The Impact of the Modifiable Factors of Nutrition Knowledge, Hedonic Hunger, Macronutrient Balance, and Body Image and Weight Control on Dietary Intake

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Abstract

Athletes' dietary requirements differ from the general population's because physical activity increases energy expenditure and nutrients play a role in recovery from exercise. A variety of factors impact athletes' dietary intake, including hedonic hunger, macronutrient balance, nutrition knowledge (NK), body image and weight control [modifiable factors (MFac)]. Most studies assessing MFac have focused on NK.

A systematic literature review (SLR) update of NK in athletes found that athletes had poor nutrition knowledge and although there was improvement in NK questionnaire (NKQ) quality since the previous SLR, the quality of tools used remained an issue for NK measurement. Furthermore, few studies benchmarked athletes' NK against other groups. Based on these findings, a cross-sectional study was conducted in athletes with community populations, nutrition students, and nutrition professionals using an up-to-date, validated NKQ. It was found that NK was not statistically different between athletes (55.81%) and community population (49.43%) groups, while nutrition professionals (77.01%) had significantly higher NK than both groups ($p < 0.001$).

To understand the impact of all MFac on dietary intake further exploration was conducted through a rapid review of SLRs. NK (n=3), body image (n=1) and weight control (n=1) SLRs were included; there were no published SLRs on the MFac of macronutrient balance and hedonic hunger. Due to the lack of research in this area, a cross-sectional study examining the impact of MFac on dietary intake was conducted with forty-two student athletes or active individuals. This study found that carbohydrate intake, body image disturbance scores, weight fluctuation, and hedonic hunger for food tasted had significant impact (R^2=64.6%, Adj R^2=0.8%, $p<0.001$) on dietary energy intake.

This thesis confirms that dietary intake is impacted by a variety of factors. Future studies should use larger sample sizes, with interventions focusing on individual MFac to determine how dietary intake can be most significantly impacted.

Statement of authorship

"This thesis includes work by the author that has been published or accepted for publication as described in the text. Except where reference is made in the text of the thesis, this thesis contains no other material published elsewhere or extracted in whole or in part from a thesis accepted for the award of any other degree or diploma. No other person's work has been used without due acknowledgment in the main text of the thesis. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution. All research procedures reported in the thesis were approved by the relevant Ethics Committee."

Amy Elizabeth Janiczak

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Publications

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Preface

This thesis was developed as part of the Honours to Masters transition pathway. This pathway allowed for an existing Honours project to be carried into a full Masters thesis.

The aim of the initial Honours project was to assess Australian athletes' nutrition knowledge, diet quality, and the association between these factors. The Honours project included two papers, which are outlined below. At the end of that Honours year, the researcher transitioned to a Masters of Science. The extended aims of this Masters project were to explore the impact of hedonic hunger, macronutrient balance, NK, and body image and weight control on dietary intake in student athletes and exercisers.

Overview of thesis and chapters to come

Chapter one is a systematic literature review updating previous systematic reviews on nutrition knowledge in athletes and the relationship between nutrition knowledge and dietary intake.

Chapter two is a cross-sectional study. The aim of the second paper was to use an updated, validated tool to explore NK of Australian athletes, and to benchmark athletes' knowledge against other groups – community population, nutrition students, and nutrition professionals.

Chapter three is a rapid review of reviews aiming to investigate the relationship between dietary intake and the modifiable factors of macronutrient balance, NK, hedonic hunger, and body image and weight control in athletes or active people.

Chapter four is an exploratory cross-sectional study investigating the modifiable factors of nutrition knowledge, macronutrient balance, hedonic hunger, and body image and weight control in relation to dietary intake in student athletes and exercisers.

Chapter One: 'A systematic review update of athletes' nutrition knowledge and association with dietary intake'

Preface

A systematic literature review was conducted as part of an Honours project through La Trobe University in Nutrition, under the supervision of Dr. Gina Trakman and Dr. Brooke Devlin. This was then updated and submitted for publication to the British Journal of Nutrition. The presentation of this systematic literature review is in alignment with publication requirements for the British Journal of Nutrition.

This chapter consists of the full manuscript accepted for publication by the British Journal of Nutrition, formatted to be consistent with the style of the thesis. The referencing style used here is in accordance with the referencing style used by that journal. All Supplementary Material referenced within this chapter is available in Appendix A.

Contribution information.

AJ completed independent screening, data extraction, and quality assessment, and drafted the manuscript. GT completed independent screening, data extraction, and quality assessment, and assisted with manuscript preparation. BD assisted in decision making regarding screening and data extraction and reviewed the manuscript. AF assisted with manuscript preparation.

Title: A systematic review update of athletes' nutrition knowledge and association with dietary intake

Running title: Athlete nutrition knowledge and diet intake

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Abstract

Athletes' dietary intakes sometimes do not meet sports nutrition guidelines. Nutrition knowledge (NK) is one factor that may influence dietary intake, but NK measurement tools are often outdated or unvalidated, and results regarding athletes' NK are equivocal. The aims of this systematic review were to update previous systematic reviews by examining athletes' NK and to assess the relationship between athletes' general NK, sport NK and dietary intake. MEDLINE, CINAHL, Scopus, SPORTDiscus, Web of Science, and Cochrane were searched for studies published between November 2015 and November 2020, that provided a quantitative measure of NK and described the NK tool used. Twenty-eight studies were included; study quality was assessed using JBI checklists and data on NK score, diet intake was extracted. Eight studies utilised validated, up-to-date NK measurement tools. Mean general and sport NK% scores varied between 40.2% ± 12.4 and 70 % ± 9. Mean protein and carbohydrate consumption were 1.1-3.4 g/kg.bw/day and 2.4-4.6 g/kg.bw/day, respectively. Weak-to-moderate, positive associations were found between NK and positive dietary behaviours. Due to a wide variety of NK measurement tools used, it is difficult to synthesise results to determine overall NK in athletes. Overall, there appears to be a low standard of knowledge. Quality of measurement tools for NK has improved but remains an issue. Future studies should use relevant, current validated NK tools, or validate tools in their study population. More research is needed into the relationship between NK and other modifiable factors influencing dietary intake.

Introduction

Athletes' diets are one of several factors that influence their preparation for, performance in, and recovery from competitive sport. The impact of diet on performance can be positive or negative [(1)], but the margin between winning and losing efforts is also miniscule at times. Nutrition strategies for athletes include preparation for training and competition, as well as providing appropriate nutrients to support recovery [(2, 3)]. Consuming a combination of macronutrients and micronutrients, in the appropriate amounts, at the right time can impact performance in training or competition as well as recovery and immune function [(2, 4-6)].

Previous research indicates that team-sport athletes' dietary practices do not meet sport nutrition recommendations [(7)]. Failure to meet recommendations can be detrimental to the health of the athlete and overall athletic performance [(8)]; for example, not consuming appropriate amounts of protein can inhibit new protein synthesis [(9)] or athletes not meeting energy requirements may experience unplanned weight loss [(2)], which may impact muscle mass as well as fat mass. It is therefore important to explore possible reasons why athletes might not meet these recommendations. Factors influencing dietary intake include gender, socioeconomic status, taste, convenience, and possibly—the type of sport played, athletic level, nutrition support from sporting club, previous nutrition education, and nutrition knowledge (NK) [(10, 11)]. Of these factors, NK has been explored frequently in recent peer-reviewed literature. A higher level of NK in the general population is associated with a greater intake of 'healthy' foods [(12)] and there is evidence that there is a positive, but weak association between general NK and diet quality in athletes [(13, 14)].

General and sports NK can be assessed using several available tools [(15-17)], with new tools designed specifically for measuring NK in athletes developed in the past five years [(18-20)]. The current review focuses on tools developed in the past five years because it acts as an update to previous literature reviews, with the most recent having been published in 2016 [(21)]. As with all tools, validation must be completed to a sufficient degree to ensure results reflect outcomes being measured. Trakman [(21)] noted in a previous review that tools for measurement of NK were often not appropriately validated for use. Some tools used to measure NK may have undergone psychometric testing (i.e. have been validated) but may no longer be valid due to outdated information contained within the tool itself [(21)]. Extensive modification of items within tools due to translation or changes to accommodate local diet trends may impact validation.

NK is thought to be poor amongst athletes. While there has been no set standard for what constitutes adequate NK, our previous literature review shows that mean percentage scores (i.e. percentage of correct responses) vary widely [(21)], with 21 of the included studies demonstrating scores below 60%. Several studies have benchmarked the NK of athletes against other groups. A review found the NK of athletes to be equal to or greater than the NK of non-athletes [(10)]. One study comparing the NK of coaches, athletic trainers, and strength and conditioning specialists from the National Collegiate Athletic Association (across all divisions and a wide variety of sports) found 9% of athletes and 83.1% of strength and conditioning specialists achieved a NK score greater than 75% [(22)].

A systematic review of athletes' NK was published in 2016, providing equivocal results concerning the state of athletes' NK at the time [(21)]. A large number of studies have been published in this area since 2016. The recent development of current, validated tools has provided researchers with new tools with which to further study athletes' NK [(18-20)]. This review differs from previous reviews in that it focuses on athlete NK and the relationship with athlete dietary intake [(21,23)] with a systematic literature review study design [(24)]. These factors make it worthwhile to revisit a systematic review of athletes' NK to determine if the previous conclusions on studies in this area are still applicable. The aims of this review are to summarise athletes' general and sports NK scores reported in the past five years, and to examine the quality of the tools used in assessment of general and sports NK. The secondary aim of this review is to evaluate the association between athletes' NK and dietary intake.

Materials and Methods

This systematic review was conducted following the PRISMA guidelines [(25)] and the protocol registered with PROSPERO (protocol registration ID CRD42020184263).

Search Method

One reviewer (AJ) systematically searched the MEDLINE, CINAHL, Scopus, SPORTDiscus, Web of Science, and Cochrane databases. For the Medline search, the terms Nutrition Knowledge and Athlete were mapped to the Subject Headings of NUTRITIONAL SCIENCES and ATHLETE respectively (see Supplementary Material for complete search). The following keywords were then added to the search: "Sport nutrition knowledge" OR "General nutrition knowledge" OR "Nutrition knowledge" AND Sport* OR Athlete* (Supplementary Material). References for all included studies were checked for further potential studies to be included in the final review.

Inclusion and Exclusion Criteria

In order to be included in this review, studies were required to fulfil eligibility criteria as outlined in Table 1. Athletes were defined as any individual participating in an organised sport. Organised sport is defined as physical activity, involving competition and membership with sporting groups. For the purposes of this review, adolescents have been excluded due to the potential for age related confounding factors.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	**Exclusion Criteria**
Original research (cross-sectional, observational, and baseline data from intervention studies)	Reporting general and sport nutrition attitudes, behaviour, habits, or intake (without reporting knowledge)
Use standardised questionnaires to measure general and sports NK	Unpublished theses or grey literature
Athletes 17 years of age or older	Athletes under 17 years of age
English language	Qualitative studies
Peer-reviewed	
Published between November 2015 and November 2020	
Report a quantitative measure of general and/or sports NK	

Screening Process

Two reviewers (AJ and GT) independently screened all papers for eligibility by reviewing title and abstract, then full-text papers. Disagreements were addressed by discussion, or with a third reviewer (BD) where necessary. Three studies deemed eligible for inclusion through the initial screening process were not included because the full-text article could not be retrieved for data extraction.

Data Extraction

A purpose-designed Google-spreadsheet was used to extract data from the included studies. One reviewer (AJ) extracted the data from all included studies and the second reviewer (GT) checked the extracted data for inconsistencies. Any inconsistencies were first discussed to attempt to reach consensus; if consensus could not be reached, the third reviewer (BD) was enlisted to decide. Data extracted with this form included: author and date, basic study information (aim, location, setting, study design, recruitment methods), basic questionnaire information (questionnaire name, number of items, subsections included), secondary outcome measurement tool used and format, participant demographics (sample size, age, gender), primary outcome results (mean % score and range of the NK questionnaires), and secondary outcome results (dietary intake measures, either by macronutrient and/or micronutrient intake or food group intake), as well as correlation measures between NK and dietary intake where available.

Quality Assessment

The quality of individual studies was assessed using the Joanna Briggs Institute Checklist for Analytical Cross Sectional Studies [26], for assessment of all studies. This assessment tool was chosen as the most appropriate for the study design of studies included in the review. Guidelines for quality assessment were agreed upon among researchers.

Points were allocated for each question within the scale – 'yes' accounting for one point, and 'no' or unclear receiving zero points for that question. Validity of the main NK assessment tool received a score out of two, with a tool requiring a minimum of three types of validity assessment to receive two points, and one or two types of validity assessment to receive one point. Due to differences in total possible points awarded to each paper, the final ranking for each paper was converted to a percentage to allow for comparison (Supplementary Material).

Analysis

Due to the different NK assessment tools used across the reviewed studies, it was not possible to perform a meta-analysis on these results (see Table 2 for results). Synthesis for this systematic review is narrative – consisting of a descriptive comparison of results across studies. Where applicable, we also summate differences between genders, athletic ability, measurement tools, and reported sports.

Results

The initial search provided 1249 articles. After excluding articles that were published prior to November 2015 (n=100) and duplicated papers (n=312), there were 837 articles included in the abstract and title screening, with 70 articles eligible for full-text screening. Information on the selection process is presented below (Fig. 1). Three studies [27-29] could not be retrieved for full-text screening through university subscription or contact with authors. Full-text screening resulted in 28 studies included in the systematic review, with one additional paper identified through searching reference lists of included studies. One paper was removed during the data extraction process when it was identified as not meeting selection criteria for eligibility.

Study Characteristics

The majority of studies (n=23) in this review utilised a cross-sectional design. The remaining five studies employed a quasi-experimental design, with education program interventions. The results of included studies are presented in Table 2. These studies included 3117 participants in total, with 11 [30] to 430 [31] participants per study. Nine countries were represented, with ten studies being conducted in the USA and eight studies conducted in Australia (Table 2). Thirty-four sports were represented in these studies, with Australian football, baseball, and soccer being the most popular sports reported. Of the Australian studies (n=8), seven studies looked at Australian football [11, 18, 32-36], one paper also looked at soccer [32], while another also included netball and 'other' participants [18]; one Australian-based study looked exclusively at soccer [37].

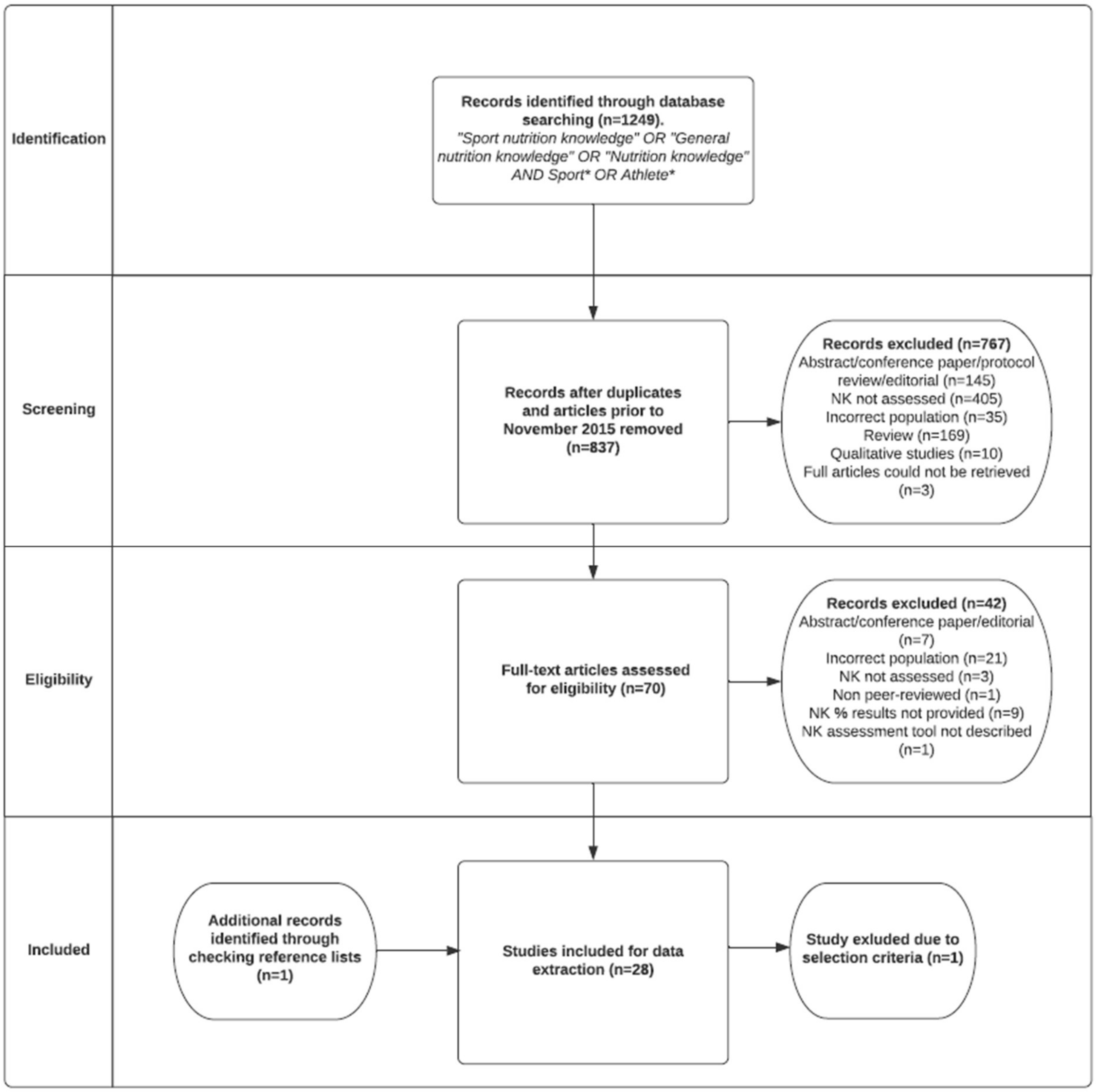

Figure 1. Selection process flow chart. NK, nutrition knowledge. n, number of studies.

Table 2. Data extraction for NK in athletes

Study information (author(s), year, study location)	Sport	Participant information (total number, age, gender)	Questionnaire information	Mean % scores (total, general, & sports where available)
Abbey, Wright, & Kirkpatrick 2017 [60] USA	American football	n=88 19.6±1.7 (mean ± SD) Male=88	Torres-McGehee et al. [22] 17 multiple-choice questions topics: macronutrients, micronutrients, supplements, weight management, and hydration included 3 questions regarding nutrition info sources, comfort with sources, and perceived adequacy	Mean ± SD TNK = 55.2±16.3%
Andrews, Wojcik, Boyd, & Bowers 2016 [54] USA	baseball, tennis, track and field, men's soccer, softball	n=123 Age not specified Male=76, Female=47	Torres-McGehee et al. [22] 19 item questionnaire 3 demographics 16 - multi-choice on sport nutrition	Mean ± SD TNK = 56.9±14.3%
Andrews & Itsiopoulos 2016 [37] AUS	soccer	Professional n=29 22 (18-27) Male=29 Semi-professional n=44 21(18-33) Male=44	FNKQ [38] Professional - 94 GNK, 29 SNK knowledge of dietary recommendations, sources of nutrients, and food and fluid choices Semi-professional - 83GNK, 26 SNK 7 removed from SNK Added items adapted from Zinn et al. (3) or sport nutrition publication (1)	NK Mean ± SD Professional:Semi-professional GNK = 54.1±13.4:56.8±11.7 SNK = 56.9±15.5:61.3±15.9 TNK = 54.8±13.0:57.9±11.6
Argolo, et al. 2018 [63] Brazil	table tennis	n=17 33±10.8 (mean ± SD) Male=17	Nascimento et al. & Leite et al. [30, 39] Demographics, 14 questions validated NK test (basic nutrition, Brazilian Food Guide Pyramid, Sport nutrition)	Mean (SD) Total = 66.7 (10) Basic nutrition = 97 (9.4) Food pyramid = 17.6 (10) Sports nutrition = 79.4 (21)

Balaravi et al. 2017 [40] Malaysia	not specified	n=50 Median age=22(IQR=6) Male=33 Female=17	Validated by expert panel for this study 16 questions - knowledge 8 questions - attitude towards supplement/doping relationship	Mean % (SD) <25 years = 58.75 (13.9) >25 years = 65.81 (10.3)
Blennerhassett, McNaughton, Cronin, & Sparks 2019 [64] UK	ultra-endurance	n=101 Male=41.7±8.1, (mean ± SD) Female=39.0±9.6 (mean ± SD) Male=74, Female=27	SNKQ adaptation ULTRA-Q [17] 8 demographic questions & sources of NK 76 questions - nutrients (37), fluid (8), recovery (11), body composition (12), supplements (8)	Mean ± SD Total = 68.3±9.5 Nutrients = 70.8±11.5 Fluid = 58.2±18.6 Recovery = 77.8±15.3 Body composition = 70.1±15.4 Supplements = 51.1±30.6
Coccia, Fernandes, & Altiti 2020[49] USA	baseball, softball, and swimming	n=50 19.62±1.483 Male=11, Female=39	Developed by authors based on Dietary Guidelines of Americans 2010 recommendations 5 items – regarding fruits and vegetables, dietary fat, dairy and whole grains	n=28 Mean ± SD, % Pre-test:Post-test 3.04 (1.02), 60.8%: 3.52 (1.12) 70.4%
Condo, Logman, Kelly, & Carr 2019 [36] AUS	Australian football	n=30 24.15±4.1 (mean ± SD) Female=30	SNKQ [17] 88 questions - general nutrition concepts, fluid, recovery, weight control, supplements	Median (IQR), % General nutrition concepts = 28 (7), 60.8 Fluid = 6 (7), 66.7 Recovery = 4 (3), 57.1 Weight control = 7 (3), 46.7 Supplements = 2 (3), 18.2 Total = 48 (12), 54.5
Devlin, Leveritt, Kingsley, & Belski 2017 [32] AUS	Australian football, soccer	n=66 23±4 (mean ± SD) Male=66	FNKQ [38] 123 questions - dietary recommendations (12), sources of nutrients (69), choosing everyday foods (10), alcohol (3), sports nutrition (29)	Mean % (SD) TNK = 57 (9.7) GNK = 56 (9.7) SNK = 60 (14.5)
Hardy, Kliemann,	not specified	n=194 18-19 - 95 (49%), 20-	GNKQ [16] 4 sections: dietary recommendations, sources	Mean ± SD TNK = 58.4 (8.5)

Evansen, & Brand 2017 [65] USA		21 - 83 (42.8%), >=22 - 16 (8.2) Male=82 Female=112	of foods/nutrients, choosing everyday foods, and diet-disease relationships gender, age, college cumulative GPA, nutrition courses taken during high school and college, student-athlete status, sports in which they currently participate energy drink questions for people who identified themselves as energy drink consumers	
Holden et al. 2018 [59] USA	baseball, women's volleyball, women's soccer, track and field, American football	n=80 Age not reported Male=49 Female=31	SNKQ [17] 88 total questions Demographic questions – age, gender, GPA, year in school, race Six sections – nutrients, fluid, recovery, weight gain, weight loss, and supplements	Mean ± SD TNK = 48±8
Jenner, Devlin, Forsyth, & Belski 2020 [33] AUS	Australian football	n=26 24.2±4.2 (mean ± SD) Female=26	NSKQ [15] 89 questions - weight management (13), macronutrients (30), micronutrients (13), sports nutrition (13), supplements (12), alcohol (8) demographic questions (age, education status, experience in AF)	Mean ± SD Total = 50.6 ± 14 Weight management = 57 ± 17 Macronutrients = 60 ± 17 Micronutrients = 41 ± 22 Sports nutrition = 51 ± 19 Supplements –=23 ± 14 Alcohol = 70 ± 23
Jenner et al. 2018 [34] AUS	Australian football	n=46 24.2±4.0 (mean ± SD) Male=46	NSKQ [15] 89 questions - weight management (13), macronutrients (30), micronutrients (13), sports nutrition (13), supplements (12), alcohol (8)	Mean % (SD) Total = 46 (14.6) Weight management = 49 (18.5) Macronutrients = 58 (17) Micronutrients = 39 (19.2) Sports nutrition = 47 (22.3) Supplements = 28 (15.8) Alcohol = 53 (22.5)

Judge et al. 2016 [56] USA	American football	n=100 18 - 18, 19 - 26, 20 - 18, 21 - 23, 22 - 12, 23 - 3 Male=100	Nichols et al. [43] Demographic questions - age, ethnic group, team position, number of seasons played, previous nutrition education, sources of information knowledge, attitude and behaviour questions - fluid and hydration, primary sources of nutrition information, dietary information, barriers to fluid consumption	Mean % (SD) TNK = 69.4 (11.2)
Lohman, Carr, & Condo 2019 [35] AUS	Australian football	n=71 Elite=25±13 (mean ± SD) Sub-elite=21±3 (mean ± SD) Male=37	SNKQ [17] 88 questions - general nutrition concepts (46), fluid (9), recovery (7), weight control (15), supplements (11)	Median (IQR), % Elite (n=37):Sub-elite (n=34) Total = 45 (11), 51%; 45 (17), 51% General nutrition concepts = 27 (8), 59%: 57 (8), 58% Fluid = 6(8), 67%:6(6), 67% Recovery = 3 (2), 43%: 3 (3), 43% Weight control = 7 (4), 47%: 7 (3), 47% Supplements = 3 (3), 27%: 2 (4), 18%
Madrigal, Wilson, & Burnfield 2016 [51] USA	American football, track and field, soccer, volleyball, basketball, bowling, gymnastics, rifle, swimming/diving, golf, wrestling	n=196 Mean=20.1 (SD=1.2) Male=145 Female=51	SNKQ [17] 61 questions - general nutrition (35), hydration (6), weight control (8), recovery (3), supplements (9)	Median (IQR), % Males:Females Total (n=119&45) - 29(22-35), 49.5:30(23-36), 49.2 General nutrition (n-131&47) = 21(16-23), 60:21(18-24), 60 Hydration (n-141&51) = 3(2-4), 50:3(2-4), 50 Weight control (n=137&51) = 2(1-4), 25:2(1-4), 25 Recovery (n=135&51) = 1 (0-2), 33.3:1(1-2), 33.3 Supplements (n=140&49) = 2(0-3), 22.2:1(0-3), 11.1

Magee, Gallagher, & McCormack 2016 [31] Ireland	rugby/Gaelic/soccer, sprinting, endurance, Gaelic, hockey, karateka, netball, army officer cadets, cycling, bootcamp, golf	n=430 Age not reported Genders not reported	SNKQ [17] 87 questions - general nutrition (41), fluid (9), recovery (11), weight control (15), supplements (11)	Mean % (SD) Total = 52.9 (3.45) General Nutrition Score = 58.5 (4.3) Fluid score = 55.6 (5.6 Recovery score = 45.5 (6.8) Weight control score = 53.3 (5) Supplement score = 27.3 (6.8)
McCrink, McSorley, Grant, McNeilly, & Magee 2020[60] Northern Ireland	Gaelic football	n=24 (for NSKQ results) Median = 23.0 (IQR = 20.0, 27.0) Male=24	NSKQ [15] 89 questions - weight management (13), macronutrients (30), micronutrients (13), sports nutrition (13), supplements (12), alcohol (8)	Mean % ± SD Total - 40.2 ± 12.4 Macronutrients - 46.8 ± 14.5 Micronutrients - 41.0 ± 22.3 Weight management - 44.6 ± 18.4 Supplements - 20.5 ± 16.1 Sports nutrition - 30.1 ± 14.9 Alcohol - 52.6 ± 21.5
Mitchell et al. 2016 [57] USA	baseball	n=57 Control=20.03 (Mean) Experimental=19.83 (Mean) Male=57	GNKQ [16] 110 questions - dietary recommendations (11), sources of foods/nutrients (69), choosing everyday foods (10), diet-disease relationships (20)	Mean % (SD not available) Control pre: experimental pre Overall = 50.67:47.30 Dietary recommendations = 55.90:54.82 Sources of foods/nutrients = 57.28:51.01 Choosing everyday foods = 40.00:50.30 Diet-disease relationships = 30.35:28.85
Murphy & O'Reilly 2020 [61] Ireland	hurling	n=328 elite n=129, sub-elite n=136 18-21= 70 22-27= 127 28-32=47	GNKQ [16] 89 sports NK questions – nutrient types (46), recovery (7), fluid (9), weight management (15), supplements (11)	Median, % (IQR) Section 1 - 22, 50% (18-24)* Section 2 - 5, 62.5% (4-6) Section 3 - 5, 45.5% (4-7) Section 4 - 1, 25% (1-2) Section 5 - 7, 58.3% (6-8)

		33+=21 Male=328		Section 6 - 3, 27.3% (2-4) Total - 42, 48.8% (37-47)
Nascimento et al. 2016 [30] Brazil	not specified	n=11 (adult participants) 23.7 (SE=0.53) Male=11	Goncalves et al. & Zawila et al. [42, 47] 14 questions - basic nutrition (3), Brazilian food pyramid (1), sports nutrition (10)	Mean % (SD) Total = 70 (9) Basic nutrition = 89.7 (23) Food pyramid = 28.4 (26) Sports nutrition = 84.5 (11)
Renard, Kelly, Cheilleachair, & Cathain 2020 [62] Ireland	football & camogie	n=328 18-24 n=215 25-30 n=83 31+ n=30 Female=328	ANSKQ [15] 37 questions - general nutrition (17) (energy density, role & sources of macro and micronutrients, alcohol), sports nutrition (20) (macronutrient & fluid requirements, weight loss and gain strategies, supplementation)	Mean % (SD) TNK - 46.0 (11.8) GNK – 58.2 (15.6) SNK - 40.4 (13.0) Football TNK - 46.0 (12.0) GNK - 58.2 (15.0) SNK - 40.4 (13.7) Camogie TNK - 46.3 (11.3) GNK - 59.1 (13.6) SNK - 40.4 (11.6)
Rossi et al. 2017 [58] USA	baseball	n=15 19.3 (1.0) Male=15	Sport Nutrition Questionnaire [45] 46 questions - demographics, dietary behaviours, hydration, weight control, dietary supplements, general nutrition, sports nutrition, protein, strategies for training, food choices	Mean % (SD) 56.7 (SD = ±11.4)
Saribay & Kirbas 2019 [52] Turkey	track and field, soccer, basketball, handball, other	n=150 17 years n=112 18+ n=38 Gender split not available	Nutrition Knowledge Scale for Adolescents [44] 38 questions - adequate and balanced diet (9), food items (21), nutrient related health problems (8)	Mean ± SD 17 years = 53.6 ± 12.7 18+ years = 51.4 ± 13.1
Simpson,	hockey	n=17	Questionnaire of Nutritional Knowledge [17, 41]	Mean ± SD

Gemming, Baker, & Braakhuis 2017 [53] New Zealand		19±0.7 (mean ± SD) Male=17	47 questions - basic nutritional knowledge (11), behavioural effects of food availability and choice (8), sports NK and practices (28) + demographics	Total = 54.7±14.3 General NK = 58.8±21.8 Hydration = 61.4±20.5 Body composition = 29.4±18.19 Dietary supplements = 44.7±26.01 Recovery nutrition = 70.7±14.6 Event nutrition = 43.08±14.62 Training nutrition = 60.8±29.44
Trakman, Forsyth, Hoye, & Belski 2018 [18] AUS	Australian football, netball, other	n=181 17-25 = 85, 26-35 = 66, >=36 = 26 Male=69 Female=108	A-NSKQ [15] 37 questions - general nutrition (17) (energy density, role & sources of macro and micronutrients, alcohol), sports nutrition (20) (macronutrient & fluid requirements, weight loss and gain strategies, supplementation)	Mean ± SD TNK = 47±12 GNK = 59 (18) SNK = 35 (18)
Trakman et al. 2018 [11] AUS	Australian football	n=140 Elite AF: Nonelite AF 17-25 - 29:26 26-35 - 17:20 36+ - 0:7	NSKQ [15] 89 questions - weight management (12), macronutrients (30), micronutrients (13), sports nutrition (13) (hydration, nutrition before, during, after), supplementation (13), alcohol (8)	Mean ± SD (%), Range (%) Elite AF: Nonelite AF Total = 45.5+/-14.7, 10-69: 50.9+/-11.0, 28-72 Weight management = 48.3+/-18.0, 15-77: 56.7+/-17.8, 15-92 Macronutrients = 57.0+/-17.3, 13-83: 58.9+/-15.3, 27-97 Micronutrients = 38.8+/-18.8, 15-70: 49.9+/-16.3, 15-85 Sports nutrition = 46.5+/-22.2, 8-69: 46.0+/-14.7, 8-70 Supplements = 27.7+/-16.6, 0-67: 34.3+/-19.1, 0-67 Alcohol = 52.4+/-22.9, 0-88: 70.5+/-17.00, 25-75
Werner, Guadagni, &	women's rowing, field hockey, basketball,	n=125 Age not provided	General and Sport Nutrition Knowledge Questionnaire [48]	Mean % (SD) TNK - 57.5 (18.6)

Pivarnik 2020 [55] USA	soccer, golf, men's football, basketball, ice hockey	Male=55, Female=70	62 questions – general nutrition (29) and sport nutrition (33)	GNK - 57.2 (19.8) SNK - 58.5 (19.4)

n, number of participants. SD, standard deviation. IQR, interquartile range. TNK, Total NK. GNK, General NK. SNK, Sports NK. AF, Australian football. FNKQ, Food and Nutrition Knowledge Questionnaire. SNKQ, Sports Nutrition Knowledge Questionnaire. GNKQ, General Nutrition Knowledge Questionnaire. NSKQ, Nutrition for Sport Knowledge Questionnaire. ANSKQ, Abridged Nutrition for Sport Knowledge Questionnaire.

*Reported as 18-14 in original paper, corrected values reported here.

Seventeen NK tools were used, in full or adapted by researchers, as the measurement tools across the included studies [15-17, 22, 30, 38-49]. Due to the differences between NK measurement tools, it is not feasible to directly compare results from different tools as questions contained within tools can differ greatly. Where possible, we have made comparisons based on participant characteristics across studies that utilised the same tool.

Quality assessment

Raw quality assessment data for individual studies is available in Supplementary Material. Seven studies received 50% or less for their quality assessment [49-55]. Fifteen studies scored between 51% and 80% [30-32, 34-37, 40, 56-62]. The remaining six studies scored between 81% and 100% [11, 18, 33, 63-65], with the highest rating of 100% going to only one study [11].

Risks of bias within these studies mainly related to lack of validity of the NK tool in testing and generalisability of results. Sixteen of the included studies employed fully validated measurement tools; seven studies utilised partially validated measurement tools. This lack of validation for the measurement tools leaves the results produced by those studies open to measurement bias, making it difficult to ascertain athletes' NK [15]. While validated tools are available, these tools are not necessarily used appropriately by researchers. It is important to note here that validation does not speak to how up to date a tool may be and how current the information within it is.

Only seven of the included studies contained detailed information associated with the athletes' training, such as: sport played, years playing sport, hours spent training per week, or similar aspects related to athletic calibre. For the remaining 21 studies, the generalisability of results is difficult to ascertain. Other factors influencing the quality ratings of studies were lack of clear reporting of recruitment methods (n=14), response rates (n=23), and completion rates (n=19) of questionnaires.

Of note, recruitment of participants in many studies was reliant upon convenience sampling and study samples are often small; however, due to the small number of athletes involved in elite sports and heterogeneity of this group, small sample sizes may be representative of the target population.

Ten of the included studies examined correlation between NK and dietary intake; only six of these studies identified possible confounders and implemented a statistical strategy to deal with those confounding factors. This indicates an inappropriate use of statistical analysis within studies, potentially introducing statistical bias and misrepresentation of results.

Questionnaire

General Nutrition Knowledge Questionnaire (1999)

The General Nutrition Knowledge Questionnaire (GNKQ) tool by Parmenter & Wardle [16] was used in three studies in this review [57, 61, 65]. This tool was fully-validated in a population of undergraduate students and contains 110 items with 4 subsections – dietary recommendations, sources of foods/nutrients, choosing everyday foods, and diet-disease relationships. Total mean percentage scores for this tool ranged between 47.30% (SD not available) [57] and 58.4±8.5%. Mitchell et al. [57] reported the scores for the subsections, which showed that the subsection with the lowest score was diet-disease relationships for both the control and experimental groups. The highest scores were in the subsection of sources of foods/nutrients for the control group and dietary recommendations for the experimental group.

Sports Nutrition Knowledge Questionnaire (2005)

Questionnaire use and validation

Six of the included studies employed the Sports Nutrition Knowledge Questionnaire (SNKQ) [17], which was fully validated for content, construct, and test-retest validity in nutrition and business university students. One of these studies adapted and validated the SNKQ for use [64] and this will be described below (ULTRA-Q Adaptation). Studies were in Australian football, baseball, volleyball, soccer, track and field, American football, and a variety of collegiate sports [31, 35, 36, 51, 59]. The SNKQ has a maximum 88 items – subsections include general nutrition concepts, fluid, recovery, weight control, and supplements. Three studies used this tool in full [35, 36, 59]. The remaining two studies used 87 and 61 items; the removal or alteration to items allowed for concepts to be updated to more recent recommendations, while maintaining the original subsection topics of the SNKQ [31, 51]. Madrigal et al. and Magee et al. did not undertake or discuss tool validation after tool modification.

Results across studies and sub-section scores

Total percentage scores for studies using the SNKQ varied between 48±8% and 54.7±14.3%. Those studies that included results of subsections showed that participants often scored lowest in supplement sections [31, 35, 36, 51]. Performance varied across studies, with highest scores achieved in different subsections including nutrients [51], fluids [35, 36], and recovery [53, 64].

Comparisons across sports and athletic calibre

Due to the use of adapted or modified tools, the results of three of these studies could not be compared against those of other studies [31, 51, 64]. The three studies able to be compared here looked at various sports: women's Australian Rules football [36], baseball, women's volleyball, women's soccer, track and field, and football [59], and elite and sub elite Australian football [35]. The three sports with highest scores for total NK were women's Australian Rules football (Median = 60.8%), and elite and sub-elite Australian Football (Median = 51% and 51%). The three sports with the lowest mean scores were American football (46±7%), track and field (48±7%), and women's soccer (49±1%).

ULTRA-Q Adaptation

The Blennerhassett et al.[64] study investigated NK in ultra-endurance athletes. The tool used was a validated (for content validity and test-retest reliability) adaptation of the SNKQ, containing 76 items in the sections of nutrients (37), fluid (8), recovery (11), body composition (12), and supplements (8). Ultra-endurance athletes within this study had a total mean score of 68.3±9.5%. Results from this study are unable to be compared to studies utilising the SNKQ due to possible differences in the measurement tool caused by adaptation.

Torres-McGehee et al. (2012)

Questionnaire use and validation

Two studies [50, 54] utilised adaptations of the partially validated (for construct validity) Torres-McGehee et al. tool [22], using either 17 items or 19 items within the questionnaire. Studies were in American football, baseball, tennis, track and field, soccer, and softball. Andrews et al. [54] completed content validity testing and internal consistency testing using Cronbach's alpha, making the tool partially validated. However, Abbey et al. [50] did not undertake any validation.

