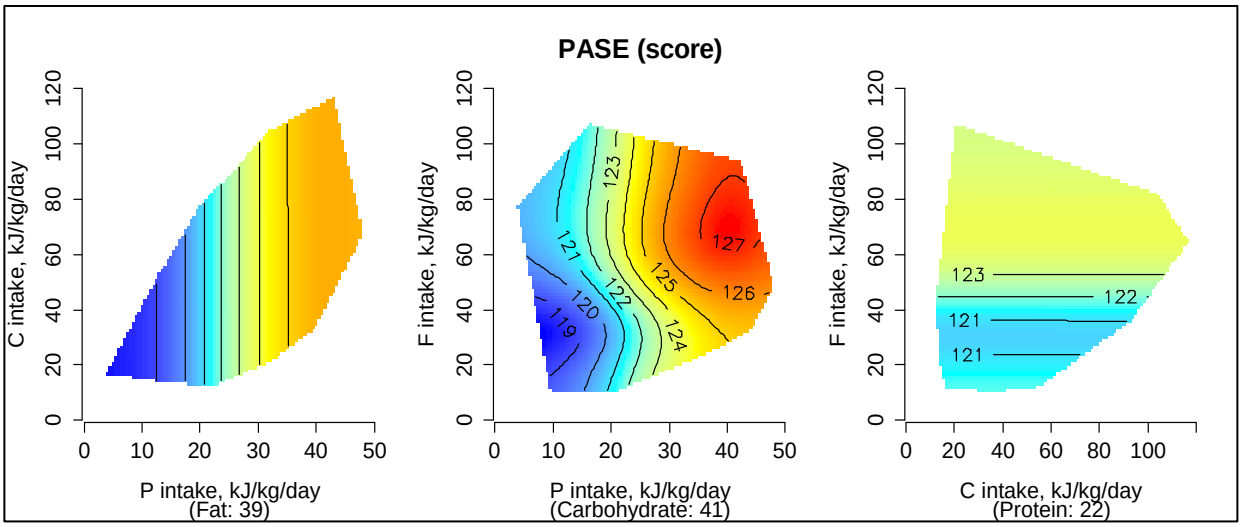
PASE ranged from 0 to 507 (median=123) in participants (n=701) with complete data on grip strength, physical activity level, walking speed, weight loss, body weight, frailty scores and macronutrient intakes. GAM results showed no statistically significant association between PASE score and macronutrient intakes (**Table 9**). GF graphs, however, showed that there was a tendency for higher PASE scores (more physically active) in participants who consumed more protein (**Figure 9**).

Table 9. Coefficients from GAMs for PASE scores of 701 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.629	8	0.141	0.15
Carbohydrate	0.002	8	0.000	0.53
Total fat	0.002	8	0.000	0.44
Protein, Carbohydrate	0.000	3	0.000	0.97
Protein, Total fat	0.444	3	0.211	0.22
Carbohydrate, Total fat	0.000	3	0.000	0.95
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.43

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 9. Response surfaces showing the relationship between macronutrient intake (kJ/kg) and PASE scores in 701 participants



PASE, physical activity scale for the elderly; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

10) Grip strength

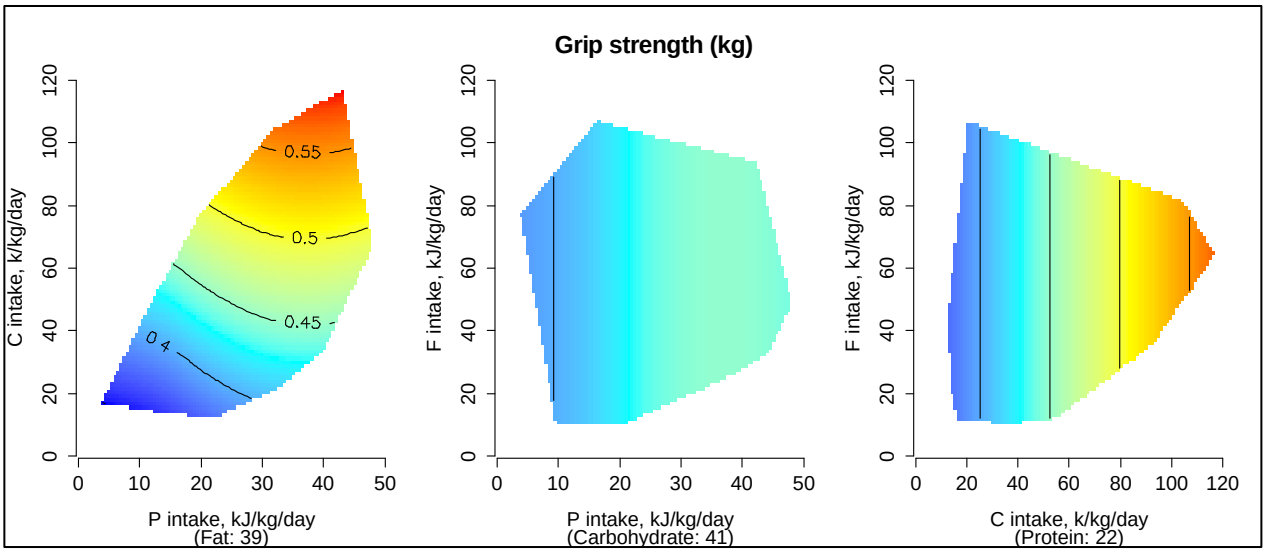
Grip strength adjusted for body weight ranged from 0.15 to 1.05 kg (median=0.43) in participants with complete data on grip strength, physical activity level, walking speed, weight loss, body weight, frailty scores and macronutrient intakes (n=701). GAM results showed that both protein and carbohydrate intake were independently associated with grip strength (**Table 10**). GF graphs showed that participants who consumed higher amounts of carbohydrate or protein, had the strongest grip strength (**Figure 10**).

Table 10. Coefficients from GAMs for grip strength (kg/kg) of 701 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.626	8	1.040	0.004
Carbohydrate	0.969	8	3.828	<0.001
Total fat	0.000	8	0.000	0.55
Protein, Carbohydrate	0.000	3	0.000	0.94
Protein, Total fat	0.000	3	0.000	0.45
Carbohydrate, Total fat	0.000	3	0.000	0.55
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.80

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 10. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and grip strength (kg/kg) in 701 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

11) Walking speed

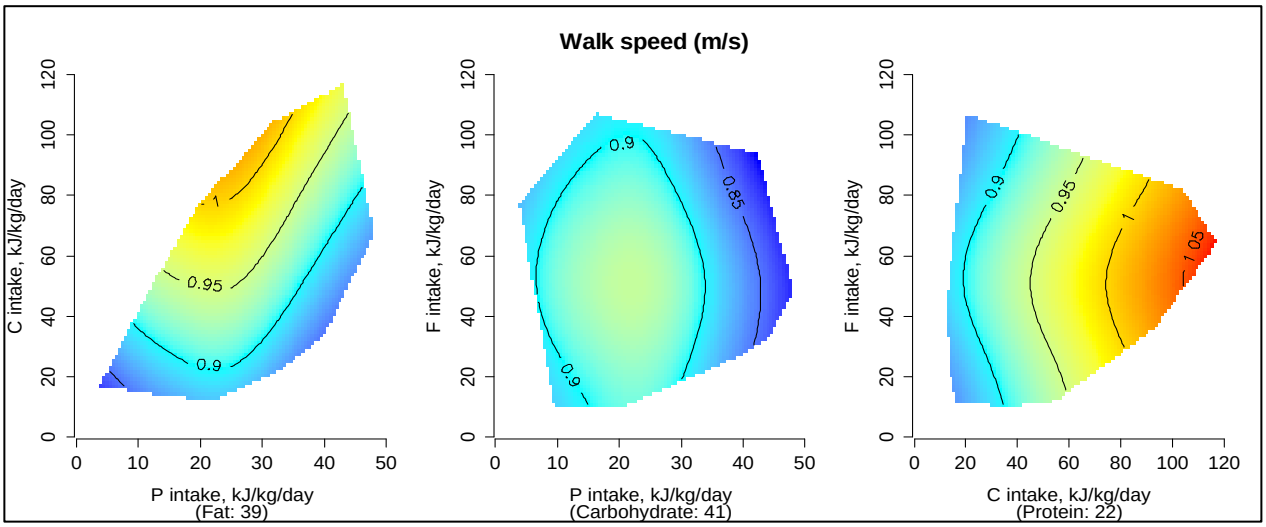
Walking speed (m/s) ranged from 0.23 to 1.53 kg (median=0.9) in participants with complete data on body weight, grip strength, physical activity level, walking speed, weight loss, body weight, frailty scores and macronutrient intake (n=701). GAM results showed that both protein and carbohydrate intakes were independently associated with walking speed (**Table 11**). GF graphs revealed that participants who consumed ≥95kJ/kg (5.6g/kg) of carbohydrate or between 20kJ/kg and 25kJ/kg (1.2g/kg and 1.5g/kg) of protein, walked faster (**Figure 11**).

Table 11. Coefficients from GAMs for walking speed (m/s) of 701 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.646	8	0.506	0.06
Carbohydrate	0.884	8	0.951	0.002
Total fat	0.000	8	0.000	0.50
Protein, Carbohydrate	0.000	3	0.000	0.41
Protein, Total fat	0.938	3	0.564	0.13
Carbohydrate, Total fat	0.000	3	0.000	0.35
Protein, Carbohydrate, Total fat	0.296	10	0.042	0.15

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 11. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and walking speed (m/s) in 701 participants



M/s, meters per second; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

12) Weight loss

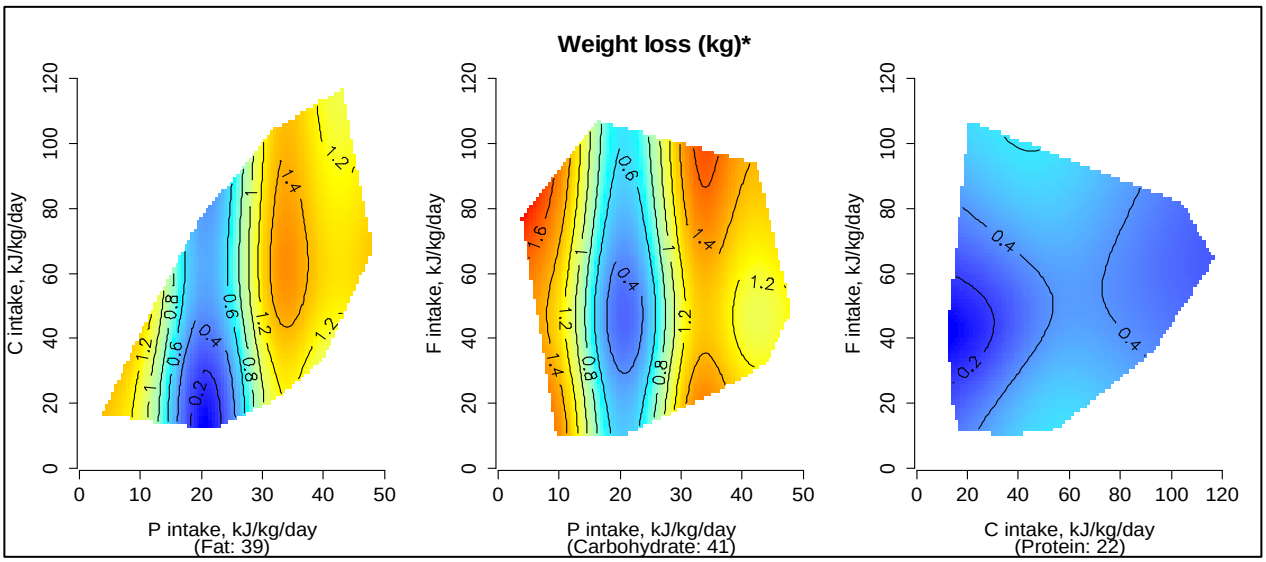
Weight loss above 15% of maximum weight (or above weight at 25 years of age) ranged from 0 to 68kg (median=0) in participants with complete data on grip strength, physical activity level, walking speed, weight loss, body weight, frailty scores and macronutrient intake (n=701). GAM results showed protein intake was significantly associated with weight loss above 15% of self-reported heaviest weight or weight at 25 years of age (**Table 12**). GF graphs indicated that it was particularly those participants who consumed either very low or very high amounts of protein that lost the most weight (**Figure 12**).