Results across studies and sub-section scores

The total mean nutrition scores were 55.2±16.6% [50] and 56.9% SD=14.3 [54]. Scores across sports have been compared; results show men's soccer players achieved the highest score 59.4±%, followed by track and field (57.4±11.3%), tennis (56.7±15.8%), American football (55.2±16.3%), baseball (55.2±15.0%), and softball (54.4±15.4%). Abbey et al. [50] found that less than 50% of participants correctly answered questions relating to athlete macronutrient balance, micronutrients, ergogenic aids, body composition, and muscle mass, and more than 75% of participants correctly answered items on fuel for exercise, creatine supplementation, rehydration, and electrolyte loss [50 p. 4].

No studies using this tool benchmarked athletic groups against other cohorts or compared results across athletic calibres.

Food and Nutrition Knowledge Questionnaire (2015)

Two studies [32, 37] utilised the Devlin & Belski tool [38], which was originally developed as an amalgamation of the GNKQ tool and a sports specific knowledge assessment tool by Shifflet et al. [16, 38, 46]. Studies were in soccer and Australian football. This tool contains 123 items under the subsections of dietary recommendations, sources of nutrients, choosing everyday foods, alcohol, and sports nutrition. This tool was not validated by Devlin and Belski [38] in the original creation of this tool, nor was this validated by Devlin et al. [32]; although, Andrews and Itsiopoulos [37] completed content validity testing on their modified version. Changes were made to the tool by Andrews and Itsiopoulos [37] when assessing the NK of semi-professional players, though the full tool was used to assess professional players in their study. The Andrews and Itsiopoulos [37] study found that semi-professional players had higher mean scores for all areas of the questionnaire than their professional counterparts – general NK (56.8±11.7% and 54.1±13.4% respectively), sport NK (61.3±15.9% and 56.9±15.5% respectively), and total score (57.9±11.6% and 54.8±13.0% respectively). Devlin et al. [32] reported a total NK score of 57±9.7%, GNKQ mean percentage score of 56±9.7%, and sport NK score of 60±14.5%.

Nutrition for Sports Nutrition Knowledge Questionnaire (2017)

Six studies [11, 18, 33, 34, 60, 62] employed the NSKQ or A-NSKQ [15, 18, 66]. The NSKQ has 87 to 89 questions, broken into six subsections – weight management, macronutrients, micronutrients, sports nutrition, supplements, and alcohol. Two studies utilised the abridged form of this tool, A-NSKQ [18, 62], while the remaining four used the entire tool [11, 33, 34, 60]. The entire NSKQ tool was validated for content validity, construct validity, and testing of item behaviour. The A-NSKQ [15, 18, 66] was also validated for construct validity, internal validity, and test-retest reliability, and contains 35 or 37 items in two subsections – general nutrition and sports NK.

The total mean percentage scores for the NSKQ ranged between 40.2±12.4% and 50.9±11%, while the A-NSKQ means were 47±12% and 46±11.8%. The studies which used the entire tool provided details of subsection results. The lowest scores across all studies were in the subsection of supplements, ranging between 20.5±16.1% and 34.3±19.1%. Female Australian football players (70±23%), Irish Gaelic football players (52.6±21.5%), and non-elite Australian Football players (70.5±17%) scored the highest results in the subsection of alcohol [11, 33, 60]. Elite and professional Australian Football players scored highest under the subsection of macronutrients (57±17.3% and 58.9±15.3% respectively) [11, 34]. The studies using the shortened tool showed that athletes across the sports of Female Irish football and camogie players (GNK=58.2±15.6%, SNK=40.4±13.0%), Australian football players, netball players, and 'other' athletes (GNK=59±18%, SNK=35±18%) scored higher in the general NK section of the questionnaire than the sports NK section [18, 62]. The results of the NSKQ and A-NSKQ cannot be compared due to the differences between the two tools.

The remaining studies used tools not used in any other study included in this review.

Argolo et al. [63] utilised an amalgamation of two questionnaires [30, 39] resulting in a 14-item tool containing sections on basic nutrition (3), Brazilian Food Guide pyramid (1), and sport nutrition (10), which was tested for discriminative validity, internal consistency, and construct validity. For the table tennis players, the total percentage mean score was 66.7±10%. The area with the highest score was basic nutrition (97±9.4%). The area of lowest score was the food pyramid based on the Brazilian food pyramid (79.4±21%).

Balaravi et al. [40] generated a 24-item tool for use in their paper containing sections on supplement NK (16) and attitudes towards supplement-doping (8), which was partially validated by testing for content validity and internal consistency in Malaysian athlete populations. For the purposes of this study, the results of the supplement NK section of the tool will be reported. The results from this study showed that elite Malaysian athletes from various sports mean percentage scores of 58.75% for athletes less than 25 years of age and 65.81% for athletes over 25 years of age.

Coccia et al. [49] developed a 5-item multiple choice tool for use in their paper that assessed NK related to fruits, vegetables, dietary fat, dairy, and whole grains, which was not validated for use. The mean percentage score of the baseball, softball, and swimming athletes was 60.8±20.4%.

Judge et al. [56] assessed NK in American football players using the 17-item tool developed by Nichols et al. containing items focused on hydration, which was tested for content validity in college athletes [43]. The total mean percentage score from this study was 69.4±11.2%.

Nascimento et al. [30] used a 14-question tool that was an amalgamation of two tools previously used [42, 47] containing sections on basic nutrition (3), Brazilian food pyramid (1), and sports nutrition (10). This study looked at athletes in various sports. Nascimento et al. [39] tested the resulting tool for validity, using construct validity test and item discrimination to achieve partial validation. Adults in this study had a mean percentage score of 70±9% for the overall questionnaire. Participants scored highest in the subsection of basic nutrition, 89.7±23%, and lowest in the subsection on the Brazilian food pyramid, 28.4±26%.

Rossi et al.'s [58] study of baseball players utilised a partially-validated, 46-item tool, which was an adaptation of the Sports Nutrition Questionnaire [45] containing sections on hydration, weight control, dietary supplements, general nutrition, sports nutrition, protein, strategies for training, and food choices. The total mean percentage score for this study was 56.7±11.4%.

Saribay & Kirbas's [52] adolescent athlete study used the 38-item tool developed by Oz et al. [44] (Nutrition Knowledge Scale for Adolescents), which was tested for test-retest reliability and internal consistency; this tool contains subsections on adequate and balanced diet (9), food items (21), and nutrient related health problems (8). Participants 18 years and older had a mean percentage score of 51.4±13.1% and participants 17 years of age had a mean percentage score of 53.6±12.7%. No statistically significant difference was reported between age groups included in this study (14 years to 18 years and over).

Simpson, Gemming, Baker, & Braakhuis [52] employed an unvalidated, 47-item tool adapted from Burkhart [41] and Zinn et al.[17] (Questionnaire of Nutritional Knowledge), which contains sections on basic nutritional knowledge (11), behavioural effects of food availability and choice (8), and sports NK and practices (28). The elite athletes in this study had an overall mean percentage score of 54.7±14.3%. Participants scored highest on questions related to recovery nutrition (70.7±14.6%) and lowest on questions related to body composition (29.4±18.2%).

Werner, Guadagni, and Pivarnik's [(55)] study of Division I collegiate athletes in the USA used the fully-validated General and Sport Nutrition Knowledge Questionnaire, 62-item tool first developed by Callela et al. [(48)], which included subsections on general (29) and sport nutrition (33). The total mean percentage score was 57.5±18.6%.

Dietary intake

Twelve studies included data on dietary intake. Dietary intake was measured using a variety of methods: food frequency questionnaires, food diaries, 24-hour food recalls, and four-day semi-quantitative food records. Macronutrients were reported in various ways: grams per day, grams per kilogram of bodyweight per day, or percent of total energy intake. Comparisons between studies are limited due to varying methods of collecting and reporting diet intake data. Those studies including amounts of protein and carbohydrate measured in grams per kilogram of body weight per day [(32, 34-37, 60, 63)] had results varying between 1.1 g/kg.bw/day and 3.4 g/kg.bw/day of protein and 2.4g/kg.bw/day and 4.6g/kg.bw/day for carbohydrate. Daily carbohydrate intake recommendations for sport nutrition vary between 3 and 12 g/kg.bw/day, while daily protein intake recommendations for sport nutrition are between 1.2 and 2.0 g/kg.bw/day [(2)]. Mean fibre values across studies (n=7) varied between 15g and 45.8g per day [(34-37, 50, 60, 63)]. Studies reporting fat intake in grams per kilogram of body weight per day produced results between 0.9g/kg.bw/day and 1.6g/kg.bw/day [(32, 34, 35, 60)]. Saturated fat intake was reported as between 9.4% and 13.4% of total energy intake [(35, 36, 60, 63)]. A summary of dietary intake data is provided in Supplementary Material.

A small number (n=5) of studies reported various micronutrient intakes. Sodium intakes ranged between 2063.3mg and 9404.3mg per day [(36, 50, 60, 63)]. Reported calcium intakes ranged from 648mg to 1080.9mg per day [(34, 36, 60, 63)]. Potassium intakes fell between 3109mg and 6298.1mg per day [(36, 50, 60)]. Zinc intakes were between 8.8mg and 11.7mg per day [(36, 60, 63)].

Correlation between dietary intake and NK

Studies which examined correlations between dietary intake and NK (n=6) reported multiple associations, which are outlined in Supplementary Material. Andrews & Itsiopoulos [(37)] noted moderate positive correlations between sports NK and mean energy intake ($r = 0.31$, $p = 0.04$) in Australian soccer players, as well as between sports NK and carbohydrate intake ($r = 0.35$, $p = 0.02$). Argolo et al. [(63)] found a negative correlation between Brazilian adult table tennis players' total NK and their sodium intake (r = -485, $p < 0.05$). Australian Football and soccer players displayed a weak, statistically significant, positive correlation between sport NK and both total energy intake and total carbohydrate intake ($r^2 = 0.046$, p = 0.014, and $r^2 = 0.043$, p = 0.039, respectively); a medium-large, statistically significant, negative correlation was also found in elite Australian football players between general and sports NK score and total protein intake ($r^2 = 0.244$, p = 0.026 and $r^2 = 0.382$, p = 0.016, respectively) [32]. A significant, negative correlation between NK scores in dietary recommendations and higher intake of caffeinated energy drinks was reported (r = 0.48, $p < 0.001$) in American student-athletes [65]. A study of Australian football players [34] demonstrated a moderate, positive association between NK scores and meeting estimated energy requirements (r = 0.325, p = 0.031), as well as NK scores being positively associated with protein, fibre, and calcium intakes (r= 0.348, p = 0.021; r = 0.510, p= 0.001; and r = 0.428, p = 0.004, respectively). Murphy at al.'s [61] study of Irish hurlers found a weak to moderate positive association between NK and the Australian Recommended Food Score (a diet quality score validated for use in athlete populations) (r = 0.3, p = 0.007), with sub-elite players having a weak positive association (r = 0.26, p = 0.002) and elite players have a moderate positive association (r = 0.35, p = 0.006).

Discussion

NK amongst athletes is a popular topic, with 28 studies published over the past five years included in this review. Thirteen of these included studies have also explored the dietary intake of athletes, and six studies reported correlations between NK and dietary intake. This review includes 3117 participants from nine countries, participating in 34 different sports.

According to evidence presented here, many athletes do not meet minimum NK requirements to 'pass' a NK test (based on the convention of 50%, n=8), suggesting that they are unfamiliar with general and sports-specific dietary recommendations. Of the 10 studies that set a 'pass' mark for adequate NK, three studies using the NSKQ [15] for NK measurement achieved an 'average' or 'medium' score (non-elite AF players -50.9±11%, female AF players – 50.6±14%, variety of US sports – 57.5±18.6%) [11, 33, 55]. The remaining studies had poor or inadequate levels of NK [11, 18, 34, 50, 54, 59, 60, 62]. Calculation of an overall mean score is not possible due to the use of different tools. Studies which had cut offs for 'pass' showed that athletes did not achieve passing marks. For other studies, mean percentage scores ranged between 40.2% and 70%. Because these were not benchmarked, it is difficult to say if these results are poor or not. These percentages seem low based on face value. Prior systematic reviews had a wider range of scores, with a low of 38.8% and a high of 83.7% in a 2016 systematic review [21] and scores between 34% and 71% in a 2011 review [10]. This wide variety of potential scores may be related to the tools used to measure NK or the population in which NK is being tested. These results may indicate potential knowledge gaps in athletes that will enable athletic support staff to establish relevant nutrition education programs for athletes. It may be possible to use NK assessment tools to measure knowledge before and after the intervention to assess if the education program used was beneficial for the athletes.

Athletes' poor NK could be due to a number of factors. Andrews et al. (54) suggest that the poor NK scores of collegiate athletes within their study may be due to a lack of emphasis on the importance of nutrition for athletic performance by coaches and trainers. A previous study of athletes, coaches, strength and conditioning specialists, and trainers found that only 35.9% of coaches, 9% of athletes, 71.4% of trainers, and 83.1% of strength and conditioning specialists had adequate nutrition knowledge (22), suggesting that coaches are not best placed to provide nutrition information to athletes and this task should be left to a team dietitian. Studies have reported mixed findings in relation to the association between having been given advice by a dietitian and nutrition knowledge, with researchers noting that a lack of an association may be because advice provided to athletes by team dietitians focuses more on practical food choice recommendations rather than the types of information assessed using NK tools (32, 37).

As the recommended intake of protein and carbohydrate is dependent upon the type of sport and training the athlete is participating in, it is only possible to comment on these intakes when they either do not meet or exceed any recommended intakes. As such, it appears that athletes are below or meeting the requirements for carbohydrate intake for light intensity activities, when compared with current sport nutrition recommendations (2). The current sport nutrition recommendations for protein intake range between 1.2 and 2.0 g/kg.bw/day (2). However, the reported intake for protein indicates that some athletes are exceeding this range by 70%, with a maximum mean intake of 3.4g/kg.bw/day. A review examining protein intake in soccer players found that only two of the 16 studies had participants with protein intake exceeding current sport nutrition guidelines (2.3g/kg.bw/day), and in one study participants did not meet the recommendations (1.0g/kg.bw/day) (67). Burke et al.'s 2006 (67) review examined carbohydrate intake in soccer players indicated all soccer players included with the 16 studies being reviewed consumed carbohydrate within the range for current carbohydrate recommendations (4.2-8.3 g/kg.bw/day). However, a 2019 review (68) found a heterogeneous array of results for carbohydrate intake in soccer players (both junior and senior), with results between 2.9 g/kg.bw/day and 12.9 g/kg.bw/day, with senior players displaying a lower maximum carbohydrate intake than junior players (5.9 g/kg.bw/day and 12.9 g/kg.bw/day, respectively). Results of the current review indicate the athletes in the included studies consumed a much lower range of carbohydrate intake (2.4-4.6 g/kg.bw/day). The wider variety of sports included in the current studies should provide for greater variation in carbohydrate consumption due to differences in dietary requirements between sports. However, the smaller range of results may indicate a poor understanding of the benefit of carbohydrate consumption within the athletes included in the study or may be reflective of the popularity of low-carbohydrate diets in athletes in recent years.

The correlation between nutrition knowledge and dietary intake reported in this review demonstrate that those athletes with a higher level of nutrition knowledge are more likely to apply that knowledge to their dietary intake in a positive fashion. This includes moderate positive correlations between nutrition knowledge and other factors, including mean energy intake, carbohydrate intake, fibre, and calcium intakes, and negative correlations between nutrition knowledge and factors such as: sodium intake and energy drink intake. The relationship between nutrition knowledge and protein was examined in two studies (32, 34) and found to be both positively correlated in professional Australian football players ($r = 0.348$, $p = 0.021$) and negatively correlated in elite Australian football players ($r^2 = 0.244$, $p = 0.026$ and $r^2 = 0.382$, $p = 0.016$ respectively). Spronk et al.'s (23) systematic review found that higher nutrition knowledge in the general population was associated with greater intake of fruits and vegetables, cereals or fish, fibre, calcium, and some core food groups, along with lower intake of fat and sweetened beverages, which could prove beneficial as small differences can be important in elite sports. This confirms that modifying nutrition knowledge is worthwhile when aiming to modify dietary intake. However, the difference in correlation between nutrition knowledge and protein intake suggests that further research is required to investigate this. Athlete protein requirements differ in relation to athlete goals, for instance increased protein intake in athletes wanting to increase muscle mass or those losing weight to minimise muscle loss. In these cases, it is possible that the high protein intake is impacted by an overall restriction of energy (including protein) to maintain lean physique; if protein intake is expressed as %E intake, a decrease in protein intake could reflect an appropriate increase in carbohydrate intake.

While NK has been found to have a weak, positive correlation with dietary intake in the general population (23), NK is not the only factor that could potentially impact dietary intake. Birkenhead and Slater's review (13) placed these factors into the groups of 'physiological and biological', 'lifestyle, beliefs and knowledge', psychological, social, and economic. To understand how a nutrition/dietetics professional may impact these factors, they have been classified into modifiable, semi-modifiable, and non-modifiable factors [69]. No previous studies have examined relationships between the factors that are modifiable by nutrition/dietetic professionals (hedonic hunger, macronutrient balance, NK, and body image and weight control) and dietary intake in athletes. A recent qualitative study of factors influencing dietary intake of professional Australian football players found four main categories of factors body composition assessment and goals, seasonal changes (preseason and competitive season), interpersonal factors related to peers, family and mood, and NK and support [70]. These factors closely relate to the factors of body image and weight control, macronutrient balance, hedonic hunger, and NK [71]. Body composition assessment and goals are closely linked with body image and weight control, seasonal changes are related to alteration of macronutrient balance to achieve goals, the influence of peers and family is related to the availability of food and hedonic hunger, and NK is a constant. This similarity between players' understanding of influences on their dietary intake and factors that nutrition/dietetic professionals can influence indicates a need to investigate these factors further.

Previous systematic reviews related to athletes' NK have found that studies are flawed with inadequate statistical reporting, use of tools that are unvalidated [21], and a lack of benchmarking [10], as well as use of tools that are outdated. The included studies in this review still exhibit a lack of complete validation with 12 studies not using fully validated tools for measuring NK; five studies used unvalidated tools [31, 48-50, 52], and seven studies used partially validated tools [30, 37, 40, 52, 54, 56-58]. Studies may fail to use appropriately validated tools because the methods of proving validity for a measurement tool can be time consuming and difficult to complete. Of note, where studies did use validated tools (n = 16), eight studies utilised tools that were more than 15 years old [16, 17]. Due to the changes in practice and understanding around athlete nutrition within the past 15 years, it is unlikely that older tools reflect current recommendations. The questionnaires used in studies[11, 18, 33, 34, 52, 55, 60, 62] that utilised newer tools included the NSKQ (n=4) [15], the A-NSKQ (n=2) [18], The General and Sport Nutrition Knowledge Questionnaire (n=1) [65], and an amalgamation of two tools that were validated for the study (n=1) [30, 39]. This selection indicates that there are a variety of tools available; it should be noted that this is not an exhaustive list of potential validated NK measurement tools for use. It is recommended that when selecting NK measurement tools, a tool that is validated within the research target population would be best or validation within the research target population should be carried out. In studies published since 2020, new, validated tools may not have been used extensively to date due to a possible delay in conducting studies (due to the COVID-19 pandemic) and publishing relevant results.

A recent systematic review by Capling et al. [72] determined that there is substantial variability in dietary assessment methods in athletes. A variety of dietary assessment methods were used within the included studies, including food frequency questionnaires (n=2), food record (n=1), 24-H food recall (1), 24-H dietary assessment tool (n=2), multi-pass 24-H food recalls (n=2), 3-day food diaries (n=2), and a 7-day food diary (n=1). While the dietary assessment methods used within these studies are validated and considered appropriate for use within the general population, there are some athlete-specific factors that these dietary assessment methods may not take into consideration. Because this is an emerging area of study, the validity of dietary assessment tools has been accepted as complete if it is a tool that has been validated for use within the general population.

There have been a number of reviews within this space. Spronk et al.'s 2014 review examined NK and dietary intake of community populations and athletes, with a larger focus on community population data [23]. Trakman et al.'s 2016 review examined the NK of athletes and coaches emphasising the knowledge gaps within these populations, without examining the dietary intake of athletes in relation to dietary intake [21]. A recent narrative review examines NK of US collegiate athletes and how sports dietitians impact NK and behaviours in those athletes, excluding athletes outside of US collegiate sport [24]. Heaney et al.'s 2011 review combined NK and dietary intake in athletes, however, there has been a wide variety of research published between 2011 and 2020 requiring evaluation in this space [10]. It can be seen from the evidence here that an updated review of this area was required which examined the relationship between NK and dietary intake in athletes specifically.

Limitations

A limitation of this paper is the quality of the studies included in this review. The majority of studies included in this review were cross-sectional studies, or quasi-experimental studies, with many studies having small participant groups without mentioning power calculations, which may impact the generalisability of the studies to the wider target populations. Some of the tools used to assess NK are also limiting. Tools were not designed for assessment of athlete populations [16, 44], were more than ten years old and likely out of date (i.e., not reflective of current nutrition recommendations) [16, 17, 42, 43, 45-47], or have not been fully validated [30, 32, 37, 40, 50-54, 56-58]. Therefore, results must be interpreted with caution. A wide range of tools used to assess NK made comparison of results difficult between studies, therefore a meta-analysis was not possible for this review. NK scores measured with tools that do not provide ratings or pass values have not been benchmarked against other population groups (e.g., nutrition experts or community populations), which provides results without context within the larger NK landscape. Dietary intake results are also heterogeneous, making comparisons difficult across all applicable studies. This review has examined the influence of NK on dietary intake, but other influences on dietary intake have not been investigated here.

A large portion of the included studies were conducted in American and European populations across a wide range of sports. All controls or comparators within the included studies were athletes. It should be noted that inadequate descriptions of sporting levels or calibres make comparing these results between studies problematic, as these descriptions may be different between countries and sports. No studies compared the NK of athletes to community populations.

Publication bias is possible as grey literature was not examined, and three studies could not be retrieved to be screened. There is also a possibility that studies in this field have not been published due to negative or inconclusive results. This review was limited to studies published in the English language and thus may have excluded some studies on the basis on language or region. This form of bias is not often an issue within this field, due to the smaller scale studies including relatively small sample sizes.

Conclusion

This review suggests athletes have poor general and sports NK, and often do not meet nutrition recommendations. However, inconsistent validation of tools used in these studies mean that these results must be interpreted with caution. NK and dietary intake were weakly associated in athletes. There are flaws in the measurement of NK, due to lack of validation. Newly created NK assessment tools are lending greater reliability to the results produced. It is necessary for future research to examine a population of athletes, across varying sporting levels, types and regions, investigating NK and its correlation with dietary intake. It would be beneficial to also benchmark athlete general and sport knowledge and dietary intake against that of community populations. Finally, future studies should consider undertaking a holistic investigation of modifiable factors influencing athletes' dietary intake by looking at NK in combination with other modifiable factors that may impact dietary intake.

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Conflicts of Interest

None.

Authorship

AJ completed independent screening, data extraction, and quality assessment, and drafted the manuscript. GT completed independent screening, data extraction, and quality assessment, and assisted with manuscript preparation. BD assisted in decision making regarding screening and data extraction and reviewed with manuscript. AF assisted with manuscript preparation.

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Chapter Two: Athletes' nutrition knowledge is similar to community populations: a benchmarking study of general and sports nutrition knowledge in athletes

Preface

A cross-sectional study was completed to explore nutrition knowledge in athletes using a validated nutrition knowledge questionnaire and benchmark athlete nutrition knowledge against that of community populations, nutrition students, and nutrition professionals. The previous systematic literature review was used to inform the tool used for measurement of nutrition knowledge and use of comparators within this cross-sectional study.

The aim of this cross-sectional study was originally to investigate both nutrition knowledge and dietary intake; due to a lack of participants willing to provide dietary intake data, it was necessary to examine nutrition knowledge alone. It was believed that this inability to recruit participants to provide dietary intake data may have been related to the participant burden of three day food diary.

Referencing style used here is APA 7 in accordance with discipline recommendations.

Introduction

Diet can impact athletic performance. Due to the regular, intense activity that is an integral part of being an athlete, the requirements for various macro- and micro-nutrients for athletes can be somewhat different to the requirements of the general population (Thomas et al., 2016). The specific dietary needs of athletes can vary depending on the types of sport they participate in, what their playing position is in that sport, the level at which they compete, and the frequency and intensity of their training. By following special diets, athletes can impact athletic performance and target goals specific to different types of sports. For example, a low-carbohydrate ketogenic diet may help in reducing body mass for those competing in powerlifting/Olympic weightlifting (Greene et al., 2018) or may decrease total work capacity in basketball players (Michalczyk et al., 2019). Despite the importance of optimal dietary intake for athletes, many do not follow evidence-based nutrition strategies (Jenner et al., 2018).

In certain circumstances, the use of supplementation can also influence athletic performance and body composition, but supplements need to be taken in alignment with evidence-based protocols (Australian Institute of Sport (AIS), 2021). Supplementation is commonplace amongst athletes; however, athletes do not always take supplements with appropriate expert consultation (Baltazar-Martins et al., 2019).

To maintain peak athletic performance, it is necessary to consider and account for the individual dietary and supplementation requirements of the athlete. Athletes often do not have access to the level of nutrition or dietetic support necessary to properly evaluate their individual requirements (Trakman et al., 2019).

Theoretical framework – why assess nutrition knowledge?

Not all factors that influence dietary intake and supplement use are susceptible to change, it is therefore necessary to acknowledge the theoretical framework this project was constructed within. A review by Birkenhead and Slater (2015) stated that factors that influence athletes' dietary intake include: taste, convenience, price, cultural beliefs, food availability, involvement in sport, and nutrition knowledge (NK). The theoretical framework of Birkenhead and Slater (2015) includes all factors that affect dietary change behaviours. These factors exist in three categories, according to the ability of professionals to influence change, these are: modifiable, semi-modifiable, and non-modifiable (Trakman, 2018) (See Figure 1). Factors within the semi-modifiable and non-modifiable categories are most often related to physiological, social, or economic factors, which can be difficult or impossible to modify. For this reason, modifiable factors are most often targeted by professionals working with athletes and investigated. Modifiable factors that can influence changes in dietary behaviours, include NK, body image, weight control, hedonic hunger, and macronutrient balance (Trakman, 2018).

For the purposes of this study, the key modifiable factor of NK was examined; supplement use and interest in special diets were also assessed. It has long been acknowledged that there is a relationship between NK and dietary intake in the general population (Spronk et al., 2014). This relationship has also been observed in athlete populations (Andrews & Itsiopoulos, 2016), although there appears to be a higher positive association between NK and dietary intake in athlete populations than general population (Spronk et al., 2014). Studies have shown NK can be modified through implementation of nutrition education programs (Mitchell et al., 2016; Nascimento et al., 2016). Dietitians can help modify supplement use and implementation of special diets through consultation with those who require these, although dietitian consultations are not available to all athletes (Trakman et al., 2019).

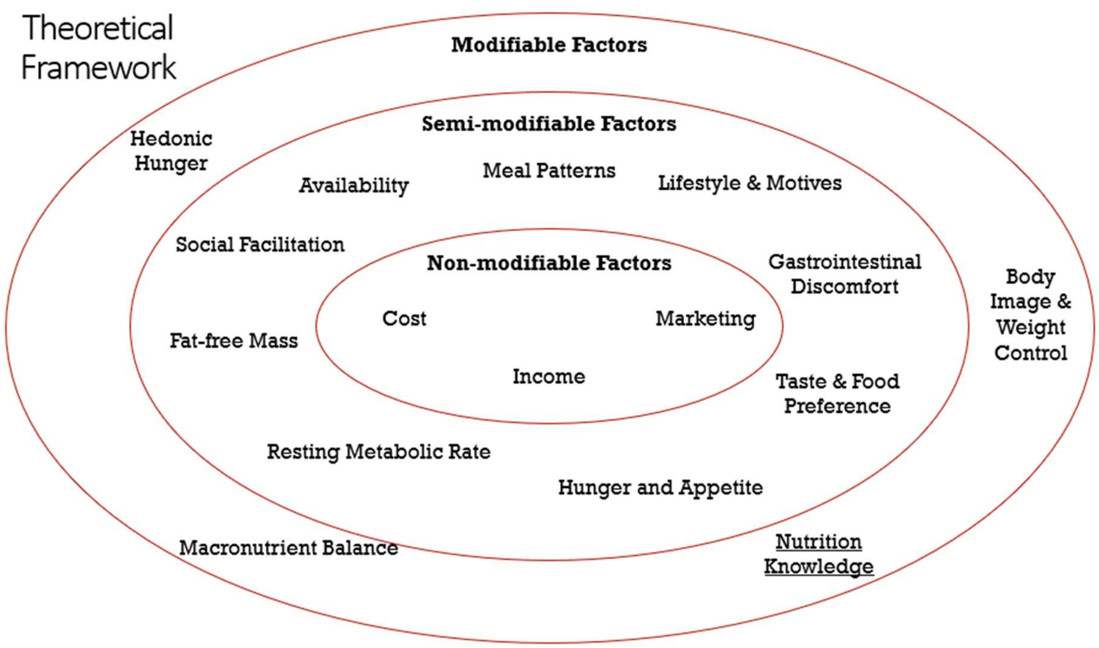


Figure 1 Visualisation for theoretical framework of factors which influence dietary intake.

It is necessary to first understand the level of NK within a group before attempting to create and implement an education program (Devlin, 2016; Trakman, 2018). A number of factors influence NK, including gender, type of sport played, athletic level, support services available, previous nutrition education, level of general education, and age of athlete (Heaney et al., 2011; Trakman et al., 2018b). Previous literature exploring NK in athletes has made use of simple cross-sectional study designs to assess knowledge gaps in athletes (Devlin et al., 2017; Hardy et al., 2017; Jenner et al., 2018).

Assessment of NK can also be used to inform the development of education programs in the future (Andrews & Itsiopoulos, 2016; Jenner et al., 2020; Trakman et al., 2018b). To assess the impact of a specific nutrition education program, NK can be assessed using pre-test/post-test examination (Mitchell et al., 2016; Nascimento et al., 2016).

Current NK in athletes

As per our theoretical framework, NK is often measured as one of the modifiable factors that may affect dietary intake or as part of an assessment of nutrition education (Heaney et al., 2011). NK in athletes has been measured in at least 28 publications in the period between October 2015 and November 2020 using various NK questionnaires. Studies that have examined NK in athletes have returned low overall percentage scores for NK in this group – although many studies did not provide definitions of 'passing' grades, scores appeared to be low (Janiczak et al., 2021). In addition to looking at NK in a cross-sectional manner, studies have compared athletes and looked at demographic factors that influence NK.

Athletes vs non-athletes NK

A 2011 systematic review of NK in athletes found that the overall NK of athletes was similar or greater than those of non-athlete comparator groups, and lower than dietetic interns (Heaney et al., 2011). A 2012 study found that athlete (65.3%, SD = 13.1) and community populations (72.3%, SD = 11.1) had statistically significantly different scores in total general NK (p=0.002), and scores were lower than the benchmarking group of nutrition professionals (98.3%, SD = 4.6) by a significant amount (p=0.000) (Spendlove et al., 2012).

Gaps in athletes NK

Subsection scores provide some general information about areas of low knowledge (Devlin et al., 2017; Trakman et al., 2018b). Identification of general areas where athletes lack knowledge can be of assistance in creation of education programs to improve knowledge in those areas. Subsections where athletes scored highest varied widely between studies, but 'basic'/'general' nutrition (Argôlo et al., 2018; Madrigal et al., 2016: Nascimento et al., 2016) and sources of foods/nutrients (Mitchell et al., 2016) tended to be higher scoring sections. Likewise, there was some disparity in sections where athletes performed poorly but authors frequently reported low supplement sub-section scores (Blennerhassett et al., 2019; Condo et al., 2019; Jenner et al., 2020; Jenner et al., 2018; Lohman et al., 2019; Madrigal et al., 2016; Magee et al., 2017; Trakman et al., 2018b).

Sport type and other factors influencing athletes NK

The majority of recent studies examining elite and non-elite athletes found that non-elite, team-sport athletes have been found to have equal or greater mean total NK percentage score (NK% score) than elite athletes (Andrews & Itsiopoulos, 2016; Lohman et al., 2019; Trakman et al., 2018b). In studies utilising the Zinn et al. (2005) questionnaire, athletes from team sports such as American Football (Holden et al., 2018) or female Australian Rules Football (Condo et al., 2019) scored lower than athletes from individual ultra-endurance sporting events (Blennerhassett et al., 2019), 48.8% and 54.5% versus 68.3% respectively. In some studies, the relationship between nutrition knowledge and demographic factors, such as age, sex, socio-economic status, and level of education (Spronk et al., 2014), has been assessed. The theoretical framework of this study posits that in addition to the aforementioned 'non-modifiable factors', there may be a relationship between other factors and nutrition knowledge. Of particular interest is whether NK is associated with the use of special diets and supplements; therefore general diet pattern (e.g. keto/vegetarian/vegan) and supplement consumption were also assessed.

Special diets

An athlete's dietary choices impacts their performance. Special diets may include vegan/vegetarian diet, ketogenic/low carbohydrate-high-fat (LCHF) diet, or diets which exclude particular food groups or alter macronutrient intake to differ greatly from generally accepted recommendations. Current consensus guidelines for athletes recommend adequate carbohydrate intake dependent on activity (3-12g/kg/day), between 1.2 and 2.0g/kg/day of protein spread throughout the day and in proximity to strenuous exercise sessions, appropriate intake of micronutrients, especially iron, Vitamin D, calcium, and antioxidants (Thomas et al., 2016). Nutrient reference values (NRVs) are thought to be appropriate for most athletes, except for iron, for which requirements can be increased by up to 70% when compared to the general population (National Health and Medical Research Council, 2020; Thomas et al., 2016). Studies have shown athletes often do not follow consensus guidelines and often have an interest in 'alternate' diets (special diets) that do not necessarily align with the guidelines described (Durkalec-Michalski et al., 2019; Michalczyk et al., 2019; Nebl et al., 2019; Rogerson, 2017). In recent years, many studies have explored the relationship between athletic performance and special diets (Barnard et al., 2019; Durkalec-Michalski, et al., 2019; Rogerson, 2017). Michalczyk et al. (2019) investigated anaerobic performance after consumption of a low-carbohydrate diet followed by carbohydrate loading in male basketball players. However, the relationship between NK and special diet consumption has not been explored in this population.

Supplements

Supplementation may contribute to athletes achieving peak performance, but they are not essential. Recent studies have examined the evidence for use of supplements in athletic and active populations. A recent comparative meta-analysis of whey protein supplement interventions in active adults found a statistically significant reduction of fat mass ($p < 0.001$) and non-statistically significant increases in fat-free mass ($p = 0.381$) (Castro et al., 2019). A 2019 systematic review of the effect of caffeine supplements on sports performance found that caffeine supplements were effective in improving aerobic performance; evidence suggests that caffeine supplementation in athletes has an ergogenic effect on anaerobic capacity (Mielgo-Ayuso et al., 2019). There is continuing work concerning the use of supplements for enhancing athletic performance, looking at established supplements (including caffeine, creatine, beta-alanine, etc.), equivocal supplements (such as: citrate, phosphate, carnitine), and developing supplements (Peeling et al., 2018). Australian Institute of Sport (AIS) has established the AIS Sports Supplement Framework to classify sports foods and supplements into a ranking system (AIS, 2021). Due to the continuing work concerning supplements and their effect on athletic performance, it is essential that consumers of supplements and nutrition professionals have a strong understanding of the evidence for use of different supplements. Such knowledge will reduce the risk of inappropriate and unsafe supplement practices.

Athletes have been shown to consume more supplements than the general population in the US, with 60% of athletes included in a 2016 meta-analysis using some type of dietary supplement (Knapik et al., 2016). Eighty-two percent of fitness centre users in Switzerland were found to consume an average 17.1 supplement serves per week made up of an average of 6.9 different products (Mettler et al., 2020). A sample of Australian elite swimmers reported 97% of athletes consuming supplements or sports foods within the year prior to study completion, with participants associated with the Australian Institute of Sport consuming more ergogenic supplements (Shaw et al., 2016). Athletes consuming supplements often do not possess adequate information regarding the supplements that they consume, including active ingredients, side effects, or mechanism of action (Dascombe et al., 2009). The use of protein supplements among Australian adolescent athletes has shown that athletes access supplements which may be against recommendations due to lack of proper education of athletes, coaches, and parents (Whitehouse & Lawlis, 2017). Many researchers have explored supplement use in athletes, exploring both specific supplements (Dudgeon et al., 2017; McMahon et al., 2017; Whitehouse & Lawlis, 2017) or a wide range of supplements (Baltazar-Martins et al., 2019; Mettler et al., 2020). However, few studies have explored general and sport NK in relation to supplement use in athletes, with studies often focusing more on supplement specific knowledge (Blennerhassett et al., 2019; Condo et al., 2019; Jenner et al., 2018).

Gaps in Literature

Previous studies have left some gaps in knowledge related to these topics. Many of the papers assessing NK included in recent literature reviews (Janiczak, 2021; Trakman et al., 2016) have used questionnaires that were either not appropriately validated for the population or out of date for use being published prior to 2015, before the release of the most recent international society for sports nutrition concerns statements (Thomas et al., 2016), and likely based on outdated nutritional advice. The tool being used in this study is the Nutrition for Sport Knowledge Questionnaire (NSKQ) (Trakman et al., 2017), a tool that has been validated for use in populations being examined (athletes and nutrition students) and contains up-to-date nutrition information. The validated NSKQ (Trakman et al., 2017) looks at general and sports NK, while other studies have used outdated or poorly validated tools to assess NK, which may impact the validity of their results. Tools published more than 10-15 years prior likely contain recommendations that have since changed.

In recent years, Australian athlete populations have not been studied across all sports with few Australian-based studies on NK in athletes between October 2015 and November 2020. Of those studies conducted within Australia, the focus has primarily been on team sports, such as: netball, AFL, or soccer.

Of the eight studies completed within Australia since October 2015 (Andrews & Itsiopoulos, 2016; Condo et al., 2019; Devlin et al., 2017; Jenner et al., 2020; Jenner et al., 2018; Trakman et al., 2018a; Trakman et al., 2018b) there have been no studies to compare athletes' general and sports NK against that of the general population or against nutrition students or nutrition professionals. Those studies which have performed group comparisons did so between elite and non-elite athletes only (Andrews & Itsiopoulos, 2016; Devlin et al., 2017; Trakman et al., 2018b). NK% scores for athletes are often reported in isolation of comparator groups that would provide context for the result. Exploring the general and sports NK scores of athletes in comparison with other groups has relevance, as it allows for 'benchmarking' of athletes' NK against community populations. Comparison with other groups also allows for assessment of whether athletes are likely to have been exposed to additional nutrition education, although it should be noted that NK may be acquired through a variety of means outside of nutrition education. NK scores of athletes may be considered arbitrary if they are not benchmarked against community groups, who are oft presumed to have lower sports nutrition knowledge than athletes. While the current study will measure NK in athletes, community populations, and nutrition professionals, it also examines the sports NK of these groups focusing upon an Australian population. By using nutrition students and professionals as comparator groups, the effect of extensive nutrition education can be assessed.

A 2016 systematic review (Knapik et al., 2016) included only one paper from 1991 looking at Australian athletes' usage of dietary supplements (Burke et al., 1991), which looked at male elite soccer players and male triathletes. Few studies have investigated the relationship between NK and supplement use in athletes in recent years; the primary interest in those studies investigating this relationship was supplement information without examination of total general and sports NK (Duvenage et al., 2015; Sekulic et al., 2019; Whitehouse & Lawlis, 2017).

Recent studies which have examined special diets in athletes have not assessed associated NK. Additionally, many recent studies reported athlete nutrient or dietary intake, but there has not been any exploration of whether athletes have an interest in or are aiming to follow specific diets to the author's knowledge. Due to the limited research concerning special diet consumption and NK scores, it was hypothesised that those consuming a special diet would have higher NK than those who did not.

Aims

The purpose of this study was to use an up-to-date, validated tool to explore NK of Australian athletes, and to benchmark athletes' knowledge against other groups – community population, nutrition students, and nutrition professionals.

The secondary aims of this study were:

- To explore how specific demographic factors may impact NK in athletes and benchmarking groups.
- To investigate differences in NK between types of athletes (elite and non-elite; team and individual sports).
- To explore if there was any difference between NK (overall and supplementation specific NK) and supplement intake.
- And finally, to explore if there was any difference in NK (overall, weight management, macronutrient, and micronutrient subsections) between those who consumed a special diet and those who did not.

The hypotheses of this study were fourfold and are outlined here:

1) Athletes will have higher general and sports NK than community populations, but lower general and sports NK than nutrition students and nutrition professionals;

2) Non-elite athletes will have greater NK than elite athletes;

3) Individual-sport athletes will have higher NK than those who participate in team sports;

4) Those who regularly consume supplements will have a higher NK than those who do not consume supplements regularly.

Methods

Study design

This cross-sectional study examined the primary outcome of general and sport NK. The primary populations examined were athletes within Australia, with comparator groups of community populations, undergraduate nutrition students and nutrition and dietetics education professionals within Australia. The exposures investigated in this study included prior nutrition education, supplement use, special diet consumption, and various demographic factors.

Setting

The setting for this study was online. Demographic information and general and sports NK were gathered via an online questionnaire between May 2020 and August 2020 (Qualtrics, 2020; Trakman et al., 2017). Due to COVID-19 lockdown and restrictions in many areas of Australia during the time of this study, the setting for completion of this questionnaire was likely in participants' homes (not within sporting facilities or similar locations). It was possible for participants to make queries regarding this study via email or through social media.

Ethics

This study received ethics approval from the Human Research Ethics Committee of La Trobe University, with the code HEC19513 (approval date 6 February, 2020). The design of this study complies with the National Statement on Ethical Conduct in Human Research regarding studies involving Human Subjects (Australian Government, 2007 (Updated 2018)).

Recruitment

Population

Four groups were recruited for this study – athletes, community population members, nutrition students, and nutrition/dietetic education professionals (See Table 1 for detailed Inclusion/Exclusion criteria). Linear regression analysis for factors influencing diet quality across four modelling factors (NK, age, sex, athletic level) required a total of 107 participants for medium effect size (d=0.5), p=0.05, Power of 95% (Faul et al., 2007).

Table 1. Inclusion criteria.

Community Population	Athlete Population	Nutrition Students	Nutrition/Dietetic Professionals
18 years or older	18 years or older	18 years or older	18 years or older
Speak fluent English	Speak fluent English	Speak fluent English	Speak fluent English
	Play sport in an organised league	Enrolled/completed a nutrition degree	Working in the La Trobe University Nutrition and Dietetics department.
	Train at least 5 hours per week		

In order to recruit athlete participants for this study, sporting organisations were contacted with a request to disseminate documentation for recruitment to their athletes. Contact with sporting organisations was made through social media, email, or website contact forms. Documentation included information on the study and a link to complete the questionnaire. The first page of the survey required participants to provide informed consent to continue on to complete the survey. A wide variety of sporting organisations were contacted regarding this study, including local sporting leagues (List available in Appendix B), professional sporting teams, or state and national sporting bodies. Sporting organisations contacted were predominantly in Victoria and Queensland, with smaller numbers of organisations contacted within other states. The organisations contacted were male, female, or mixed gender clubs. The types of sports targeted through this process included: Australian football, baseball, soccer, netball, basketball, cricket, tennis, squash, and athletics. In June 2020, 102 sporting organisations were contacted, with follow up contact for those with email addresses two/four weeks later if no response was received (see Appendix B). Another round of 253 sporting organisations were contacted in early August 2020. Recruitment was cut off on 17 August 2020, as there was not a significant increase in uptake after the August round of recruitment emails were sent out.

Information concerning this study was also included in an Orienteering newsletter; an organisation that a university staff member was involved with. Student athletes in the La Trobe Elite Athlete Program (LEAP) were invited to participate via email. Convenience and snowball sampling methods were utilised to further recruitment.

Recruitment for community population members included contact via social media. University students were invited via email and their online learning management site. La Trobe teaching staff were invited via email.

Since participants were not contacted directly, the exact number of individuals who viewed the invitation was unknown and thus it is not possible to calculate the response rate for this study.

Athletes were recruited from May 2020 – August 2020; non-athletes were recruited from May 2020-August 2020; staff were recruited in August 2020. A large part of the data collection process for this study was undertaken between June and August 2020, during this time COVID-19 restrictions were still in place for some sporting facilities and athletes participating in training may not have been training at the same level as prior to COVID-19.

Data collection

NK was assessed using the NSKQ developed by Trakman et al. (2017), which was previously validated for use in Australian team-sport athletes. All participants were presented with the consent agreement prior to beginning the online questionnaire. This questionnaire included an informed consent form specific to this study, 27 demographic questions (initial section) and 87 knowledge items (maximum score 87), with sections on weight management (12), macronutrients (30), micronutrients (13), sports nutrition (12), supplementation (12), alcohol (8) (See Appendix C for full questionnaire). This questionnaire was administered online via Qualtrics (2020).

Groups were defined as having 'poor' NK with a NK% score of 0-49% (n=7), 'average' between 50-64% (n=24), 'good' between 65-74% (n=8), and 'outstanding' a score of 75% or greater (n=3) (Trakman et al., 2018b). The original NSKQ was chosen to allow for in-depth data concerning knowledge gaps in participants; an abridged version may have increased completion rate at the expense of subsection-specific information. Demographic questions previously created as part of the NSKQ (Trakman, 2018) were adjusted as necessary and added to for use in this study. The author added the following questions: "What is your current living situation?", "What position do you play?", "Do you follow a specific diet? (e.g. Vegan, Ketogenic)", "Do you regularly take supplements? (e.g. Multivitamin, Creatine)", and "How would you rate your nutrition knowledge?" (see Appendix D). The updated survey was piloted with a general population convenience sample (n=3) before distribution to study participants. The questionnaire was completed within ten minutes by participants within the pilot group.

Demographic information included: age, weight, country of birth, living arrangements, sport played, position played, hours per week, years in sport, weight, height, nutrition information sources, education level, supplement use, special diet intake, NK perception, and previous nutrition education. Demographic questions were modified for distribution to La Trobe University Nutrition/Dietetics teaching staff and orienteering groups to allow for differences within these groups from the original target group of team-sports athletes. Modifications for both groups included more inclusive language around types of sporting activity participated in – language was originally aimed towards team sports and needed to be modified to include those who participate in individual sport activities. Additional modifications were made to the demographics section distributed to the La Trobe University Nutrition/Dietetics teaching staff – this included removal of questions regarding if they were university students and what they were studying, and instead included questions related to how long they had been in the nutrition/dietetics industry and information on additional qualifications related to Sport Nutrition.

Thirty-three participants received an incorrectly phrased question – "Which is a better recovery meal option for an athlete who wants to lose weight? Assume they are training in the morning, have already had breakfast, a mid-morning snack." This question was designed to relate to weight gain, rather than weight loss. Therefore, answers for this question were not valid for this subset. Responses for this question were removed for this subset and the total score was reduced to a maximum of 86 to account for this error.

Data Analysis

Missing data

NSKQ surveys with missing values were accepted where up to 11% of responses (nine questions) were missing; based on a level of response that was previously used during the development of this questionnaire (Trakman, 2018). Responses for the NSKQ were forced within Qualtrics, meaning that any missing values were within the final section of the NSKQ (the alcohol section). All scores for those incomplete questionnaires were scored according to the number of total responses received rather than the total 87 items.

Analysis of NK

Data analysis for this study was completed using SPSS version 26 (IBM, 2019). Graphing for visual representation of score distributions were completed using Graphpad Prism 8 (Graphpad Software, 2018).

The original statistical analysis plan was to conduct multiple regression analysis on the total dataset to investigate the ability of age, gender, BMI, level of education, and nutrition education to predict NK scores of all participants; and to examine the impact of sport played, years spent playing that sport, the level of participation, and hours spent training each week on the NK of athletes. Data was checked to ensure it met the required assumptions (Berry, 1993; Lund Research, 2018); however, as the data collected did not meet required assumptions, it was not possible to complete a multiple regression analysis (see Appendix E). Other univariate analyses (simple linear regression analysis and ANCOVA testing) were also not possible due to sample size. Instead, multiple t-tests were conducted to detect differences in NK based on demographics and athlete-specific factors as described below.

Normality testing was completed using the Kolmogorov-Smirnov test or Shapiro-Wilk test for all continuous variables (samples with below 50 cases used the Shapiro-Wilk test). Visual examination of histograms for continuous variables was used as the secondary determiner of normality. Visual inspection of boxplots was used to check for outlying values, with 5% trimmed means used to determine if outliers significantly impacted the mean of continuous values. As outliers detected did not significantly impact 5% trimmed means, they were not removed from the analysis.

In order to explore the relationships between groups, one-way ANOVA tests (for parametric data) and Kruskal-Wallis H tests (for non-parametric data) were used where three or more groups were examined, including: differences between study groups NK% scores (which was calculated as total score/87 multiplied by 100) and subsection scores, differences in NK% scores between education level groups, and perceived personal NK groups, as well as differences between NK level groups and number of years in sport and number of hours training per week. Independent-samples t-tests (for parametric data), Mann-Whitney U tests (for non-parametric data) or Welch's t-test (for groups of unequal distribution) were used to explore differences of NK between two groups, such as: regular supplement use, previous nutrition education, or special diet intake, as well as differences between elite and non-elite athletes, or team and individual sports athletes. Correlations between age and NK percent scores, as well as NK% score and BMI, were measured using Pearson's r correlation testing for parametric data. Cut off points for interpretation of r were as follows: 0.1 – 0.3 = small correlation, 0.3 – 0.5 = moderate correlation, and >0.5 = strong correlation (Cohen, 1988). Alpha value for significance was set at 0.05. Bonferroni correction for multiple tests was applied to account for type 1 errors. Statistical significance is reported uncorrected and with the Bonferroni adjusted p-values. Percentage results of each section were compared by group to determine if there was an indication of potential responder fatigue in the final subsection.

As mentioned previously, the response rate for this study could not be calculated. However, completion rate of the questionnaire was evaluated by calculating percentages for those who did or did not complete the questionnaire for the total study population and for each study group. As previously determined by Trakman et al. (2018a), participants with more than 10% (9 or more items) of items not completed were classified as not having completed the survey. The completion rate of the questionnaire was also calculated for the total study population and for each group. The completion percentage was calculated to determine where the majority of those who did not complete the questionnaire stopped progress.

Distributions of NK scores were of interest for this project because the spread of knowledge within groups and subsections is an important factor to understand knowledge gaps, therefore the choice was made to present this data graphically using a violin plot.

Results

Participants

Demographic information for all participants is available in Table 2. Approximately half of participants were athletes (n=33, 46.5%). The sample was predominantly female (n=57, 80.3%), born in Australia (n=52, 73%), with a bachelor degree (n=44, 62%). Athlete specific demographics are available in Table 3. All participants who completed the questionnaire were eligible for inclusion in one of the four study groups.

A total of 71 participants completed the questionnaire, including athletes (n=33, 46.5%), community population members (n=13, 18.3%), nutrition students (n=18, 25.4%), and nutrition professionals (n=7, 9.9%). Three members of the nutrition student group were also athletes. It was determined that due to their education and method of recruitment, these participants would be included in the nutrition student group rather than the athlete group. Similarly, three members of the nutrition professionals group also competed in sports. The nutrition education of these participants differentiated them sufficiently from the 'athlete' group to necessitate their inclusion with the nutrition professional group. None of the nutrition professionals had undertaken additional sports nutrition education. One participant recruited via athlete groups did not complete a minimum of five hours a week of training in their sport and therefore was classified as a community population member.

Table 2. Participant characteristics for participants who completed the NSKQ

Participant groups, n(%)	Total n=71	Athletes n=33 (46.5%)	Community populations n=13 (18.3%)	Nutrition students n=18 (25.4%)	Nutrition professionals n=7 (9.9%)
Gender, n(%)					
Male	14(19.7)	7(21.2)	5(38.5)	1(5.6)	1(14.3)
Female	57(80.3)	26(78.8)	8(61.5)	17(94.4)	6(85.7)
Country of birth, n(%)					
Australia	52(73.2)	28(84.8)	7(53.8)	13(72.2)	4(57.1)
Outside of Australia	19(26.8)	5(15.2)	6(46.2)	5(27.8)	3(42.9)
Take supplements, n(%)					
Yes	37(52.1)	18(54.5)	6(46.2)	11(61.1)	2(28.6)
No	34(47.9)	15(45.5)	7(53.8)	7(38.9)	5(71.4)
Special diet, n(%) n=70				n=17	
Yes	15(21.4)	8(24.2)	0(0)	7(41.2)	0(0)
No	55(78.6)	25(75.8)	13(100)	10(58.8)	7(100)
Level of education, n(%)					
High school	2(2.8)	1(3.0)	1(7.7)	0(0)	0(0)
Diploma	6(8.5)	1(3.0)	4(30.8)	1(5.6)	0(0)
University (Bachelor/Undergraduate degree)	44(62.0)	24(72.7)	4(30.8)	16(88.9)	0(0)
University (Master/Honours degree)	11(15.5)	5(15.2)	4(30.8)	1(5.6)	1(14.3)
University (Doctoral degree)	8(11.3)	2(6.1)	0(0)	0(0)	6(85.7)
Living situation, n(%)					
Alone	5(7.0)	1(3.0)	2(15.4)	0(0)	2(28.6)
With partner/children	41(57.7)	10(30.3)	10(76.9)	16(88.9)	5(71.4)
With parents	17(23.9)	14(42.4)	1(7.7)	2(11.1)	0(0)
With unrelated adults	8(11.3)	8(24.2)	0(0)	0(0)	0(0)
State of residence, n(%) n=69					
QLD	17(24.6)	3(9.1)	10(76.9)	4(22.2)	0(0)
NSW	9(13.0)	1(3.0)	2(15.4)	6(33.3)	0(0)
VIC	38(55.1)	26(78.8)	1(7.7)	4(22.2)	7(100)
SA	1(1.4)	0(0)	0(0)	1(5.6)	0(0)
WA	4(5.8)	2(6.1)	0(0)	2(11.1)	0(0)
Nutrition education, n(%)					
Yes	39(54.9)	11(33.3)	3(23.1)	18(100)	7(100)
No	32(45.1)	22(66.7)	10(76.9)	0(0)	0(0)
Age, mean(SD, 95%CI)	32.2(11.8, 29.4-35.0)	Median (IQR) 23.0(10.5)	35.6(7.1, 31.3-39.9)	35.1(9.6, 30.3-39.9)	40.4(11.1, 30.1-50.7)
Weight, mean(SD, 95%CI)	67.5(14.2, 64.1-70.9)	Median (IQR) 61.0(13.0)	69.1(19.8, 57.2-81.1)	72.6(12.6, 66.3-78.9)	65.7(6.5, 59.7-71.7)
Height, mean(SD, 95%CI) n=70	1.68(0.094, 1.66-1.71)	n=32 Median	Median (IQR)	1.68(0.08, 1.64-	1.66(0.07, 1.60-1.73)

		(IQR) 1.67(0.12)	1.65(0.23)	1.71)	
BMI, mean (SD, 95%CI) n=70	23.7(3.9, 22.8-24.7)	n=32 Median (IQR) 22.04 (2.53)	24.37(4.82, 21.45-27.28)	25.89 (4.54, 23.63-28.15)	23.78(2.66, 21.32-26.24)

Note. n, number of participants. SD, standard deviation. BMI, body mass index.

Athletes, community populations, nutrition professionals, and nutrition students

NK correct versus incorrect response data is presented in Appendix F. The median and distributions of scores for each group in the total NK scores and all NK subsections of the questionnaire vary greatly (Figure 2). The community population group had the widest range of scores for all subsections and the total NK% scores. The alcohol subsection knowledge was similar between all groups (Medians(IQR)=75(18.8)-87.5(12.5)%), although minimum scores for nutrition students and professionals were higher than athlete and community population minimum scores (See Figure 2).

Nutrition professionals (77.0%, IQR=12.6) had a statistically significantly higher overall median NK% score than community population (49.4%, IQR=27.6) and athlete groups (55.8%, IQR=9.6), p=0.001 and p=0.001 respectively (Table 4). While nutrition students (63.4%, IQR=8.7) also scored a higher overall median NK% score than both the community population and athlete groups, the difference between groups was not statistically significant, p = 0.084 and p = 0.207 respectively. Nutrition professionals scored higher across all sections than other groups, except sport nutrition where athletes' scores were equal (refer to Table 4). Nutrition students scored higher than athletes and community populations in four sections (macronutrients, micronutrients, supplementation, and alcohol); community population scores were equal to nutrition students in weight management and athletes scores were higher than nutrition students in sport nutrition. Athletes scored higher median scores than community populations in macronutrients, sports nutrition, supplementation, and alcohol; however, statistically significant differences between the two groups were only found in sports nutrition (Mean difference = 1.80, 95% CI [0.69, 2.91], p = 0.028). Responses for individual questions were beyond the scope of this study, but detailed analysis of this data is planned for a future project; a summary of these results have been included as supplementary material (See Appendix F)

Table 3. Athletic sample demographics information

	Athletes n=33	**Non-athletes (Community population, nutrition students, and nutrition professionals)**
Hours Trained per week, Mean (SD, 95%CI)	9.70(4.95, 7.94-11.45)	n=25 Median (IQR) 4.00 (6.00)
Years in Sport, Median (IQR)	8.00(9.00)	n=9 7.00(15.00)
Level of sport played, n(%)		n=9
Local league	11(33.3)	4(10.5)
State league	7(21.2)	1(2.6)
National league	8(24.2)	4(10.5)
International	7(21.2)	0(0)
Sport played, n(%)	n=32	n=22
Australian football	4(12.5)	0(0)
Basketball	4(12.5)	0(0)
Cricket	3(9.4)	0(0)
Cycling	2(6.3)	0(0)
Hockey	1(3.1)	0(0)
Running(endurance)	3(9.4)	2(9.1)
Sprinting	2(6.3)	0(0)
Other	2(6.3)	3(13.6)
I don't play sport	0(0)	13(59.1)
Netball	2(6.3)	1(4.5)
Boxing	1(3.1)	0(0)
Squash	0(0)	1(4.5)
Weightlifting	3(9.4)	0(0)
Martial Arts	1(3.1)	1(4.5)
Volleyball	1(3.1)	0(0)
Lacrosse	1(3.1)	0(0)
Orienteering	2(6.3)	0(0)
Touch Football	0(0)	1(4.5)
Team Vs. Individual, n(%)	n=30	n=6
Team	16(53.3)	2(33.3)
Individual	14(46.7)	4(66.7)

Note. n, number of participants. SD, standard deviation. IQR, interquartile range.

Table 4. Median nutrition knowledge scores for participants across participation groups

	All participants (n=71)	**Athletes (n=33)**	**Community populations (n=13)**	**Nutrition students (n=18)**	**Nutrition professionals (n=7)**	**Difference between groups test results**	**Post hoc testing (significant results)**
Total Percent Score, Median (IQR)	59.30 (16.64)	55.81 (9.60)	49.43 (27.59)	63.37 (8.72)	77.01 (12.64)	χ^2 (3) = 19.725, p = <0.0005	community group and nutrition professional (Mean difference = -22.93, 95% CI [-35.80, -10.05], p = 0.001*) athlete group and nutrition professionals (Mean difference = -18.94, 95% CI [-26.65, -11.23], p = 0.001*)
Weight Management, Median (IQR), % correct (IQR)	9.00 (3.00), 75%(25.00)	8.00 (3.00), 66.7%(25.00)	9.00 (4.00), 75%(33.33)	9.00 (3.25), 75%(27.08)	11.00 (2.00), 91.7%(16.67)	F(3, 67) = 6.988, p = <0.005	nutrition professionals 25% higher than athletes (Mean difference = -3.43, 95% CI [-4.98, -1.88])
Macronutrients, Median (IQR), % correct (IQR)	17.00 (6.00), 56.7%(2.00)	17.00 (5.00), 56.7% (16.67)	16.00 (8.50), 53.3%(28.33)	17.50 (4.00), 58.3% (13.33)	22.00 (3.00), 73.3%(10.00)	X^2(3) = 13.161, p = 0.004	athletes and nutrition professional groups (Mean difference = -5.36, 95% CI [-8.57, -2.16], p = 0.007*) community population and nutrition professional groups (Mean difference = -6.85, 95% CI [-11.44, -2.25], p = 0.004*)
Micronutrients, Median (IQR), % correct (IQR)	8.00 (3.00), 61.5%(23.08)	6.00 (4.00), 46.2% (30.77)	6.00 (4.00), 46.2%(30.77)	8.50 (2.00), 65.4% (15.38)	10.00 (3.00), 76.9%(23.08)	X^2(3) = 13.613, p = 0.003	athletes and nutrition professional groups (Mean difference = -2.63, 95% CI [-4.59, -0.67], p = 0.040*)
Sports Nutrition, Median (IQR), % correct (IQR)	6.00 (3.00), 50%(25.00)	7.00 (2.00), 58.3% (16.67)	4.00 (2.50), 33.3%(20.83)	6.00 (3.00), 50%(25.00)	7.00 (3.00), 58.3%(25.00)	X^2(3) = 14.071, p = 0.003	community population and athlete (Mean difference = 1.80, 95% CI [0.69, 2.91], p = 0.028*) groups community population and nutrition professional (Mean difference = -3.20, 95% CI [-4.87, -1.52], p = 0.002*) groups

Supplementation, Median (IQR), % correct (IQR)	6.00(5.00) 50%(41.67)	6.00 (3.00) 50%(25)	5.00 (5.00) 41.7%(41.67)	7.00(4.25) 58.3% (35.42)	10.00(4.00) 83.3%(33.33)	$X^2(3)$ = 10.815, p = 0.013	community population and nutrition professional (Mean difference = -3.76, 95% CI [-6.58, -0.93], p = 0.02*) groups athlete and nutrition professional (Mean difference = -3.39, 95% CI [-5.19, -1.58], p = 0.02*) groups
Alcohol, Median (IQR), % correct (IQR)	n=70 7.00(1.00) 87.5%(12.50)	n=32 6.50(1.00) 81.25%(12.50)	6.00(1.50) 75%(18.75)	7.00(1.00) 87.5%(12.50)	7.00 (2.00) 87.5%(25.00)	$X^2(3)$ = 6.308, p = 0.098	

Note. Shapiro-Wilk test of normality used for samples under 50. Kolmogorov-Smirnov test of normality used for samples over 50. Visual inspection of histograms was a secondary test of normality

**Statistically significant result for pairwise comparison*

Differences in NK Based on Demographic Factors

Gender comparison

The recruited sample was predominantly female (n=57, 80.3%) with males making up 19.7% (n=14) of the sample; females also made up the majority of all study groups (athletes 78.8%, community populations 61.5%, nutrition students 94.4%, and nutrition professionals 85.7%). Due to the uneven numbers of males and females recruited for this study, it was not possible to complete any meaningful comparison between the genders regarding NK% scores (refer to Table 3).

Age

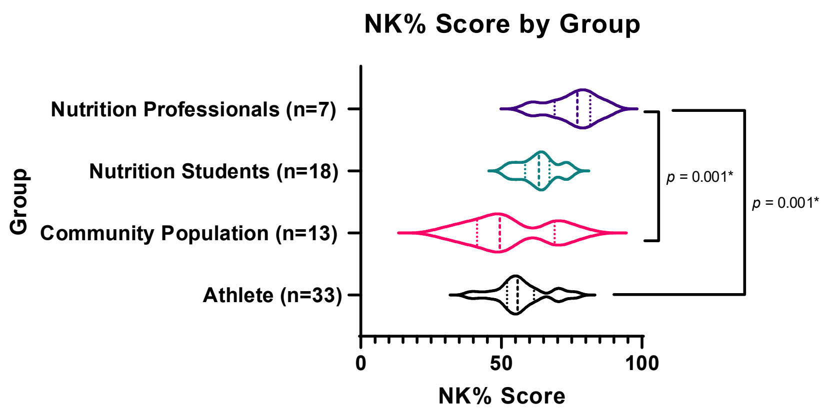
The mean age for the sample population was 32.2 years old (SD=11.8, 95% CI 29.4-35.0). The median age of athletes was 23.0 (n=33, IQR = 10.5). The mean ages of groups increased from nutrition students (n=18, 35.1, SD=9.6, 95% CI 30.3-39.9), to community populations (n=13, 35.6, SD=7.1, 95% CI 31.3-39.9), to nutrition professionals (n=7, 40.4, SD=11.1, 95% CI 30.1-50.7). A moderate positive correlation between NK% score and age was found to be statistically significant, $r(69) = 0.32$, p = 0.007. The coefficient of determination for this test shows that age was statistically related to 10% of the variability in NK% score in this sample.

BMI

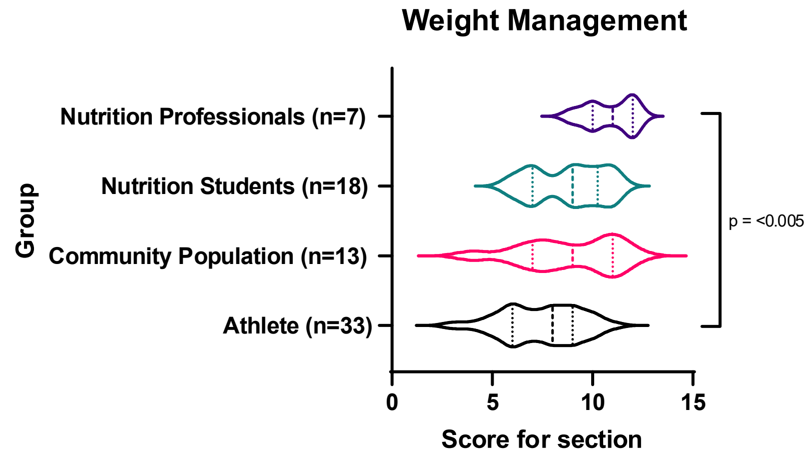
The mean BMI for the total sample was 23.7 (SD= 3.9, 95% CI 22.8-24.7). No significant correlation was detected between BMI and NK% score, $r(68) = -0.012$, $p = 0.925$.

Education level comparison

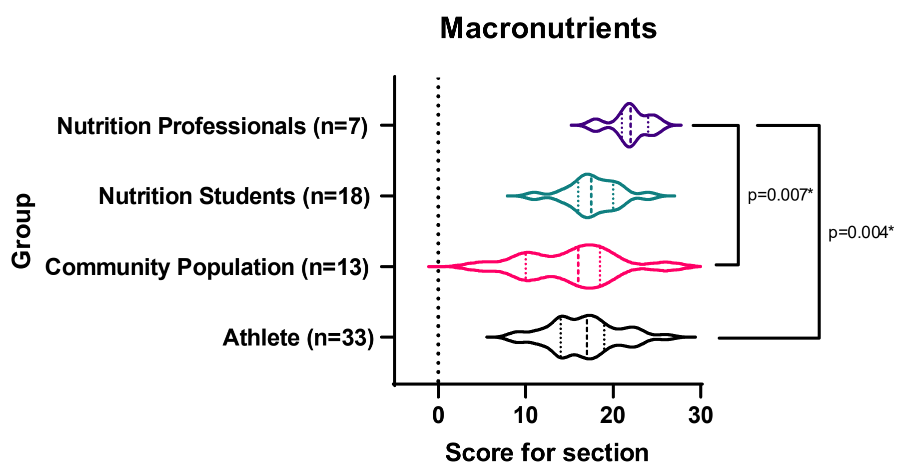
The majority of the sample (n=43, 62.0%) had a bachelor or undergraduate degree. Eleven participants (15.5%) held an honours or master's degree. Eight participants (11.3%) had a doctoral degree. In the athlete group, 24 participants (72.7%) held bachelor or undergraduate degrees, five (15.2%) held honours/master's degrees, and two (6.1%) held doctoral degrees. A statistically significant difference in NK was found in the total cohort between those with a diploma and those with a doctoral degree ($p = 0.009$); no statistically significant differences in NK were detected between any other group combinations.



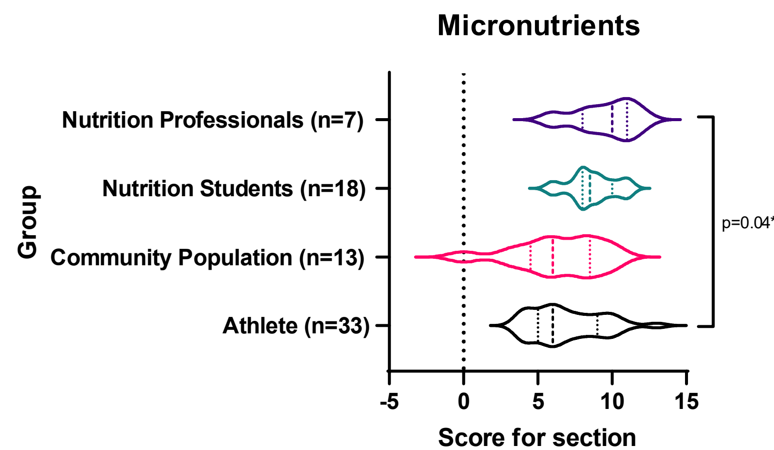
?2 (3) = 19.725, *p* = <0.0005



F(3, 67) = 6.988, *p* = <0.005



?^{2}(3) = 13.161, *p* = 0.004



?^{2}(3) = 13.613, *p* = 0.003

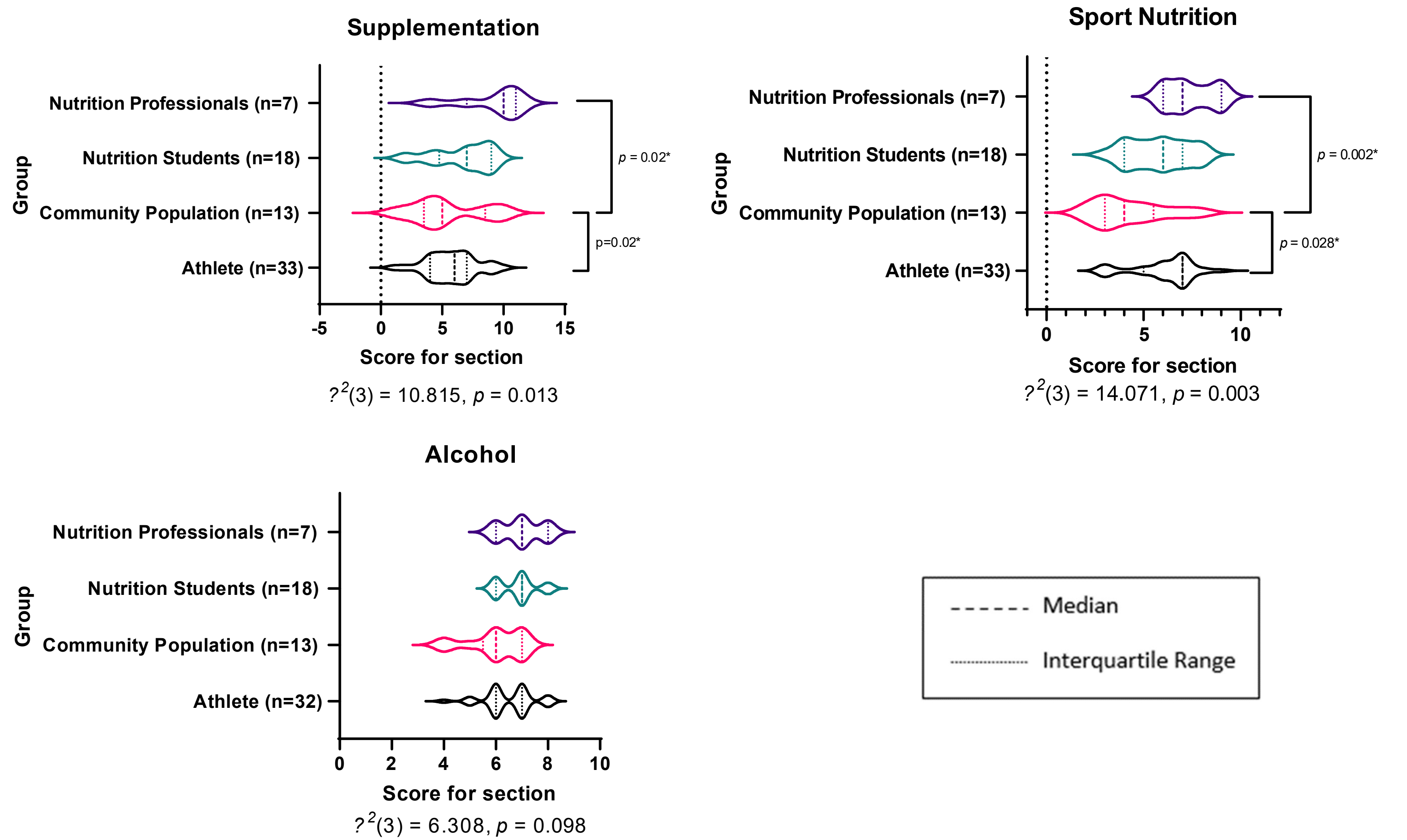


Figure 2 Distribution of scores between groups for total and subsection results with significance.
The solid line represents median. Dotted lines represent Quartile 1 (Q1) and Quartile 3 (Q3).

Previous nutrition education

Thirty-nine of the participants in this sample had previous formal nutrition education (54.9%), with the remainder having none. The definition for nutrition education was any formal studies in human nutrition, including a University subject, University course, a specialised course, an online course, or other diploma. Both nutrition students (n=18) and nutrition professionals (n=7) reported 100% of participants had previous nutrition education, as expected based on inclusion criteria. Eleven members of the athlete group (33.3%) and three members of the community population group (23.1%) had previous nutrition education. There was a statistically significant difference in the median NK% scores for the total dataset between those with nutrition education (65.12%) and those without (53.76%), U = 241, z = -4.427, p = < 0.0005. Subsequent analysis on only athlete participants (athlete subgroup) examining the effect of previous nutrition education in athletes showed statistically significant differences in median NK% scores, U = 66.5, z = -2.082, p = 0.036. The median NK% scores of athletes who had completed previous nutrition education (60.47%) were higher than those who had not undertaken any nutrition education (54.91%), which may not be clinically relevant without assessment of knowledge gaps.

Perception of personal NK

Participants rated their own NK as below average (n=5, 7.0%), average (n=25, 35.2%), above average (n=40, 56.3%), and outstanding (n=1, 1.4%). There was no statistically significant difference found between the mean rank of NK% scores of groups according to perceived personal NK, $\chi^2(3)$ = 6.919, p = 0.075. The mean ranks of NK% scores increased in the following order: below average (26.80), average (28.88), above average (41.33), and outstanding (47.00). It must be noted that the group who perceived their NK as outstanding only consisted of one participant.

Number of years in sport

The number of years of experience in their sport varied for the whole cohort between one year and 35 years. The median years in sport for the total sample was 7.5 (IQR = 9.00). Due to violations of requirements for correlational testing, it was necessary to use between group testing for this analysis. A Kruskal-Wallis H test was conducted to investigate if there were differences in years playing a sport between the levels of NK. Median years playing a sport did not increase according to NK score groups, but rather increased from poor (6.00), to good (6.50), to outstanding (7.00), to average (10.00) NK levels. The differences in years playing sport were not statistically significantly different between NK score groups, χ^2 (3) = 1.274, p = 0.735. The athlete subgroup results demonstrated a not statistically significant difference in years playing sport between groups, χ^2 (3) = 0.222, p = 0.974.

Number of hours training per week

The number of hours spent training on average per week varied amongst participants, between one and 22 hours per week. The mean hours training per week for the total sample was 7.81 (SD=5.06, 95% CI 6.48-9.14). The variables of NK% score and number of hours trained per week violated the assumptions for correlational testing, making it necessary to use between group testing for this analysis. The groups used in this test were the same as described in the previous section. The median hours trained per week did not increase up the ordinal NK level groups but increased by this order from the good (5.00, n=12), to poor (5.50, n=12), to average (8.00, n=28), to outstanding (9.00, n=6) NK levels. The differences in the average hours of training per week between the different NK level groups were not statistically significant, χ^2 (3) = 3.460, p = 0.326. Testing of the athlete subgroup demonstrated that mean ranks of the number of years playing a sport were not statistically significantly different between NK level groups, χ^2 (3) = 1.208, p = 0.751.

Elite versus non-elite

Athletes who competed in local or state leagues were categorised as non-elite (n=18); and those who competed in national or international leagues/competition were categorised as elite (n=15). Elite athletes achieved similar median NK% scores (56.98) to non-elite athletes (54.91). Median NK% score was not statistically significant between elite athletes and non-elite athletes, U=-154.50, z = 0.705, p = 0.486.

Team versus individual sports

The type of sport played by athletes has been classified as either a team sport or an individual sport. Three athletes did not provide specifics of their sport, stating 'other'; as such, 30 athletes are included in this analysis. Those who participated in individual sports had a similar median NK% score (56.07) to those who participated in team sports (54.91). Differences in median NK% score were not statistically significant for team sport athletes and individual sport athletes, U = 122.50, z = 0.437, p = 0.667.

Supplement use

Approximately even numbers of participants consumed supplements (n=37, 52.1%) compared with those who did not (n=34, 47.9%). Two nutrition professionals consumed supplements – one reported Vitamin D only in winter months, whilst the other did not provide further details. Athletes who consumed supplements (n=18, 54.5%) reported consuming iron (6), creatine (5), protein (5), multivitamins (4), vitamin B12 (3), magnesium (3), B vitamins (2), vitamin D (2), beta alanine (1), collagen blend (1), super greens Powder (1), omega 3 (1), vitamin C (1), and methylsulfonylmethane (1). Further breakdown of supplement intake by group is provided in Figure 3.