Table 12. Coefficients from GAMs for weight loss (kg)* of 701 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.965	8	1.167	0.01
Carbohydrate	0.000	8	0.000	0.66
Total fat	0.000	8	0.000	0.77
Protein, Carbohydrate	0.001	3	0.000	0.48
Protein, Total fat	0.000	3	0.000	0.78
Carbohydrate, Total fat	0.793	3	0.415	0.21
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.97

* Weight loss above 15% of self-reported heaviest weight or at 25 years of age

Figure 12. Response surfaces showing the relationship between macronutrient intake (kJ/kg) and weight loss (kg)* in 701 participants



Weight loss above 15% of self-reported heaviest weight or at 25 years of age; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day.

Blood markers

13) Glucose (mmol/L)

Participants fasting glucose levels ranged from 2.7 to 16.7 mmol/L (median=5.3) in the 628 participants with complete data on fasting glucose, body weight and macronutrient intakes. GAM results showed that the ratio of all macronutrients were significantly associated with fasting glucose levels (p=0.001, **Table 13**). GF graphs showed that participants who had the highest fasting glucose levels were those who consumed a relatively high amount of fat (≤110kJ/kg or

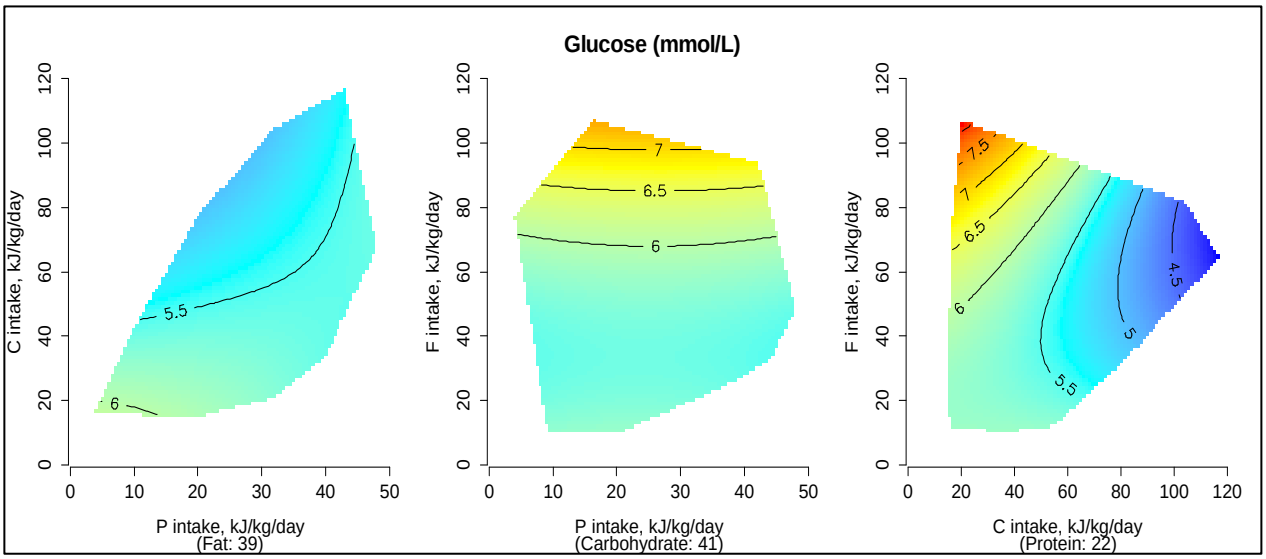
≤3g/kg) with low amounts of carbohydrate (≤25kJ/kg or ≤1.5g/kg) and protein (≤15kJ/kg or 0.9g/kg) (**Figure 13**).

Table 13. Coefficients from GAMs for glucose (mmol/L) of 628 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	0.44
Carbohydrate	0.619	8	0.203	0.002
Total fat	0.000	8	0.000	0.19
Protein, Carbohydrate	0.000	3	0.000	0.74
Protein, Total fat	0.001	3	0.000	0.42
Carbohydrate, Total fat	0.000	3	0.000	0.64
Protein, Carbohydrate, Total fat	5.073	10	1.665	0.001

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 13. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and plasma glucose (mmol/L) in 628 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

14) Insulin and unadjusted macronutrient intake

Participants fasting insulin levels ranged from 8 to 682 pmol/L (median=44) in the 634 participants with complete data on fasting insulin and macronutrient intakes. GAM results reviewed, although not statistically significant, that there was a tendency of higher insulin levels in participants with high fat and protein intakes (**Table 14**). GF graphs showed that participants who

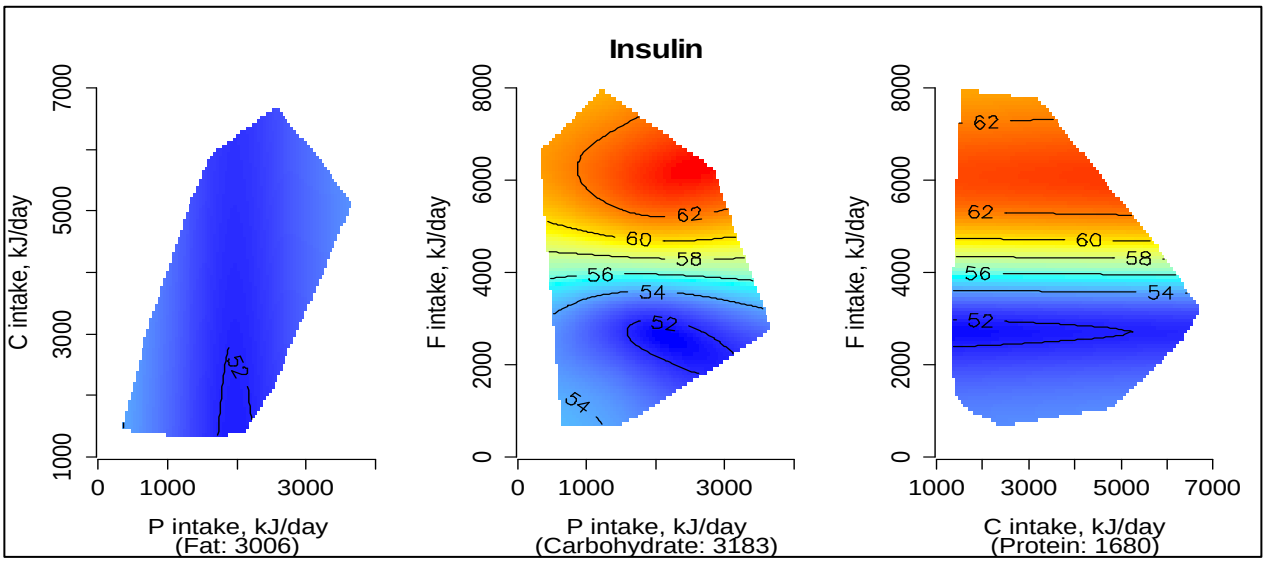
had the highest fasting insulin levels were those who consumed a relatively high amount of fat (~5000kJ/day) while consuming >1000 kJ/day of protein (**Figure 14**).

Table 14. Coefficients from GAMs for insulin (pmol/L) of 634 participants

Nutrient (s) (kJ/day)	EDF	Ref. DF	F	p-value
Protein	0.002	8	0.000	0.666
Carbohydrate	0.023	8	0.003	0.321
Total fat	0.402	8	0.067	0.114
Protein, Carbohydrate	0.000	3	0.000	0.676
Protein, Total fat	0.946	3	0.624	0.071
Carbohydrate, Total fat	0.001	3	0.000	0.428
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.676

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 14. Response surfaces showing the relationship between macronutrient intakes (kJ/day) and insulin (mg) in 634 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

15) Prostate-specific antigen (PSA)

PSA ranged from 0.05 to 56.8 (ng/dL) (median=1.9) in participants with complete data on PSA, body weight and macronutrient intake (n=729). GAM results showed no statistically significant

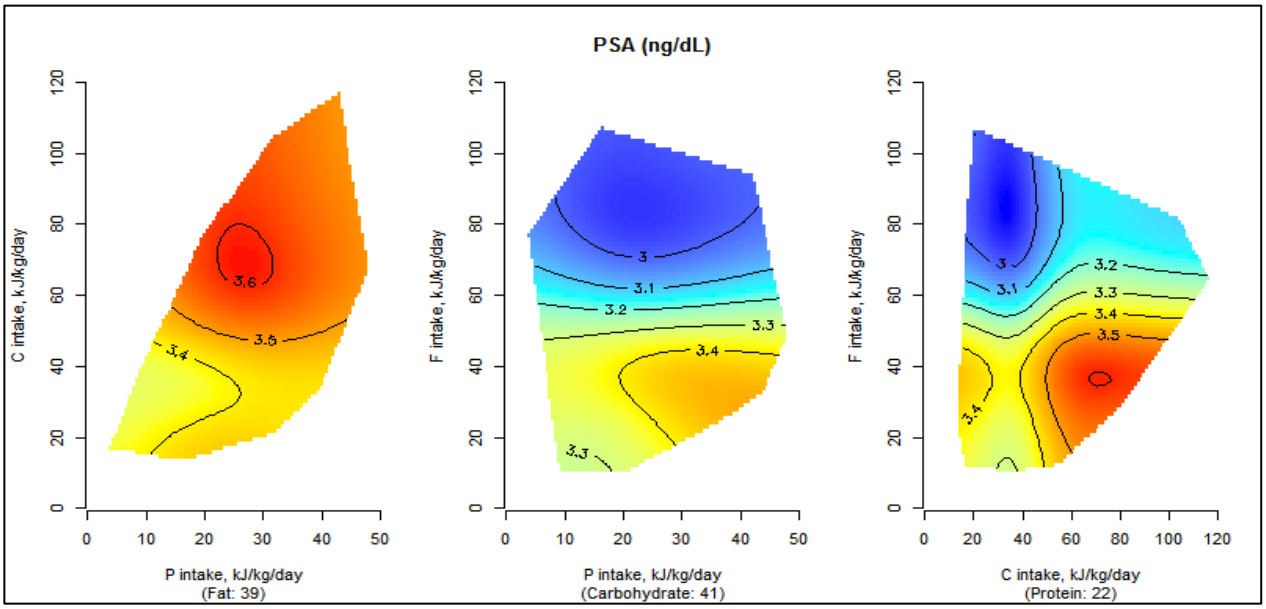
association between PSA and any macronutrient intake (**Table 15**). GF graphs showed a tendency for lower PSA levels when fat intake was higher (**Figure 15**).