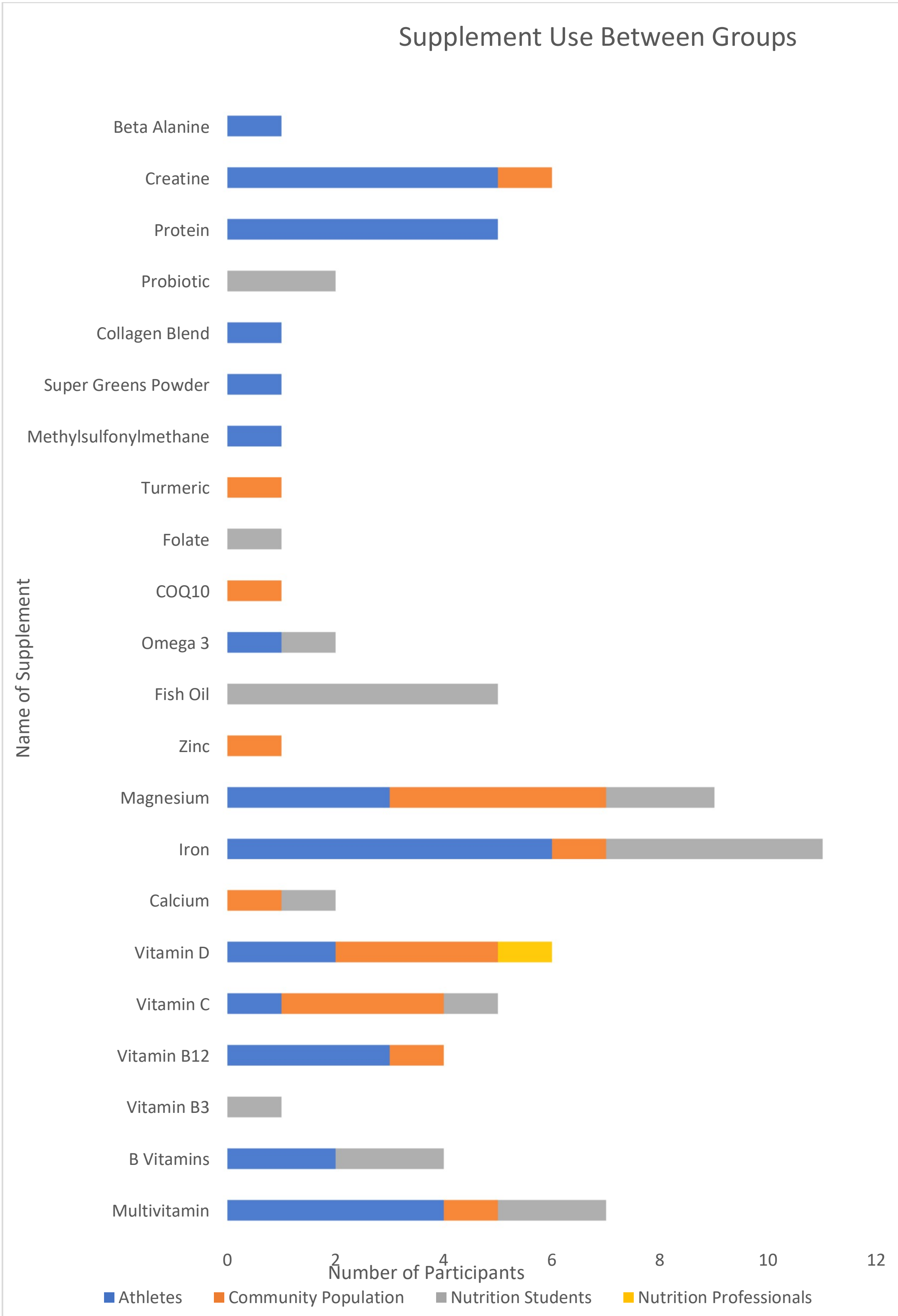


Figure 3 Supplement intake rates for each supplement by group.

The mean NK% scores for those consuming supplements was 58.43% versus those not consuming supplements, which was 60.97%. The differences in NK% scores and supplementation subsection scores between those who reported taking supplements and those who did not were not statistically significant, $t(69) = -0.919$, $p = 0.361$ and $t(69) = -0.589$, $p = 0.558$, respectively.

NK% scores and supplementation subsection scores for athletes consuming supplements and those who do not were not statistically significantly different for either group (Figure 4). The distribution of the scores of athletes not consuming supplements was wider than that of those consuming supplements (refer to Figure 4). NK% scores for athletes show a wider range for those who did consume supplements than those who did not.

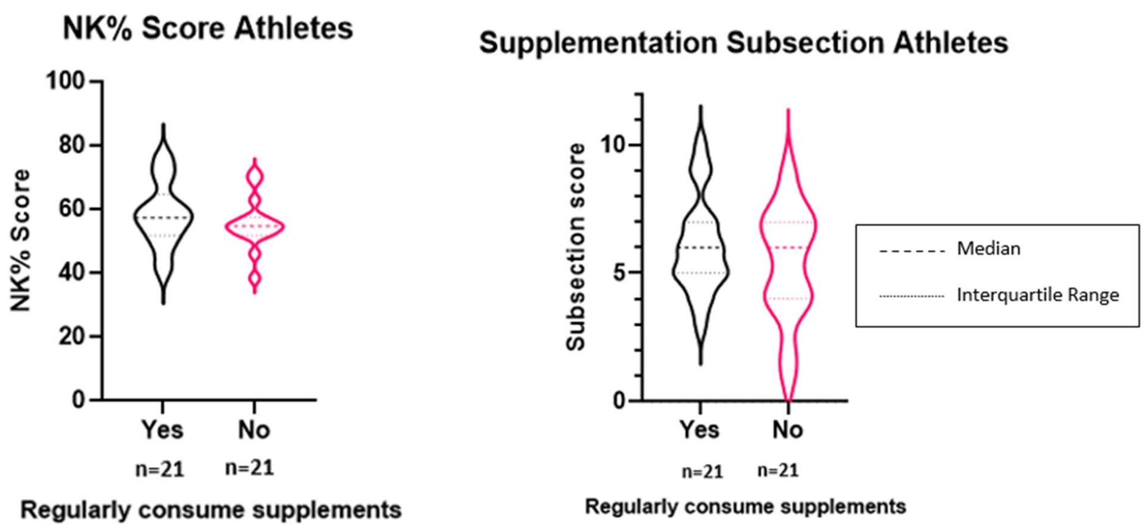


Figure 4 NK scores for participants that regularly consume supplements.
The solid line represents median. Dotted lines represent Q1 and Q3.

Special diet

Fifteen participants consumed a special diet; these included: vegetarian/vegetarian lacto ovo/vegan (8), pescatarian (2), gluten free (1), low FODMAP (1), higher protein and fat (1), macronutrient tracking (1), and ketogenic (1). Seven of the vegetarian/vegan participants also reported taking supplements of various types. The mean NK% score was similar for those consuming a special diet and those not consuming a special diet (0.47% higher in those who consumed a special diet, 95% CI, -4.52 to 5.45). The difference in NK% score between those consuming a special diet (60.00, SD=7.00) and those who did not (59.55, SD=12.61) was not statistically significant, $t(41.03) = 0.188$, $p = 0.852$.

No statistically significant difference in NK% scores existed between athletes who consumed a special diet and those who did not (see Figure 5). Differences according to special diet consumption were calculated for the NK% score and the subsections most related to dietary intake, namely -

weight management, macronutrients, and micronutrients (see Figure 5). Athletes consuming a special diet had a smaller range of scores in the macronutrient responses than those not consuming a special diet. Both groups of athletes had similar ranges of scores for micronutrients, with a large range of possible scores. It is important to note that the disparity in numbers between these two groups may have impacted distributions of scores.

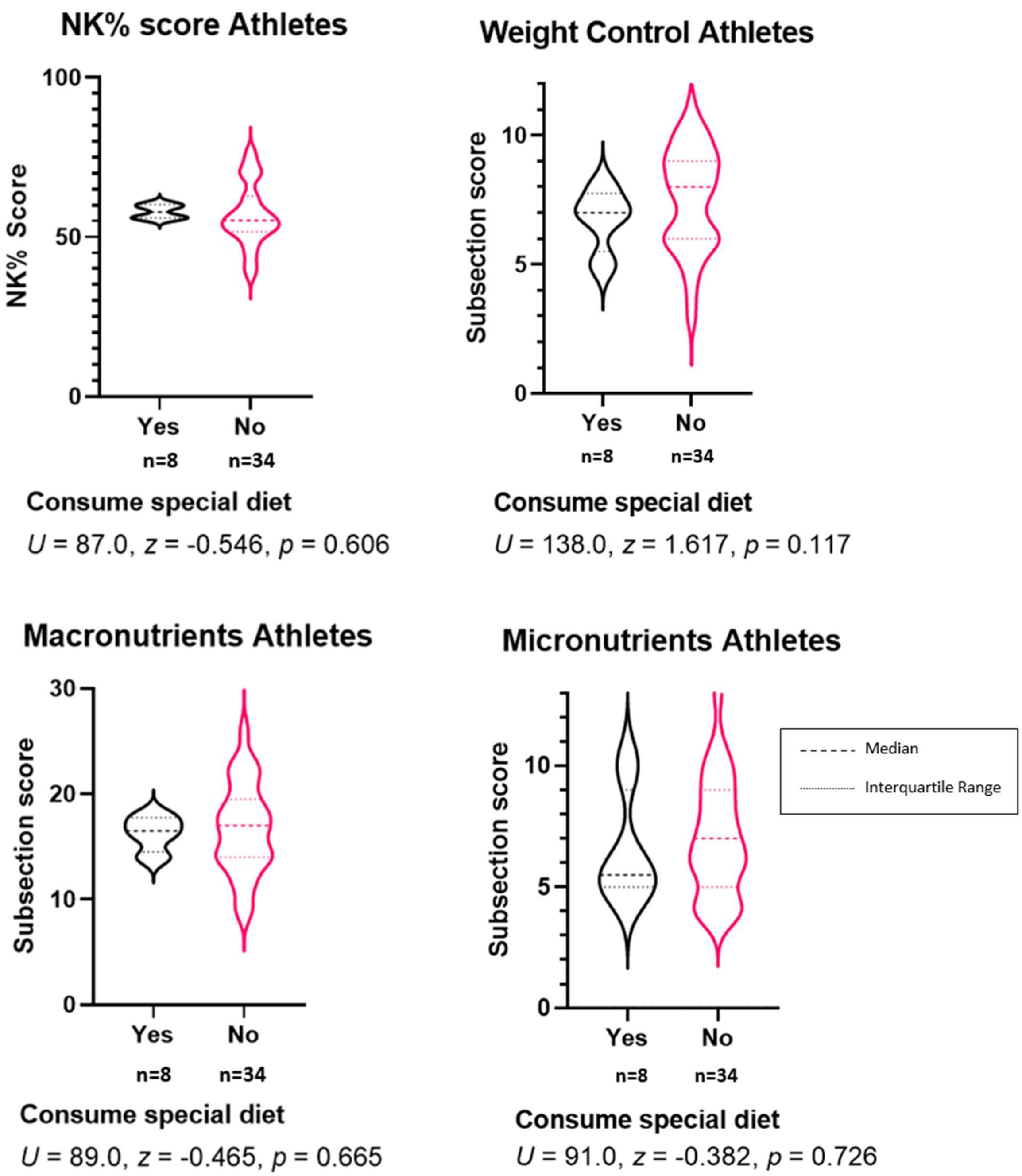


Figure 5 Graphing for Special diet variable against total percent score and relevant subsection scores.
The solid line represents median. Dotted lines represent Q1 and Q3.

Completion rate analysis

Recruitment for this project involved contact with 396 organisations (specifics provided in Appendix B). Response rates for this questionnaire could not be calculated, as it was not possible to know how many potential participants received the recruitment documentation after it was provided to the sports associations. The total number of participants who began the questionnaire was 107 (See Table 5). Of those that began the questionnaire, 36 (33.0%) did not complete the questionnaire to a degree that could be included in the final dataset for analysis. The completion rate within the recruitment period was 66.4% (n=71). Drop-out was highest for the community population and lowest for nutrition professionals.

Table 5. Completion rate details

	Included	Not Included
Total (n=107)	71 (66.4%)	36 (33.6%)
Athlete (n=49)	33 (67.3%)	16 (32.7%)
Community population (n=22)	13 (59.1%)	9 (40.9%)
Nutrition Students (n=28)	18 (64.3%)	10 (35.7%)
Nutrition Professionals (n=8)	7 (87.5%)	1 (12.5%)

Of those that clicked the link, four participants (11.1%) did not continue past informed consent. Thirteen participants (36.1%) did not continue past the question 'Do you play sport?'. In total, 25 participants (69.4%) did not continue past the demographic portion of the questionnaire. The remaining 11 participants completed the questionnaire to the following degree: weight management subsection – nine participants (25%), macronutrients subsection – one participant (2.8%), and micronutrients subsection – one participant (2.8%).

Responder fatigue

The demographics were presented as the initial section of the online survey. This was followed by the NKSQ sections in the following order: weight management, macronutrients, micronutrients, sports nutrition, supplementation, and alcohol. As this order was static for every participant, it is not possible to prove the presence of responder fatigue. For section one on weight management, scores ranged from 25 to 100%. The scores for section two on macronutrients ranged from 16.7% and 86.7%. The micronutrients section (section three) produced scores between 0% and 100%. The section on sports nutrition (section four) had scores ranging between 16.7% and 75%. And for section five on supplementation, scores ranged between 8.3% and 91.7%. While the results from the last section ranged from 50% to 100%. From these results, it appears that participants did not experience responder fatigue during this questionnaire. Maximum and minimum results varied by section, but there does not appear to have been a downward trend in scores throughout the sections of the questionnaire. It is likely that these results provide an insight into gaps in NK within this sample.

Discussion

The main findings of this study are five-fold. 1) Athletes have similar general and sports NK to community populations, while nutrition professionals have a higher general and sports NK than athletes and community populations. 2) Elite and non-elite athletes achieved similar NK% scores. 3) Individual-sport athletes had similar NK% scores to team-sport athletes. 4) Those individuals regularly consuming supplements achieved similar NK% scores to those individuals who did not consume supplements, although the distribution of NK% scores for those consuming supplements was narrower than those who did not. 5) NK% scores were similar for those consuming a special diet and those not consuming a special diet.

Total NK scores

The results of this study partially confirm the primary hypothesis; athletes had similar total NK% scores than community populations, while nutrition professionals and nutrition students had higher total NK% scores than athletes. However, the sport nutrition scores were equal for athletes and nutrition professionals, with other groups scoring lower in this area.

Athletes versus community population

The sample of athletes included in this study achieved comparable results to the community population members included – with no statistically significant difference between group NK% scores. Trakman et al.'s (2016) systematic review found that athletes' scores relative to non-athlete comparator groups varied between studies. A recent study found that ultra-endurance athletes had a significantly higher NK score than a general population comparator group (Blennerhassett et al., 2019). Due to the fact that analysis is underpowered, it is possible that a difference does exist between athlete and community populations, but the sample is not large enough for this to be significant.

The differences in findings between existing studies could be attributed to a number of factors. The current study examines a wide variety of sports, with no one sport providing a large percentage of participants and approximately equal numbers of athletes in team and individual sports. This study was underpowered to examine differences between specific sports. However, inclusion of such a wide variety of sports in the same category of 'athlete' may account for the current findings. The current study looks at athletes of various types, including experienced/inexperienced athletes, elite and non-elite athletes. Due to notable differences (discussed below) between types of athletes (elite and non-elite), amalgamation of athlete types could account for the similarity in NK scores between the community population and athlete groups in this study. Differences in results could also be affected by the community sample recruited – the community population sample in the current study was recruited via social media, which may not have provided a 'true' community sample, rather individuals highly interested in nutrition. The difference in findings may also be due to the tool used for assessment of NK.

Athletes versus nutrition professionals and nutrition students

The current study found that there was a significant difference between the median NK% scores of nutrition professionals and both athletes and community population members. Nutrition students did not have statistically significantly different NK% scores or subsection specific scores when compared against nutrition professionals, athletes, or community population members.

Previous studies have also shown that nutrition professionals have a higher level of NK than that of athletes or the general population (Blennerhassett et al., 2019; Spendlove et al., 2012), and nutrition students have higher NK than athletes (Trakman et al., 2017). This would be expected due to the high level of nutrition education undertaken by both nutrition professionals and nutrition students. It would be expected that nutrition professionals that specialise in sport nutrition would have a higher sport NK score than general nutrition professionals. However, this was not assessed within the current study, as none of the nutrition professionals that participated in the study had any additional training in sport nutrition. While the nutrition professionals had higher overall scores than athletes, their sports NK was similar to that of athletes, which emphasises the need for specialist dietitians to work with athletes due to the complexity of sports nutrition.

The fact that athletes possess a similar overall median NK% score to community population members implies that athletes are not receiving or searching out significant amounts of additional nutrition education that may assist with their pursuit of improved athletic performance, or that the information they are receiving is either incorrect or not fully understood. The type of education can mean athletes are able to choose the right foods (procedural education) but not know the number-based nutrient recommendations (declarative education) (Dickson-Spillmann & Siegrist, 2011). Ideally, athletes would be provided with nutrition education by their sporting associations, which has been tailored to the requirements of the sport and the athletes participating.

Athletes' knowledge in context

In the current study, athletes' median total NK% score was 55.81%, which was categorised as an 'average' score (Trakman et al., 2018b). Recent studies which have used the NSKQ (Trakman et al., 2017) in Australian football players, returning NK% scores between 46 and 51% which were categorised as 'poor' to low 'average' (Jenner et al., 2020; Jenner et al., 2018; Trakman et al., 2018b). The wide variety of assessment tools used in other studies makes it difficult to directly compare data between studies. However, it appears that athletes in general have low NK. Blennerhassett et al. (2019) and Holden et al. (2018) used the Zinn et al. (2005) survey, and set minimum thresholds for adequate NK, 75% and >70%, respectively, with neither of their study populations meeting these values. Condo et al. (2019) also used the Zinn et al. (2005) tool without setting minimum thresholds; the median scores of participants were 54.5%, and thus below both the minimum thresholds set by Holden et al. (2018) and Blennerhassett et al. (2019). A paper which used a combination of two validated tools with some changes made to items within the tool (Devlin & Belski, 2015) found that Australian team-sport players had a mean NK% score of 57% (Devlin et al., 2017), which is an average score based on the Trakman et al. (2018a) classification and below the minimum threshold for adequate knowledge based on classifications by other researchers. Overall, the sample of athletes in the current study achieved higher NK% scores compared against athletes in previous studies that utilised the same questionnaire. This higher NK% scores in athletes could be due to a wider variety of sports and sport types assessed in this study, as previous research has found NK% scores differ between sport type (Magee et al., 2017). Regardless of sport, study, or questionnaire, athletes have low NK, indicating room for improvement in this area and providing opportunities for creation of education programs.

Subsection results

The lowest median scores in subsections for the total dataset were sports nutrition and supplementation (50%), while the highest median score in a subsection was for alcohol (87.5%). Athletes' lowest median score was in the micronutrients section (46.2%), and highest median score was in the alcohol section (81.25%). Previous studies looking at NK in athletes using the NSKQ found that the supplementation subsection was the lowest scored section for the team-sports athletes tested (Jenner et al., 2020; Jenner et al., 2018; Trakman et al., 2018b), although the highest scoring subsections for these studies were alcohol (Jenner et al., 2020) and macronutrients (Jenner et al., 2018; Trakman et al., 2018b). Studies which utilised the Zinn et al. (2005) survey to examine NK in a wide variety of types of athletes found that the lowest scoring subsection was supplementation (Blennerhassett et al., 2019; Condo et al., 2019; Lohman et al., 2019; Madrigal et al., 2016; Magee et al., 2017); the highest scoring subsection for these studies varied between recovery (Blennerhassett et al., 2019), fluid (Condo et al., 2019; Lohman et al., 2019), and general nutrition (Madrigal et al., 2016; Magee et al., 2017). Differences in these findings may be due to the fact that the current study looks at 'general' athletes (team-sport and individual-sport athletes) while previous publications using the NSKQ have focused on team-sport athletes. Research shows inconsistent differences between individual-sport athletes and team-sport athletes (Janiczak et al., 2021). These results indicate there was a variety of higher scoring subsections within these studies; however, the supplementation subsection was consistently one of the lowest scored. . These results indicate that athletes may not receive or understand information regarding supplementation or micronutrients. A much higher level of knowledge in the alcohol subsection indicates that athletes were more likely to be exposed to information regarding this topic. However, this information may not be related to status as an athlete. All groups achieved generally high scores in the alcohol subsection. This may be due to government messaging regarding consumption of alcohol (Drinkwise Australia, 2020). Conversely, lower scores for athletes in the area of micronutrients may be due to a general lack of education in this area, while low scores related to supplementation may be related to the large quantities of supplementation available and being advertised through various mediums causing confusion.

The community population group and nutrition students also scored highest in the alcohol section (75% and 87.5%); The lowest scoring subsections were sports nutrition for community population, nutrition students, and nutrition professionals (33.3%, 50%, 58.3%). The scores of the community population and nutrition student groups show that alcohol knowledge was quite high across sample populations. It was therefore unlikely that the alcohol knowledge found amongst athletes was entirely due to increased drinking culture associated with some sports (Scholes-Balog et al., 2016). The community population possess statistically significantly lower knowledge of sport specific nutrition (33.3%, p=0.028) or supplementation (41.7%, p=0.02) than athletes, indicating that athletes may be provided with or seek out information specific to these areas more than the community population.

Impact of demographic factors on NK

The second aim of this study was to examine the impact of a variety of demographic factors on NK, with specific attention given to the elite versus non-elite and individual versus team-sports factors.

Gender

The sample for this study was predominantly female, 80.3% (n=57). Due to the uneven recruitment of genders for this study, it was not possible to undertake any analysis regarding gender comparisons. The Heaney et al. (2011) systematic review found female NK scores were statistically significantly higher than male NK scores in four of nine studies. However, a 2016 systematic review suggested NK did not differ on the basis of gender (Trakman et al., 2016). Due to the inconsistency of previous results, it would be beneficial to conduct a study with a larger sample size to investigate potential gender differences.

Education level

The current study found a statistically significant difference of NK% scores between participants with different levels of education. Recent publications have found a statistically significant relationship between level of education and NK in Australian team-sport athletes (Jenner et al., 2020; Trakman, et al., 2018b). Recruitment for NK studies often occurs through universities (Abbey et al., 2017; Andrews et al., 2016; Hardy et al., 2017; Holden et al., 2018); therefore, participants in these studies often have a high education level making it difficult to assess education level as an impact on NK for athletes in these studies. A previous study found that education level had a significant influence on general NK scores in a study of Australian disability care workers ($p<0.0005$) (Hamzaid et al., 2018). These results suggest that general education level may have an effect on NK, possibly due to differences in comprehension and reading level. As the analysis of the current study included the total dataset, a significant relationship between education level and NK% scores for athletes in this study cannot be proven because individuals within this study sample with higher general education are also more likely to have undertaken formal nutrition education. Future studies may benefit from conducting this type of analysis in athlete and community population groups separately to identify potentially significant differences between groups, or conducting large studies powered to undertake multi-variate analyses.

Previous nutrition education

Prior formal nutrition education in the total dataset of this study was found to be a statistically significant indicator of NK. The athlete subgroups' prior nutrition education in this study was also a statistically significant factor. The current study aligns with previous findings from studies that used the NSKQ (Jenner et al., 2020; McCrink et al., 2020; Trakman et al., 2018b) indicating prior nutrition education impacted upon NK. Testing of general collegiate/student athlete sample groups in the Andrews et al. (2016) and Holden et al. (2018) publications resulted in no significant difference in NK between groups. However, testing of hydration-related NK collegiate American Football athletes (Judge et al., 2016) did result in a significant difference between groups of those with previous nutrition education and those without. Differences in results may be related to different tools used to assess NK between studies, as Andrews et al. (2016), Holden et al. (2018) and Judge et al. (2016) use different tools to Jenner et al. (2020), Jenner et al. (2018), and Trakman, et al. (2018b). Results from the current study suggest that nutrition education may impact general and sports NK, thereby proving that these types of studies exploring knowledge gaps in athletes, or any population groups, are necessary to create effective nutrition education programs, which assist in improvement of NK and dietary intake (Boidin et al., 2020; Mitchell et al., 2016). It may be beneficial to examine the effect of nutrition education on student/collegiate athletes by individual sport rather than looking at the group in general.

Age

The current study found a moderate positive, statistically significant correlation between age and NK in the total dataset. Previous studies from Argôlo et al. (2018) and Hendrie, Coveney et al. (2008) exploring age group differences have a statistically significant difference in NK, with the older group in both studies having higher NK scores than the younger group. However, Saribay and Kirbaş (2019) found no statistically significant relationship between age and NK in adolescent athletes in Turkey. The non-statistically significant result from Saribay and Kirbaş (2019) may have been due to the fact that the participants in their study were between the ages of 14 and 19 years. Studies which showed a significant difference in NK due to age had a wider range of ages – 18 to 35+ years (Hendrie, Coveney et al., 2008) or 10 to 56 years (Argôlo et al., 2018). This suggests that in order to detect significant correlations between age and NK, a broad age range is required. The current study has a narrow age range with a 95% CI of 29.4-35.0. Confounding factors may affect the relationship between age and NK, as older athletes had a higher level of education in our sample. Therefore, it would be beneficial to undertake an investigation into all possible cofounders in a larger study when an appropriately size sample can be recruited.

BMI

In the current study, there was no statistically significant correlation between NK% scores and BMI. A small number of study participants competed in weight-category sports, such as boxing, weightlifting, or martial arts (n=6). A recent study of Irish Dancers found that there was no statistically significant relationship between NK and BMI (Challis et al., 2020). A Chinese study of BMI's association with dietary knowledge and socioeconomic status found that BMI did not have a statistically significant relationship with dietary knowledge in groups of either low or high socioeconomic status (Yu et al., 2020). There was a positive association between BMI and general NK in female student and professional ballet dancers in the United Kingdom ($p=0.002$, $r=0.372$ and $p=0.04$, $r=0.567$ respectively) (Wyon et al., 2014). While these studies are in populations outside of Australia, they confirm that BMI and NK are not correlated in most populations. However, Wyon et al. (2014) found differences in populations. The significant association between BMI and general NK for ballet dancers may be closely attributed to the aesthetic factors associated with their sport/art, as well as requirements for control of weight. Relatively few studies have investigated correlation of BMI and NK% scores, possibly due to increased fat-free soft tissue making BMI an inappropriate indicator of health in many athletic populations. It was not possible to draw any conclusion regarding the current results, as the wide variety of sports included would have possible body composition variations that could not be accounted for in the current study. A recent study that investigated the relationship between fat-free mass and NK% scores found a positive correlation, and this relationship was strongest in elite athletes (Devlin et al., 2017), which indicates that an investigation of fat-free mass may be more appropriate than BMI. For the purposes of this study, an in-depth examination of body composition (via DXA scans) was not possible, future studies may benefit from such examination in relation to NK% scores.

Impact of athlete factors on NK

While some of the results discussed here are not statistically significant, this analysis was an important component of training associated with a Masters project. This study was underpowered, however, these results are discussed to demonstrate understanding of the issues surrounding this project.

Team versus individual sport

Individual-sport athletes had higher median NK% scores than team-sport athletes although this difference was not statistically significant, which partially supports the hypothesis of individual-sport athletes having higher NK than team-sport athletes. In a recent study, athletes participating in individual sports had statistically significantly higher NK% scores than athletes competing in team sports (p=0.043) (Weeden et al., 2014). Another study examining Australian athletes found that there was no statistically significant difference between athletes participating in a team or individual sport (Spendlove et al., 2012). It is possible that individual sports require a greater level of self-motivation than team sports or that a greater proportion of individual sports are weight based compared to team sports. The difference in results between the current study and the Weeden et al. (2014) study could be related to the small athlete sample size of the current study or the study population being examined, as Weeden et al.'s study had a larger sample size (n=174) and examined collegiate students within the western United States. The athletes included within the current study may have various levels of education, as well as various levels of nutrition education, while athletes within the Weeden et al. (2014) study were all students at a university level. As has been suggested by the current study, level of education can be a significant factor in NK level. These results imply that participation in different types of sport (team versus individual) likely does not impact level of NK. However, participants in the current study were not demographically matched between groups. Future studies would benefit from completion of regression analysis to identify impact of confounders.

Elite versus non-elite

Elite athletes' median NK% scores were higher than non-elite athletes, although this difference was not statistically significant different; these results did not agree with the hypothesis of non-elite athletes having higher NK than elite athletes. It is possible that elite athletes would not require a high level of NK due to the presence of club dietitians, as well as club-provided food in some circumstances. Recent studies in Australian team sports report no statistically significant difference between elite and non-elite athletes (Andrews & Itsiopoulos, 2016; Devlin et al., 2017; Lohman et al., 2019). However, one recent study by Trakman et al. (2018b) using the NSKQ found that non-elite Australian football athletes had a statistically significantly higher NK score than their elite counterparts. Study findings could be different due to the tool used to measure the NK scores of athletes or may be due to the fact that athletes included in the current study were not specifically team-sport athletes, but rather general 'athletes'. Due to the disagreement of findings, future studies should examine larger samples of sports outside Australian football athletes using the NSKQ to determine if a significant difference occurs on a sport-by-sport basis.

Hours training per week

The difference between NK level groups and hours spent training per week in the current study was not statistically significant. It was assumed that more hours spent training per week would correlate with more experienced athletes, who would have greater exposure to nutrition support and the advice of teammates resulting in greater NK; it is also possible that a greater interest in physical activity may correlate with greater interesting in NK. A recent study looking at NK specific to supplementation doping found no statistically significant difference between hours trained per week and NK (Balaravi et al., 2017). Demographic information concerning the number of hours spent training has been gathered within previous studies (Andrews & Itsiopoulos, 2016; Argôlo et al., 2018; Blennerhassett et al., 2019; Nascimento et al., 2016; Simpson et al., 2017; Trakman et al., 2018a; Trakman et al., 2018b). However, recent studies have not investigated a correlation between number of hours spent training per week and NK% score. Ideally, it would be possible to investigate demographic factors that impact NK, including hours training per week. However, it would be necessary to employ regression model testing to determine the impact of such demographic factors on NK, because hours training is likely to be associated with other demographic factors. The current study was not appropriately powered for this type of analysis.

Years' experience in sport

The current study found no statistically significant relationship between NK level groups and number of years' experience in sport. Previous studies agree with these findings with no statistically significant association between NK and number of years participating in sport (Jenner et al., 2020; Saribay & Kirbaş, 2019). These results imply that athletes do not gather significant amounts of NK with prolonged immersion in sport. Study findings should be further explored with a larger sample population to confirm that this relationship between years in sport and NK is not statistically significant. It may be beneficial to investigate the possibility that athletes rely on nutrition recommendations that are no longer valid.

Supplement Use

The current study found no significant differences in NK% scores between participants who did not consume supplements and those who did (the total dataset p=0.361 and the athlete subgroup p=0.325), which does not confirm the hypothesis that those consuming supplements would have higher NK than those who do not. Recent findings have shown a difference between supplement knowledge scores and supplement use, with those consuming supplements having higher supplement knowledge (Balaravi et al., 2017). Sekulic et al. (2019) found that general NK and supplement knowledge was a predictor for supplement use in team-sport athletes in South-eastern Europe. This difference in results could be attributed to the use of different tools for measurement of NK, the difference in population types participating in each study, or difference in supplements investigated (as discussed below). Results regarding this portion of the study were inconclusive. Future studies in this area may benefit from a larger sample size.

The types of supplements consumed by athletes can be assessed for appropriateness based on the AIS Sports Framework (AIS, 2021). Group A supplements include sports foods, medical supplements, and performance supplements "… for use in specific situations in sport using evidence-based protocols". (AIS, 2021, p. 5). Athlete participants flagged Group A supplements as part of their supplement use 23 times. Group B supplements include supplements that require further research before they can be recommended for wider use (AIS, 2021, p. 5). Athletes flagged Group B supplements in their supplement regime three times. Ten mentions were made of other supplements not included in AIS documentation, meaning these supplements are most likely included in Group C; this class included supplements which "scientific evidence [is] not support of benefit amongst athletes". (AIS, 2021, p. 6). The majority of supplements consumed by athletes (63.9%) were Class A supplements, which indicates athletes are largely consuming supplements that have been deemed as appropriate for athlete consumption. However, existing literature indicates that athletes typically have poor NK concerning supplements (Jenner et al., 2020; McCrink et al., 2020; Trakman et al., 2018b). The median NK% score was not statistically significantly different between those athletes consuming supplements and those who do not, suggesting that athletes may not have complete comprehension of supplementation possibilities, benefits, and risks. The current study did not gather data on existing deficiencies or methods of supplement use to determine appropriateness of supplement use; therefore, it was not possible to determine which supplements were necessary due to deficiency or being used according to recommendations. It would be interesting to investigate NK% scores based on evidence-based and non-evidence-based supplement intake; however, it was not possible to complete this analysis due to the wide variety of supplements used by individuals.

Twenty-two supplement occurrences were associated with nutrition students, one was associated with a nutrition professional, and community population supplement use comprised the remaining 18 supplement occurrences. Data collection did not confirm supplement recommendation by a medical or dietetics professional, making suitability of each supplement for intake difficult to determine. While suitability of supplements for the community population members cannot be determined from the data collected, the difference in median NK% scores between those who consumed supplements and those who did not in this group was also not statistically significant. This suggests that the pitfalls of supplement use that athletes are susceptible to also applies to the community population, as found in a study in Karachi (Qidwai et al., 2012).

Special diet

There was no statistically significant difference in median NK% scores or relevant subsection scores between those who consume a special diet and those who do not; these results do not confirm the initial assumption regarding athletes consuming a special diet having higher NK than those who did not. Fad diets may correlate with higher presumed NK but lower actual NK; this hypothesis requires further investigation in a larger sample size. No recent studies have investigated NK in relation to a specific, non-conventional diet to the author's knowledge. Many studies have investigated the impact of diet on athletic performance (Burke et al., 2006; Burke et al., 2003; Reale et al., 2017; Routledge et al., 2020).

Some special diets (such as ketogenic diet, or veganism) are restrictive in nature - restricting or removing one or more food groups or types of food from a diet. Vegan diets, if not properly planned, could lead to various possible dietary issues in athletes and recreational exercisers, including Vitamin D, energy, protein, long-chain *n*-3, iron, zinc, riboflavin, fat, B12, calcium, or iodine deficiencies (Rogerson, 2017). Other diets that restrict different food groups may lead to different deficiencies or performance impairment. Athletes' poor understanding of nutrition in general, and weight management, macronutrients, and micronutrients specifically, may cause vulnerability to these deficiencies while consuming special diets.

A previous systematic review found some positive associations between NK and dietary intake in athletes, 77.8% (Heaney et al., 2011) and 71.4% of included studies with positive correlations between NK and positive dietary behaviours (Spronk et al., 2014). The results of this study suggest that athletes consuming a special diet may not have the NK to maintain appropriate intake of necessary vitamins and minerals to maintain health and athletic performance. Further study in this area would be beneficial to determine if this similarity in NK would be maintained in a larger sample, as such a sample may assist in creation of a nutrition education program for athletes consuming a special diet.

Strengths

This study benchmarked NK of athletes against other populations provided context for these NK% scores, offering an understanding of the areas where athletes' NK differed from the benchmarked populations; this had not been done in an athletic population previously. The use of an up-to-date tool that was validated in Australian athlete populations (NSKQ) ensured the validity of these NK% scores in the tested sample. A large number of sporting groups were contacted for participation in this study (See Appendix B). The inclusion of athletes from both team and individual type sports provided information concerning a general group of Australian athletes, which had not recently been tested in this type of study.

Limitations

There were a number of limitations associated with this study.

Recent studies have demonstrated that athletes often have a lowest score in sections related to supplementation (Jenner et al., 2018; Lohman et al., 2019; Madrigal et al., 2016). However, studies that included subsections regarding alcohol knowledge in athletes demonstrated that understanding for this section could range between the highest scoring section (Jenner et al., 2020; Trakman et al., 2018b), the second highest scoring section (Jenner et al., 2018; Trakman et al., 2018b), or the lowest scoring section (Devlin et al., 2017). These studies have utilised two differing tools, with the high scores being achieved within the NSKQ and the lowest scores being achieved within the Food and Nutrition Knowledge Questionnaire (FNKQ) (Devlin & Belski, 2015).Therefore, a consistently lower score may be due to lack of alcohol-related NK, may be due to the tool used to measure that NK, or due to responder fatigue as the alcohol-related questions occur at the end of the NSKQ.

The NSKQ was used due to the requirement for in-depth data regarding knowledge gaps related to supplementation and special diet intake. However, participant burden caused by the longer NSKQ could have led to a reduced completion rate. Trakman et al. (2018a) found that use of an abridged version of the NSKQ increased the completion rate from 54% (unabridged) to 85% (abridged). This indicates that low completion rate for this study (66.4%) may be related to the length of the survey. No true conclusions can be drawn regarding this due to the small sample size and insufficient statistical testing. Of the 36 participants who did not complete the study, 13 participants exited the survey on a question related to their participation in sport, which may indicate this question could require modification in future iterations of this survey. Piloting this study with a small group of participants to gather feedback on wording and possible changes may improve completion rates.

A high percentage of participants who did not complete the survey exited before completing demographic data collection (69.4%), indicating that the demographic data collection may have been problematic for those participants. The data collected does not provide information regarding what issue participants had with this section. It may be beneficial to re-examine the content, style, and placement of questions within this section for future use. While it does not appear that there was responder fatigue associated with the length of the questionnaire, this cannot be determined with the testing and results shown within this study.

This study was underpowered according to power calculations provided in the methods. Recruitment of enough participants may have been hampered by the advent of COVID-19 during the data collection period of this study. Due to government requirements during this time, many sporting facilities were closed. This may have caused disruption to athlete training schedules, as athletes were unable to attend regular sporting facilities and training. Some sporting organisations contacted noted increased requests regarding research participation related to COVID-19. Prior commitments to other research opportunities led club officials to decline participation in further research that may burden their athletes in an already stressful time. Due to the small sample size of this study, this study sample is likely unrepresentative of the target population, making results non-generalisable.

A limitation and strength of this study was that athlete participants competed in a wide variety of sports. Due to the small sample size, it was not possible to complete statistical testing by sport, but rather testing was completed by type of sport and level of sport played. This limits generalisability of these results to athletes in particular sports. Similarly, as a smaller percentage of males completed the study compared to females, this sample was not likely to be representative of athlete population. It was also not possible to complete gender comparisons as part of this study. The wide variety of sports represented is also a strength of this study due to the inclusion of athletes with varying sport nutrition and performance requirements.

Due to the method of recruitment, it was not possible to calculate a response rate for this survey. This presents difficulties with assessing uptake of the survey when compared to other similar studies, which may indicate non-response bias. As the questionnaire for this study was completed unobserved, this introduces the possibility of self-reporting bias with participants being able to look up answers. This bias appears to be unlikely based on the average completion time of the questionnaire. It should also be noted that the cross-sectional, observational study design designated as a level IV on the NHMRC levels of evidence (Commonwealth of Australia, 2000) limits this study to exploratory evidence.