Table 15. Coefficients from GAMs for PSA (ng/dL) of 729 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.002	8	0.000	0.377
Carbohydrate	0.001	8	0.000	0.520
Total fat	0.240	8	0.035	0.187
Protein, Carbohydrate	0.428	3	0.194	0.239
Protein, Total fat	0.556	3	0.257	0.190
Carbohydrate, Total fat	0.000	3	0.000	0.450
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.544

PSA, Prostate-specific antigen; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 15. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and PSA (ng/dL) in 729 participants



PSA, Prostate-specific antigen; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

16) WCC

WCC ranged from 3 to 81 (x10^9/L) (median=6.3) in participants with complete data on WCC, body weight and macronutrient intake (n=727). GAM results showed no statistically significant

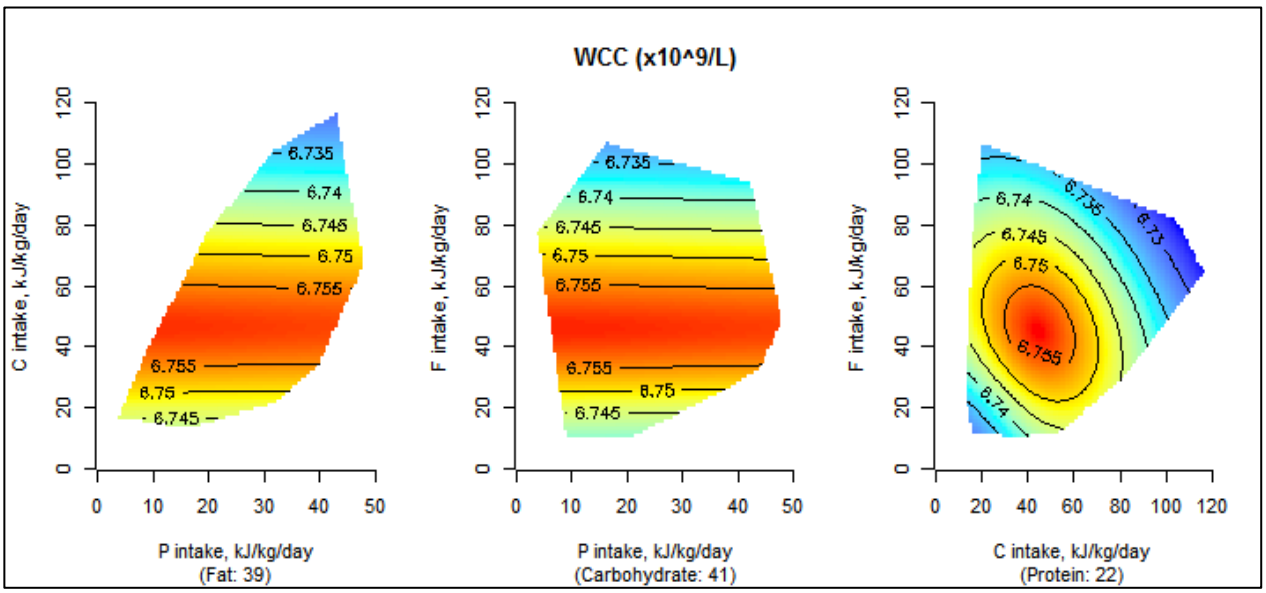
association between WCC and any macronutrient intake (**Table 16**). GF graphs did not reveal any noticeable differences in macronutrient intake of participants with high WCC levels (**Figure 16**).

Table 16. Coefficients from GAMs for WCC (x10^9/L) of 727 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.001	8	0.000	0.389
Carbohydrate	0.001	8	0.000	0.615
Total fat	0.001	8	0.000	0.790
Protein, Carbohydrate	0.001	3	0.000	0.397
Protein, Total fat	0.000	3	0.000	0.597
Carbohydrate, Total fat	0.075	3	0.025	0.355
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.710

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 16. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and WCC (x10^9/L) in 727 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

17) Haemoglobin

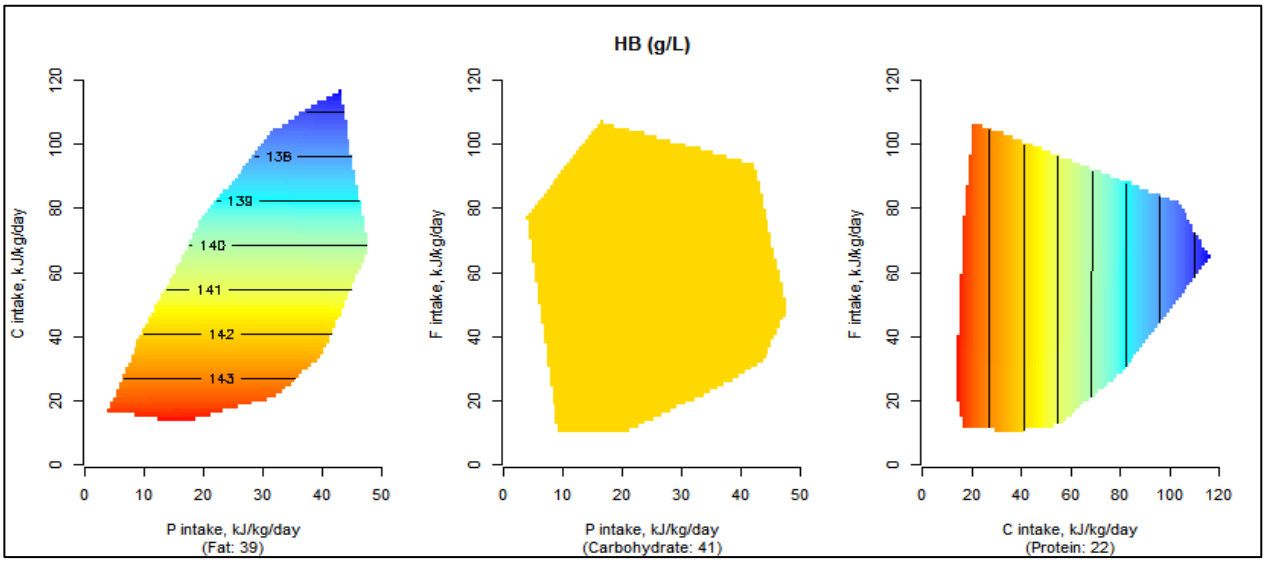
Haemoglobin ranged from 94 to 181 (g/L) (median=143) in participants with complete data on haemoglobin, body weight and macronutrient intake (n=727). GAM results showed that haemoglobin levels were associated with carbohydrate intake (p=0.016, **Table 17**). GF graphs showed that participants with lower haemoglobin levels tended to have a higher intake of carbohydrate (**Figure 17**).

Table 17. Coefficients from GAMs for haemoglobin (g/L) of 727 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.001	8	0.000	0.565
Carbohydrate	0.829	8	0.603	0.016
Total fat	0.001	8	0.000	0.536
Protein, Carbohydrate	0.000	3	0.000	0.655
Protein, Total fat	0.000	3	0.000	0.521
Carbohydrate, Total fat	0.000	3	0.000	0.542
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.848

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 17. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and haemoglobin (g/L) in 727 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

18) Creatinine

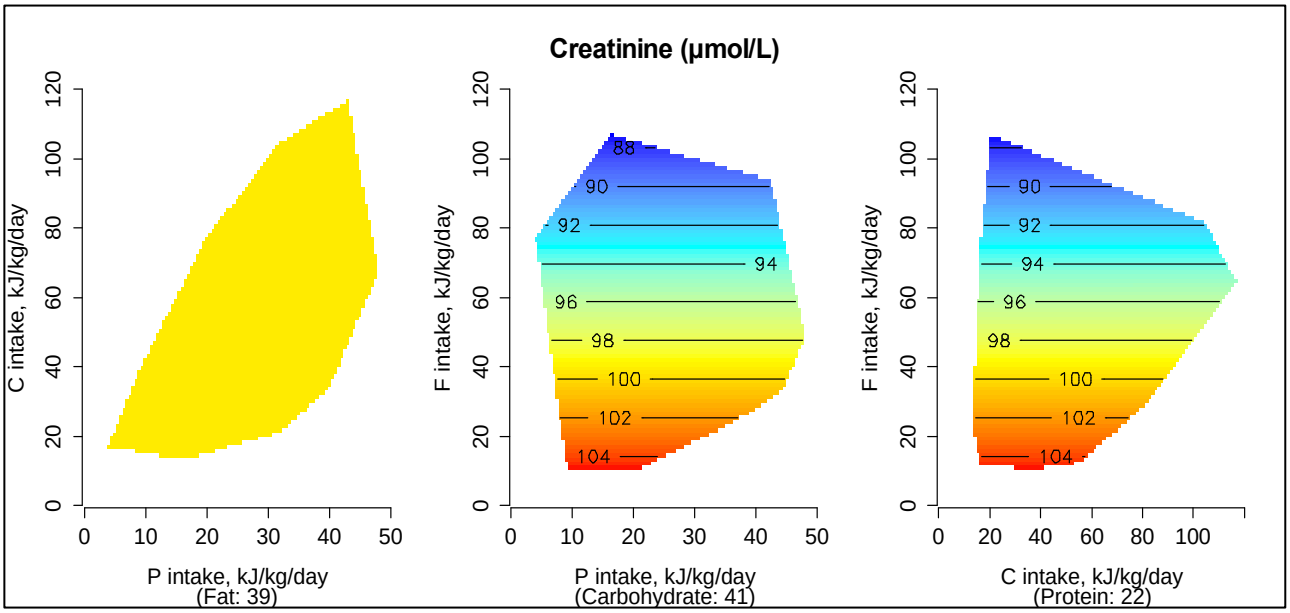
Creatinine levels ranged from 44 to 474 (µmol/L) (median=92) in participants with complete data on creatinine and macronutrient intake (n=729). GAM results showed that creatinine levels were statistically significant associated with fat intake (p=0.008, **Table 18**). GF graphs showed that participants with higher creatinine levels had a higher intake of fat (**Figure 18**).

Table 18. Coefficients from GAMs for creatinine (µmol/L) of 729 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	1.000
Carbohydrate	0.000	8	0.000	1.000
Total fat	0.861	8	0.751	0.008
Protein, Carbohydrate	0.000	3	0.000	1.000
Protein, Total fat	0.000	3	0.000	0.613
Carbohydrate, Total fat	0.000	3	0.000	0.908
Protein, Carbohydrate, Total fat	0.000	10	0.000	1.000

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 18. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and creatinine (µmol/L) in 729 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

19) Albumin

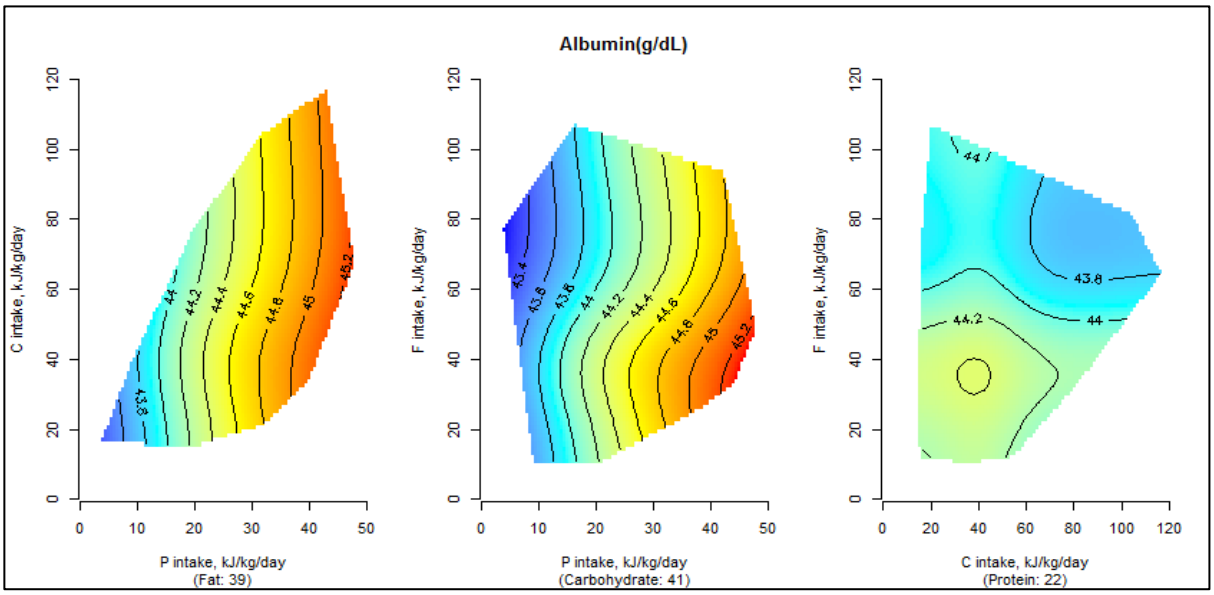
Albumin ranged from 33 to 54 (g/L) (median=44) in participants with complete data on body weight, albumin and macronutrient intake (n=631). GAM results showed that albumin levels were associated with protein intake (**Table 19**). GF graphs showed that participants with lower albumin levels tended to have a low intake of protein (**Figure 19**).

Table 19. Coefficients from GAMs for albumin (gdL) of 631 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.862	8	0.777	0.004
Carbohydrate	0.001	8	0.000	0.437
Total fat	0.000	8	0.000	0.651
Protein, Carbohydrate	0.534	3	0.262	0.215
Protein, Total fat	0.987	3	0.795	0.087
Carbohydrate, Total fat	0.001	3	0.000	0.312
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.631

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 19. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and albumin (g/dL) in 631 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

Dietary fibre and micronutrients

20) Dietary fibre

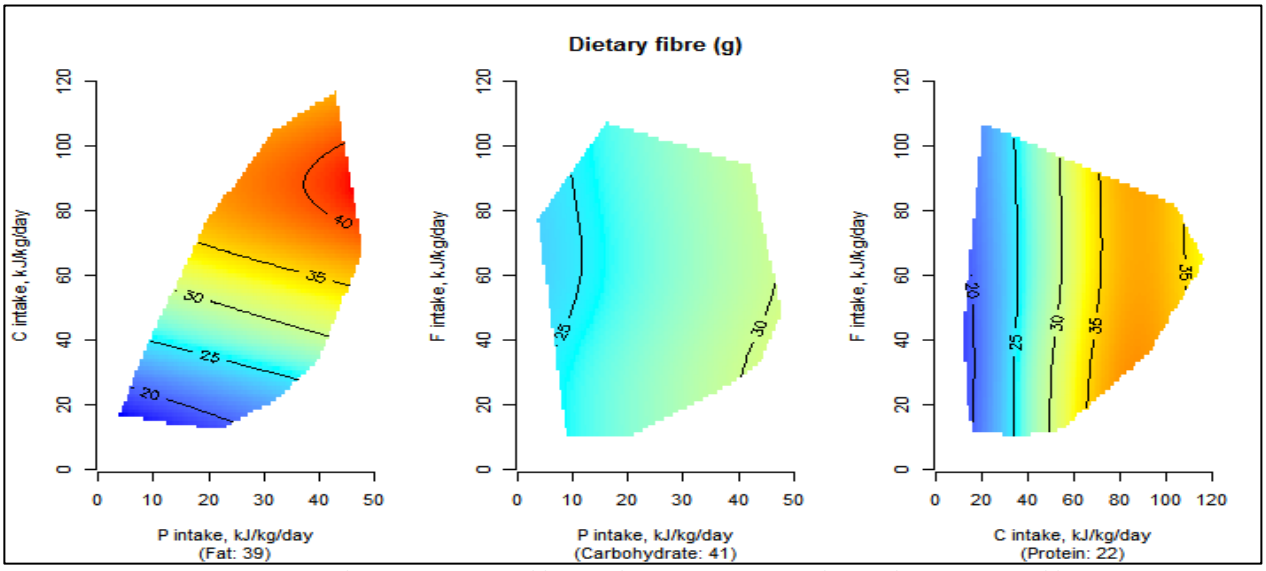
Dietary fibre intake ranged from 7 to 78 (g) (median=26) in participants with complete data on dietary fibre intake and macronutrient intake (n=750). GAM results showed that dietary fibre intake was independently associated with carbohydrate and protein intake (**Table 20**). GF graphs showed that dietary fibre intake was higher when protein and/or carbohydrate intake were higher (**Figure 20**).

Table 20. Coefficients from GAMs for dietary fibre (g) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.870	8	0.826	0.005
Carbohydrate	3.059	8	9.741	0.000
Total fat	0.000	8	0.000	0.714
Protein, Carbohydrate	0.000	3	0.000	0.389
Protein, Total fat	0.000	3	0.000	0.603
Carbohydrate, Total fat	1.028	3	0.724	0.111
Protein, Carbohydrate, Total fat	0.000	10	0.000	0.623

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 20. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and dietary fibre (g) in 750 participants



GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

21) Vitamin C

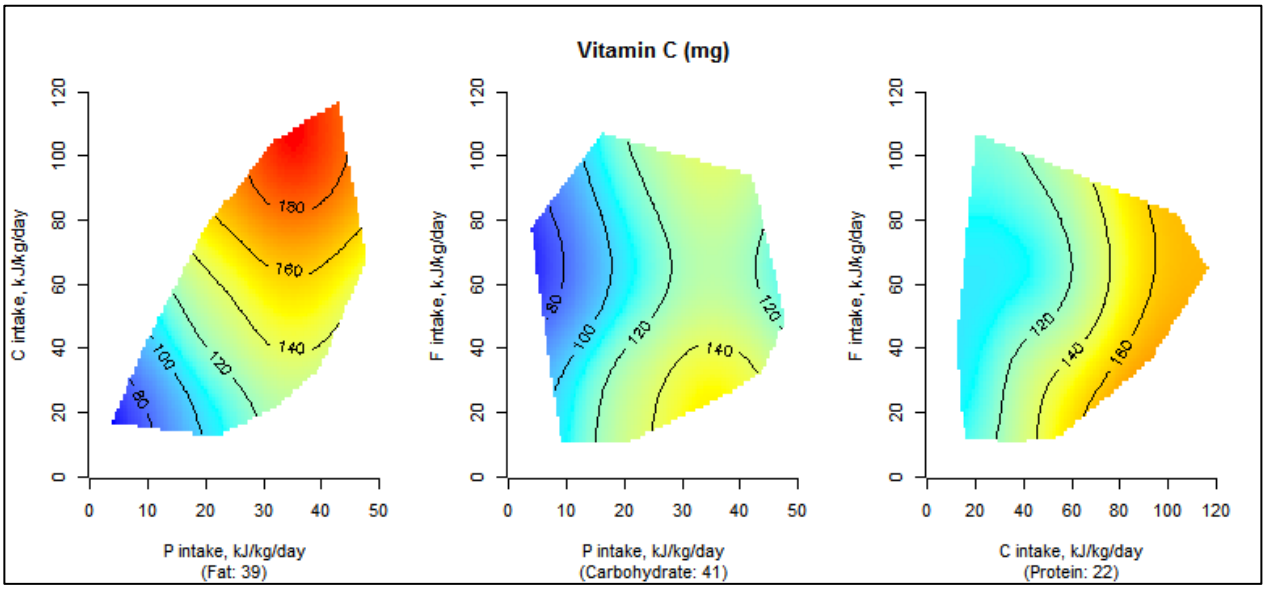
Vitamin C intake ranged from 4 to 641 (mg) (median=105.6) in participants with complete data on body weight, vitamin C and macronutrient intake (n=750). GAM results showed that vitamin C intake was independently associated with carbohydrate and protein intake as well as with the ratio of intake of carbohydrate to fat (**Table 21**). GF graphs showed that vitamin C intake was higher when protein and/or carbohydrate intake were higher while fat intake was intermediate (**Figure 21**).

Table 21. Coefficients from GAMs for vitamin C (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.133	8	1.895	0.000
Carbohydrate	1.899	8	1.933	0.000
Total fat	0.028	8	0.003	0.242
Protein, Carbohydrate	0.000	3	0.000	0.425
Protein, Total fat	0.000	3	0.000	0.498
Carbohydrate, Total fat	2.039	3	3.378	0.001
Protein, Carbohydrate, Total fat	0.001	10	0.000	0.621

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 21. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and vitamin C (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

22) Vitamin D

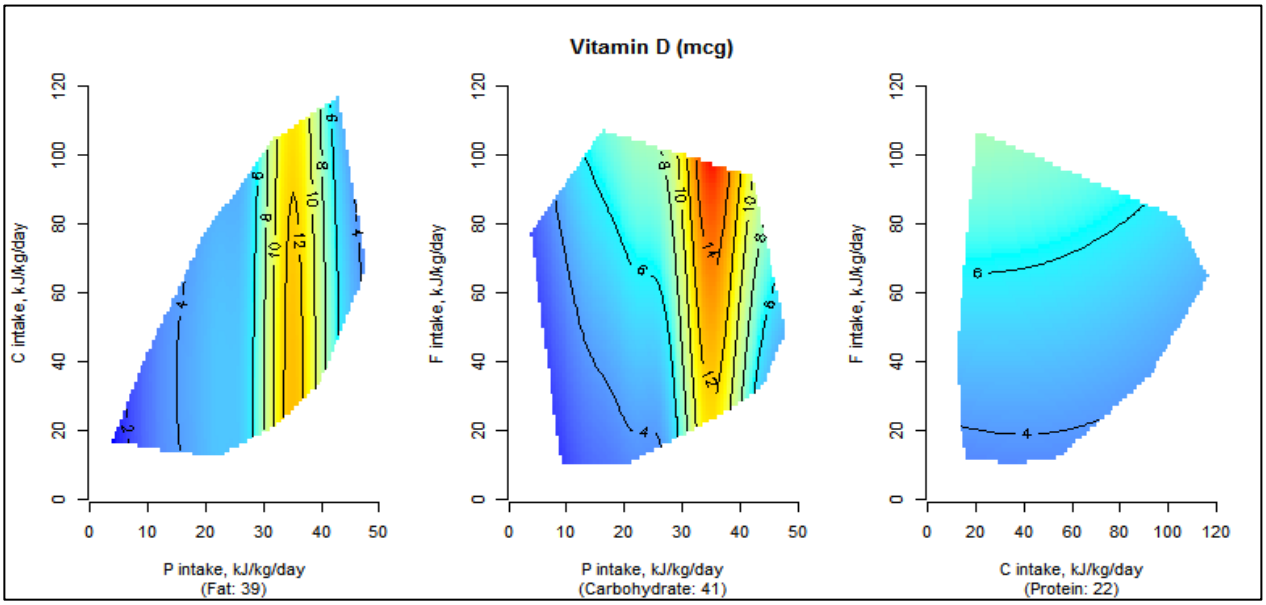
Vitamin D intake ranged from 0.2 to 208 (mg) (median=4.5) in participants with complete data on body weight, vitamin D and macronutrient intake (n=750). GAM results showed that vitamin C intake was independently associated with protein and fat intake (**Table 22**). GF graphs showed that vitamin D intake was particularly higher when fat intake was above 70kJ/kg/day (1.9g/kg/day) and protein intake was somewhere between 30-40kJ/kg/day (1.8-2.3g/kg/day) (**Figure 22**).

Table 22. Coefficients from GAMs for vitamin D (mcg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	4.864	8	3.977	0.000
Carbohydrate	0.001	8	0.000	0.427
Total fat	0.716	8	0.310	0.040
Protein, Carbohydrate	0.000	3	0.000	1.000
Protein, Total fat	0.000	3	0.000	0.771
Carbohydrate, Total fat	0.000	3	0.000	0.926
Protein, Carbohydrate, Total fat	0.681	10	0.079	0.272

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 22. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and vitamin D (mcg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

23) Vitamin E

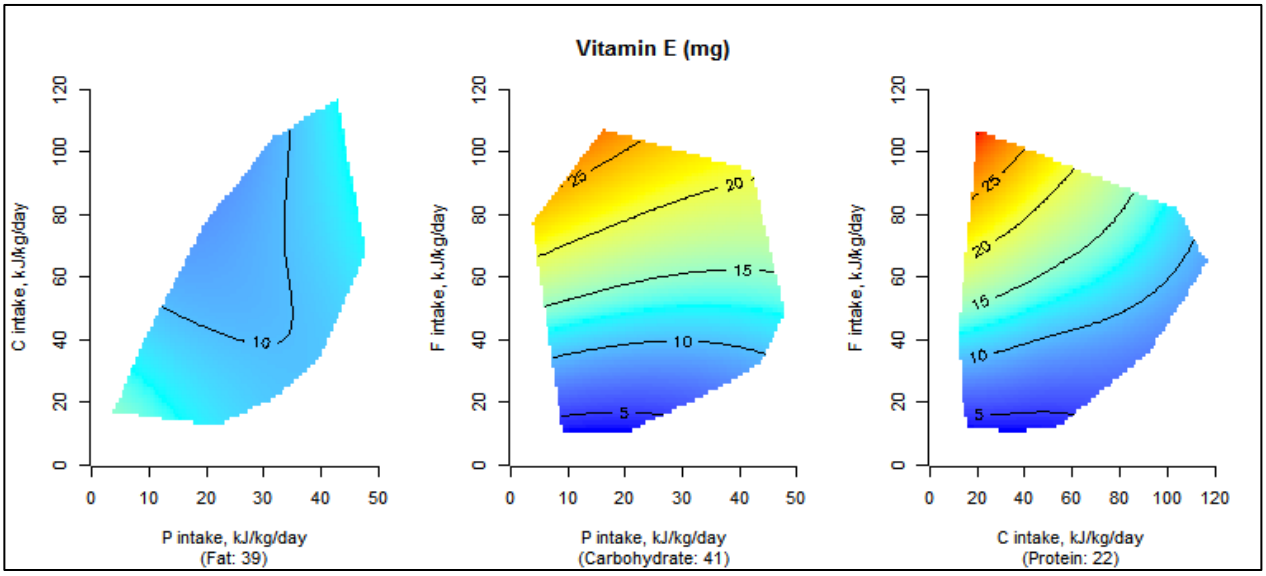
Vitamin E intake ranged from 2.4 to 54.2 (mg) (median=9.7) in participants with complete data on body weight, vitamin E and macronutrient intake (n=750). GAM results showed that vitamin E intake was independently associated with protein and fat intake as well as the ratio of all macronutrients (**Table 23**). GF graphs showed that vitamin E intake was particularly higher when fat intake was above 90kJ/kg/day (2.4g/kg/day), carbohydrate intake was <40kJ/kg/day (2.3g/kg/day) and protein intake was < 20kJ/kg/day (1.8g/kg/day) (**Figure 23**).