The sampling methods utilised for this study may bias responders, as participants are more likely to have an active interest in nutrition and having their knowledge assessed. The sample contained more females than males, which could be related to the fact that females are generally more interested in their health than males (Hendrie, Cox et al., 2008).

In order to probe for possible responder fatigue, Paired t-tests or Wilcoxon-Signed rank tests were planned to compare various factors such as total score vs. macronutrients, total score vs. weight, and total score vs. micronutrients. These results would then be evaluated for greater difference in later sections. However, it was not possible to complete this testing due to the study being underpowered.

Implications

Athletes may not have the NK to assist in making healthy dietary choices for recovery and athletic performance. As athletes' NK of macronutrients and micronutrients was poor, this may result in an inability to follow recommendations for dietary intake in athletes, regardless of awareness of recommendations. As athletes and community population members had similar levels of total NK, it was possible that athletes and community population members had received similar minimal education. However, the athlete group in this study had higher NK over the community population members with regards to macronutrients, sports nutrition, supplementation, and alcohol, indicating that athlete NK was different (although not always significantly) to community population members. Differences between elite and non-elite athletes did not align with initial hypothesis, nor did the differences between groups for supplement intake. Although these differences were not statistically significant, this merits further investigation, along with other inconclusive demographic results in this study. By understanding the current state of NK in athletes, sports nutrition professionals may be better placed to provide appropriate nutrition education and support to their athletes to improve and maintain their athletic performance.

From these results, it can be seen that age, education level, and nutrition education likely correlate with NK scores across all sports. These factors themselves are likely to be highly correlated. Other factors such as BMI, number of years in sport, number of hour training per week, elite versus non-elite, team versus individual sports, supplement use, and special diet did not achieve statistical significance for a general athlete group; however, this does not negate the possibility that these factors may be significant for specific sports or in larger study populations.

Directions for future study

Future studies may benefit from targeted assessment of knowledge gaps in athletes, by examining individual question correct response rates to identify areas where nutrition education could be improved. It may also be beneficial to perform a qualitative study with athletes to determine how best to close these knowledge gaps with nutrition education programs. As recent studies were not found regarding the relationship between special diets and NK% scores, future studies may benefit from examining athletes/general population members voluntarily consuming special diets and their NK% scores, as well as examining supplement intake and NK% scores in Australian athletes. In order to ensure generalisability of results, larger study sample sizes should be employed for future studies.

Further examination of modifiable factors that influence dietary intake could provide further understanding of the interplay of these factors. NK is only one factor that influences dietary intake/food choices in athletes (Birkenhead & Slater, 2015). It is necessary to examine NK in combination within the context of other environmental, community, and individual factors that are known to influence food choice in athletes (Birkenhead & Slater, 2015).

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Conflicts of Interest

The author declares no conflicts of interest in relation to this study or the results reported herein.

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Chapter Three: Modifiable factors that impact dietary intake – rapid review of systematic reviews

Preface

This rapid review of systematic reviews was conducted as part of the transition to a Masters of Science. The inclusion of the four modifiable factors (nutrition knowledge, hedonic hunger, macronutrient balance, and body image and weight control) meant that a review of all original research related to these factors and dietary intake was not feasible in the time available. Therefore, it was necessary to examine systematic reviews related to the modifiable factors being investigated. The review was necessary in order to explore the existing research surrounding these modifiable factors and ensure that a study exploring all four modifiable factors had not previously been conducted.

Referencing style used here is APA 7 in accordance with discipline recommendations.

Introduction

Many studies have explored the impact of diet on athletic performance, leading to published sports nutrition recommendations (Thomas et al., 2016). However, motivation to enhance performance is only one driver of dietary intake in athletes and there are other factors influencing individual dietary choices (Birkenhead & Slater, 2015). Due to the importance of diet for athletic performance, it is important to understand which factors influence dietary intake in athletes.

A theoretical framework of factors influencing dietary intake in athletes was developed by Birkenhead and Slater (2015) and subsequently expanded upon by other researchers (Devlin, 2016; Jenner et al., 2021; Trakman, 2018). The Birkenhead and Slater (2015) narrative review identified a range of factors influencing athlete food choices, which were broadly categorized as: physiological and biological (hunger and appetite; macronutrient balance; fat-free mass, resting metabolic rate, and hunger; taste and food preferences; gastrointestinal discomfort); lifestyle, beliefs and knowledge (lifestyle and motives for participating in sport; health beliefs; nutrition knowledge (NK)); psychological (body image and weight control; hedonic hunger); social (availability, social facilitation, and marketing; culture and religion); and economic (cost and income).

Devlin (2016) noted factors that may be more modifiable by accredited sports dietitians, including NK, attitudes, nutrition goals, and body composition, considering genetics while providing advice. Trakman (2018) classified the factors presented by Birkenhead and Slater (2015) from the perspective of a dietitian and described the factors influencing dietary intake in athletes as modifiable, semi-modifiable, and non-modifiable factors. Trakman (2018) identified four factors as being modifiable by a nutrition professional, including NK, body image and weight control, hedonic hunger, and macronutrient balance; these factors can be influenced by tailored education programs or counselling sessions. In a recent qualitative study with Australian football players (Jenner et al., 2021), players identified four categories of factors that may influence their dietary intake that roughly align with previous studies, which were NK and support, concerns around body composition assessment (i.e. body image) and body composition goals, interpersonal factors (e.g. mood and peers, family) and stage of competition seasonal changes. Several studies have assessed the influence of some of the aforementioned factors on dietary intake. In particular research has been published on: NK, hedonic hunger, macronutrient balance, weight control and body image.

NK is the cognitive process related to understanding nutrition recommendations. NK in athletes is one factor that has been explored extensively across an array of studies, with many studies looking at NK in isolation, and others assessing the relationship between NK and dietary intake (Andrews & Itsiopoulos, 2016; Blennerhassett et al., 2019; Holden et al., 2018; Jenner et al., 2020). Systematic reviews exploring the NK of athletes have found that studies exploring NK often use tools that are out of date or not properly validated, with scores provided without context; while this has improved in recent years, this lack of up-to-date, validated tools to measure NK still acts as a limitation for many current studies (Janiczak et al., 2021; Trakman et al., 2016). Studies exploring the relationship between NK and dietary intake have found weak-to-moderate, positive correlations between NK and positive dietary behaviours (Andrews & Itsiopoulos, 2016; Argôlo et al., 2018; Devlin et al., 2017; Hardy et al., 2017; Jenner et al., 2018; Murphy & O'Reilly, 2020).

Hedonic hunger is the desire to consume food to experience the pleasure associated with its taste (Birkenhead & Slater, 2015). Studies which have looked at hunger and dietary intake examined how exercise may impact serum hormone levels, found significant reductions in blood ghrelin levels after exercise in long-distance runners, sprint athletes, and male power-athletes (Kojima et al., 2016; Kojima et al., 2019; Oshima et al., 2017). A 2019 review of disinhibition in the general population (Bryant et al., 2019) found that individuals with greater levels of disinhibition exhibited poorer dietary behavior, and more impulsive response to palatable foods, suggesting hedonic hunger influences dietary intake in these individuals; lean individuals did not demonstrate a significant relationship between disinhibition and eating without hunger. Ayaz et al. (2018) found that food-addicted females in the general population were found to have significantly higher intakes of energy, protein, fat, fibre, and micronutrients than females with no food addiction. Importantly, studies which have examined hedonic hunger are often completed within the general population or overweight/obese populations rather than athlete populations.

Macronutrient balance refers to the proportion of total energy intake consumed as carbohydrate, protein, and fat. Athletes may require more protein and carbohydrates according to recommendations (Thomas et al., 2016); however, it is still possible for these requirements to fit within the Acceptable Macronutrient Distribution Range (AMDR) for the general population (National Health and Medical Research Council, 2014). Macronutrient intakes have been widely examined in athletes (Antonio, 2019; Black et al., 2018; Colombani et al., 2013; Helms et al., 2014; Pochmuller et al., 2016). However, it is important to note that studies examined athlete macronutrient intake in relation to the recommended intakes for athletes (Aerenhouts et al., 2011; Black et al., 2018) and improvement in performance due to differing intakes of macronutrients (Anderson et al., 2017; Born et al., 2019; Campbell et al., 2018; Casazza et al., 2018; Colombani et al., 2013; Di Girolamo et al., 2017; Greene et al., 2018; Hansen et al., 2016). None of these studies have directly examined the effect that macronutrient balance has on dietary intake in athletes. However, it has been found that replacing protein with carbohydrate (CHO) in drinks led to faster gastric emptying, while higher protein content increased gut hormone response and increased effectiveness of insulin responses (Giezenaar et al., 2018). The slower gastric emptying associated with protein consumption may lead to prolonged feelings of fullness, which in turn may reduce caloric intake overall (Hutchison et al., 2015).

Body image is “Individuals’ self-perception and attitudes (e.g., thoughts, feelings) about their body.” (Petrie & Greenleaf, 2012, p. 160) Body image and weight control are thought to influence dietary intake in athletes due to the increased awareness of physique in weight-class based sports and the belief that improved physique may benefit athletic performance (Birkenhead & Slater, 2015). Plateau et al. (2017) found that retired athletes often expressed a need to relearn internal hunger and satiety signals and how to eat in a healthy manner in isolation of extreme exercise, as well as recognizing that they were able to eat with less restrictions. This relationship with body image and weight control in athletes is often engrained at a young age. A 2016 study (Berkovich et al., 2016) found that 80% of adolescent judo athletes used rapid weight loss prior to competition, including methods such as increasing physical activity, skipping meals, and fasting.

In recent years, there have been a number of studies which have examined the modifiable factors of nutrition knowledge, macronutrient balance, hedonic hunger, and body image and weight control on dietary intake in athletes (Anyzewska et al., 2018; Baker et al., 2014; Devlin et al., 2016; Martinez-Rodriguez & Roche, 2017). While all these factors in some way influence athlete food choices, it is not known to what degree these factors may influence food choices individually or in concert, and whether the impact of each factor varies between individuals based on person-factors such as age and gender. Moreover, there have been no reviews to date that collate all modifiable factors with dietary intake to confirm the frameworks proposed by Birkenhead and Slater (2015), Devlin (2016), Trakman et al. (2016), and Jenner et al. (2020). A greater understanding of the factors influencing athletes’ dietary intakes will support the development of practical strategies promoting recommended dietary practices. The aim of this rapid review was to investigate the relationship between dietary intake and the modifiable factors of macronutrient balance, NK, hedonic hunger, and body image and weight control in athletes or active people. The expected outcomes of this review were that there would be small, moderate relationships in any direction between several factors and dietary intake.

Materials and Methods

This rapid systematic literature review was conducted following the PRISMA guidelines under the guidance of the WHO Rapid Review Guidelines and the Cochrane Rapid Review Guidelines (Garritty et al., 2020; Page et al., 2021; Tricco et al., 2017). For further information regarding the protocol for this rapid review, PROSPERO protocol registration ID CRD42021243169.

Inclusion and Exclusion Criteria

In order to be included in this rapid systematic literature review, studies were required to fulfil eligibility criteria as outlined in Table 1.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria	**Exclusion Criteria**
Reviews must examine the relationship between dietary intake in athletes or exercisers and at least one of the modifiable factors of hedonic hunger, macronutrient balance, NK, and body image and weight control.	Any review which examines one of the modifiable factors of hedonic hunger, macronutrient balance, NK and body image and weight control without examining the relationship with dietary intake.
Systematic reviews of cross-sectional studies, before-after studies, and randomised controlled trials.	Original research (cross-sectional studies, before-after studies, randomised controlled trials), abstracts, conference posters, narrative reviews, editorials, honours/masters/doctoral theses, and other reports that have not been peer reviewed.
Athletes or exercisers of any level.	Qualitative studies.
Healthy participants 17 years or older.	Children under 17 years of age or non-athletes, unless results for athletes of an appropriate age are reported separately within the study.
	Individuals suffering from a disorder which may act as a confounder for the factor being measured (e.g. eating disorders).

Search Method

One reviewer (AJ) searched MEDLINE, CINAHL, and SPORTDiscus databases for relevant articles. The search terms Dietary Intake, Athlete/exerciser, Hedonic Hunger, Macronutrient Balance, Nutrition Knowledge, Body Image, and Weight Control were mapped to the Medline Subject Headings of EATING, ATHLETE, HUNGER, DIETARY PROTEINS/FATS/CARBOHYDRATES, NUTRITIONAL SCIENCES, BODY IMAGE, and BODY WEIGHT, respectively. The following keywords were searched: Sport* OR Athlete* OR Exerciser* AND "Dietary intake*" AND (("Hedonic hunger" OR Appetite) OR ("Macronutrient balance*" OR "Macronutrient ratio*") OR ("Sport nutrition knowledge" OR "General nutrition knowledge" OR "Nutrition knowledge") OR ("Body image") OR ("Weight control" OR "Weight change")). The syntax of these search terms was adapted for use in other databases. 'Peer Reviewed' limits were applied in CINAHL and SPORTDiscus. English language limitations were applied to all searches. No age limits were applied to the searches. The searches included all papers from database inception to March 2021. Articles with participants 17 years and under were excluded manually. As per rapid review guidelines, papers which were unavailable through La Trobe University Library and database subscriptions were not included in this review and reference lists were not searched for additional articles.

Screening Process

Data extraction was completed in two phases: title/abstract and full-text screening. One reviewer (AJ) screened all abstracts. GT screened 20% of abstracts to minimise risk of selection bias (Garritty et al., 2020; Tricco et al., 2017). Conflicts were resolved via discussion of results. One reviewer (AJ) screened the remaining abstracts. For full-text screening, AJ and GT screened all included full-text articles independently, with any conflicts resolved via discussion of results.

Data Extraction

Data was extracted by one reviewer (AJ) and checked by a second reviewer (GT). Any conflicts were discussed between the three reviewers to reach consensus (AJ, GT, and AF). A purpose-designed Google spreadsheet was formatted and used to extract data from the included reviews. The data extracted included:

- Review information (paper title, authors, year published, DOI/URL, country of publication, registration details of the review protocol)
- Basic study information (aim, number of studies included, inclusion and exclusion, date range, design of primary studies included, study population)
- Dietary intake tool information (item generation, number and type of questions, response format)
- Secondary outcome information (modifiable factor measured, tools used, response format)
- Participant demographics (total number, presence of comparator group, gender, age, other demographics if collected, such as type of sport played, ethnicity and education level)
- Main findings (description of the intervention and the control conditions, outcomes and details of key findings (summary and quantitative pooled results if available))
- Quality assessment (tool used, methodological quality of studies results)

Quality Assessment

The quality of individual reviews was assessed using the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses (Aromataris et al., 2015). This checklist contains eleven criteria examining the clarity of the review question, appropriateness of inclusion criteria, search strategy, sources and resources, appraisal techniques, data extraction techniques and synthesis techniques, as well as assessing bias and recommendations. Possible responses were 'yes', 'no', or 'unclear', with reviews receiving one point for each question answered ‘yes’ and zero points for each question answered ‘no’ or ‘unclear. Scores for most reviews were out of 11, except for papers that were not designed to provide policy and/or practice recommendations, which were scored out of ten. Total percentages were then calculated for each review to determine quality.

Two reviewers (AJ and GT) completed the JBI Critical Appraisal Checklists independently, with discrepancies between assessments discussed to reach a conclusion. Results of the quality assessment did not act as a method of exclusion from the review.

Analysis

Data for each review was tabulated to provide an overview of findings and quality assessment for each review. Synthesis for this systematic literature review was narrative with no meta-analysis due to the heterogeneity of outcomes being assessed.

Results

A total of 1240 papers were retrieved with the initial database search. After excluding duplicates (n=266), 974 articles were included for abstract and title screening, with 42 articles eligible for full-text screening. Information on the selection process is presented below (Fig. 1). One article ("Perfectionism and Dieting in College Athletes," 2020) could not be retrieved for full-text screening through university subscription. Full-text screening resulted in eight papers to be included for data extraction. Three of these papers were removed during the data extraction process when they were identified as not meeting selection criteria for eligibility (Beaulieu et al., 2016; Noll et al., 2017; Panao & Carraca, 2020).

Study characteristics

One review included both athlete and community populations (Spronk et al., 2014) with the remaining reviews including athletes only (n=4) (Table 2). The total number of participants included in all studies was 34,444. Spronk et al. (2014) reported community and athlete populations separately. The community population in the Spronk et al. (2014) review consisted of 23,725 participants, with mean ages ranging from 18 (SD not provided) and 76 (SD = 5.9). The athlete/retired athlete population across all reviews included 10,719 participants, with a youngest mean age of 10 (SD = 3.2) (Samadi et al., 2019) and an oldest mean age of 50.7 (SD = 15.1) (Buckley et al., 2019). Regions respresented in the original studies included in reviews were Americas (45), Asia (6), Europe (39), Oceania (4), and Africa (1). Heaney et al. (2011) did not provide information on the original countries represented. A number of sport types are represented across reviews, including team (13) and individual sports (57), with some reviews reporting studies with mixed sports (22), various sports (5), or no sport specified (2). Spronk et al. (2014) did not provide a breakdown of sports types included in the review.

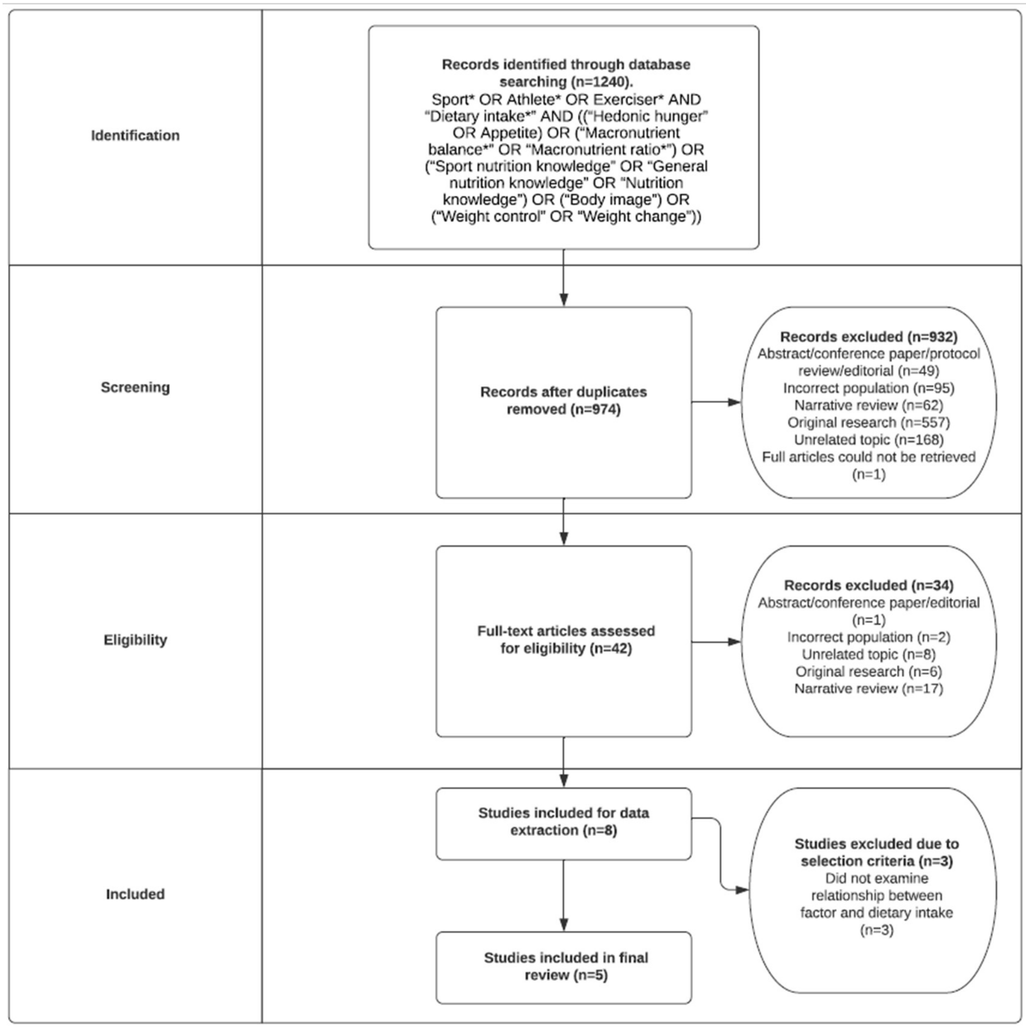

Figure 1 Flow chart for selection process

Table 2. Data extraction table of study design and characteristic information from included reviews

Authors (Year), and Review Registration	Date Range & Number of studies included	Aim	Inclusion/Exclusion	Design of primary studies	Study population (total number of participants), Gender, and Age	Comparator groups
NK						
Boidin et al. (2020) CRD42018083952	Inception to June 2019, 22	Investigate nutrition education interventions' relationship with dietary intake in athletes. Compare different education delivery modalities.	Inclusion - randomised controlled trials, quasi-experimental, and pre-post interventions - athletes (male and female, between 12 and 65, all sports, all athletic levels) - Interventions including individual/group counselling/education, in person or virtual modalities included IF primary outcome (change in dietary intake (energy, macronutrients, micronutrients, and /or food groups, diet quality/index) reported quantitatively. Exclusion -abstracts and studies not reported in English	Single arm - intervention group only (n=12) Double arm - intervention and control (n=10)	Athletes between the ages of 12 and 65 (965) 80.5% female Mean age - 19.8	Control groups in double arm studies (those not included in nutrition education programs)
Heaney et al. (2011) Not mentioned	Inception to March 2010, 29	Systematically review NK in athletes and its association with dietary intake.	Inclusion -original research - human participants - English - measurement of general or overall sport-NK via a standardised instrument (reported as quantitative measure) - athletes - 13 years or older - any gender, able-bodied athletes, athletes with non-intellectual disabilities - dietary intake assessed using a quantitative outcome measure (nutrient intake, food groups, quantitatively derived score rating diet intake)	Not described	Athletes ages 13+ (3191) 1651 Female means of 14.9 ±1.8 and 30 ± 7.6	Non-athletes

			Exclusion - studies measuring NK in coaches, athletics trainers, dancers, or nonathletes - studies limiting NK measurement to one particular topic			
Spronk et al. (2014) Not mentioned	Inception - November 2012, 29	Systematically review evidence on the relationship between NK and dietary intake across all populations	Inclusion - original research (randomised controlled trials, cross-sectional, and quasi-experimental designs - adults (18+) - human participants - peer-reviewed - all population groups - any language - use an instrument that provided a quantitative assessment of NK (reporting participant scores) - quantitative assessment for dietary intake also required (intake of one or more nutrients, consumption of servings, or a diet quality score or index) - examine the association between NK and dietary intake using statistical analysis Exclusion - abstracts, reviews, reports, and theses	randomised controlled trials, cross-sectional studies, and quasi-experimental designs	Athletic (7) and community (22) populations (24234) Mixed-sex samples (13) Women (4) Men (1) Gender not identified (1) 77% women, 23% men Athletes - Males (1), Female (3), mixed-sex (3) 18-97 Seven studies ≥50 years athletes - between 17 and 28	Community populations (22)
Body image and body dissatisfaction						
Buckley et al. (2019) CRD42018106470	Inception to August 2018, 16	Investigate the relationship individuals have with food and their bodies after retiring from competitive sport.	Inclusion English language peer-reviewed journals studies with participants including male or female retired athletes describe dietary behaviours and outcomes studies referring to either: eating behaviours with or without body image/body dissatisfaction	Cross-sectional/cohort (8), Mixed methodology (4), Qualitative (4)	Retired athletes (2588) Gender not discussed Mean/median age not provided for all studies	1 study - general population

			Exclusion studies referring exclusively to the body full text not available only reference made to food or body occurred from the lens of retired athletes using retrospection of their athletic career aforementioned outcomes were not included in the study results			
Weight loss						
Samadi et al. (2019) Not mentioned	2001-2017, 17	Review evidence on prevalence and types of RWL, high-risk behaviours, dietary intake and anthropometric data in combat sports.	Inclusion - descriptive-analytical, case-control, and cross-sectional studies - studies assessing effects of RWL behaviours on food intake and anthropometric measurements Exclusion - review, meta-analysis, randomised clinical trial, letters, comments, short communications, ecological studies, and animal studies	Descriptive-analytical, Case-control, and Cross-sectional studies	Athletes (3466) Both genders n= 5, Men n=5, Gender not provided n=12 Adolescents (9), adults (5), adults and adolescents (3)	Not identified

Notes. NK, nutrition knowledge

The modifiable factors included within the papers.

Three of the included reviews investigated NK in relation to dietary intake in athletes (Boidin et al., 2020; Heaney et al., 2011; Spronk et al., 2014), with one study examining specifically the change in NK due to education interventions (Boidin et al., 2020). Body image and body dissatisfaction in relation to dietary intake in athletes was investigated within one review (Buckley et al., 2019). One review examined weight loss in relation to dietary intake in combat sport athletes, looking specifically at high-risk rapid weight loss behaviours (Samadi et al., 2019), although no included reviews investigated the relationship between weight control in athletes and dietary intake. The relationship between hedonic hunger and dietary intake in athletes was not examined in any included reviews; nor was the relationship between macronutrient balance and dietary intake in athletes.

NK

NK in athletes was measured via questionnaires for the majority of studies within two of the included reviews, with some studies not reporting the tool used for NK measurement (Heaney et al., 2011; Spronk et al., 2014). The Heaney et al. (2011) review found that the majority of athlete NK scores exceeded 50% within studies (19 out of 22 studies), with athletes usually scoring higher than comparison groups (five out of seven) unless comparison groups included nutrition students (two of seven). The Spronk et al. (2014) review was focused upon the relationship between NK and dietary intake, without reporting the NK scores from individual studies. The Boidin et al. (2020) review does not provide measurements of NK, instead gathering information on nutrition education programs and changes to dietary intake pre and post intervention.

NK vs dietary intake

Three of the included reviews (Boidin et al., 2020; Heaney et al., 2011; Spronk et al., 2014) investigated NK in relation to dietary intake in athletes. These reviews examined differing aspects of NK in relation to dietary intake, which makes it inappropriate to combine the results of these reviews statistically (See Table 3). Positive associations were found between NK and dietary intake in two of the included reviews (Heaney et al., 2011; Spronk et al., 2014). The Spronk et al. (2014) review found most studies looking at athletes (five out of seven) had a weak, positive association between NK and positive dietary behaviours ($p < 0.44$), while those studies with a community sample comparator found weak, positive associations between NK and dietary intake in 14 out of 22 studies ($p < 0.5$) and no significant association in 8 of 22 studies. Heaney et al. (2011) reported weak positive associations (individual correlations $r < 0.44$) between NK and dietary intake in five out of nine studies. Boidin et al. (2020) found diet improved via significant increases in post intervention energy intake (6/7 single-arm studies, effect size (ES) 0.4-2.3; $p<0.05$) and within intervention groups in energy intake (2/4 double-arm studies, ES 0·4–0·8; $p<0.05$); carbohydrate intake increased post-intervention (4/8 single-arm studies, ES 0.7-2.4; $p<0.05$) and large significant increases in intervention groups (2/5 double-arm studies, ES 1.4-1.8; $p< 0.05$); results for protein intake were variable across included double-arm studies with protein intake increased in two studies and decreased in two studies, while 6/10 single-arm studies met protein intake requirements post-intervention.

Table 3. Outcomes for NK or education interventions in relation to dietary intake

Review	Study types	Outcomes
Boidin et al. (2020)	Intervention studies (n=22) - Single-arm studies (n=12) - Double-arm studies (n=10)	Inconsistent dietary changes. Single-arm studies - 5/12 studies change in ≥1 nutrition parameter Double-arm studies - 9/10 studies change in ≥1 nutrition parameter
Heaney et al. (2011)	Cross-sectional studies	Weak, positive association between NK and dietary intake (5/9 studies)
Spronk et al. (2014)	Randomised controlled trials, cross-sectional studies, and quasi-experimental designs.	Weak, positive association between NK and positive dietary behaviours (5/7 studies)

Note. NK, nutrition knowledge.

Body image and body dissatisfaction

Body image and body dissatisfaction of retired athletes was investigated in one systematic literature review (Buckley et al., 2019). A thematic analysis of included body image and body dissatisfaction studies found three main themes from papers included in the review: body dissatisfaction and grief, disordered eating and compensation, and long-term influence of sporting culture. Body dissatisfaction and grief was most often evident in recently retired athletes, with change in body composition leading to body dissatisfaction in 55% of healthy weight ex-gymnasts and swimmers (Buckley et al., 2019). The long-term influence of sporting culture is related to continuing athletic group identification and the various difficulties experienced throughout the individual's athletic career, with those experiencing career dissatisfaction being 2.4 times more likely to develop eating disorder symptoms during retirement (Buckley et al., 2019).

Body image and body dissatisfaction vs. dietary intake

The Buckley et al. (2019) review included four studies exploring adverse nutrition behaviours (binge eating and dietary restriction) among retired athletes, which found these behaviours in 42-65% of retired athletes with unwanted changes to body composition acting as triggers for these behaviours. One included study noted that retired athletes often had a lower drive for thinness and exhibited less bulimic symptomology than general population control groups (athlete: 3.3 ± 5.3, control: 4.0 ± 5.3 and athlete: 0.6 ± 1.1, control: 1.0 ± 3.0, respectively) (Buckley et al., 2019).

Weight loss

One review looked at intentional weight loss in combat sport athletes (Samadi et al., 2019), which are weight class athletes that need to make weight for competition. Athletes utilised a wide variety of weight loss methods (6/17 studies did not report the methods used) over a period between five days and one week (Samadi et al., 2019). A wide range of negative effects were reported including dizziness, tension, anger, confusion, anxiety, and fatigue (Samadi et al., 2019). Studies reported reductions in body fat, fat free mass, and total body water (n=7), reduction in vigour post weight loss (n=2), and pre-competition weight loss caused weakness, muscle cramps, and myalgia (n=1), with only one study reporting no observed change (Samadi et al., 2019).

Weight loss vs. dietary intake

Samadi et al. (2019) found four studies which investigated the relationship between weight loss and dietary intake. The majority of studies (three out of four) observed reduction in energy, carbohydrate, protein, fat, water, vitamin, and mineral intake before competition, with one study also exploring post competition intake of energy, carbohydrate, water, and sodium and finding intake increased (Samadi et al., 2019).

Quality assessment

All reviews were scored out of 11 using the JBI Critical Appraisal Checklist for Systematic Reviews (Aromataris et al., 2015). Scores were converted to percentages to allow comparison of quality. Percent scores for quality ranged between 18.2% and 90.9% (See Appendix H). Two reviews scored less than 50% (18.2% (Heaney et al., 2011) and 45.5% (Samadi et al., 2019)), two reviews scored 72.7% (Buckley et al., 2019; Spronk et al., 2014) and one scored 90.9% (Boidin et al., 2020).

Only one review (Buckley et al., 2019) specifically described the research question for their review. Samadi et al. (2019) did not include specific details of the population or sport requirements in the inclusion criteria, include searches using specialised databases, or use an appropriate method of quality assessment for articles. Heaney et al. (2011) did not provide any policy or practice recommendations based on their findings. Methods of combining studies were described in two reviews (Boidin et al., 2020; Buckley et al., 2019), with the other reviews not providing clear description of the synthesis method. One study addressed the possibility of publication bias (Boidin et al., 2020), although none of the included studies undertook an Egger's test or funnel plot to accurately assess the possibility of publication bias.

All included reviews (n=5) conducted critical appraisal of the studies included. Four reviews utilised appropriate methods of critical appraisal, with one review using an inappropriate tool for critical appraisal (STROBE statement) (Samadi et al., 2019). Boidin et al. (2020) found poor study quality for single-arm studies and fair study quality for double-arm studies. See detailed results in Table 4.

Table 4. Critical appraisal results of studies included within reviews

Review	Tool Used	Outcome of Critical Appraisal
Boidin et al. (2020)	Downs and Black	Single-arm studies – mean score 12/21 (range 7-15) Double-arm studies – mean score 15/25 (range 11-20)
Buckley et al. (2019)	Pluye et al. (2009).	Between 0% and 100% 0% = 1, 17% = 1, 33% = 4, 66% = 9, and 100% =1
Heaney et al. (2011)	Downs and Black	Between 7 and 16 out of 18
Samadi et al. (2019)	STROBE Statement*	All studies = high quality
Spronk et al. (2014)	Downs and Black	Mean critical appraisal score of 11.2 out of 17 Scores ranging between 2-17 • Mean score for study reporting quality, overall validity of design and data analysis was 7.4 out of 10 (range 1-10). • Validity for NK instruments mean 2.5 out of 5 (range 0-5).

*Note. *The STROBE Statement is a set of guidelines used for reporting observational study results. This tool is not suitable for use in critically appraising studies.*

Discussion

As can be seen from the small number of systematic reviews included in this rapid review, there is a lack of published studies that have explored the relationship between dietary intake and NK, hedonic hunger, macronutrient balance, and body image and weight control. Most reviews concentrate on the relationship between NK and dietary intake (n=3), two reviews cover dietary intake in relation to body image and weight control separately, and the topics of dietary intake in relation to macronutrient balance and hedonic hunger were not covered by any review included here. This suggests a lack of investigation in these areas. Included reviews found weak, positive correlations between positive dietary behaviours and NK (Heaney et al., 2011; Spronk et al., 2014), as well as indicating increases in energy intake and carbohydrate intake following a nutrition education intervention (Boidin et al., 2020). The review that examined body image and body dissatisfaction in relation to dietary intake found adverse dietary behaviours such as binge eating and dietary restriction exhibited within retired athletes, and these behaviours could be triggered by body composition changes caused by the reduction of intense exercise which accompanies athletic life (Buckley et al., 2019). Acute weight loss methods used for meeting weight requirements for sport also have been found to decrease energy and nutrient intake in combat sport athletes (Samadi et al., 2019).

Included reviews demonstrated a weak, positive association between NK and healthy dietary behaviors (Heaney et al., 2011; Spronk et al., 2014), which has been demonstrated within more recent studies showing moderate, positive correlations between sports NK and carbohydrate intake in Australian male soccer players (Andrews & Itsiopoulos, 2016) and moderate, positive correlations between NK scores and meeting energy requirements, protein, fibre, and calcium intakes (Jenner et al., 2018). Boidin et al. (2020) demonstrated that nutrition education interventions were capable of increasing total energy intake and carbohydrate intake; the impact on protein intake was found to be inconclusive as intake was below recommended in 5/10 single-arm studies prior to intervention, with three of those studies demonstrating protein intake below recommendations post-intervention. Unfortunately, due to the fact that Boidin et al. (2020) did not report on NK directly, it is unclear what type of correlation may exist between NK and final dietary intake within this review. NK may be increased with nutrition education programs, such as those examined in the Boidin et al. (2020) review. Trakman (2018) suggested that nutrition education programs were viable methods of modifying NK and subsequently dietary intake. A recent review found that studies utilizing nutrition education interventions to increase NK usually reported significant increases in NK post intervention (Tam et al., 2019). Some studies in recent years (Andrews & Itsiopoulos, 2016; Argôlo et al., 2018; Jenner et al., 2018) that have examined the relationship between NK and dietary intake found positive associations between NK and protein ($r=0.35$, $p=0.02$), fibre ($r=0.51$, $p=0.001$), and calcium intake ($r=0.43$, $p=0.004$) in Australian football players (Jenner et al., 2018), as well as sport NK and energy intake ($n=46$, $\rho=0.31$, $p=0.04$) and carbohydrate intake ($n=46$, $\rho=0.35$, $p = 0.02$) in Australian soccer players (Andrews & Itsiopoulos, 2016). One study also found a negative correlation between NK and sodium intake in table tennis players ($r=-0.485$, $p<0.05$) (Argôlo et al., 2018). The findings of this review are in line with recent studies and reviews into NK and dietary intake. From this, the relationship between NK and dietary intake appears to be weak-to-moderate in athletes.

The Buckley et al. (2019) review suggests that identification with the athlete group after retirement can be detrimental to retired athletes' perception of body composition changes caused by the change in training status from active to retired athlete. Body composition has been identified as a factor influencing dietary behaviours and food choice in Australian Football players, with perceived pressures related to assessment of body composition and diet strategies tailored to meet body composition goals (Jenner et al., 2021). Female athletes have identified themselves as muscular, different from others, and identified increased concern regarding weight (Beckner & Record, 2016). These findings indicate that the predisposition with body composition that is present within current athletes continues on into retirement among some athlete groups. It is possible that identification of self using terms related to body composition could be problematic for individuals once they retire from athletics and are faced with body composition changes that counter their self-identity. This challenge to self-identity may be alleviated through counselling; further research into this would be beneficial.

Athletes preparing for competition were found to have reduced intakes of a wide range of nutrients (Samadi et al., 2019) which could impact subsequent competition performance. Coaches have also been found to focus extensively on 'healthy' eating and eating to maintain or improve performance for athletes to the point of encouraging disordered eating behaviours within athletes (Beckner & Record, 2016). It was expected that athletes would exhibit this change in nutrient intake that may impact performance. Weight control (specifically weight loss) in relation to dietary intake has been found to be closely tied with competition (Samadi et al., 2019). Further research into the effectiveness of education programs for promoting healthy pre- and post- competition nutrition strategies may help athletes maintain competition performance.

There were no reviews published which examined hedonic hunger or macronutrient balance in relation to dietary intake; however, some insights can be gained through recently published studies. A study investigating changes in macronutrient balance within overweight adults found that there was no significant difference in weight-loss diet results with different macronutrient intakes (Sacks et al., 2009). A recent study using the Athlete Food Choice Questionnaire (AFCQ) found that there are a variety of factors that may influence food choices; the top two factors reported were performance and sensory appeal (Thurecht & Pelly, 2020). Sensory appeal is quite similar to hedonic hunger in that it examines the appeal of food available, as well as the taste and flavour of foods (Thurecht & Pelly, 2020). Unfortunately, Thurecht & Pelly's (2020) study did not examine the relationship between hedonic hunger and dietary intake in athletes. It is important to be aware that this lack of research related to athletes indicates a significant gap within the available literature. Further research into the relationship between dietary intake and the modifiable factors of hedonic hunger and macronutrient balance in athletes would assist in developing a complete model for impacting dietary intake through the manipulation of modifiable factors.

Quality assessment

Two of the included reviews have quality percent scores below 50%, which may be indicative of poor quality in the case of Samadi et al. (2019). However, these low scores could also be indicative of differing systematic literature review guidelines being prevalent at the time of publication (for example, Heaney et al. (2011)).

Limitations

When examining NK in athletes, studies often provide scores without context (Janiczak et al., 2021). Many studies measure NK of athletes without comparison to community populations or nutrition experts (Abbey et al., 2017; Andrews & Itsiopoulos, 2016; Devlin et al., 2017; Judge et al., 2016; Madrigal et al., 2016) and without providing an indication of what constitutes a 'passing' score (Andrews & Itsiopoulos, 2016; Blennerhassett et al., 2019; Devlin et al., 2017; Hardy et al., 2017; Judge et al., 2016; Nascimento et al., 2016; Saribay & Kirbaş, 2019; Simpson et al., 2017). However, it is worth noting that not all questionnaires being used to assess NK in athlete populations are fully validated for use (Janiczak et al., 2021; Trakman et al., 2016).