Table 23. Coefficients from GAMs for vitamin E (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	0.109
Carbohydrate	0.660	8	0.243	0.000
Total fat	2.005	8	8.337	0.000
Protein, Carbohydrate	0.551	3	0.242	0.221
Protein, Total fat	0.012	3	0.004	0.210
Carbohydrate, Total fat	0.001	3	0.000	0.666
Protein, Carbohydrate, Total fat	5.017	10	2.762	0.000

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 23. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and vitamin E (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

24) Total folate

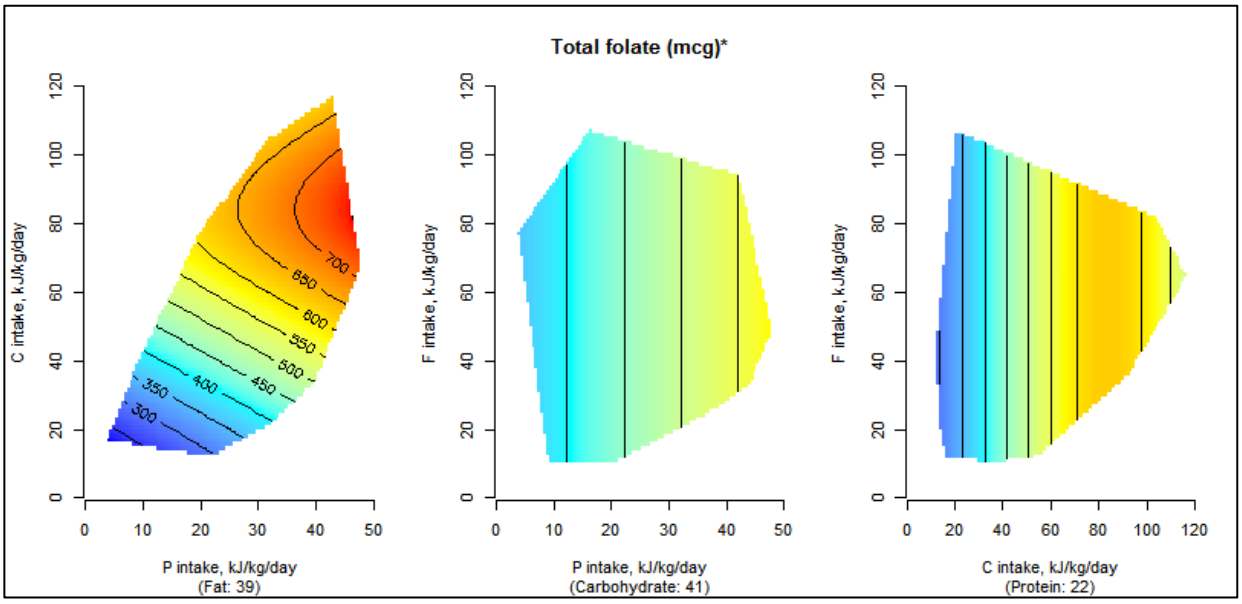
Total folate intake ranged from 55.9 to 1432.5 (mcg) (median=384.9) in participants with complete data on body weight, total folate and macronutrient intake (n=750). GAM results showed that total folate intake was independently associated with protein and carbohydrate intakes (**Table 24**). GF graphs showed that total folate intake was higher when protein intake was ≥40kJ/kg/day (≥2.3g/kg/day) or carbohydrate intake was between 70-100kJ/kg/day (4.1-6g/kg/day) (**Figure 24**).

Table 24. Coefficients from GAMs for total folate (mcg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.933	8	1.703	0.000
Carbohydrate	2.704	8	7.496	0.000
Total fat	0.001	8	0.000	0.803
Protein, Carbohydrate	0.000	3	0.000	0.622
Protein, Total fat	0.000	3	0.000	0.668
Carbohydrate, Total fat	0.001	3	0.000	0.485
Protein, Carbohydrate, Total fat	0.003	10	0.000	0.578

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 24. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and total folate (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

25) Retinol

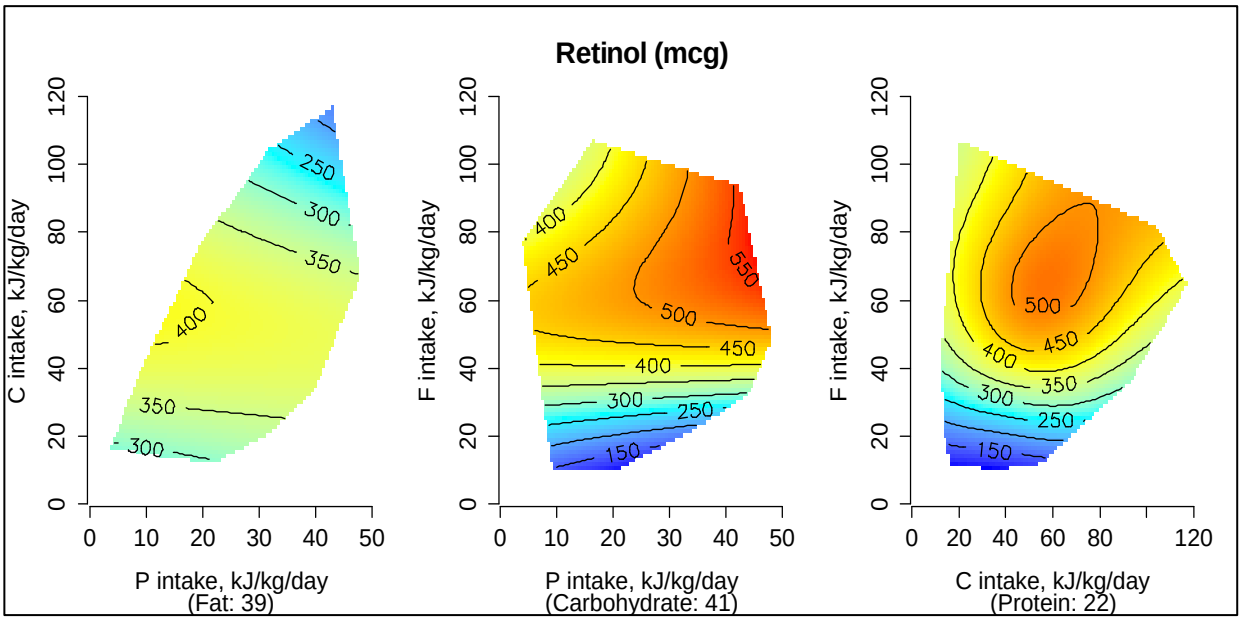
Retinol intake ranged from 13.4 to 4738.3 (mcg) (median=309.1) in participants with complete data on body weight, retinol and macronutrient intake (n=750). GAM results showed that retinol intake was independently associated with fat as well as with the ratio of carbohydrate to fat intakes (**Table 25**). GF graphs showed that retinol intake was higher when carbohydrate intake was between 40-80kJ/kg/day (2.3-4.7 g/kg/day) or fat intake was between 60-90kJ/kg/day (1.6-2.4g/kg/day) (**Figure 25**).

Table 25. Coefficients from GAMs for retinol (mcg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.000	8	0.000	0.714
Carbohydrate	0.001	8	0.000	0.203
Total fat	0.890	8	0.874	0.000
Protein, Carbohydrate	0.000	3	0.000	0.658
Protein, Total fat	0.000	3	0.000	0.345
Carbohydrate, Total fat	2.413	3	4.765	0.000
Protein, Carbohydrate, Total fat	2.395	10	0.410	0.092

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 25. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and retinol (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

26) B-carotene

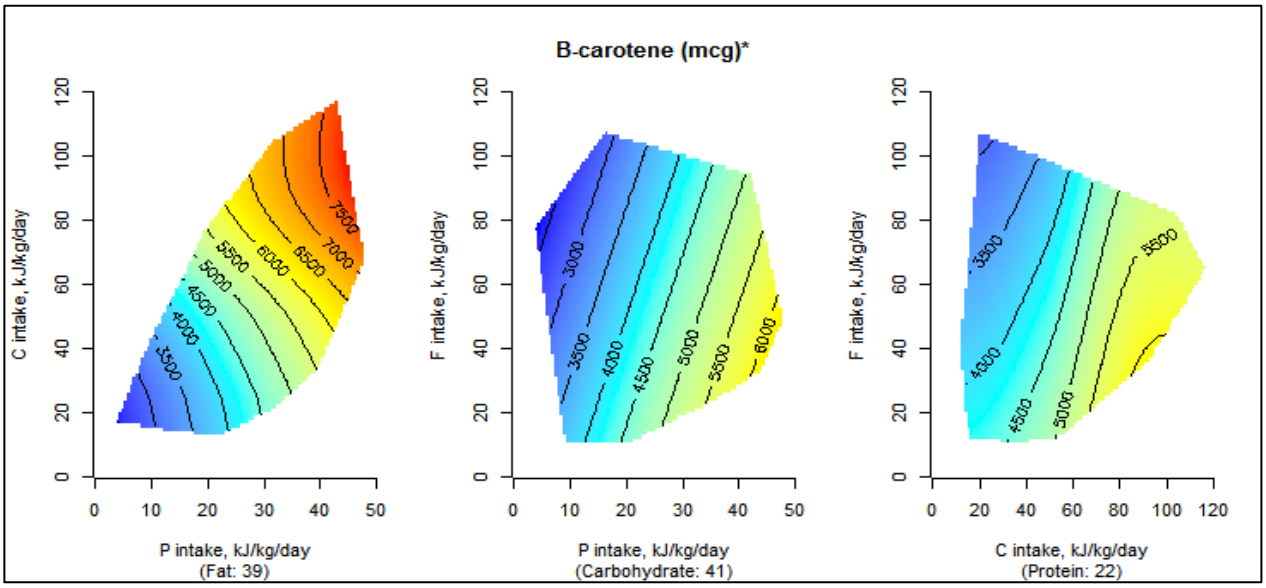
B-carotene intake ranged from 154.2 to 31104.1 (mcg) (median=3791.6) in participants with complete data on body weight, B-carotene and macronutrient intake (n=750). GAM results showed that B-carotene intake was independently associated with all the macronutrients (**Table 26**). GF graphs showed that B-carotene intake was higher when carbohydrate and protein intake was high and fat intake was 20-60kJ/kg/day (0.5-1.6g/kg/day) (**Figure 26**).

Table 26. Coefficients from GAMs for B-carotene (mcg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.939	8	1.894	0.000
Carbohydrate	1.942	8	1.502	0.001
Total fat	0.814	8	0.541	0.021
Protein, Carbohydrate	0.001	3	0.000	0.348
Protein, Total fat	0.001	3	0.000	0.794
Carbohydrate, Total fat	0.000	3	0.000	0.941
Protein, Carbohydrate, Total fat	0.001	10	0.000	1.000

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 26. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and B-carotene (mcg) in 750 participants



*B-carotene equivalent; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

27) Thiamin

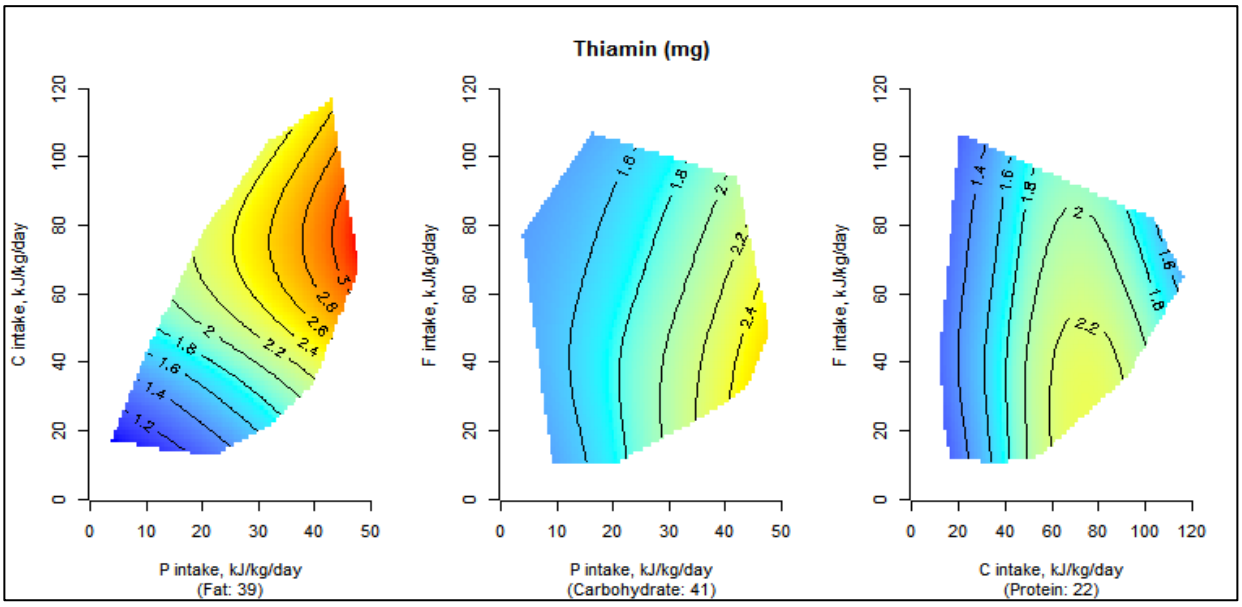
Thiamin intake ranged from 0.27 to 16 (mg) (median=1.6) in participants with complete data on body weight, thiamin and macronutrient intake (n=750). GAM results showed that thiamin intake was independently associated with protein and carbohydrate intakes (**Table 27**). GF graphs showed that thiamin intake was higher when carbohydrate intake was somewhere between 60-100kJ/kg/day (3.5-6g/kg/day) and protein intake was ≥40kJ/kg/day (≥2.3g/kg/day) (**Figure 27**).

Table 27. Coefficients from GAMs for thiamin (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.891	8	1.012	0.000
Carbohydrate	2.329	8	2.948	0.000
Total fat	0.003	8	0.000	0.203
Protein, Carbohydrate	0.000	3	0.000	0.316
Protein, Total fat	0.377	3	0.161	0.183
Carbohydrate, Total fat	0.000	3	0.000	0.404
Protein, Carbohydrate, Total fat	1.862	10	0.307	0.084

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 27. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and thiamin (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

28) Riboflavin

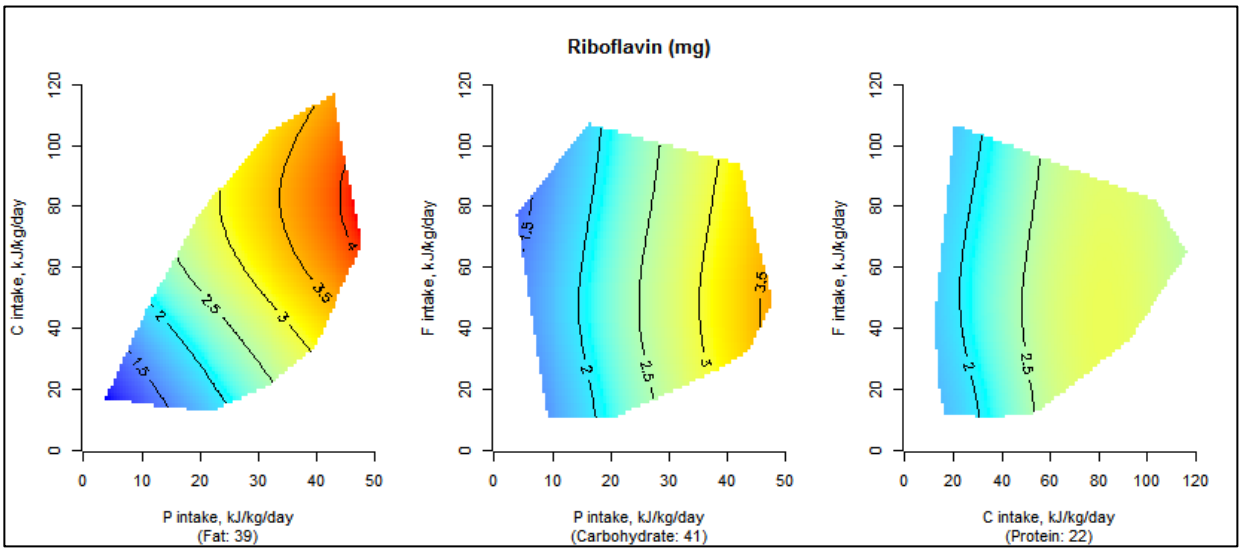
Riboflavin intake ranged from 0.36 to 17.5 (mg) (median=2.2) in participants with complete data on body weight, riboflavin and macronutrient intake (n=750). GAM results showed that riboflavin intake was independently associated with protein and carbohydrate intakes (**Table 28**). GF graphs showed that riboflavin intake was higher when carbohydrate intake was somewhere between 70-100kJ/kg/day (4.1-6g/kg/day) and protein intake was ≥40kJ/kg/day (≥2.3g/kg/day) (**Figure 28**).

Table 28. Coefficients from GAMs for riboflavin (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.978	8	5.412	0.000
Carbohydrate	2.137	8	2.672	0.000
Total fat	0.001	8	0.000	0.291
Protein, Carbohydrate	0.001	3	0.000	0.192
Protein, Total fat	0.004	3	0.001	0.210
Carbohydrate, Total fat	1.026	3	0.597	0.130
Protein, Carbohydrate, Total fat	0.011	10	0.001	0.317

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 28. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and riboflavin (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

29) Niacin

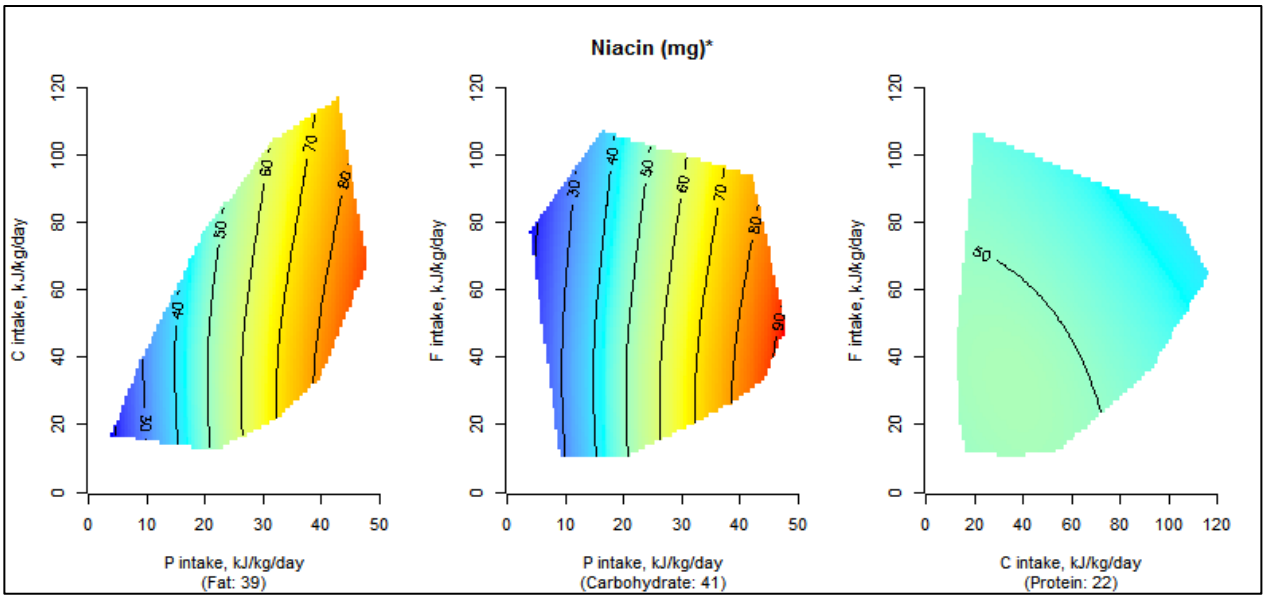
Niacin intake ranged from 11.3 to 112.4 (mg) (median=50) in participants with complete data on body weight, niacin and macronutrient intake (n=750). GAM results showed that niacin intake was independently associated with protein as well as with the ratio of all macronutrients (**Table 29**). GF graphs showed that niacin intake was higher when protein intake was ≥40kJ/kg/day (≥2.3g/kg/day) (**Figure 29**).

Table 29. Coefficients from GAMs for niacin* (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.001	8	85.718	0.000
Carbohydrate	0.006	8	0.001	0.362
Total fat	0.002	8	0.000	0.374
Protein, Carbohydrate	0.000	3	0.000	0.830
Protein, Total fat	0.002	3	0.001	0.296
Carbohydrate, Total fat	0.004	3	0.001	0.356
Protein, Carbohydrate, Total fat	0.963	10	2.574	0.000

*Niacin equivalents; GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 29. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and niacin (mg) in 750 participants



*Niacin equivalent; C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

30) Calcium

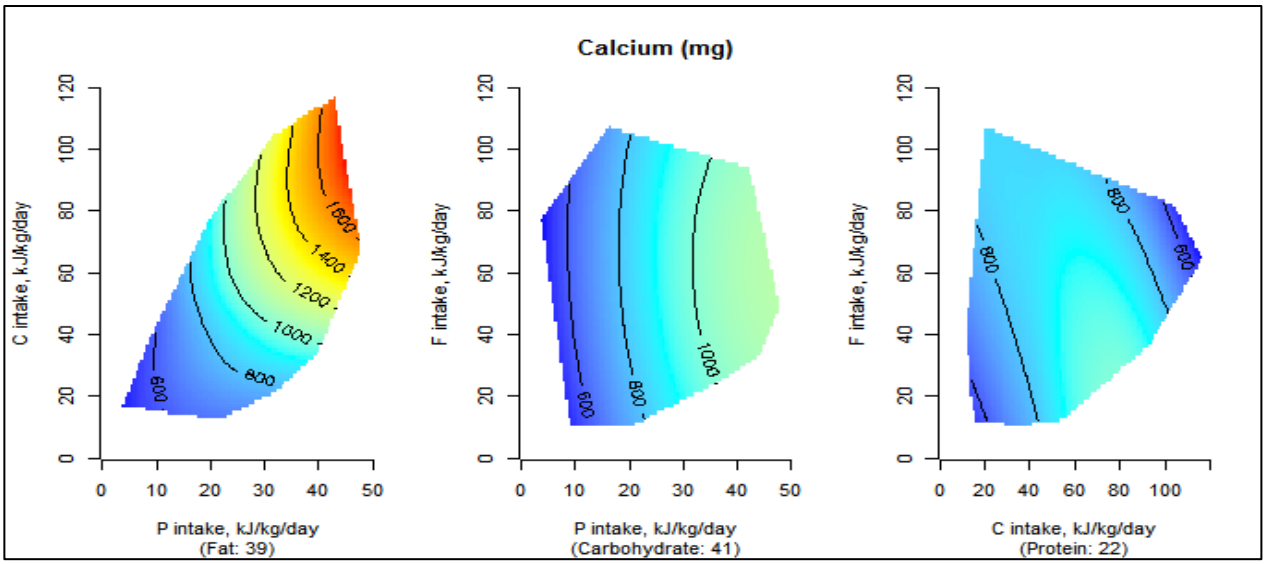
Calcium intake ranged from 221.4 to 3230 (mg) (median=800.8) in participants with complete data on body weight, calcium and macronutrient intake (n=750). GAM results showed that calcium intake was independently associated with carbohydrate and protein intakes as well as with the ratio of intake of all macronutrients (**Table 30**). GF graphs showed that calcium intake was higher when protein and/or carbohydrate intakes were higher (**Figure 30**).