While the rapid review methodology used here closely resembles the systematic literature review, it is not as rigorous as a true systematic literature review, which allows rapid reviews to be conducted in a short period of time. Publication bias may be a factor regarding this review for a number of reasons. All reviews included in this rapid review were published in English. Reviews that were not available through La Trobe University Library and database subscriptions were not included in this review and reference lists were not checked for any additional relevant articles to be screened. Only examining systematic reviews allowed this review to be more manageable for the time period allowed. Ideally, future reviews would examine original research and grey literature.

The number of reviews included was relatively small, which may indicate a lack of research in this area or a need for more individual reviews to be completed on each modifiable factor. This small number of reviews could also be related to the methodology of the rapid review – by focusing on systematic literature reviews alone, a large body of original research was excluded from this review. It is also possible that search terms related to body composition in athletes could have been employed within this rapid review to provide a more comprehensive view of issues related to body image in athletes.

Future directions for research

Further research into the relationship between all of these modifiable factors and dietary intake in athletes within one study would assist in creating a more holistic approach to modification of dietary intake. It would be beneficial to conduct more in-depth systematic literature reviews of original research, which examine the relationship between individual modifiable factors and dietary intake. Even though the theoretical framework used here has been discussed by several authors and a strong rationale for these factors influencing intake, there is limited objective research on the topic. A qualitative study into impacts on dietary intake amongst athletes from different sports found NK, weight and body composition, lack of requisite skills, and time, money and food access all act as barriers to healthy dietary behaviours (Heaney et al., 2008). Athletes are known to not meet dietary recommendations (Andrews & Itsiopoulos, 2016; Condo et al., 2019; Devlin et al., 2017; Jenner et al., 2018), it is therefore important to investigate the factors that can influence their dietary intake to improve athletic performance and overall health.

Conclusion

This rapid review found a small number of published reviews exploring athlete dietary intake in relation with nutrition knowledge, body image, or weight control. No reviews were identified that explored hedonic hunger or macronutrient intake in relation to dietary intake. The quality of the included reviews ranged widely, indicating a need for more high quality work in these topics. Further study exploring the relationship between dietary intake and the included modifiable factors is required.

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Chapter Four: The impact of hedonic hunger, macronutrient balance, nutrition knowledge, and body image and weight control on dietary intake in student athletes and exercisers

Preface

This cross-sectional study was designed as an exploration of factors that influence dietary intake in student athletes and active people. The previous rapid review informed the background and gap for this cross-sectional study, as well as the population of interest.

The aim of this study was to investigate the impact of the modifiable factors previously mentioned on dietary intake in student athletes and exercisers. Approximately half of the participants who enrolled in the study and agreed to continue on to the Australian Eating Survey (AES) did not complete the AES. One person was asked to test the AES process for registration encountered technical difficulties. However, the AES team were unable to confirm that this affected completion by other participants.

Referencing style used here is APA 7 in accordance with discipline recommendations.

Introduction

Athletes commonly use nutrition strategies to improve athletic performance, enhance recovery from training, and achieve body composition changes that provide performance benefits or are required for aesthetic reasons (Thomas et al., 2016). With athletes having different performance and body composition goals, the role of nutrition can vary significantly between sports and individual athletes. Several factors, including performance goals, influence athletes' dietary intake (Birkenhead & Slater, 2015). Due to the widespread importance of nutrition within athletic communities, and the fact that athletes often fail to meet recommended nutrition guidelines (Devlin et al., 2017), it is important to understand the factors that influence dietary intake in athletes.

Several authors (Birkenhead & Slater, 2015; Devlin, 2016; Jenner et al., 2021; Trakman, 2018) have proposed theoretical frameworks to describe factors that influence dietary intake in athletes. Birkenhead and Slater (2015) identified and categorised factors influencing dietary intake in athletes as follows: physiological and biological (hunger and appetite; macronutrient balance; fat-free mass, resting metabolic rate, and hunger; taste and food preferences; gastrointestinal discomfort); lifestyle, beliefs and knowledge (lifestyle and motives for participating in sport; health beliefs; nutrition knowledge); psychological (body image and weight control; hedonic hunger); social (availability, social facilitation, and marketing; culture and religion); and economic (cost and income). Devlin (2016) further stated that some factors were more modifiable by accredited sports dietitians, including nutrition knowledge, attitudes, nutrition goals, and body composition. Trakman (2018) built on the work of Devlin to classify factors presented by Birkenhead and Slater (2015) and categorize factors influencing dietary intake in athletes as modifiable, semi-modifiable, and non-modifiable factors. Four factors were identified as being modifiable by professionals working with athletes, including nutrition knowledge, body image and weight control, hedonic hunger, and macronutrient balance (Trakman, 2018). The Jenner et al. (2021) qualitative study with Australian football players identified four groups of influences on dietary intake that approximately align with previous frameworks, which were nutrition knowledge and nutrition support, body composition (which aligns with body image and weight control), and interpersonal factors (peers and family, and mood); a new 'factor' also emerged related to seasonal changes (playing seasons), which is likely to be particularly relevant to team sport athletes, especially at an elite level. Based on the work of Trakman (2018), a framework has been developed for this current study.

This study will focus on nutrition knowledge, hedonic hunger, macronutrient balance, and body image and weight control. A summary of key studies on each of the included factors is presented below.

Nutrition knowledge is the cognitive process associated with the understanding of nutrition practices and recommendations. Nutrition knowledge in athletic populations has been studied extensively. Recent reviews examining nutrition knowledge in athletic population have identified poor to average nutrition knowledge in athletes (Janiczak et al., 2021; Trakman et al., 2016). A large number of these studies have been conducted with university level athletes, presumably because this population group is convenient to study. When examining the relationship between nutrition knowledge and dietary intake, reviews have identified significant, weak, positive associations between higher nutrition knowledge and dietary behaviour in line with nutrition guidelines of the time (Heaney et al., 2011; Spronk et al., 2014). A review by Boidin et al. (2020) examined the relationship between nutrition education interventions and dietary intake; this review found significant increases in carbohydrate and energy intake in half of the studies included, and variable protein intake across included studies. Tam et al. (2019) found a significant increase in nutrition knowledge in the majority of studies implementing nutrition education interventions; however, some of the included studies utilised insufficiently validated tools for measurement of nutrition knowledge.

Body image is an individual's perception and attitude towards their own body (Petrie & Greenleaf, 2012). Poor body image and weight control in athletes has often been related to the pressures to maintain body composition for their sport, whether this is due to weight-class requirements for competition, performance impacts, or aesthetics (for athletes such as gymnasts or body builders) (Anderson & Petrie, 2012; Babusa & Tury, 2012). In sports that emphasize leanness or low body mass, research has found that athletes are more susceptible to disordered eating (Byrne & McLean, 2002). A recent review on weight loss practices in combat athletes found significant reductions in energy, carbohydrate, protein, fat, water, vitamin, and mineral intake prior to competition in three out of four studies (Samadi et al., 2019). In sports with qualifying weight categories, athletes may be prohibited from competition if they do not meet weight requirements; within these types of sports high emphasis on weight during competition is understandable if not recommended (Carl et al., 2017). In aesthetic and weight-dependent sports (e.g. sport climbing), it is less clear and difficult to know whether performance is diminished or enhanced with weight loss (Sundgot-Borgen & Garthe, 2011). A recent study on body image and body dissatisfaction found adverse nutrition behaviours such as binge eating and dietary restriction were found in 42-65% of retired athletes, with these behaviours possibly being triggered by changes to body composition that would have been undesirable during athletic competition (Buckley et al., 2019).

Macronutrient balance describes the relative contribution of carbohydrate, protein, and fat to total energy intake. Macronutrient balance has been speculated to influence overall dietary intake since protein, carbohydrate and fat can have variable effects on gastric emptying, hunger hormones and overall satiety. Research has shown that high carbohydrate beverages induced faster gastric emptying than high protein beverages (Giezenaar et al., 2018). By slowing gastric emptying through increased protein consumption, individuals may extend satiety and thereby reduce total energy intake, which may be desirable in some athletes. Athletes' macronutrient balance can vary from day to day due to the recommended periodization of macronutrients to assist with athletic goals (Stellingwerff et al., 2019; Thomas et al., 2016). While there has been a large amount of research into macronutrient intakes in athletes (e.g. adolescent sprinters and male rugby union players), existing research has primarily gauged current consumption in relation to sports nutrition guidelines (Aerenhouts et al., 2011; Black et al., 2018) or aimed to determine the most advantageous amount and timing of macronutrients to assist with athletic goals (Anderson et al., 2017; Born et al., 2019; Campbell et al., 2018; Casazza et al., 2018; Colombani et al., 2013; Di Girolamo et al., 2017; Greene et al., 2018; Hansen et al., 2016) rather than on balance between macronutrients and how this influences total energy intake ad libitum.

Hedonic hunger is defined as "an 'appetite' for the pleasurable tastes of food" (Birkenhead & Slater, 2015, p. 1516). Research exploring hedonic hunger reports differences following exercise, between those who consume additional food to compensate for energy consumed during exercise and those who do not consume additional food in compensation (Birkenhead & Slater, 2015). Previous research into hedonic hunger in athletes focuses on the impact of exercise on hedonic hunger, rather than the relationship between hedonic hunger and dietary intake in athletes. Research has indicated that high levels of disinhibition are linked with overcompensation for expended energy through exercise (King et al., 2012). Higher levels of disinhibition are also linked to poorer quality dietary intake and more impulsive response to palatable food in normal weight or overweight/obese individuals, which would have significant impacts on both the amount of energy intake and the quality of dietary intake (Bryant et al., 2019). Females with food addiction exhibited higher intakes than females without food addiction in energy, protein, fat, fibre, and micronutrients (Bryant et al., 2019).

While the four factors of nutrition knowledge, body image and weight control, macronutrient balance, and hedonic hunger have been explored in previous literature on athletes/student exercisers, they have never been explored together. The population of student athletes and student exercisers is used in the current study as student athlete populations have been studied in previous research in nutrition knowledge and body image (Abbey et al., 2017; Andrews et al., 2016; Ayala, 2020). By investigating student athletes and exercisers, the level of education and age of participants would not confound results.

Aim

The primary aim of this study is to measure the influence of the modifiable factors of nutrition knowledge, body image and weight control, macronutrient balance, and hedonic hunger on student athlete and exercisers' diet quality scores. The second aim is to assess the association of these factors in student athletes and exercisers. The third aim is to examine differences in outcome measures based on socio-demographic factors. Due to limited published literature related to the modifiable factors listed and dietary intake, this study is exploratory in nature.

Methodology

Study design

This cross-sectional study exploring the association between dietary intake and the other outcomes of macronutrient balance, hedonic hunger score, body image related scores, weight fluctuation score, and nutrition knowledge score (see Data Collection for detailed outcome information). The primary population examined was Australian undergraduate university students who actively participate in exercise or sport. The exposures investigated in this study included prior nutrition education, sport participation, and various demographic factors.

Setting

Participants attending any university were recruited to participate in an online survey. Recruitment advertising commenced in March 2021. The data collection period for this study was March to May 2021. Participants were able to make queries regarding this study via email.

Ethics

Ethics approval for this study was granted by the La Trobe University Human Research Ethics Committee (HEC21041) (approved March 9, 2021). Participants provided implied consent to continue within the study. This study complies with the National Statement on Ethical Conduct in Human Research regarding studies involving Human Subjects (Australian Government, 2007 (Updated 2018)).

Recruitment

Current undergraduate students attending any Australian university were recruited for this study. The inclusion criteria for students were between 18 and 35 years of age, speak fluent English, access to internet and a suitable device, and participation in some type of sport or purposeful exercise for a minimum of 2.5 hours per week. Exercise was defined as physical activity that is planned, structured, and repetitive, and performed to improve or maintain physical fitness (Araujo, 2016). The minimum of 2.5 hours of exercise or training per week is based on the physical activity guidelines set out by the Australian Government (Department of Health, 2019). For this study, individuals who were pregnant and/or lactating were excluded, as these factors could influence dietary intake and weight gain outside of the factors being investigated.

To recruit student participants for this study, five methods of recruitment were used. The first method of recruitment was advertising to any undergraduate student athletes and exercisers within Australia via posting advertising material to Twitter (@LTUnutrition). The second method of recruitment was by contacting sporting organisations (n=25) through email to request organisation administrators forward advertising material to their athletes (via email, Facebook, or flyer). The third method of recruitment for undergraduate athlete and exerciser students was contacting course coordinators to request advertising material for the study be added to the Learning Management System for their relevant disciplines. The fourth strategy for recruitment was advertising the study via various La Trobe student Facebook pages. The fifth, and final, recruitment method was to post advertising material flyers around university buildings. Students were then able to self-identify suitability for participating in the study. Initial advertising material was sent out at the end of March 2021, with two follow-up advertisements sent out at two-week intervals.

As students were not contacted directly by the researchers, it was not possible to calculate the response rate for this study. Instead, a completion rate for those who started the study was calculated.

Data Collection

Seven tools were used to gather data within this study, including: demographic data, Contour Drawing Rating Scale (Thompson & Gray, 1995), Weight fluctuation measure (developed by the author), The Power of Food Scale (Lowe et al., 2009), Body Image Disturbance Questionnaire (Cash et al., 2004), Abridged Nutrition for Sport Knowledge Questionnaire (Trakman, Forsyth, Hoye, et al., 2018), and the Australian Eating Survey (Collins et al., 2015). All tools were administered online. The initial sections (demographics data, Contour Drawing Rating Scale, Weight Fluctuation Measure, Power of Food Scale, Body Image Disturbance Questionnaire, and Abridged Nutrition for Sport Knowledge Questionnaire) were delivered via REDCap (Harris et al., 2019; Harris et al., 2009). Upon completion of these sections, participants were registered with the Australian Eating Survey, which was completed via the Australian Eating Survey specific webpage.

Demographics data collected for this study consisted of 19 items. Fourteen items were completed by all participants, these included: age, gender, previous nutrition education and type, weight, height, special diet and type, supplement consumption and type, rating of nutrition knowledge, importance of a healthy diet for athletic performance, and email address for registration to the Australian Eating Survey. Participants who did not play a sport received a question regarding hours of physical activity per week; however, participants who played sport completed four items regarding sport played, level of sport, years in sport, and hours of training. This section was adapted from previously created demographic questions used as part of the Nutrition for Sport Knowledge Questionnaire (Trakman, Forsyth, Hoye, et al., 2018).

Body image was assessed using two scales Contour Drawing Rating Scale and Body Image Disturbance Questionnaire, use of the questionnaire along with the scale captures differing aspects of body image (Shroff et al., 2009). The Contour Drawing Rating Scale contains four items all of which are reported on a 9-point scale. Participants choose the body type most closely resembling their current body type, what they believe the average body type of the opposite gender to be, and the ideal body types of themselves and the opposite gender. The body image scores for the Contour Drawing Rating Scale were calculated as the difference between the current body type and the ideal body for the self and the opposite gender. Whereas the Body Image Disturbance Questionnaire measured body image disturbance with 12 items, seven of which were multiple choice (coded 1 to 5) and five of which are open-ended responses. The Body Image Disturbance Questionnaire includes seven items examining concerns related to appearance, mental preoccupation with appearance, associated emotional distress, social/occupational/other types of impairment to daily functioning, interference with social life, school/job/role functioning, or consequential behavioural avoidance (Cash et al., 2004). The Body Image Disturbance Questionnaire score was calculated as a mean of the seven multiple choice items. Open-ended responses provide qualitative data for clarification of responses to the multiple-choice questions.

Cash and Grasso (2005) found that university students had mean Body Image Disturbance Questionnaire scores of 1.81 (SD = 0.67) for females and 1.57 (SD = 0.60) for males. Hrabosky et al. (2009) found that individuals with anorexia nervosa had mean Body Image Disturbance Questionnaire scores of 3.39 (SD = 0.93), those with bulimia nervosa had mean scores of 3.52 (SD = 0.88), and those with body dysmorphia disorder had mean scores of 4.30 (SD = 0.62). Following this pattern, individuals with a Body Image Disturbance Questionnaire score 3 and above will be considered as having high body image disturbance. Individuals with scores below 3 will be considered as normal body image disturbance levels.

Validated tools for measurement of weight fluctuation were examined for use. The Weight fluctuation subscale of the Restraint Scale (van Strien et al., 2002) was piloted with a group of non-nutrition individuals and found to be inappropriate for use as individual who did not weigh themselves regularly and therefore could not provide accurate quantitative measures of weight change. Therefore, a weight fluctuation measure (Weight Fluctuation Measure) was developed by A

Janiczak for the purposes of this study; due to time restrictions, this tool was not validated. The Weight Fluctuation Measure tool included 3 items – querying possible medical conditions affecting weight, subjective measurement of weight change (five-point scale), scale indicator of body type six months prior to completion of the survey (nine-point scale). The scale indicator of previous body type would then be compared to the current body type reported in the Contour Drawing Rating Scale; the difference in body type was then converted to a score (-8 up to 8). This score indicates weight loss (negative score), weight gain (positive score), or a stable weight (zero score). For the purposes of this analysis, only the scale indicator of weight change was utilised.

Hedonic hunger was measured using the Power of Food Scale (Lowe et al., 2009); a 15-item survey validated for use in university students, which uses a five-point Likert scale. The total score was the average of all items. The Power of Food Scale contains three subscales, including: food available (6), food present (4), and food tasted (5). The scores for these subscales were the mean of items related to those subscales. Higher scores indicate greater power of food, which is indicative of greater hedonic hunger.

Nutrition knowledge was assessed using the Abridged Nutrition for Sport Knowledge Questionnaire developed by Trakman, Forsyth, Hoye, et al. (2018), which was previously validated for use in Australian team-sport athletes. This tool was selected to assess sports nutrition knowledge as it was validated in both elite and recreational athletes. The primary interest of this study was sports nutrition knowledge rather than general nutrition knowledge alone. The Abridged Nutrition for Sport Knowledge Questionnaire is comprised of 35 items, made up of two sections: general nutrition knowledge (11) and sport nutrition knowledge (24). The unabridged Nutrition for Sport Knowledge Questionnaire would provide in-depth data concerning subsections of weight management, macronutrients, micronutrients, sports nutrition, supplementation, and alcohol. However, the Abridged Nutrition for Sport Knowledge Questionnaire was used to reduce participant burden, given the number outcomes being measured in the present study. Abridged Nutrition for Sport Knowledge Questionnaire scores of 0-50% indicate poor nutrition knowledge, 51-65% indicate average nutrition knowledge, 66-74% indicates good nutrition knowledge, and 75% or higher indicates excellent nutrition knowledge (Trakman, Forsyth, Middleton, et al., 2018).

Macronutrient balance and dietary intake were assessed using the Australian Eating Survey (Collins et al., 2015), which is a validated food frequency questionnaire used to assess habitual dietary intake within the previous three to six months. The version of the tool used was validated for use in the Australian adult population. The Australian Eating Survey consists of 15 demographic questions (for example: age, weight, height, gender, supplement use, eating and sitting behaviours) and 123 questions related to commonly consumed foods in the subsections: drinks (9), milk and dairy foods (10), breads and cereals (10), sweets and snacks (12), main meals (29), other foods (17), vegetables (24), fruit (11), and miscellaneous (1). Participants were provided with a dietary analysis report after completion of the Australian Eating Survey, which included information on average daily energy intake, proportion of healthy versus nutrient-poor foods, the Australian Recommended Food Score details, and macro and micronutrient intake data. The Australian Recommended Food Score is a tool developed and validated for evaluation of diet quality in adults and estimation of nutrient intake (Collins et al., 2015). This report also acted as incentive for participants to complete the surveys. The data provided to researchers included average grams of intake per macro and micronutrient, energy intake from food groups, percent of total energy intake from macronutrients and food groups, and Australian Recommended Food Score details (possible scores between 0-73), as well as record of the participant's response to each question included in the Australian Eating Survey.

Data analysis

Missing data

The Nutrition for Sport Knowledge Questionnaire accepted surveys with up to 11% of responses (nine questions) missing values; a level of response that was previously established by Trakman (2018) as acceptable. In the case of the Abridged Nutrition for Sport Knowledge Questionnaire, 90% of responses are required for inclusion, which requires 31.5 items to be completed. As such, 32 items in the Abridged Nutrition for Sport Knowledge Questionnaire must be completed for these responses to be included in the complete dataset, with the scores being graded out the total number of questions completed. Responses within the Abridged Nutrition for Sport Knowledge Questionnaire were forced through REDCap meaning that missing values occurred if the respondents exited the survey before completion. For participants to be registered for the Australian Eating Survey, they were required to complete the Abridged Nutrition for Sport Knowledge Questionnaire and indicate their desire to be registered as the final item of the REDCap survey.

Participants who did not complete all items within the Australian Eating Survey did not receive a report regarding their diet. Only data from fully completed Australian Eating Survey were included within the Australian Eating Survey dataset provided to researchers. A 2009 paper looking at missing values in food frequency questionnaires found that imputing zero in place of missing values would only be accurate 60% of the time and therefore imputing zero values may cause bias within the data depending on the variable being imputed (Fraser et al., 2009). Therefore, bias caused by imputing values is not present within the Australian Eating Survey dataset.

Statistical analysis

Data analysis was completed using SPSS version 27. Normality testing was completed using the Kolmogorov-Smirnov test or the Shapiro-Wilk test (for samples above 50 and samples below 50, respectively). Visual inspection of Normal Q-Q plots was used to confirm normality of distribution. Visual inspection of histograms was used to identify outliers, with the 5% trimmed mean checked to determine if the outliers present were having a large impact upon the mean of the value.

Differences between the scale variables in dichotomous demographic groups (e.g. male vs. female, or consuming supplements vs. not consuming supplements) were analysed using Independent sample t-tests or Mann-Whitney U tests for parametric and non-parametric data, respectively. Correlations between all continuous variables were measured using Spearman's rho in a crosstabulation, due to violations of test assumptions by a number of these tests. In order to provide comparable results, Spearman's rho was used for all correlation tests within the crosstabulation. Upon the advice of a statistician (XL), stepwise regression analysis was completed on variables found to be significantly correlated through the Spearman's correlation crosstabulation of complete data (records including AES information). As this study was exploratory in nature and there is no practical or conceptual model available, a stepwise regression model was deemed appropriate for this purpose. A one-sample Wilcoxon-signed rank test was used to test for difference between the study sample's macronutrient balance and a general population's macronutrient balance from the 2012 Australian National Health Survey (Grech et al., 2018).

Power calculation

A sample size of 385 participants was required to ensure that the sample was representative of the target population of undergraduate students in Australia (CheckMarket, 2020). The sample size required was based on 2019 Higher Education Statistics of students enrolled in any type of higher education in 2019 between the ages of 18 and 39 (1414712) (Department of Education, Skills and Employment, 2020), a 5% margin of error and a 95% confidence level. Given that participants also needed to participate in sport, and mature age students were excluded, the estimated sample size may be an overestimation of the number of participants required for a representative sample.

The sample size required for comparison between gender (male/female) and sporting level (elite/nonelite) was 28 participants for each group, a minimum of 56 participants total, based on a power calculation for two-tailed t-test with a large effect size ($d = 0.80$), alpha value of 0.05, and Power of 80% (Faul et al., 2007).

The sample size for correlation (bivariate normal model) testing between variables required a sample size of 64 participants, with a medium effect size ($d = 0.30$), alpha value of 0.05, and Power of 80% (Faul et al., 2007).

For linear multiple regression analysis of factors that influence diet quality based on modelling six predictors (nutrition knowledge, Body Image Disturbance Questionnaire score, Power of Food Scale score, Contour Drawing Rating Scale scores, macronutrient balance, and weight fluctuation levels), 48 participants were required for a small effect size (d = 0.20), alpha value of 0.05, and Power of 80% (Faul et al., 2007).

Results

Participant characteristics

One hundred and eleven participants began the surveys for this study; eighty-two participants completed the demographics, Contour Drawing Rating Scale, Weight fluctuation scale, Power of Food Scale, Body Image Disturbance Questionnaire, and Abridged Nutrition for Sport Knowledge Questionnaire (referred to as Part 1); forty-two participants completed all surveys for this study (referred to as Total). The completion rate for all surveys was 38.2%, while the completion rate for the first section of the study was 74.5%.

The majority of participants were female, 68.3% for Part 1 and 78.6% of those who completed Total, respectively. The median age for participants was 21 years of age (IQR: 3) (See Table 1). Percentages of participants who played sport was similar between Part 1 and Total (64.6% and 64.3%, respectively). Fourteen sport types were represented in Part 1, with 40.2% of participants at the local league level. The majority of participants in Part 1 and those who completed the Total survey had not completed any nutrition education, 81.7% and 83.3% respectively. Seven diet types were represented across the 28 participants (34.1%) who consumed a special diet, while 20 supplement types were represented in the 34 participants (41.5%) who consumed supplements. It is important to note that 35 instances of special diets were selected, and 97 instances of supplements were selected – indicating that there are multiple diets and supplements selected by some participants. Of the participants consuming a special diet (n=25), the majority followed vegan, vegetarian, and pescatarian diets (n=14). The diets categorised as other included: wholefood vegan, vegetarian (low fructose and sorbitol), dairy free, lactose free, and a high-protein carb-restrictive diet.

Table 1. Participant characteristics

Variable	Part 1 n=82	Total N=42
Gender - Male - Female	 26 (31.7%) 56 (68.3%)	 9 (21.4%) 33 (78.6%)
Age Median (IQR)	Median 21.0 (3)	Median 21.0 (3)
Plays Competitive Sport - Yes - No	 53 (64.6%) 29 (35.4%)	 27 (64.3%) 15 (35.7%)
Sport Type	N=53 AFL (5) Basketball (3) Cycling (2) Hockey (2) Endurance Running (5) Soccer (football) (7) Swimming (1) Triathlon (1) Netball (5) Boxing (1) Weightlifting (5) Martial Arts (2) Touch Football (1) Other (13)	N=27 AFL (2) Basketball (2) Cycling (2) Hockey (1) Endurance Running (4) Soccer (football) (3) Triathlon (1) Netball (1) Boxing (1) Weightlifting (1) Martial Arts (1) Other (8)
Level of Sport - Local league - State league - National league - International	N=53 33 (62.3%) 10 (18.9%) 6 (11.3%) 4 (7.5%)	N=27 14 (51.9%) 7 (25.9%) 3 (11.1%) 3 (11.1%)
Nutrition education - Yes - No	 29 (35.4%) 53 (64.6%)	 15 (35.7%) 27 (64.3%)
Nutrition student - Yes - No	 15 (18.3%) 67 (81.7%)	 7 (16.7%) 35 (83.3%)
Special Diet - Yes - No	 54 (65.9%) 28 (34.1%)	 25 (59.5%) 17 (40.5%)
Special Diet Types	N=28 Vegan (7) Vegetarian (13) Pescatarian (3) Low FODMAP (1) Gluten Free (4) Intermittent Fasting (2) Other (5)	N=25 Vegan (6) Vegetarian (7) Pescatarian (1) Low FODMAP (1) Gluten Free (2) Intermittent Fasting (1) Other (5)
Supplement Intake - Yes - No	 34 (41.5%) 48 (58.5%)	 15 (35.7%) 27 (64.3%)
Supplement Types	N=34 Multivitamin (7) Protein supplement (14) Beta Alanine (3)	N=15 Multivitamin (2) Protein supplement (5) Beta Alanine (2)

	Creatine (7) Probiotic (3) Omega 3 (3) Fish Oil (5) Zinc (4) Magnesium (13) Iron (16) Calcium (1) Vitamin D (7) Vitamin C (3) B Vitamins (4) Folate (1) Collagen (2) Fibre (1) Lysine (1) Maca (1) Tyrosine (1)	Creatine (3) Probiotic (2) Omega 3 (1) Fish Oil (1) Magnesium (6) Iron (10) Calcium (1) Vitamin D (4) Vitamin C (2) B Vitamins (3) Folate (1) Collagen (2) Lysine (1)

Notes Sports were categorised with 20 predetermined categories, one of which was 'other' allowing participants to specify a sport that was not included within the list (such as ballet, cross country skiing, or gymnastics).

Report baseline results

Results for Contour Drawing Rating Scale, Body Image Disturbance Questionnaire, Weight Fluctuation Score, Power of Food Scale, and Abridge Nutrition for Sport Knowledge Questionnaire are provided below (Table 2). Mean % Total Nutrition Knowledge was average (55.12%, SD: 12.29). Contour Drawing Rating Scale indicated that participants believe they needed to lose weight to meet the ideal (Median: -1.0, IQR: 2) and that the opposite gender on average needed to lose weight to meet the ideal (Median: -1.0, IQR: 1). Median Body Image Disturbance scores were below threshold for body image disturbance (Part 1 median: 2.0, IQR: 1.43; Total median: 2.14, IQR: 1.57). Weight fluctuation score indicated low levels of weight fluctuation (Part 1 median: 0.0, IQR: 2; Total median: 0.0, IQR: 1). Power of Food Scale mean scores were 2.83 (SD: 0.81), with higher scores equating to greater influence by hedonic hunger.

Table 2. Results across outcome measures.

Variable	Part 1 (n=82)	Total (n=42)
ANSKQ - %TNK - %GNK - %SNK	 Mean (SD) 55.12 (12.29) Median (IQR) 72.73 (27.27) Mean (SD) 49.44 (14.93)	 Mean (SD) 55.85 (13.27) Median (IQR) 72.73 (27.27) Mean (SD) 50.10 (16.32)
CDRS - Current vs. Ideal - Opposite Average vs. Ideal	Median (IQR) -1.0 (2) -1.0 (1)	Median (IQR) -1.0 (2) -1.0 (1)
BIDQ	Median (IQR) 2.0 (1.43)	Median (IQR) 2.14 (1.57)
Weight fluctuation	Median (IQR) 0.0 (2)	Median (IQR) 0.0 (1)
PFS - Average (1-5) - Food Available (1-5) - Food Present (1-5) - Food Tasted (1-5)	 Mean (SD) 2.83 (0.81) Median (IQR) 2.75 (1.71) Median (IQR) 2.88 (1.75) Median (IQR) 2.9 (1.05)	 Mean (SD) 2.79 (0.80) Median (IQR) 2.58 (2.0) Median (IQR) 2.50 (2.06) Mean (SD) 2.96 (0.85)

Note. ANSKQ, Abridged Nutrition for Sport Knowledge Questionnaire score. %TNK, Percent of Total Nutrition Knowledge questions correct. %GNK, Percent of General Nutrition Knowledge questions correct. %SNK, Percent of Sport Nutrition Knowledge questions correct. CDRS, Contour Drawing Rating Scale score. BIDQ, Body Image Disturbance Questionnaire score. PFS, Power of Food Scale.

Results taken from the Australian Eating Survey – Australian Recommended Food Score, Kilojoule intake, fat/kg, carbohydrate/kg, protein/kg, fat % of energy (E), carbohydrate % of E, and protein % of E – are provided below (Table 3).

Table 3. Average results from the Australian Eating Survey (n=42).

Variable n=42	Mean % (SD) Range
ARFS	38.64 (9.03) 37
KJwithDF	9208.29 (2587.25) 12605.66
CHO/kg/bw	4.05 (1.43) 7.05
Fat/kg/bw	1.23 (0.36) 1.42
PRO/kg/bw	1.35 (0.47) 1.96
CHO% of E Median (IQR) Range	48.07 (12) 37
Fat% of E Median (IQR) Range	34.05 (9) 28
PRO% of E	16.29 (3.92) 17

Note. ARFS, Australian Recommended Food Score. KJwithDF, Kilojoule intake with dietary fibre. CHO/kg/bw, carbohydrate intake per kilogram of body weight. Fat/kg/bw, fat intake per kilogram of body weight. PRO/kg/bw, protein intake per kilogram of body weight. CHO% of E, carbohydrate percentage of total energy intake. Fat% of E, fat percentage of total energy intake. PRO% of E, protein percentage of total energy intake.

Associations between modifiable factors

Crosstabulation of Spearman's correlations for the full final sample (n=42) demonstrate energy intake significantly correlates with intake of fat/kg/body weight (r_s=0.78, *p* = 0.000), carbohydrate/kg/body weight (r_s=0.63, *p* = 0.000), protein/kg/body weight (r_s=0.71, *p* = 0.000), Weight Fluctuation score (r_s=0.39, *p* = 0.011), Power of Food Scale Food Tasted scale (r_s=-0.35, *p* = 0.022), and Body Image Disturbance Questionnaire score (r_s=-0.34, p = 0.028). The diet quality score (Australian Recommended Food Score) was significantly associated with Power of Food Scale Food Present scale (r_s=-0.31, *p* = 0.046), but not other variables. Associations between the diet quality score and nutrition knowledge scores were r_s=0.24 (% Total Nutrition Knowledge *p*=0.123), r_s=0.21 (% General Nutrition Knowledge *p*=0.185), and r_s=0.20 (% Sport Nutrition Knowledge *p*=0.215). Information on all crosstabulation results available in Appendix I.

Regression analysis

A total of 19 models were tested for use (details available in Appendix J). Initial models utilized linear regression analysis following the process outlined within Laerd Statistics (Lund Research, 2013). Subsequent models were conducted as per advice from a statistician (XL), using variables found to have significant correlations within the Spearman's correlation crosstabulation within a stepwise analysis model. All regression analyses included participants who completed the Australian Eating Survey (n=42). In order to explore modifiable factors that influence dietary intake that are significantly associated with dietary intake, the first regression model examines the impact of Body Image Disturbance Questionnaire score, Weight Fluctuation Score, Power of Food Scale Food Tasted scale, and carbohydrate/kg/body weight on kilojoule intake (Megajoule intake with dietary fibre), F(4, 37) = 16.90, *p* = <0.001. R^2 for the overall model was 64.6% with an adjusted R^2 of 60.8% (See Table 4). A second regression model examined the relationship between Body Image Disturbance Questionnaire scores and significantly correlated variables (Power of Food Scale Food Available scale, Megajoule intake with dietary fibre, and Current vs. Ideal Contour Drawing Rating Scale), F(3, 38) = 7.95, *p* = <0.001. R^2 for the overall model was 38.6% with an adjusted R^2 of 33.7% (See Table 5).

Differences in outcome measures based on socio-demographic factors

Differences in diet intake and other outcomes on the basis of gender, prior nutrition education status, supplement consumption, and special diet consumption were assessed. Given the number of variables assessed, only differences that were statistically significant have been described here. All statistics presented are for the full sample, unless they refer to data taken from the AES.

There were statistically significant differences between genders in a number of variables. Males had a significantly higher scores than females for energy intake with dietary fibre (Mean rank males: 29.0; females: 19.45; *p*=0.038) and Current vs. Ideal Contour Drawing Rating Scale score (Median

Table 4. Stepwise Univariate Analysis Examining Megajoule Intake with BIDQ score, Weight Fluctuation Score, PFS Food Tasted Scale, and Carbohydrate/kg/body weight.

	Megajoule Intake with Dietary Fibre							
	Model 1		Model 2		Model 3		Model 4	
Variable	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Intercept	4.353	8.40-10.1	6.729		6.946		9.190	
CHO/kg	1.20	3.60-4.49	1.123		1.058		0.984	
BIDQ			-0.915	2.00-2.53	-0.918		-0.834	
WFS					0.745	-0.21-0.35	0.730	
PFS Food Tasted							-0.719	2.70-3.23
R^2	0.438		0.528		0.593		0.646	
Adj R^2	0.424		0.503		0.560		0.608	
ΔR^2	0.438		0.09		0.065		0.053	
P value	<0.001		<0.001		<0.001		<0.001	

*Note. N=42. * p<0.05, ** p<0.001. CHO/kg, Carbohydrate per kilogram of body weight. BIDQ, Body Image Disturbance Questionnaire score. WFS, Weight Fluctuation Score. PFS, Power of Food Scale.*

males: 0; females: -1; *p* = 0.005). Females had significantly higher scores than males in Body Image Disturbance Questionnaire mean (Median males: 1.43; females: 2.14; *p* = 0.002) and hedonic hunger of Power of Food Scale Average score, Power of Food Scale Food Available, Power of Food Scale Food Present, and Power of Food Scale Food Tasted (Mean male: 2.33, SD: 0.7; female: 3.03, SD: 0.76; *p* <0.001, Median male: 1.833; female: 3.0; *p* = 0.004, Mean rank male: 34.43; female: 53.67; *p* = 0.002, Mean rank male: 31.0; female: 55.1, *p* <0.001, respectively) (See Table 6).

There were significant differences between those with prior nutrition education and those without prior nutrition education: % Total Nutrition Knowledge (nutrition education: 52.43; no nutrition education: 36.98; *p* = 0.005), % General Nutrition Knowledge (nutrition education: 53.45; no nutrition education: 40.25; *p* = 0.019), % Sport Nutrition Knowledge (nutrition education: 50.83; no nutrition education: 37.87; *p* = 0.019), and Opposite average vs. Ideal Contour Drawing Rating Scale score (nutrition education: 1; no nutrition education: -1, *p* = 0.047) (See Table 7).

Those who consumed supplements were significantly different from those who did not consume supplements in two areas: Opposite average vs. Ideal Contour Drawing Rating Scale score (*p* = 0.025) and Australian Recommended Food Score extras consumption (*p* = 0.031) (See Table 8).

Those consuming a special diet had significant differences to those who did not consume a special diet in a number of areas: with decreased Australian Recommended Food Score meat consumption

Table 5. Stepwise Univariate Analysis Examining Body Image Disturbance Questionnaire score with Megajoule intake, Current vs. Ideal Contour Drawing Rating Scale score, and Power of Food Scale Food Available Score.

	BIDQ Score					
	Model 1		Model 2		Model 3	
Variable	β	95% CI	β	95% CI	β	95% CI
Intercept	0.120	2.00-2.53	0.376		0.371	
PFS Food Available	0.077	2.32-2.93	0.065		0.052	
MJ Intake			-0.024	8.40-10.01	-0.025	
Current vs. Ideal CDRS Score					-0.044	-1.53- -0.66
R^2	0.183		0.282		0.386	
Adj R^2	0.162		0.246		0.337	
ΔR^2	0.197		0.134		0.121	
P value	0.005		0.002		<0.001	

*Note. N=42. * p<0.05, ** p<0.001. PFS, Power of Food Scale. MJ Intake, Megajoule intake. CDRS, Contour Drawing Rating Scale.*

(*p* = 0.001), fat/kg/body weight (*p* = 0.033), protein/kg/body weight (*p* = 0.009), Protein % of E (*p* <0.001) and Fat % of E (*p* = 0.001) and increased consumption of Australian Recommended Food Score meat alternatives (*p* <0.0001), and Carbohydrate % of E (*p* = 0.002) (See Table 9).