Table 30. Coefficients from GAMs for calcium (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.897	8	0.997	0.000
Carbohydrate	1.988	8	0.830	0.000
Total fat	0.001	8	0.000	0.306
Protein, Carbohydrate	0.001	3	0.000	0.383
Protein, Total fat	0.000	3	0.000	0.678
Carbohydrate, Total fat	0.001	3	0.000	0.239
Protein, Carbohydrate, Total fat	5.461	10	1.602	0.003

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 30. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and calcium (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

31) Iron

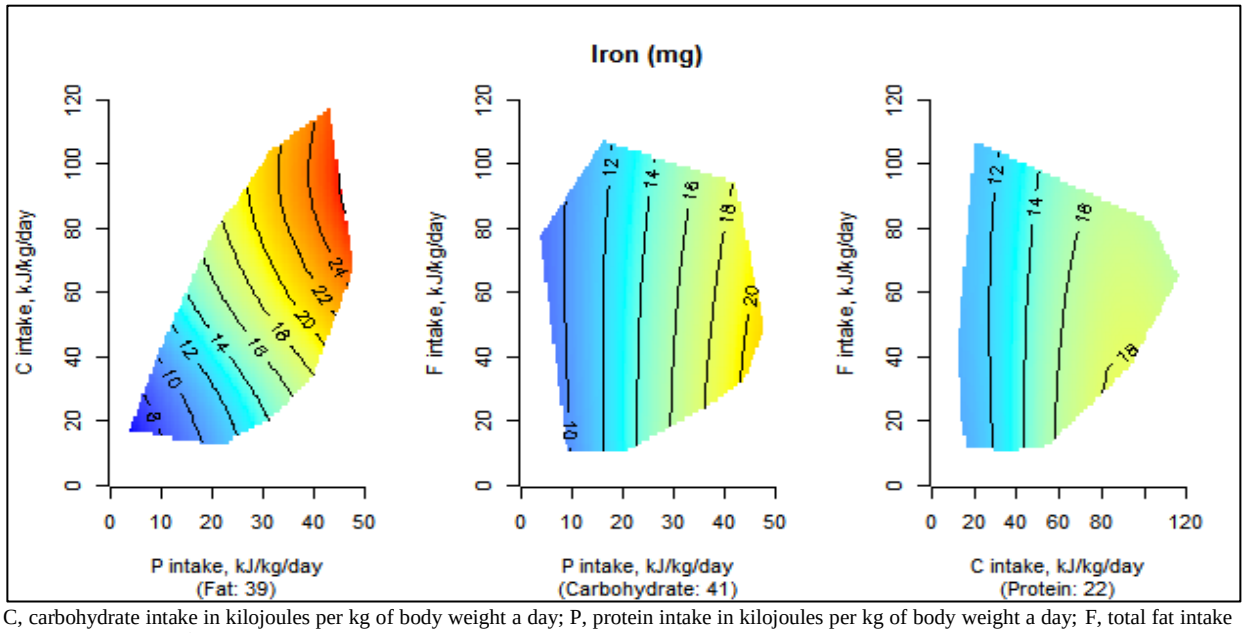
Iron intake ranged from 2.6.to 103.6 (mg) (median=12.8) in participants with complete data on body weight, iron and macronutrient intake (n=750). GAM results showed that iron intake was independently associated with carbohydrate and protein intakes (**Table 31**). GF graphs showed that iron intake was higher when protein and/or carbohydrate intakes were higher (**Figure 31**).

Table 31. Coefficients from GAMs for iron (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.962	8	3.114	0.000
Carbohydrate	1.998	8	2.325	0.000
Total fat	0.004	8	0.000	0.318
Protein, Carbohydrate	0.000	3	0.000	0.728
Protein, Total fat	0.002	3	0.000	0.306
Carbohydrate, Total fat	0.001	3	0.000	0.330
Protein, Carbohydrate, Total fat	1.378	10	0.195	0.170

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 31. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and iron (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

32) Zinc

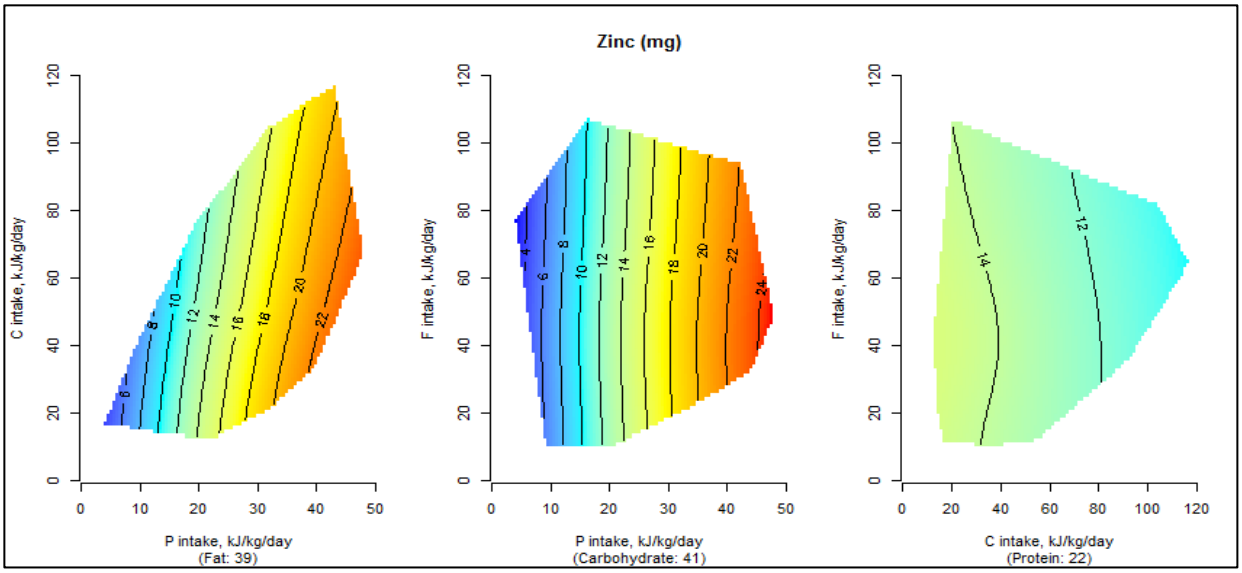
Zinc intake ranged from 2.4.to 47.7 (mg) (median=13.3) in participants with complete data on body weight, zinc and macronutrient intake (n=750). GAM results showed that zinc intake was independently associated with carbohydrate and protein intakes (**Table 32**). GF graphs showed that zinc intake was higher when protein and/or carbohydrate intakes were higher (**Figure 32**).

Table 32. Coefficients from GAMs for zinc (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.620	8	75.823	0.000
Carbohydrate	0.919	8	1.419	0.000
Total fat	0.000	8	0.000	0.776
Protein, Carbohydrate	0.000	3	0.000	1.000
Protein, Total fat	0.000	3	0.000	0.322
Carbohydrate, Total fat	0.872	3	0.513	0.117
Protein, Carbohydrate, Total fat	0.446	10	0.080	0.080

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 32. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and zinc (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

33) Phosphorus

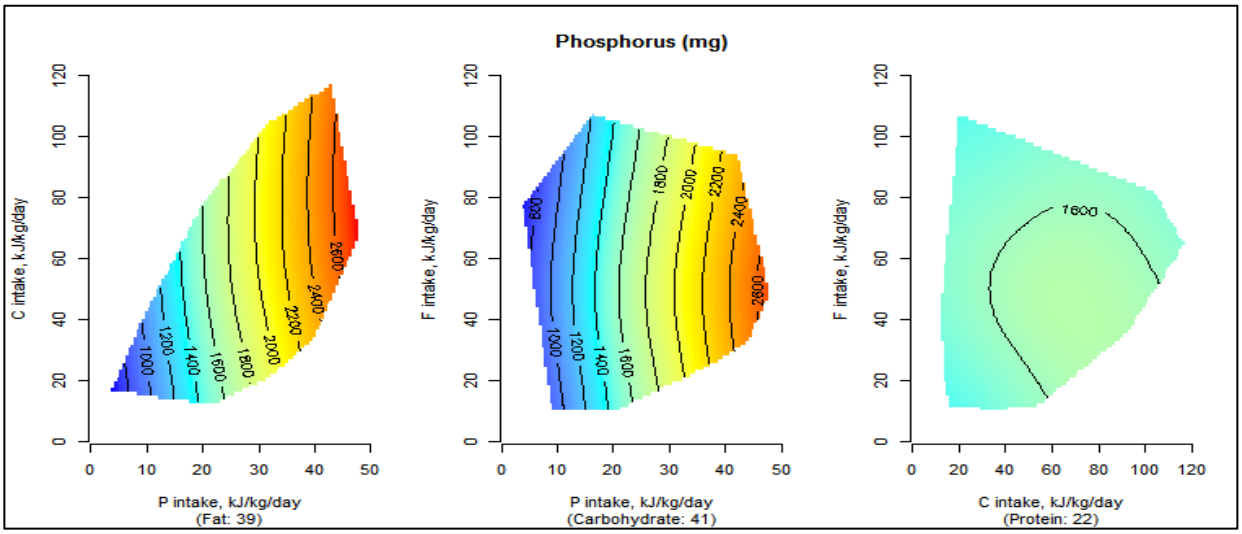
Phosphorus intake ranged from 345 to 4551.6 (mg) (median=1588) in participants with complete data on body weight, phosphorus and macronutrient intake (n=750). GAM results showed that zinc intake was independently associated with carbohydrate and protein intakes (**Table 33**). GF graphs showed that phosphorus intake was higher when protein and/or carbohydrate intakes were higher (**Figure 33**).

Table 33. Coefficients from GAMs for phosphorus (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	2.309	8	38.843	0.000
Carbohydrate	1.233	8	0.471	0.003
Total fat	0.001	8	0.000	0.568
Protein, Carbohydrate	0.001	3	0.000	0.315
Protein, Total fat	0.001	3	0.000	0.242
Carbohydrate, Total fat	1.851	3	2.082	0.003
Protein, Carbohydrate, Total fat	1.341	10	0.168	0.140

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 33. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and zinc (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

34) Sodium

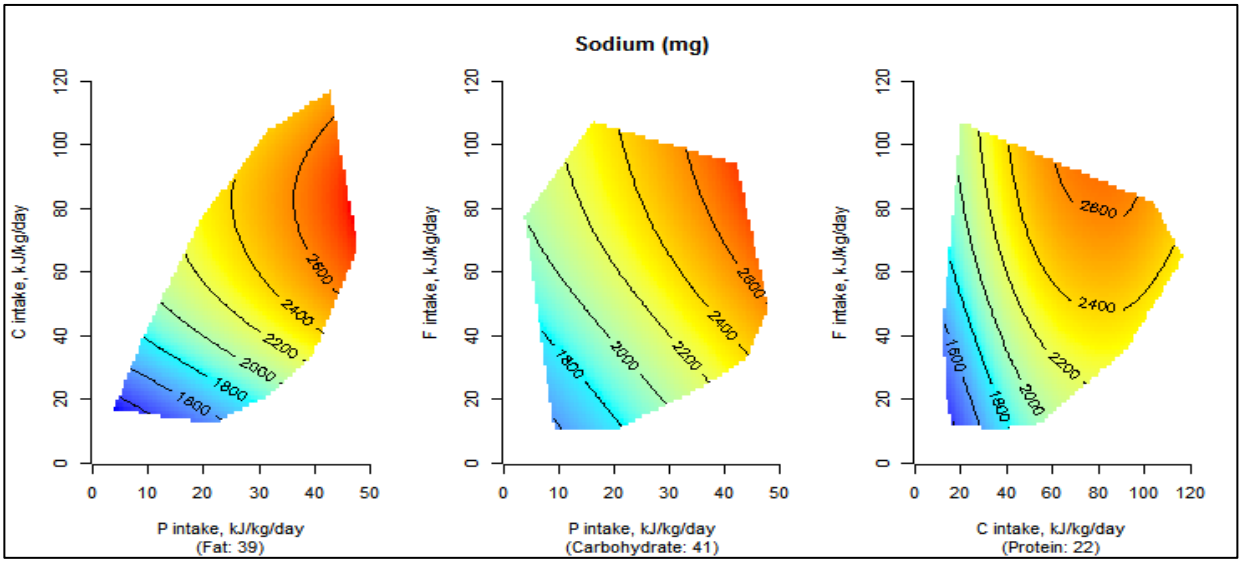
Sodium intake ranged from 535.8 to 11818.5 (mg) (median=1947.4) in participants with complete data on body weight, sodium and macronutrient intake (n=750). GAM results showed that potassium intake was independently associated with carbohydrate, protein and fat intakes (**Table 34**). GF graphs showed that sodium intake was higher when any of the macronutrients were higher (**Figure 34**).