Macronutrient Intake Analysis

Forty-two participants provided Australian Eating Survey data for this study. There was a statistically significant difference between the median proportion of energy from protein within participants from this study (16% of energy from protein) and results from the 2012 Australian Dietary Survey (18.1% of energy from protein), with a significantly lower protein consumption, z=-3.073, p=0.002. There was a statistically significant higher median proportion of energy from fats within participants from this study (34% of energy from fats) and results from the 2012 Australian Dietary Survey (31.2% of energy from fats), z=2.585, p=0.010. Median proportion of energy from carbohydrate within participants from this study (48% of energy from carbohydrates) was statistically significantly higher than results from the 2012 Australian Dietary Survey (45.3% of energy from carbohydrates), z=2.484, p=0.013. All macronutrient intake percentages within the current study were within the Acceptable Macronutrient Distribution Range (National Health and Medical Research Council, 2014).

Table 6. Differences in outcome measure based on gender (n=82).

	Male Scores	Female Scores	Test result
Energy intake with dietary fibre (n=42) Mean rank	29.0	19.45	U=81.0, z=-2.069, p=0.038 (exact sig)
Current vs. Ideal CDRS score Median (IQR)	0(1)	-1(2)	U = 629.5, z = -2.818, p=0.005
BIDQ Median (IQR)	1.43(0.79)	2.14(1.36)	U=1198.5, z=3.071, p=0.002
PFS Mean	2.33 (0.7)	3.03(0.76)	t (93) = -4.177, p <0.0001
PFS Food Available Median (IQR)	1.833 (1.67)	3.0(1.33)	U=1293.0, z=2.904, p=0.004
PFS Food Present Mean rank	34.43	53.67	U=1318.0, z=3.113, p=0.002
PFS Food Tasted Mean rank	31.0	55.1	U=1414.0, z=3.903, p<0.0001

Note. CDRS, Contour Drawing Rating Scale. BIDQ, Body Image Disturbance Questionnaire score. PFS, Power of Food Scale score. IQR, interquartile range.

Table 7. Differences in outcome measure based on prior nutrition education (n=82).

	Prior nutrition education group scores	No prior nutrition education group scores	Test result
%TNK Mean rank	52.43	36.98	U=512.0, z=-2.792, p=0.47
%GNK Mean rank	53.45	40.25	U=641.5, z=-2.349, p-0.019
%SNK Mean rank	50.83	37.87	U=560.0, z=-2.343, p=0.019
Opposite average vs. Ideal CDRS score Median (IQR)	1(1)	-1(1)	U=1295.5, z=1.988, p=0.47

Note. %TNK, percentage of total nutrition knowledge questions correct. %GNK, percentage of general nutrition knowledge questions correct. %SNK, percentage of sport nutrition knowledge questions correct. CDRS, Contour Drawing Rating Scale. IQR, interquartile range.

Table 8. Differences in outcome measure based on supplement intake.

	Those who consume supplement group score	Those who do not consume supplements group score	Test result
ARFS extras consumption (=42) Mean rank	26.63	18.65	U=279.5, z=2.156, p=0.031
Opposite average vs. Ideal CDRS score (n=82) Median (IQR)	-1.0 (1)	-1.0 (1)	U=1417.0, z=2.246, p=0.025

Note. ARFS, Australian Recommended Food Score. CDRS, Contour Drawing Rating Scale. IQR, interquartile range.

Table 9. Differences in outcome measure based on consumption of a special diet (n=42).

	Those who consume a special diet group score	Those who do not consume a special diet group score	Test result
ARFS meat consumption Mean rank	14.0	26.6	U=85.0, z=-3.378, p=0.001
ARFS meat alternatives Mean rank	30.38	15.46	U=363.5, z=3.910, p<0.0001
fat/kg/bw Mean (SD)	1.09 (0.29)	1.33(0.38)	t(40)=2.211, p=0.33 [b]
PRO/kg/bw Mean rank	15.71	25.44	U=114.0, z=-2.524, p=0.012
PRO% of E Mean rank	13.32	27.06	U=73.5, z=-3.579, p<0.0001
Fat% of E Mean (SD)	30.65 (4.17)	36.36(5.99)	t(40)=3.405, p=0.002
CHO% of E Median (IQR)	56 (12)	47(10)	U=331.0, z=3.044, p=0.002

Note. ARFS, Australian Recommended Food Score. Fat/kg/bw, fat intake per kilogram of body weight. PRO/kg/bw, protein intake per kilogram of body weight. PRO% of E, protein percentage of total energy intake. Fat% of E, fat percentage of total energy intake. CHO% of E, carbohydrate percentage of total energy intake.

Discussion

The aims of this study were to measure the influence of the modifiable factors of nutrition knowledge, body image and weight control, macronutrient balance, and hedonic hunger on student athlete and exercisers' food choices, as well as to assess the association between these factors in student athletes and exercisers. There were relatively few significant correlations between variables, with no significant correlations found between diet quality and body image disturbance or other modifiable factors. Regression analysis demonstrated that up to 61.4% of difference in energy intake could be due to Body Image Disturbance Questionnaire scores, Weight Fluctuation Scores, Power of Food Scale Food Tasted scores, and carbohydrate/kg of body weight. It was found that males in this sample exhibited lower body image disturbance and hedonic hunger scores than females, while having a significantly higher kilojoule intake than females. Those with prior nutrition education had significantly higher nutrition knowledge scores than those without prior nutrition education. Individuals who consumed supplements were found to consume significantly more Australian Recommended Food Score extras than those who did not consume supplements. And those who followed a special diet consumed significantly less meat, protein, and fat and significantly more meat alternatives and carbohydrates. The macronutrient intake in this study sample was significantly different to the 2012 Australian National Health Survey (Grech et al., 2018), having increased fat intake and decreased intakes for both protein and carbohydrate.

Associations between modifiable factors

Energy intake would be expected to be significantly correlated with fat, carbohydrate, and protein g/kg/body weight, as each macronutrient, along with alcohol, are components of energy consumed. The correlations between energy intake and other significant variables could be due to a number of factors. Positive, significant correlation between energy intake and weight fluctuation score (r_s = 0.387, p = 0.011) could be related to dieting behaviours, as weight loss often coincides with energy deficits (Hall, 2008). A negative, significant correlation was found between energy intake and PFS Food Tasted (r_s= -0.353, p = 0.022). This relationship may be because Power of Food Scale is a measure of urge to eat rather than actual consumption of food (Howard et al., 2021) and the urge to eat may be ignored within athlete or active populations who do not compensate for energy expended during exercise (Birkenhead & Slater, 2015). It is also likely that individuals who are consciously restricting energy intake for the purposes of weight loss may ignore the urge to eat due to dietary choices in line with the diet goals (Buckland et al., 2013). Similarly, energy intake's significant, negative correlation with Body Image Disturbance Questionnaire score (r_s = -0.340, p = 0.028) may be because individuals with high body image disturbance scores are more likely to exhibit disordered eating behaviours (Hrabosky et al., 2009) or may have a kilojoule deficit due to dieting behaviours. Further investigation of the difference in energy intake between athlete compensators and non-compensators in relation to these factors would be of interest.

Body image disturbance scores were significantly, positively correlated with hedonic hunger scores (PFS) both total and for the Food Available subscale (r_s = 0.39, p = 0.011 and r_s = 0.43, p = 0.005, respectively). It has been previously found that Power of Food Scale scores were positively associated with dieting, but the Power of Food Scale Food Tasted subscale was not (Lipsky et al., 2019). Individuals with anorexia nervosa, bulimia nervosa, or body dysmorphic disorder are more likely to have higher Power of Food Scale scores and experience greater body image distress than control individuals (Hrabosky et al., 2009). Considering the fact that individuals with body dysmorphia type disorders are more likely to have higher total Power of Food Scale scores, it is logical that Power of Food Scale be associated with high body image disturbance scores. It would be beneficial to investigate these claims within athlete populations to determine their accuracy within this population.

The Australian Recommended Food Score food quality index's negative, significant correlation with the Power of Food Scale Food Present subscale (r_s = -0.31, p = 0.046) indicates that the influence of food present negatively impacts the quality of the food consumed. This may have been influenced by dietary changes due to a change in food environment (Caspi et al., 2012) caused by individuals spending more time in the home because of COVID-19 restrictions around working and recreation.

Non-significant correlations occurred between a number of factors. A number of these require further investigation with a larger sample size to determine if these correlations may be significant or of similar magnitude in a more representative sample. For instance, the Australian Recommended Food Scores were weakly, positively correlated with % Total Nutrition Knowledge, % General Nutrition Knowledge, and % Sport Nutrition Knowledge (r_s = 0.24, p = 0.126, r_s = 0.21, p = 0.185, and r_s = 0.20, p = 0.215, respectively) of the magnitude expected based on previous studies (Spronk et al., 2014).

Regression analysis

The first regression analysis model developed within this study found that energy intake was significantly impacted by body image disturbance, weight fluctuation, hedonic hunger when food has been tasted, and carbohydrate intake by 61.4%. The second regression analysis model within this study found that body image disturbance was significantly impacted by hedonic hunger when food is available, energy intake, and current vs. ideal Contour Drawing Rating Scales scores by 40.9%. While not all factors investigated were found to be significantly associated with energy intake or diet quality in this study, this result does confirm that there is a moderate to large association between energy intake and some modifiable factors within this population, as well as body image disturbance scores and some of the included modifiable factors. As there have been no other studies which have explored this type of analysis previously, it would be beneficial to perform a similar analysis in a larger sample of athletes with more varied backgrounds. It is possible that other semi-modifiable (such as lifestyle and motives for participating in sport, fat-free mass, resting metabolic rate, hunger and appetite, taste and food preference, gastrointestinal discomfort, meal patterns, availability, and social facilitation) non-modifiable factors (such as cost, income, and marketing) (Trakman, 2018) may explain the remaining variance in intake; this possibility should be explored further in future studies.

Differences in outcome measures based on socio-demographic factors

There were significant differences in hedonic hunger (Power of Food Scale) scores across the total score and all three subscales (Power of Food Scale Average score, Power of Food Scale Food Available, Power of Food Scale Food Present, and Power of Food Scale Food Tasted) between males and females, as well as the Current vs. Ideal Contour Drawing Rating Scale score, Body Image Disturbance Questionnaire mean, and Kilojoule intake with dietary fibre. Energy intake may be expected to be greater for men than for women due to the higher energy requirements of men. However, the differences in Contour Drawing Rating Scale and Body Image Disturbance Questionnaire scores may be due to a higher rate of body image disturbance in women than men. It has previously been found that college women had a higher rate of body image disturbance than men (Cash & Grasso, 2005; Cash et al., 2004), with heavier women having greater body image disturbance than lighter women and white women having greater body image disturbance than African American women (Cash et al., 2004). PFS has been found not to differ between genders in a population of college students in the UK (Lowe et al., 2009). The difference in findings between the current study and Lowe et al. (2009) may be due to a difference in populations examined. The population for this study was required to participate in exercise for a minimum of 2.5 hours/week. However, the Lowe et al. (2009) study did not specify the level of activity within the population that was measured.

Nutrition education was found to have significant positive relationships with % Total Nutrition Knowledge, % General Nutrition Knowledge, % Sport Nutrition Knowledge, and Opposite average vs. Ideal Contour Drawing Rating Scale score. A significant difference between the nutrition knowledge of those with prior nutrition education and those without prior nutrition education was found in the Trakman, Forsyth, Hoye, et al. (2018) study to validate the Abridged Nutrition for Sport Knowledge Questionnaire. When measuring knowledge concerning fluid intake in Division 1 American Football players, significant differences were found between those who sat in on nutrition lectures and those who had taken a nutrition class or those who had not formal nutrition education (Judge et al., 2016). Similarly, nutrition knowledge was not significantly different among college level athletes in various sports with and without prior nutrition education (Andrews et al., 2016). Due to the disparity of results, it would be prudent to conduct more focused research in specific athlete groups to identify whether there are person and sport-specific factors that influence diet intake. It is also important to conduct controlled nutrition (or other) intervention studies in order to assess which factors can be modified to improve diet intake, as this is likely to have the most impact on athletes' overall performance. .

Those who consumed supplements had significantly higher scores for Opposite average vs. Ideal Contour Drawing Rating Scale score and a significantly increased Australian Recommended Food Score extras consumption compared to those who did not. A recent study has found that intake of various supplements is related to an increased drive to have a muscular physique in Australian adolescent boys (Yager & McLean, 2020). It is unclear from available research why the Opposite Average vs. Ideal Contour Drawing Rating Scale scores may be significantly different for those athletes who consume supplements, as research using this tool does not usually focus upon supplement use. Perhaps these significant factors are related to the dominant culture of dieting and trying to be 'healthy' amongst the population. It would therefore be beneficial to confirm these results with an appropriately powered study.

Those who followed a special diet (n=25) largely followed vegan, vegetarian, and pescatarian diets (n=14). There were significantly lower Australian Recommended Food Score meat consumption, fat/kg/body weight, protein/kg/body weight and significantly higher consumption of Australian Recommended Food Score meat alternatives, and carbohydrate % of E. The significant differences validated the information provided by the Australian Eating Survey, as it would be expected that a group of individuals that predominately follows a diet restricting food groups would exhibit significant differences in Australian Recommended Food Scores for those food groups.

Macronutrient balance may influence dietary intake because macronutrients have variable effects on hunger and satiety; for example, protein has a high thermic effect of food and may delay gastric emptying, thereby possibly reducing total energy intake (Hutchison et al., 2015). Significant increases in carbohydrates and fat percent intakes and decrease in protein percent intake in the current study compared to the Australian National Health Survey 2012 results (Grech et al., 2018) may be due to a number of factors. As information on diet trends becomes more widely available through the internet and social media, it is possible that these trends may have affected the dietary patterns of the general population since 2012 (Guan & Li, 2021). Alternatively, the differences may be due to the sample size of the current study or possibly due to the demographics of the sample size. As 28.2% of the Australian general population contained individuals with a minimum Bachelor level degree in 2012 (Australian Bureau of Statistics, 2014), it is possible this disparity in level of general education differing between the study sample containing participants enrolled in undergraduate degrees and the general population within Australia may cause dietary intake to differ from the general population in 2012. Conducting a similar study in a representative sample may assist in confirming the possible shift in average macronutrient intakes.

Limitations

The sample size for this study was relatively small, having not reached power for some types of analysis. It would be beneficial to conduct a similar study in a larger sample size. The population used within this study is not representative of the general population or the athlete population due to the fact that all participants are undergraduate students. As this study involved participants completing the first part of the survey and then being registered for the Australian Eating Survey, there was a delay of days or weeks between the participant finishing the first part of the survey and moving on to the Australian Eating Survey. It is possible that this break between completing the first lot of surveys and being registered for the Australian Eating Survey may be related to the discrepancy in completion rate.

It is worth noting that general education has been identified as a confounder in nutrition knowledge levels (Hamzaid et al., 2018; Spronk et al., 2014). Due to the fact that the population of this study consists of only individuals currently undertaking some form of undergraduate degree, it is possible that this confounder has affected the generalisability of this result to different education levels. This confounder is difficult to assess statistically, because these variables are likely to be highly colinear and therefore not suitable for assessment in a multivariate model. It was not possible to stratify the population by level of education as all participants shared the same level of education. Future studies exploring this topic may wish to include education level as a covariate in a multiple linear regression model in order to control the effect of education on nutrition knowledge or recruit non-university educated athletes, as this is an understudied population.

It should also be noted that there is a possibility that the COVID-19 pandemic may have had a continuing impact of the factors being tested within this study. It is possible that increased levels of at home study and work had an impact on the food environment by increasing food availability. This change to the food environment of participants may have impacted levels of hedonic hunger, dietary intake, macronutrient balance, and weight fluctuation within this period. If weight did fluctuate during this time, it is possible that body image has also been impacted by this. Nutrition knowledge is possibly the only factor that would not have been affected by the food environment created by the pandemic's work-from-home culture.

The tool used for measuring weight fluctuation within this study was not validated for use. As such, it is possible that the results for weight fluctuation may be biased. The use of the subjective measure of the Contour Drawing Rating Scale to measure weight fluctuation cannot provide specific weight difference.

Statistical significance was assessed within this study rather than mean difference between the two groups and the imprecision of the difference. The use of the stepwise regression model has been criticised for its lack of generalisability with a new sample of data (Judd & McClelland, 1989). The exploratory nature of this study required the use of a stepwise regression model as an initial method of modelling. These methods would need to be developed further in future studies.

Strengths

There are two main strengths to this study. One strength of this study is that it was the first study to assess multiple factors that influence dietary intake in this population. An additional strength is the use of mostly validated tools to measure outcomes. By using mostly validated tools, the risk of measurement bias has been reduced. The tools used in this study are appropriate to the population as they are validated in university students (Cash & Grasso, 2005; Cash et al., 2004, Lowe et al., 2009), athletes (Trakman, Forsyth, Hoye et al., 2018) or Australian adult populations (Collins et al., 2015). Although the athletes the NSKQ was validated within were elite and non-elite athletes, the participants of this study were consistently participating in a sport or physical activity, which may have increased their interest in/exposure to nutrition information related to performance.

Future implications

This study examined the relationship between several factors that influence dietary intake. Future directions for study could include a larger study sample from a variety of sporting types. It would be beneficial to include semi-modifiable and non-modifiable factors that may influence dietary choices along with modifiable factors, as this would create a clearer image of the degree to which all factors influence dietary intake in athletes. A longitudinal study to measure changes in modifiable factors over time in response to interventions may provide insight into how interventions may impact factors outside of their intended target. A further study of a similar nature in the general population would allow for a holistic approach to nutrition/dietetic treatment in the future. By understanding all factors believed to impact dietary choices, the impact of dietary change could be more easily quantified.

Conclusion

This study suggests that dietary intake in student athletes and exercisers correlates with the modifiable factors of macronutrient intake (fat, carbohydrate, and protein), hedonic hunger when food is tasted, weight control, and body image. Regression analysis found that dietary intake was impacted by body image scores, weight fluctuation scores, hedonic hunger when food is tasted, and carbohydrate intake. Significant difference in outcome measures were found based on a variety of socio-demographic factors. Due to the small number of participants who completed this study, these results may not be generalizable to a wider athlete population. Further study in this area could explore longitudinal measures of modifiable factors with the application of nutrition interventions.

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Appendix A
Supplementary Material

Search Strategy for Medline Database

Search for: limit 11 to yr="2015 -Current"

Results: 108

Database: Ovid MEDLINE(R) ALL <1946 to March 30, 2020>
Search Strategy:
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1 exp Nutritional Sciences/ (19477)
2 'sport* nutrition knowledge'.mp. [mp=title, abstract, original title, name of substance word, subject heading word,
floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept
word, rare disease supplementary concept word, unique identifier, synonyms] (37)
3 'general nutrition knowledge'.mp. [mp=title, abstract, original title, name of substance word, subject heading word,
floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept
word, rare disease supplementary concept word, unique identifier, synonyms] (50)

4 'nutrition knowledge'.mp. [mp=title, abstract, original title, name of substance word, subject heading word,
floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept
word, rare disease supplementary concept word, unique identifier, synonyms] (1179)

5 1 or 2 or 3 or 4 (20332)

6 Athletes/ (12585)

7 athlete*.mp. [mp=title, abstract, original title, name of substance word, subject heading word,
floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept
word, rare disease supplementary concept word, unique identifier, synonyms] (53873)
8 sport*.mp. [mp=title, abstract, original title, name of substance word, subject heading word,
floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept
word, rare disease supplementary concept word, unique identifier, synonyms] (37)exp Nutritional Sciences/ (101748)

9 6 or 7 or 8 (125853)

10 5 and 9 (293)

11 limit 10 to (English language and yr="2015-Current") (108)

Table 1. Quality assessment results based on JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies [26]

	1 Participant inclusion	2 Demographics & setting	3 Exposure	4 Athlete condition	5 Confounders identified	6 Confounder control strategies	7A NK tool validity	7B Dietary assessment tool validity	8 Appropriate statistical analysis	Total	Out of	%
Abbey et al. [50]	1	1	1	0	NA	NA	0	1	Unclear	4	8	50
Andrews et al. [54]	1	0.5	1	0	NA	NA	1	NA	Unclear	3.5	7	50
Andrews & Itsiopoulos [37]	1	1	1	1	0	0	1	1	1	7	10	70
Argolo et al. [63]	1	1	0	1	1	1	2	1	1	9	10	90
Balaravi et al. [40]	1	1	0	1	NA	NA	1	NA	1	5	7	71.42857
Blennerhassett et al. [64]	0	1	1	1	NA	NA	2	NA	1	6	7	85.71429
Coccia et al. [49]	1	1	0	0	1	1	0	1	Unclear	5	10	50
Condo et al. [36]	1	1	0	0	NA	NA	2	1	1	6	8	75
Devlin et al. [32]	1	1	0	1	0	1	0	1	1	6	10	60
Hardy et al. [65]	1	1	1	0	1	1	2	NA	1	8	9	88.88889
Holden et al. [59]	1	1	1	0	NA	NA	2	NA	Unclear	5	7	71.42857
Jenner et al. [33]	1	1	1	0	NA	NA	2	NA	1	6	7	85.71429
Jenner et al. [34]	1	1	1	0	1	0	2	1	1	8	10	80
Judge et al. [56]	1	1	1	1	1	1	1	NA	Unclear	7	9	77.77778
Lohman et al. [35]	1	1	0	0	NA	NA	2	1	1	6	8	75
Madrigal et al. [51]	1	1	0	0	0	0	0	NA	1	3	9	33.33333
Magee et al. [31]	1	1	0	0	NA	NA	2	NA	1	5	7	71.42857
McCrink et al. [60]	1	1	0	0	NA	NA	2	1	1	6	8	75
Mitchell et al. [57]	1	1	1	0	NA	NA	2	NA	Unclear	5	7	71.42857
Murphy et al. [61]	1	1	0	0	1	1	2	1	1	8	10	80
Nascimento et al. [30]	1	0	0	0	1	1	1	1	1	6	10	60
Renard et al. [62]	0	1	1	0	1	1	2	NA	1	7	9	77.77778
Rossi et al. [58]	1	0.5	0	0	1	1	1	1	1	6.5	10	65
Saribay & Kirbaş [52]	0	0.5	0	0	NA	NA	1	NA	Unclear	1.5	7	21.42857
Simpson et al. [53]	1	1	0	0	NA	NA	0	Unclear	1	3	8	37.5
Trakman, Forsyth, Hoye, & Belski [18]	1	1	1	0	NA	NA	2	NA	1	6	7	85.71429

Trakman et al. [11]	1	1	1	1	NA	NA	2	NA	1	7	7	100
Werner et al. [55]	1	0.5	0	0	NA	NA	2	NA	Unclear	3.5	7	50

Quality Assessment results utilising the JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies [26]

Table 2. Data extraction results for Dietary Intake and Correlational data between Nutrition Knowledge and Dietary Intake

Study information (Author(s), year, study location)	Participant information (total number, age, gender)	Secondary outcome results Macronutrient/Micronutrient/Food group intakes	Correlation measures
Abbey, Wright, & Kirkpatrick 2017 [50] USA	n=88 19.6±1.7 (mean±SD) Male=88	Average nutrient intake of linemen compared to the DRI Energy, kcals n=88 (5225.4±1693.6); DRI for Average Lineman (4552.9); p=0.268 Total CHO, g n=88 (549.2±261.5); Lineman (911.2); p=0.017 Dietary fiber, g n=88 (45.8±18.5); Lineman (63.7); p=0.020 PRO, g n=88 (225.00±89.6); Lineman (182.2); p=0.190 Total fat, g n=88 (192.5±60.2); Lineman (141.7); p=0.035 SFA, g n=88 (61.3±17.3); Lineman (45.5); p=0.026 MUFA, g n=88 (49.0±15.7); Lineman (50.6); p=0.769 PUFA, g n=88 (29.2±9.3); Lineman (45.5); p=0.001 Omega-3 s, g n=88 (2.4±07); Lineman (4.6); p=<0.001 Omega-6 s, g n=88 (25.5±8.7); Lineman (40.5); p=0.001 Dietary cholesterol, mg n=88 (957.6±406.3); Lineman (300); p=0.001	NA

		Sodium, mg n=88 (9404.3±3390.5); Lineman (2300); p=<0.001 Potassium, mg n=88 (6298.1±1986.5); Lineman (4700); p=0.042 Reporting Daily in % of n =88 Starches/grains - 67 Meat - 52.3 Seafood - 6 Dairy - 82.8 Fruits - 47.1 Vegetables - 38.4 Desserts/candy - 20.2 Sports drinks - 34.1 Juice - 29.9 Coffee - 3.4 Soda - 2.3 Energy drinks - 2.3 Protein powders - 33.0 Multivitamin/mineral - 18.2 Creatine - 5.7 Other - 6.9	
Andrews & Itsiopoulos 2016 [37] AUS	Professional n=29 22 (18-27) Male=29 Semiprofessional n=44 21(18-33) Male=44	Professional:Semiprofessional Energy, kJ 11525±1987:10831±3842 kJ/kg 142.3±21.1:145.1±44.8 PRO Pro:semi:recommended intakes (64) g 152.3±27.7:149.1±46.8:15.25 %EI 22.7±3.8:24.1±5.9:0.84, 1.4-1.7 g/kg 1.9±0.3:2.0±0.6:1.5-2.0 CHO g 302.4±72.3:289.7±148.5: %EI 43.6±8.3:43.3±9.3:45-65 g/kg 3.5±0.8:3.9±1.8:5-10 Fat g 95.9±31.7:85.8±37.8: %EI 30.4±7.3:29.5±7.4:20-35	Moderate positive correlations were found between SNK and average energy intake (n=46, spearman's rho=0.31, p=0.04); SNK and carbohydrate intake (n=46, spearman's rho=0.35, p=0.02); and relative to body mass (n=41, spearman's rho=0.32, p=0.04)

		Alcohol g 1.2±3.5:0.8±3.5: %EI 0.3±1.0:0.2±0.7: Fiber g 32.4±8.7:30.3±16.8:30 %EI 2.3±0.6:2.2±0.7:	
Argolo et al. 2018 [63] Brazil	n=17 33±10.8 Male=17	MEDIAN (ICC): Inadequacy % CHO (g/kg) - 3.2 (2.7-3.8):88 PRO (g/kg) - 1.1 (0.6-1.5):64.7 Fat (%) - 26.6 (19-32): 35.3 SFA (%) - 9.4 (6-13.1): 35.3 MUFA (%) - 5.2 (3.3-10): 76.5 PUFA (%) - 4.3 (2-5.1): 88.2 Fiber (g) - 15 (10-17): 94.1 MEDIAN (ICC): Inadequacy % Vit A (µg) - 484 (326-882): 70.6 Vit C (mg) - 610 (553-628): 0 Vit B1 (mg) - 1.2 (0.7-1.5): 53 Vit B2 (mg) - 1(0.7-2.5): 41.2 Vit B5 (mg) - 3.4 (3-4.4): 88 Vit B6 (mg) - 7.2 (5.6-7.6): 0 Vit B9 (µg) - 108 (0-263):76.5 Vit B12 (µg) - 3.2 (1.2-3.8): 35.3 Vit E (mg) - 8.1 (6-16): 58.8 Calcium (mg) - 648 (603-696): 100 Iron (mg) - 10 (8.6-14.6): 53 Zinc (mg) - 8.8 (7.5-13.8): 58.8 Sodium (mg) - 2485 (1940-3981): 64.7 Phosphorus (mg) - 900 (898-904):0	Negative correlation between adults' total nutrition knowledge and their sodium intake (r=-485)
Coccia et al., 2020 [49]	n=50 19.62±1.483 Male=11, Female=39	n=27 Mean (SD) Fat % of E - 31.36 (3.72) fruit and vegetable intake - 5.52 (3.00)	Not reported
Condo, Lohman, Kelly,	n=30 24.15±4.1	Energy, kJ - 7826 ± 2411.6 kJ/kg/day - 199.5±37.4	NA

& Carr [36] 2019 AUS	Female=30	PRO - g - 98±32.1 g/kg/day - 1.5±0.5 CHO, g - 192.4±51.8 g/kg/day - 3.0±0.8 Sugar, g - 86.2±33.1 % of E - 18.6±4.4 Fibre, g - 25.5±8 Total fat, g - 72.2±33.4 % of E - 33.2±6.5 SFA, g - 25.7±14.6 % of E - 11.6±3.2 MUFA, g - 29±14.1 PUFA, g - 11.4±4.8 calcium, mg - 924.8±544.7 iron, mg - 12.2±3.2 magnesium, mg - 367.5±137.8 phosphorus, mg - 1569.3±549.4 potassium, mg - 3109±1173 sodium, mg - 2063.3±957 zinc, mg - 11.7±4 selenium, µg - 98.1±64.7 vit. C, mg - 106.8±115.3 thiamine, mg - 1.9±1.9 riboflavin, mg - 2.8±2.2 niacin, mg - 25.5±8.9 folate, µg - 484.6±149.8 vitamin B12, µg - 13.7±46.8	
Devlin, Leveritt, Kingsley, & Belski 2017 [32] AUS	n=66 23±4 Male=66	Elite AF:Subelite AF: Elite Soccer Energy, MJ - 17.3±4.2:13.2±2.5:9.4±2.3 g - 295±97:171±52:140±35 PRO, g/kg/day - 3.4±1.1:2.1±0.7:1.9±0.5 %TEI - 30±8:22±7:26±6	small, statistically significant, positive correlation between level of sport nutrition knowledge and both total energy intake (r2=0.046, p=0.014) and total CHO intake (r2=0.043, p=0.039) medium-large statistically significant - negatively correlation between total nutrition knowledge score and total protein intake (r2=0.244, p=0.026 and

		CHO, g - 406±132:368±93:220±76 g/kg/day - 4.6±1.5:4.5±1.2:2.9±1.1 %TEI - 38±9:45±10:38±8 Fat, g - 137±44:100±37:83±31 g/kg/day - 1.6±0.5:1.2±0.5:1.1±0.4 %TEI - 29±6:28±8:33±9	r2=0.382, p=0.016 respectively)
Hardy, Kliemann, Evansen, & Brand 2017 [65] USA	n=194 18-19 - 95 (49%), 20-21 - 83 (42.8%), >=22 - 16 (8.2) Male=82 Female=112	Energy drink consumption? User - n=28 nonusers - n=166 < 1 drink/wk - 54% 1-2 drinks/week - 29%	Knowledge scores were 5.6 points lower for consumers over non-consumers
Jenner et al. [34] 2018 AUS	n=46 24.2±4.0 Male=46	Mean +/- SD Energy (MJ) - 9.1±1.8 CHO (g/kg/day) - 2.4±0.8 PRO (g/kg/day) - 1.8±0.4 Fat (g/kg/day) - 0.9±0.3 Fibre (g) - 27.0±7.6 Calcium (mg) - 952±287 Fruit (serves) - 1.0±0.8 Vegetable (serves) - 4.2±1.7	moderate positive association between NK scores and meeting estimated energy requirements (r=0.325, P=0.031) NK scores positively associated with protein (r=0.348, P=0.021), fibre (r=0.510, P=0.001), and calcium intakes (r=0.428, P=0.004)
Lohman, Carr, & Condo 2019 [35] Australia	n=71 Elite=25±13, Sub-elite=21±3 Male=37	Elite (n=35): Sub-elite (n=31) Energy (kJ) - 14140±5887:10412±3316 PRO (g) - 210.9±77.5:163.2±48.6 CHO (g) - 285.5±154.9:225.6±86.9 CHO (g/kg BM) - 3.2±1.6:2.8±1.1 Sugar (g) - 124.3±77.5:93.2±40.2 Sugar (%EI) - 13.3±4.6:14.2±4.3 Fibre (g) - 35.1±17.0:29.4±14.3 Total fat (g) - 147.6±56.9:96.3±36.5 Total fat (g/kg BM) - 1.6±0.6:1.2±0.5 Total fat (%EI) - 39.8±6.0:33.8±5.7	NA

		SFA (g) - 51.0±24.0:34.3±14.4 SFA (g/kg BM) - 0.6±0.2:0.4±0.2 SFA (%EI) - 13.4±2.6:12±3 MUFA (g) - 61.7±23.2:39±17.6 PRO (g/kg BM) - 2.3±0.9:2.0±0.6	
McCrink et al., 2020 [60]	n=24 (for NSKQ results) Median = 23.0 (IQR = 20.0, 27.0) Male=24	Intake (median [IQR]) energy Kcal/day - 2496.2 (2162.2, 2719.1) PRO - total, g 114.2 (96.4, 125.2) g/kg/day - 1.4 (1.2, 1.7) %EI - 18.1 (16.4, 20.8) CHO Total, g - 290.7 (234.1, 319.2) g/kg/day - 3.6 (3.0, 4.1) %EI - 46.4 (41.2, 49.4) Free sugar, % EI - 8.8 (4.9, 12.3) Fibre, g - 21.5 (18.5, 25.8) Fat Total, g - 87.0 (75.5, 97.3) g/kg/day - 1.1 (1.0, 1.3) % EI - 32.2 (28.5, 36.2) SFA, % EI - 11.7 (10.0, 13.1) MUFA, %EI - 11.3 (9.6, 13.0) PUFA, % EI - 4.5 (3.4, 5.5) Alcohol Total, % EI - 0.0 (0.0, 9.1) Intake (median [IQR]) Vitamins Vitamin A, (µg) - 859.5 (578.5, 1165.9) Vitamin D (µg) - 3.8 (1.8, 5.5) Vitamin E (mg) - 10.0 (6.9, 12.6) Thiamin (mg) - 2.3 (1.8, 2.7)	

		Riboflavin (mg) - 2.3 (2.0, 3.1) Niacin (mg) - 58.8 (46.4, 70.0) Folate (µg) - 345.4 (279.8, 425.4) Vitamin B12 (µg) - 6.2 (5.2, 9.4) Vitamin C (mg) - 91.3 (55.5, 130.9) Minerals Sodium (mg) - 2793.7 (2338.1, 3294.7) Potassium (mg) - 3796.5 (3386.2, 4408.0) Magnesium (mg) - 354.5 (312.1, 426.7) Calcium (mg) - 1080.9 (812.4, 1420.6) Iron (mg) - 14.1 (11.6, 17.5) Zinc (mg) - 11.6 (9.3, 15.6) Selenium (µg) - 54.2 (47.2, 76.7)	
Murphy & O'Reilly, 2020 [61] Ireland	n=328 elite n=129, sub-elite n=136 18-21= 70 22-27= 127 28-32=47 33+=21 Male=328	Food group intake Median, % score, IQR Vegetables – 10, 47.6%, 8-12 Fruit – 5, 45.5%, 4-6 Meat – 4, 57.1%, 3-5 Meat alternative – 3, 50%, 3-4 Grains – 6, 46.2%, 5-7 Dairy – 5, 45.5%, 4-6 Water – 1, 100%, 1-1 Extras – 1, 100%, 0-1 Total – 35, 48.6%, 30-39	Correlation between nutrition knowledge and food score Total sample - Weak to moderate positive correlation (r=0.3, p=0.007) Sub-elite athletes - Weak positive correlation (r=0.26, p=0.002) Elite athletes – Moderate positive correlation (r=0.35, p=0.006)
Nascimento et al. 2016 [30] Brazil	n=11 (adult participants) 23.7 (SE=0.53) Male=11	Adequate portion intakes n(%) Cereals - 7(50) Fruits - 8 (34.8) Vegetables - 2 (34.6) Meats and eggs - 4 (25) Dairy - 3 (23.1) Beans and nuts - 3 (33.3) Fats and oils - 4 (21.1)	NA

		Sweets - 9 (45)	
Rossi et al. 2017 [58] USA	n=15 19.3 (1.0) Male=15	Energy, kcal - 3878 (443) PRO, g - 143 (25) CHO (g) - 291 (77) Fat, g - 129 (21)	NA

SFA, saturated fatty acids. MUFA, mono-unsaturated fatty acids. PUFA, poly-unsaturated fatty acids. n, number of participants. SD, standard deviations. CHO, carbohydrate. PRO, protein. kJ/kg, kilojoule per kilogram. %EI, percentage of energy intake. g/kg, grams per kilogram. kJ/kg/day, kilojoules per kilogram per day. g/kg/day, grams per kilogram per day. % of E, percentage of energy. %TEI, percentage of total energy intake. g/kg BM, grams per kilogram of body mass.