Table 34. Coefficients from GAMs for sodium (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.924	8	1.451	0.000
Carbohydrate	2.245	8	3.335	0.000
Total fat	1.458	8	2.025	0.000
Protein, Carbohydrate	0.001	3	0.000	0.356
Protein, Total fat	0.002	3	0.001	0.283
Carbohydrate, Total fat	0.001	3	0.000	0.497
Protein, Carbohydrate, Total fat	0.004	10	0.000	0.517

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 34. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and sodium (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

35) Potassium

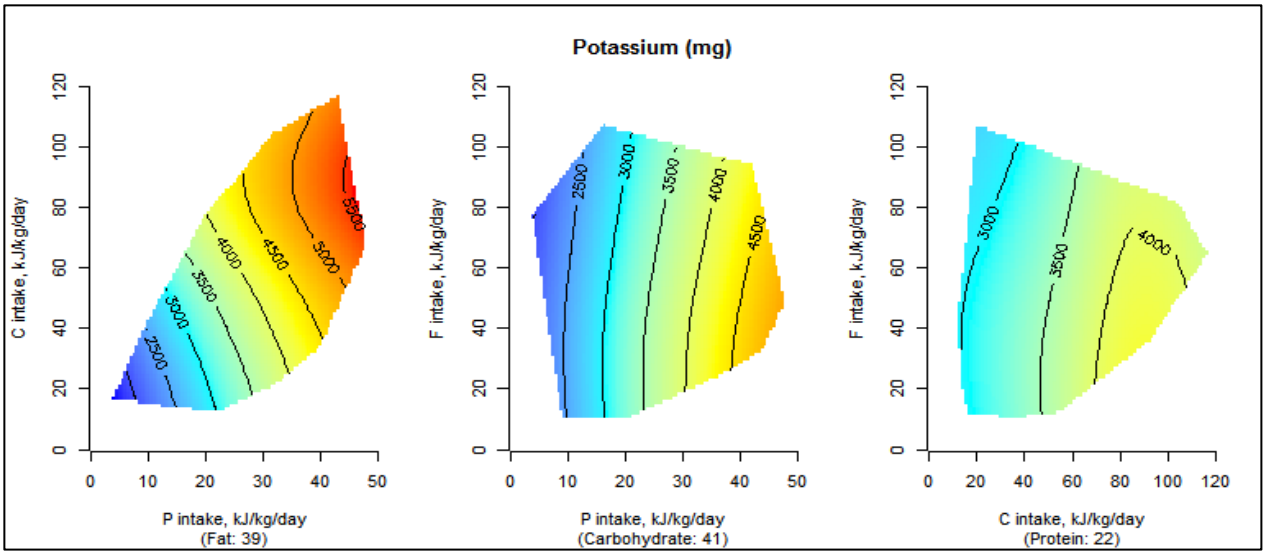
Potassium intake ranged from 488 to 8942.5 (mg) (median=3328) in participants with complete data on body weight, potassium and macronutrient intake (n=750). GAM results showed that potassium intake was independently associated with carbohydrate and protein intakes as well as with the ratio of intake of all macronutrients (**Table 35**). GF graphs showed that potassium intake was higher when protein and/or carbohydrate intakes were higher (**Figure 35**).

Table 35. Coefficients from GAMs for potassium (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.994	8	19.276	0.000
Carbohydrate	2.796	8	6.393	0.000
Total fat	0.237	8	0.039	0.221
Protein, Carbohydrate	0.000	3	0.000	0.233
Protein, Total fat	0.007	3	0.003	0.230
Carbohydrate, Total fat	0.001	3	0.000	0.456
Protein, Carbohydrate, Total fat	0.824	10	0.456	0.009

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 35. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and potassium (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

36) Magnesium

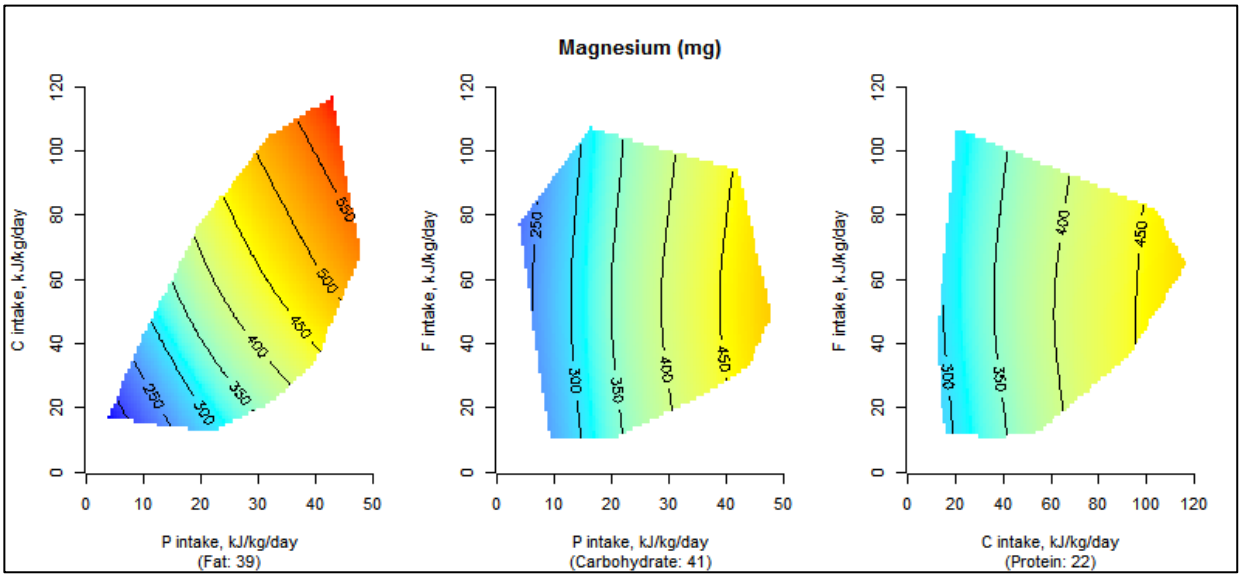
Magnesium intake ranged from 104 to 865 (mg) (median=351) in participants with complete data on dietary fibre intake and macronutrient intake (n=750). GAM results showed that magnesium intake was independently associated with carbohydrate and protein intakes (**Table 36**). GF graphs showed that magnesium intake was higher when protein and/or carbohydrate intakes were higher (**Figure 36**).

Table 36. Coefficients from GAMs for magnesium (mg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	1.978	8	12.538	0.000
Carbohydrate	1.134	8	4.804	0.000
Total fat	0.011	8	0.001	0.253
Protein, Carbohydrate	0.001	3	0.000	0.566
Protein, Total fat	0.003	3	0.001	0.269
Carbohydrate, Total fat	1.310	3	0.896	0.089
Protein, Carbohydrate, Total fat	0.012	10	0.001	0.367

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 36. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and magnesium (mg) in 750 participants



C, carbohydrate intake in kilojoules per kg of body weight a day; P, protein intake in kilojoules per kg of body weight a day; F, total fat intake in kilojoules per kg of body weight a day

37) Iodine

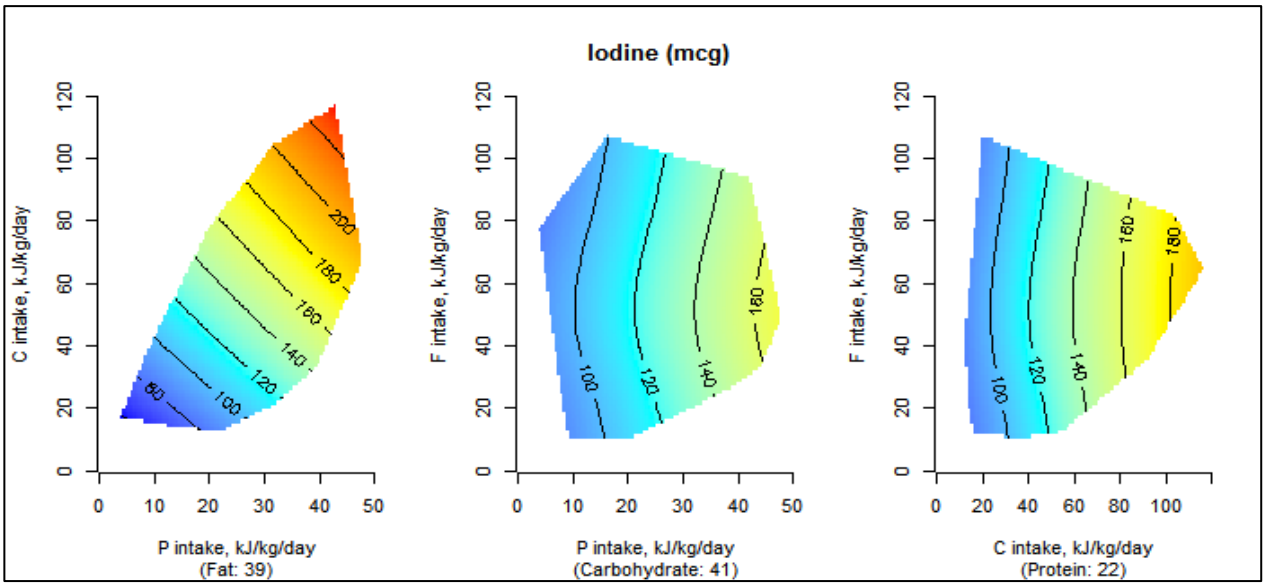
Iodine intake ranged from 19 to 414 (mcg) (median=110) in participants with complete data on dietary fibre intake and macronutrient intake (n=750). GAM results showed that iodine intake was independently associated with carbohydrate and protein intakes (**Table 37**). GF graphs showed that iodine intake was higher when protein and/or carbohydrate intake were higher (**Figure 37**).

Table 37. Coefficients from GAMs for iodine (mcg) of 750 participants

Nutrient (s) (kJ/kg)	EDF	Ref. DF	F	p-value
Protein	0.968	8	3.775	0.000
Carbohydrate	0.975	8	4.714	0.000
Total fat	0.001	8	0.000	0.658
Protein, Carbohydrate	0.000	3	0.000	0.970
Protein, Total fat	0.001	3	0.000	0.324
Carbohydrate, Total fat	1.435	3	1.071	0.083
Protein, Carbohydrate, Total fat	0.006	10	0.001	0.405

GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom

Figure 37. Response surfaces showing the relationship between macronutrient intakes (kJ/kg) and iodine (mcg) in 750 participants



GAMs, generalised additive models; Edf, estimated degrees of freedom for the model terms; Ref. DF, reference degrees of freedom