Appendix B

Sporting Organisations Contacted

Sport	Organisation	Website	Date of contact	Resent	Response
Football	Brisbane Lions	http://www.lions.com.au/	5-Jun	23-Jun	AUTOREPLY
Football	Wynnum Vikings AFL Club	www.wynnumvikingsafl.com.au	5-Jun	23-Jun	
Football	Melbourne Football Club	http://www.melbournefc.com.au/	5-Jun		Declined
Football	Slacks Creek Rugby League	https://scrlc.com.au/	5-Jun	23-Jun	
Football	AFL	https://www.afl.com.au/contact-us	5-Jun	23-Jun	AUTOREPLY
Football	Carlton Football Club	https://corporate.carltonfc.com.au/ContactUs	5-Jun	Not recontacted	AUTOREPLY
Football	Collingwood Football Club	https://www.collingwoodfc.com.au/club/contact	5-Jun	23-Jun	
Football	Essendon Football Club	https://www.essendonfc.com.au/club/contact-us	5-Jun	23-Jun	AUTOREPLY
Football	Hawthorn Football Club	https://www.hawthornfc.com.au/contact-us	5-Jun	23-Jun	AUTOREPLY
Football	Melbourne Rebels	https://melbournerebels.rugby/	5-Jun	23-Jun	
Football	Melbourne Storm	https://www.melbournestorm.com.au/	5-Jun	23-Jun	AUTOREPLY
Football	North Melbourne Football Club	https://www.nmfc.com.au/	5-Jun	23-Jun	Forward to football department

Football	Richmond Football Club	https://www.richmondfc.com.au/	5-Jun	23-Jun	AUTOREPLY
Football	St Kilda Football Club	https://www.saints.com.au/	5-Jun	23-Jun	Declined
Football	Western Bulldogs	westernbulldogs.com.au	5-Jun		Forwarded email
Football	Brisbane Broncos	https://www.broncos.com.au/	5-Jun		Declined
Football	QLD Reds Rugby	https://reds.rugby/	5-Jun		AUTOREPLY
Soccer	Brisbane Athletic Football Club	http://www.brisbaneathletic.com.au/	5-Jun	23-Jun	
Soccer	Football Queensland	http://www.footballqueensland.com.au/	5-Jun	23-Jun	
Soccer	Football Brisbane	http://www.footballbrisbane.com.au/	5-Jun	23-Jun	
Soccer	Capalaba FC	http://www.capalababulldogs.com/	5-Jun	23-Jun	
Soccer	Association of Australian Football Clubs	http://www.australianfootballclubs.org.au/	5-Jun	23-Jun	
Soccer	Melbourne City FC	https://www.melbournecityfc.com.au/	5-Jun	23-Jun	Forwarded to relevant department
Soccer	Brisbane Roar	https://www.brisbaneroar.com.au/	5-Jun	23-Jun	
Cricket	Queensland Cricket	https://www.qldcricket.com.au/about/contact-us	6-Jun	23-Jun	
Baseball	Red Sox	http://redsox.com.au/contactus-2/	7-Jun	23-Jun	
Baseball	Melbourne Aces	https://melbourneaces.com.au/contact-us/	7-Jun	23-Jun	

Baseball	Brisbane Bandits	https://brisbanebandits.com.au/	7-Jun	23-Jun	
Baseball	Melbourne Baseball Club	http://www.melbournedemons.baseball.com.au/	7-Jun	23-Jun	Posted to Facebook page
Basketball	Ipswich Basketball	https://websites.sportstg.com/assoc_page.cgi?c=1-4827-0-0-0&sID=308460	7-Jun	23-Jun	
Basketball	Basketball Queensland	http://www.basketballqld.com.au/	7-Jun	23-Jun	
Basketball	Logan Basketball	http://www.loganbasketball.com/	7-Jun	23-Jun	
Basketball	Ipswich Basketball	https://ipswichbasketball.com.au/	7-Jun	23-Jun	
Basketball	Brisbane Bullets	http://brisbanebullets.com.au/	7-Jun	23-Jun	
Basketball	Basketball Victoria	http://basketballvictoria.com.au/	7-Jun	23-Jun	
Basketball	Melbourne United	https://www.melbourneutd.com.au/	7-Jun		Queried details of study, did not continue
Cricket	Brisbane South Cricket Club	http://rochedalescc.qld.cricket.com.au/	7-Jun	23-Jun	
Cricket	South Brisbane District Cricket Club	http://www.sbdcc.org.au/	7-Jun	Not recontacted	
Cricket	Coorparoo Cricket Club	http://www.coorparoocricketclub.com.au/	7-Jun	23-Jun	
Cricket	Wynnum Manly District Cricket Club	http://wynnumcricket.com.au/	7-Jun	23-Jun	Failed
Cricket	Cricket Australia	https://www.cricketaustralia.com.au/contact	7-Jun	Not recontacted	

Cricket	Cricket Victoria	https://www.cricketvictoria.com.au/victorian-cricket-team/	7-Jun	23-Jun	AUTOREPLY
Cricket	Brisbane Heat	https://www.brisbaneheat.com.au/	7-Jun	23-Jun	
Cricket	Muddies Cricket Club	http://muddiescc.qld.cricket.com.au/	7-Jun	23-Jun	
Cricket	Wellington Wild Cats	http://www.wellowildcats.com.au/	7-Jun	23-Jun	
Cricket	Bundoora Bulls Cricket Club	http://bundoora.vic.cricket.com.au/	7-Jun	23-Jun	
Cricket	Melbourne Cricket Club	https://www.mcc.org.au/	7-Jun	Not recontacted	
Cricket	Wynnum Manly Sea Eagles Cricket	http://seaeagles.qld.cricket.com.au/	7-Jun	23-Jun	
Cricket	Manly Warringah District Cricket Club	http://www.manlycricket.com/	7-Jun		Forwarded to coaches and player welfare manager
Cricket	Brisbane Heat	brisbaneheat.com.au	7-Jun	30-Jun	
Netball	Rochedale Rovers Netball Club Inc.	http://www.rochedalerovers.qld.netball.com.au/	7-Jun	23-Jun	
Netball	Ipswich Netball Association	http://www.ipswich.netball.asn.au/	7-Jun	23-Jun	
Netball	Netball Australia	https://netball.com.au/contact	7-Jun	Not recontacted	
Netball	Collingwood Magpies Netball	https://collingwoodmagpies.com.au/contact	7-Jun	Not recontacted	

Netball	Melbourne Vixens	https://melbournevixens.com.au/contact	7-Jun	Not recontacted	
Netball	Queensland Firebirds	https://firebirds.net.au/	7-Jun	23-Jun	
Cricket	Muddies Cricket Club	http://muddiescc.qld.cricket.com.au/common/pages/public/entitydetails.aspx?	7-Jun	23-Jun 6-Aug	
Cricket	Wellington Point Cricket Club	http://www.wellowildcats.com.au/contact-us/	7-Jun	23-Jun 6-Aug	
Cricket	South Brisbane Cricket	https://www.facebook.com/SouthBrisbaneCricket	7-Jun		
Cricket	Coorparoo Cricket Club	http://www.coorparoocricketclub.com.au/common/pages/public/entitydetails.aspx?	23-Jun	6-Aug	
Athletics	QLD Athletics		25-Jun	4-Aug	
Athletics	Athletics Australia		26-Jun		Forwarded to Andrew Faichney 10 July
Softball	Softball Queensland		29-Jun	4-Aug	Replied 6 August - sent out to athletes again
Cricket	Cricket ACT	https://www.cricketact.com.au/	30-Jun	4-Aug	Responded 19 August after recruitment closed
Cricket	Cricket Tasmania	https://www.crickettas.com.au/about/contact-us	30-Jun	4-Aug	
Cricket	Hobart Hurricanes	https://www.hobarthurricanes.com.au/	30-Jun	4-Aug	
Cricket	Bendigo District Cricket Association	http://bendigocricket.vic.cricket.com.au/common/pages/public/entitydetail	30-Jun	4-Aug	Shared on social media member platforms

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Athletics	Athletics Victoria		30-Jun	4-Aug	Forwarded to groups and squads - no take up due to increased level of survey type activity during lockdown.
Football	Giants	https://www.gwsgiants.com.au/club/contact	30-Jun	4-Aug	
Football	Redcliffe Dolphins	http://redcliffedolphins.com.au/contact/	30-Jun	4-Aug	
Football	AFL NT	https://www.aflnt.com.au/about/contact-aflnt	30-Jun	4-Aug	
Football	Demons Football Club	https://www.nhfc.net.au/	30-Jun	4-Aug	
Football	Clarence Football Club	https://www.clarencefc.com.au/contact-us	30-Jun	4-Aug	
Football	NORTHERN SUBURBS RFC	http://northsrugby.com.au/about-us/contact-us/	30-Jun	4-Aug	
Football	North Sydney Bears	northsydneybears.com.au/contact-us/	30-Jun	4-Aug	
Football	Cowboys Rugby League	cowboys.com.au	30-Jun		Sent to - dpayne@cowboys.com.au
Football	Cowboys		30-Jun	4-Aug	
Football	Cronulla Sharks	sharks.com.au	30-Jun	4-Aug	
Football	Penrith Panthers	penrithpanthers.com.au	30-Jun	4-Aug	
Netball/Football	Castlemaine FNC Magpies	http://www.castlemainefnc.com.au/contact/	30-Jun	4-Aug	

Netball/Football	Eaglehawk Football Netball Club	https://eaglehawkfnc.com.au/contact.html	30-Jun	4-Aug	
Netball/Football	Gisborne Football Netball Club	http://www.gfnc.com.au/contacts	30-Jun	4-Aug	Responded 4 August - posted to Closed Facebook page
Netball/Football	GSFN Club	http://www.gsfnclub.com.au/contact/	30-Jun	4-Aug	
Netball/Football	Maryborough Football Netball Club		30-Jun	4-Aug	
Netball/Football	Sandhurst Football Netball Club	websites.sportstg.com/club_info.cgi?c=1-6148-80365-0-0&sID=123743	30-Jun	4-Aug	
Netball/Football	The Bloods South Bendigo Football and Netball Club	http://www.southbendigofnc.com.au/contact-us-social-room-hire/	30-Jun	4-Aug	
Netball/Football	Strathfieldsaye Football Netball Club	https://websites.sportstg.com/club_info.cgi?c=1-6148-80367-0-0&sID=93465	30-Jun	4-Aug	
Soccer	Collegiate Soccer League	www.collegiatesoccerleague.com.au	30-Jun	4-Aug	
Soccer	Limestone Coast Football Association	http://www.lcfa.com.au/	30-Jun	4-Aug	
Soccer	Port Lincoln Soccer Association	https://www.footballsa.com.au/port-lincoln-soccer-association	30-Jun	4-Aug	
Soccer	Riverland Soccer Association	www.riverlandsoccerassociation.com.au	30-Jun	4-Aug	
Soccer	South Australian Amateur Soccer League	www.saasl.com.au	30-Jun	4-Aug	Bounced

Soccer	South East Women's Football Association	www.sewfa.com.au	30-Jun	4-Aug	
Soccer	Yorke Peninsula Soccer Association	www.facebook.com/YpSoccer	30-Jun	4-Aug	Responded 4 August - Declined
Soccer	Jamestown Futsal	https://www.footballsa.com.au/jamestown-futsal	30-Jun	4-Aug	
Soccer	Port Augusta Futsal	https://www.footballsa.com.au/port-augusta-futsal	30-Jun	4-Aug	Declined - COVID restrictions - don't have an active season at present
Soccer	Roxby Downs Futsal	https://www.footballsa.com.au/roxby-downs-futsal	30-Jun	4-Aug	Bounced
Soccer	South Australian Futsal League	footballsa.com.au/south-australian-futsal-league	30-Jun	4-Aug	
Soccer	StarPlex Futsal	https://www.footballsa.com.au/starplex-futsal	30-Jun	4-Aug	
Soccer	Yorke Peninsula Futsal	https://www.footballsa.com.au/yorke-penisula-futsal	30-Jun	4-Aug	
Soccer	Adelaide United	https://www.adelaideunited.com.au/contact-0	30-Jun	4-Aug	Responded 12 August - declined
Soccer	South Fremantle Football Club	http://www.sffc.com.au/contact-us	30-Jun	4-Aug	
Squash	Squash Victoria		2-Jul		
Athletics	Athletics Australia		4-Aug		Follow up from Jessica's email
Baseball	All Stars Baseball	http://www.allstarsbaseball.com.au/info/committee.php	6-Aug		

Baseball	Pine Hills Lightning	https://www.pinehillslightningbaseball.com/	6-Aug			
Baseball	Windsor Royals	http://windsorroyals.com.au/contact/	6-Aug			
Baseball	Narangba Demons	http://demons.org.au/wspHome.aspx	6-Aug			
Baseball	Redcliffe Padres	https://www.redcliffepadres.com.au/	6-Aug			
Baseball	Pine River Rapids Baseball	http://rapidsbaseball.majestri.com.au/wspHome.aspx	6-Aug			
Baseball	Redlands Rays	http://redlandsrays.com.au/home/	6-Aug			
Baseball	Eagles Baseball	https://www.eagles.baseball.com.au/	6-Aug			
Baseball	Indians Baseball	http://www.indians.org.au/	6-Aug			
Baseball	Toowoomba Rangers	http://www.toowoombarangers.baseball.com.au/	6-Aug			
Baseball	Musketeers Baseball	http://www.musketeers.baseball.com.au/	6-Aug			
Baseball	Southern Stars Baseball	http://www.southernstarsbaseballclub.org/	6-Aug			
Baseball	West Bulldogs	http://www.wests.baseball.com.au/index.cfm?fuseaction=Display_Page&PageID=3083&OrgID=19506	6-Aug			
Baseball	Redbacks Baseball	https://www.facebook.com/redbacksbaseball/	6-Aug			
Baseball	Sunshine Coast Baseball	https://www.sunshinecoastbaseball.com.au/	6-Aug			

Baseball	Mudgeeraba Baseball	http://www.mudgeeraba.baseball.com.au/index.cfm?fuseaction=Display_Page&PageID=3884&OrgID=19516	6-Aug		
Baseball	Robina Braves	https://robinabraves.com/contact/	6-Aug		
Baseball	Runaway Bay Dolphins	http://www.runawaybay.baseball.com.au/index.cfm?fuseaction=Display_Page&PageID=2993&OrgID=19519	6-Aug		
Baseball	Surfers Baseball	https://surfersbaseball.com/	6-Aug		
Baseball	Alleygators Baseball	http://www.alleygators.baseball.com.au/	6-Aug		
Baseball	Nerang Cardinals	nerang.baseball.com.au	6-Aug		
Baseball	Coomera Cubs	http://www.coomera.baseball.com.au/	6-Aug		
Baseball	Bear Cubs	http://www.bearscubs.baseball.com.au/index.cfm?fuseaction=Display_Page&PageID=3229&OrgID=19482	6-Aug		
Baseball	Avengers Razorbacks	https://avengersbaseball.teamapp.com/contact_details?_detail=v1	6-Aug		
Baseball	Northern Jets Baseball	http://njbaseball.com.au/?fbclid=IwAR0xzp8xGtQAUnfWJkSOu78iGUgGxs8FOTjuoysY2hB6pbHQ9Qb7	6-Aug		

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Basketball	Southern Districts Basketball	https://sdbal.com.au/	6-Aug		
Basketball	RedCity Roar	https://www.redcityroar.com.au/	6-Aug		
Basketball	South West Metro Basketball	https://www.piratesbasketball.net.au/	6-Aug		
Basketball	Brisbane Basketball	https://brisbane.basketballqld.com.au/contact-us/	6-Aug		
Basketball	Northside Wizards	https://northsidewizards.com/	6-Aug		
Basketball	Seahawks GC Basketball	https://www.seahawksbasketball.com.au/contact-us	6-Aug		
Basketball	Gold Coast City Regional Basketball	http://www.goldcoastbasketball.com.au/contacts/	6-Aug		
Basketball	Caloundra Basketball	https://websites.sportstg.com/assoc_page.cgi?c=1-4924-0-0-0&sID=342490	6-Aug		
Basketball	University of the Sunshine Coast Basketball	https://www.uscbasketball.com.au/	6-Aug		
Basketball	Suncoast Clippers	http://www.maroochy.basketball.net.au/	6-Aug		
Basketball	Sunshine Coast Phoenix	https://websites.sportstg.com/assoc_page.cgi?c=1-	6-Aug		
Basketball	Toowoomba Basketball	http://toowoombabasketball.com.au/	6-Aug		
Basketball	Noosa District Basketball	https://www.noosacyclones.com.au/	6-Aug		

Basketball	Gympie Basketball	http://www.gympiebasketball.com.au/	6-Aug		
Basketball	Kingaroy Amateur Basketball	http://www.kingaroybasketball.sportingpulse.net	6-Aug		
Basketball	Maryborough Basketball	https://maryboroughbasketball.com/	6-Aug		
Boxing	Boxing Australia	https://www.boxingqld.org.au/contact/	6-Aug		
Cricket	Perth Scorchers	https://www.perthscorchers.com.au/contact-us	6-Aug		
Cricket	Western Australia Cricket	https://www.waca.com.au/waca/contact-us	6-Aug		
Cricket	Sydney 6ers	https://www.sydneysixers.com.au/	6-Aug		
Cricket	Sydney Thunder	sydneythunder.com.au	6-Aug		
Cricket	Bracken Ridge District Cricket Club	https://www.brackenridgedistrictcricketclub.com/contact-us.html	6-Aug		
Cricket	Cleveland Thornlands Cricket Club	http://clevelandthornlandscc.qld.cricket.com.au/common/pages/public/entitydetails.aspx?	6-Aug		
Cricket	Indooroopilly Districts Cricket Club	http://idcc.qld.cricket.com.au/common/pages/public/entitydetails.aspx?	6-Aug		
Cricket	Kenmore Cricket Club	http://www.kenmorecricket.com.au/contact-us.aspx	6-Aug		
Cricket	Redland Sharks Cricket	http://redlandsharks.qld.cricket.com.au/common/pages/public/entitydetail	6-Aug		

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Cricket	Valley District Cricket Club	http://valleydcc.qld.cricket.com.au/common/pages/public/entitydetails.aspx?	6-Aug		
Cricket	Wellers Hill Cricket Club	users.tpg.com.au/gerardhaley/contact.html	6-Aug		
Cricket	West Brisbane Cricket Club	http://www.wbcc.org.au/contact-us	6-Aug		
Cricket	Wolston Park Centenary Cricket Club	http://www.wpccricket.com.au/Contact.aspx?rw=c	6-Aug		
Cricket	Ashgrove Cricket Club	https://www.ashgrovecricket.com.au/contact-1	6-Aug		
Football	Newcastle Knights	https://www.newcastleknights.com.au/contact-us	6-Aug		
Football	Sydney Roosters	roosters.com.au/contact-us	6-Aug		Declined
Football	St George Illawarra	https://www.dragons.com.au/contact-us	6-Aug		
Football	NSW Rugby	https://nsw.rugby/about/contact-us	6-Aug		
Football	Gold Coast Titans	Titans.com.au/contact-us	6-Aug		

Football	Melbourne Victory	melbournevictory.com.au/contact-us	6-Aug		
Football	Reds Academy	https://qld.rugby/participate/find-a-club	6-Aug		
Football	QRRA Brisbane		6-Aug		
Football	Wests Bulldogs Rugby (Seniors)		6-Aug		
Football	Riverside Rebels Rugby Union Club	http://riversiderugbyclub.com.au/	6-Aug		
Football	University Of Qld RUFC		6-Aug		
Football	Easts RUC Brisbane (Seniors)		6-Aug		
Football	Brisbane Hustlers RUC		6-Aug		
Football	Brothers Rugby Club Albion (Seniors)		6-Aug		
Football	Souths Rugby Union Club (Seniors)		6-Aug		
Football	Brisbane Irish RUFC		6-Aug		
Football	Norths RUFC		6-Aug		
Football	Sunnybank Senior Rugby Club Inc		6-Aug		
Football	Wynnum and District Rugby Union (Seniors)		6-Aug		
Soccer	Newcastle Jets	https://www.newcastlejets.com.au/contact-us	6-Aug		

Soccer	Brothers TSV Football Club Inc	www.brotherstownsvillefc.com	6-Aug		
Soccer	Burdekin Senior Football Club		6-Aug		
Soccer	Estates Football Club	www.estatesfc.com.au	6-Aug		
Soccer	Goldfields United Hawks Football Club	https://goldfieldsunited.teamapp.com/	6-Aug		
Soccer	Ingham Football Club		6-Aug		
Soccer	MA Olympic Football Club	http://www.maolympic.org.au/	6-Aug		
Soccer	Northern Beaches United Football Club	http://websites.sportstg.com/club_info.cgi?clubID=137018&c=1-9391-0-0-0	6-Aug		
Soccer	Rebels FC	www.rebelsfc.com.au	6-Aug		
Soccer	Riverway Vikings FC		6-Aug		
Soccer	Ross River Senior (JCU) FC	https://www.rossriverseniorfc.com/	6-Aug		
Soccer	Saints Eagles South FC	http://websites.sportstg.com/club_info.cgi?c=1-9391-137026-0-0&sID=265379	6-Aug		
Soccer	Townsville Warriors	www.townsvillewarriorsfc.com.au	6-Aug		
Soccer	Wulguru United Football Club	www.wulguruunitedfc.com	6-Aug		
Tennis	Tennis NT	https://www.tennis.com.au/nt/contacts	6-Aug		

Tennis	Tennis ACT	https://www.tennis.com.au/act/about/staff-board-members	6-Aug		Forwarded for circulation 7 August
Tennis	Tennis QLD	https://www.tennis.com.au/qld/contacts	6-Aug		Declined 14 August
Tennis	Tennis SA	https://www.tennis.com.au/sa/contacts	6-Aug		
Tennis	Tennis WA	https://www.tennis.com.au/wa/	6-Aug		Post a flyer in the facility
Tennis	Tennis NSW	https://www.tennis.com.au/nsw/contacts	6-Aug		
Cricket	Cricket NSW	https://www.cricketnsw.com.au/about/contact-cricket-nsw	7-Aug		
Cricket	Albany & Districts Cricket Association Inc.	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Avon Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Broome Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Bruce Rock-Narembeen Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Bunbury & Districts Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Busselton Margaret River Cricket Association Inc	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		

Cricket	Carnarvon Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Central Midlands Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Central Wheatbelt Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		Bounced
Cricket	Country XI	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		Bounced
Cricket	Derby Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Dongara Cricket Club	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Donnybrook Cricket Club	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	East Kimberley Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Eastern Districts Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Eastern Goldfields Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Esperance Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		

Cricket	Exmouth Cricket Club	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Fortescue Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Geraldton Regional Cricket Board	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Great Southern Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Green Range Ongerup Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Harvey Leschenault Cricket Club	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Jurien Bay Cricket Club Inc.	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Kalgoorlie Friendly Societies Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Lakes Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Leschenault Cricket Club Inc.	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Marist Cricket Club Bunbury	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		

Cricket	Newman Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Nor-West & Murchison Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	North Midlands Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Northam Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Northern Stars	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Peel Cricket Association Inc.	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Pilbara Regional Cricket Board	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Ravensthorpe Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Regional Wheatbelt	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	South Midlands Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Upper Great Southern Cricket Association-	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		

Cricket	WA City Over 50s	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	WA Country Girls Can	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Wagin Cricket Club	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Warren Blackwood Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Wellington District Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Williams Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Cricket	Wyalkatchem Cricket Association	http://www.ccb.wa.cricket.com.au/common/pages/public/iv/clubs.aspx	7-Aug		
Football	Sydney Swans	https://www.sydneyswans.com.au/club/contact	7-Aug		
Football	Kalamunda Bulldogs	https://www.kalamundabulldogs.com/join_us	7-Aug		
Football	Willagee Bears	http://www.willageebears.com.au/	7-Aug		
Football	Rockingham Coastal Sharks Rugby League	https://rockinghamsharks.com.au/	7-Aug		
Football	Serpentine Jarradale Rugby League & Sporting Club	https://www.facebook.com/Serpentine-Jarrahdale-Rugby-League-Sporting-	7-Aug		

		Club-278173666446780/			
Football	Albany Sea Dragons Rugby League & Sporting Club Inc	https://www.facebook.com/albanyseadragons/	7-Aug		
Football	Wickham Wasps	https://wickhamwaspsrugbyleague.teamapp.com/	7-Aug		
Football	South Hedland Cougars Junior Rugby League	https://www.facebook.com/shcjrl/	7-Aug		
Football	Broome Jets Rugby League	https://www.facebook.com/BroomeJetsRugbyLeague/	7-Aug		
Football	Tom Price Steelers - RLFC	http://tompricesteelers.com/	7-Aug		
Football	Paraburdoo Pirates Rugby League and Touch Football Sports Club Inc.	facebook.com/ParaburdooPirates/	7-Aug		
Football	Albany Sharks	http://www.albanyfc.com.au/	7-Aug		BOUNCED
Football	Augusta Margaret River	http://thehawksfc.com.au/	7-Aug		
Football	Baldivis	http://www.wacfl.com.au/club_profile/169	7-Aug		BOUNCED
Football	Bayulu	http://websites.sportstg.com/team_info.cgi?id=26278650&c=0-3099-0-498053-0	7-Aug		
Football	Beverley	http://www.wacfl.com.au/club_profile/325	7-Aug		

Football	Borden	http://www.foxsportspulse.com/club_info.cgi?c=1-3096-49450-0-0	7-Aug		
Football	Boulder City	http://www.bouldertigers.com/	7-Aug		
Football	Boxwood Hills	http://www.foxsportspulse.com/club_info.cgi?c=0-3096-49448-0-0&a=clear	7-Aug		
Football	Boyup Brook	http://www.wacfl.com.au/club_profile/466	7-Aug		
Football	Bridgetown	http://www.wacfl.com.au/club_profile/467	7-Aug		
Football	Brigades	http://www.wacfl.com.au/club_profile/347	7-Aug		
Football	Brookton Pingelly	http://www.foxsportspulse.com/club_info.cgi?c=1-2654-94798-0-0&a=clear	7-Aug		
Football	Broome Bulls	http://www.foxsportspulse.com/team_info.cgi?c=1-3094-73913-263516-8951121	7-Aug		
Football	Broome Saints	http://www.broomesaintsfc.myclub.org.au/	7-Aug		
Football	Bruce Rock	http://www.foxsportspulse.com/club_info.cgi?c=7-3064-84712-0-0	7-Aug		
Football	Bullsbrook	http://www.foxsportspulse.com/club_info.cgi?c=1-3061-85068-0-0	7-Aug		
Football	Bunbury	http://www.bunburyfootballclub.com.au/	7-Aug		

Football	Burracoppin	http://www.foxsportspulse.com/club_info.cgi?c=1-3064-84708-106179-0&a=clear	7-Aug		
Football	Busselton	http://busseltonfootballclub.com.au/	7-Aug		
Football	Busselton Bombers	http://www.foxsportspulse.com/club_info.cgi?c=1-8315-162398-0-0	7-Aug		
Football	Cable Beach	http://www.foxsportspulse.com/club_info.cgi?c=1-3094-84655-0-0&a=clear	7-Aug		
Football	Calingari	http://www.foxsportspulse.com/club_info.cgi?clubid=83239&c=7-3065-0-0-0	7-Aug		
Football	Capel Kakkas	http://www.foxsportspulse.com/club_info.cgi?c=1-8315-162399-0-0	7-Aug		BOUNCED
Football	Carey Park	http://careyparkfc.com.au/	7-Aug		
Football	Carnamah Perenjori	http://www.foxsportspulse.com/club_info.cgi?c=1-3062-114928-206777-0	7-Aug		
Football	Cervantes	http://www.foxsportspulse.com/club_info.cgi?c=1-3095-97472-0-0&a=clear	7-Aug		
Football	Chapman Valley	http://www.gnfl.com.au/chapman-valley-football-club.aspx	7-Aug		
Football	Chidlow	http://www.foxsportspulse.com/team_info.cgi?c=1-3061-85070-251628-	7-Aug		BOUNCED

		18622660			
Football	Collie	http://www.collieeagles.com.au/	7-Aug		
Football	Coorow Latham	http://www.foxsportspulse.com/club_info.cgi?c=0-3062-114932-0-0	7-Aug		
Football	Cunderdin		7-Aug		
Football	Dallwallinu	http://www.foxsportspulse.com/club_info.cgi?c=7-3065-83238-0-0&a=clear	7-Aug		BOUNCED
Football	Dampier Sharks	http://www.dampiersharks.asn.au/	7-Aug		
Football	Dandaragan	http://www.foxsportspulse.com/club_info.cgi?c=1-3095-97471-0-0	7-Aug		
Football	Deanmill	http://www.deanmillfootballclub.com.au/	7-Aug		
Football	Denmark Walpole	http://denmarkfootballclub.myclub.org.au/	7-Aug		BOUNCED
Football	Derby Tigers	http://www.foxsportspulse.com/club_info.cgi?c=1-3094-73912-168542-0&a=clear	7-Aug		BOUNCED
Football	Dongara	http://www.foxsportspulse.com/club_info.cgi?c=1-3062-114931-0-0&a=clear	7-Aug		
Football	Donnybrook	http://www.donnybrookfc.org/	7-Aug		

Football	Dowerin	http://www.foxsportspulse.com/club_info.cgi?clubid=83235&c=7-3065-0-0-0	7-Aug		
Football	Dunsborough Mulies	http://www.foxsportspulse.com/club_info.cgi?c=0-8315-162401-0-0	7-Aug		
Football	Eaton	http://eatonboomers.com.au/welcome/	7-Aug		forward to secretary@eatonboomers.com.au
Football	Esperance FC	http://www.foxsportspulse.com/assoc_page.cgi?assoc=3060	7-Aug		
Football	Exmouth	http://exmouthinfo.com.au/directory/11964/exmouth-eagles-football-club	7-Aug		
Football	Federals	http://www.wacfl.com.au/club_profile/334	7-Aug		
Football	Gascoyne	http://www.foxsportspulse.com/team_info.cgi?id=18956669&client=0-6065-0-0-0&compid=344132	7-Aug		
Football	Gibson FC	http://www.foxsportspulse.com/club_info.cgi?c=0-3060-52922-0-0	7-Aug		
Football	Gingin	http://www.foxsportspulse.com/club_info.cgi?clubid=83240&c=7-3065-0-0-0	7-Aug		
Football	Gnowangerup	http://www.foxsportspulse.com/club_info.cgi?c=1-3096-49446-0-0	7-Aug		

Football	Goomalling	http://www.foxsportspulse.com/club_info.cgi?clubid=83242&c=7-3065-0-0-0	7-Aug		
Football	Halls Head	http://www.hhfc.com.au/	7-Aug		BOUNCED
Football	Harvey Brunswick Lesch	http://hblfc.com.au/	7-Aug		BOUNCED
Football	Harvey Bulls	http://www.harveybulls.com/	7-Aug		
Football	Hyden Kalgarin	http://www.foxsportspulse.com/club_info.cgi?c=1-3064-84715-0-0&a=clear	7-Aug		BOUNCED
Football	Jerramungup	http://www.foxsportspulse.com/club_info.cgi?c=1-3096-49451-0-0	7-Aug		
Football	Jurien	http://www.foxsportspulse.com/club_info.cgi?c=0-3095-97470-0-0	7-Aug		
Football	Kalannie	http://www.foxsportspulse.com/club_info.cgi?c=7-3063-96857-0-0	7-Aug		
Football	Kalgoorlie FC	http://kangasfc.com.au/	7-Aug		
Football	Kambalda FC	http://www.foxsportspulse.com/club_info.cgi?c=1-3294-41930-0-0	7-Aug		
Football	Karratha Kats	http://www.karrathakats.com/	7-Aug		
Football	Katanning	http://www.foxsportspulse.com/club_info.cgi?c=1-2654-94796-0-0&a=clear	7-Aug		

Football	Keller Tammin	http://www.foxsportspulse.com/club_info.cgi?c=1-2655-72618-0-0	7-Aug		
Football	Kojonup	http://www.foxsportspulse.com/club_info.cgi?c=1-3391-70363-0-0&a=clear	7-Aug		
Football	Koorda	http://www.foxsportspulse.com/club_info.cgi?clubid=96856&c=1-3063-0-0-0	7-Aug		
Football	Kukerin Dumbleyung	http://www.foxsportspulse.com/club_info.cgi?c=0-2654-94793-0-0	7-Aug		
Football	Kulin Kondinin	http://www.foxsportspulse.com/club_info.cgi?c=0-3064-84707-0-0	7-Aug		
Football	Kundat Djaru Cats	http://www.foxsportspulse.com/team_info.cgi?id=16807661&client=1-6955-0-254343-0&compid=254343	7-Aug		
Football	Lake Grace/Pingrup	http://www.foxsportspulse.com/club_info.cgi?c=1-3096-49445-0-0&a=clear	7-Aug		
Football	Lakes	http://www.wacfl.com.au/club_profile/290	7-Aug		
Football	Lancelin	http://www.lancelinpirates.com.au/	7-Aug		
Football	Looma	http://www.foxsportspulse.com/club_info.cgi?c=1-3094-73909-0-0	7-Aug		
Football	Mandurah	http://www.mandurahmustangs.com.au/	7-Aug		

Football	Manjimup Imperials	http://www.foxsportspulse.com/club_info.cgi?clubid=52908&c=0-3391-0-0-0	7-Aug		
Football	Manjimup Tigers	http://www.foxsportspulse.com/club_info.cgi?clubid=52907&c=1-3391-52912-344136-0	7-Aug		
Football	Mines Rovers FC	http://www.minesrovers.com/	7-Aug		
Football	Mingenew	http://www.foxsportspulse.com/team_info.cgi?c=0-3062-114929-252334-15440356	7-Aug		
Football	Moora	http://www.mooramavericks.com.au/	7-Aug		
Football	Mt Helena	http://www.foxsportspulse.com/club_info.cgi?c=1-3061-85067-0-0	7-Aug		
Football	Mukinbudin	http://www.foxsportspulse.com/club_info.cgi?clubid=96858&c=1-3063-0-0-0	7-Aug		
Football	Mullewa	http://www.gnfl.com.au/mullewa-football-club.aspx	7-Aug		
Football	Mundaring	http://www.foxsportspulse.com/club_info.cgi?c=0-3061-85069-0-0	7-Aug		
Football	Narembeen	http://www.foxsportspulse.com/club_info.cgi?c=0-3064-84709-0-0	7-Aug		
Football	Narrogin	http://www.foxsportspulse.com/comp_info.cgi?c=4	7-Aug		

		-2654-94792-358696-23329143&a=fixture			
Football	Newman Centrals	http://www.foxsportspulse.com/assoc_page.cgi?c=0-3389-0-0-0&a=clear	7-Aug		
Football	Newman Pioneers	http://www.foxsportspulse.com/assoc_page.cgi?c=0-3389-0-0-0&a=clear	7-Aug		
Football	Newman Saints	http://www.foxsportspulse.com/assoc_page.cgi?c=0-3389-0-0-0&a=clear	7-Aug		
Football	Newman Tigers	http://www.foxsportspulse.com/assoc_page.cgi?c=0-3389-0-0-0&a=clear	7-Aug		
Football	Newton Condingup FC	http://www.foxsportspulse.com/club_info.cgi?c=1-3060-52925-0-0	7-Aug		
Football	North Albany	http://www.foxsportspulse.com/club_info.cgi?c=2-3977-96123-0-0	7-Aug		
Football	North Mandurah	http://websites.sportstg.com/club_info.cgi?c=0-4765-196148-0-0	7-Aug		
Football	Northampton	http://northamptonrams.com.au/	7-Aug		
Football	Nukarni	http://www.foxsportspulse.com/club_info.cgi?client=1-3064-84711-341857-21874817	7-Aug		
Football	Nungarin Towns	http://www.foxsportspulse.com/club_info.cgi?c=1-4737-64089-0-0	7-Aug		BOUNCED

Football	Ord River	http://www.foxsportspulse.com/club_info.cgi?c=1-6955-85852-0-0	7-Aug		
Football	Paraburdoo Saints	http://www.foxsportspulse.com/club_info.cgi?c=0-6733-115987-0-0	7-Aug		AUTOREPLY
Football	Peninsula Bombers	http://www.foxsportspulse.com/club_info.cgi?c=1-3094-73908-0-0	7-Aug		BOUNCED
Football	Port Hedland Rovers	http://www.foxsportspulse.com/club_info.cgi?c=0-3584-94526-0-0	7-Aug		BOUNCED
Football	Port Wyndham	http://www.wyndhamcrocs.com.au/port_wyndham_crocs/home.html	7-Aug		
Soccer	Sydney FC	https://www.sydneyfc.com/contact-us	7-Aug		

Other contact points for recruitment

Type of Organisation	Organisation Name	Website	Date of contact	Resent	Response
Personal Trainers	HIIT and Run PT		5-Jun	26-Jun	No Response
Personal Trainers	Anthemz Holistic Health and Fitness	https://www.facebook.com/anthemzholistictrainingnutritionhealth/	5-Jun	23-Jun	No Response
Personal Trainers	JFit Personal Training & Bootcamps	https://www.facebook.com/jfitbootcamps/	5-Jun	23-Jun	No Response
Personal Trainers	New Me PT	https://www.facebook.com/greenbanknewmept/	5-Jun	23-Jun	No Response
Personal Trainers	Physical Fix	https://www.facebook.com/physicalfixpt/	5-Jun	23-Jun	No Response
Personal Trainers	FABS PT Australia	https://www.facebook.com/fabsptaustralia/	5-Jun	23-Jun	No Response
Personal Trainers	Fitter Faster Stronger PT	https://www.facebook.com/fitterfasterstronger.pt/	5-Jun	23-Jun	No Response
Personal Trainers	JS-PT	https://www.facebook.com/JSPTaus/	5-Jun	23-Jun	No Response
Personal Trainers	PT Fitness Studio	https://www.facebook.com/ptfitnessprivatestudio/	5-Jun	23-Jun	No Response
Gyms/Health	Goodlife Health	http://www.goodlife.com.au/	5-Jun	23-Jun	

Clubs	Club				
Gyms/Health Clubs	Goodlife Alexandra Hills		25-Jun	2-Jul	
Gyms/Health Clubs	Goodlife Alexandra Hills		2-Jul		Accepted 29 July for staff
Gyms/Health Clubs	Fernwood Fitness	http://www.fernwoodfitness.com.au/	7-Jun	Emailed individual clubs	
Gyms/Health Clubs	Hiit Australia	http://www.hiitaustralia.com.au/	5-Jun	23-Jun	
Gyms/Health Clubs	World Gym Australia	http://www.worldgymaustralia.com/	5-Jun	23-Jun	
Gyms/Health Clubs	Fernwood Fitness Bendigo		15-Jun		No Response
Gyms/Health Clubs	Fernwood Fitness Preston		15-Jun		No Response
Gyms/Health Clubs	Fernwood Fitness Craigieburn		15-Jun		Closed due to COVID-19 - 16 June
Gyms/Health Clubs	Fernwood Fitness Carindale		15-Jun		No Response
Gyms/Health Clubs	Fernwood Fitness Capalaba		15-Jun		No Response

Reddit/Forums	AFL Reddit	https://www.reddit.com/r/AFL/comments/hdj9wa/research_participation_opportunity/		22-Jun	Removed
Reddit/Forums	Rugby Union Reddit	https://www.reddit.com/r/rugbyunion/comments/hdj9nf/research_participation_opportunity/		22-Jun	
Reddit/Forums	Australia Reddit	https://www.reddit.com/r/australia/comments/hdj90h/research_participation_opportunity/		22-Jun	Removed
Reddit/Forums	Sample Size Reddit	https://www.reddit.com/r/SampleSize/comments/he7u7o/academic_general_and_sports_nutrition_knowledge/		24-Jun	
Academy of Sport	Queensland Academy of Sport	www.qasport.qld.gov.au	25-Jun	4-Aug	Replied 6 August - cannot participate
Fitness centre	Obstacle Obsession	https://www.facebook.com/obstacleobsession/	7-Jun		Replie 8 June - Declined
Social Media	Bachelor of Food & Nutrition OUA	https://www.facebook.com/groups/1714579905491916	26-Jun	3-Aug	
Social Media	OUA - Bachelor of Food and Nutrition	https://www.facebook.com/groups/1478852345773237	26-Jun	3-Aug	
La Trobe Contacts	La Trobe Sport		24-Jun		Forwarded to elite athletes

La Trobe Contacts	La Trobe Sport		20-Jul		
La Trobe Contacts	La Trobe Sport		15-Jul		
La Trobe Contacts	La Trobe Sport		15-Jul		
La Trobe Contacts	La Trobe Staff		24-Jul		Posted to Twitter
Sports Dietitian	SDA Advanced Sports		2-Jul		Replied 28 July - Declined
Amateur Sport	Just Play	www.justplay.com.au	30-Jun	4-Aug	
La Trobe Contacts	Centre for Sport and Social Impact		2-Jul		Forwarded to Lacrosse teams
La Trobe Contacts	Office of Allied Health		4-Aug		
La Trobe Contacts	Sport and Exercise Science		4-Aug		Requested further information
Twitter	La Trobe Nutrition	https://twitter.com/LTUnutrition/status/1286543402293633029?s=20	24-Jul		
Facebook Page	Thinking Nutrition	https://www.facebook.com/search/top?q=think%20nutrition	2-Jul		Responded 2 July - posted on Facebook

Appendix C

Complete NSKQ tool with correct responses highlighted.

Weight Management

Q1.1 Which nutrient do you think has the most energy (kilojoules/calories) per 100 grams (3.5 ounces)?

- ❍ Carbohydrate
- ❍ Protein
- ❍ Fat
- ❍ Not sure

Q1.2 Do you agree or disagree with the following statements about weight loss?

	Agree	Disagree	Not Sure
1. Having the lowest weight possible benefits endurance performance in the long term (Disagree)	❍	❍	❍
2. Eating more protein is the most important dietary change if you want to have more muscle (Disagree)	❍	❍	❍
3. Eating more energy from protein than you need can make you put on fat (Agree)	❍	❍	❍

Q1.3 Do you think the diet changes below are good ways to lose weight?

	Yes	No	Not Sure
1. Swapping carbohydrates/energy dense foods for low-energy foods like vegetables (Yes)	❍	❍	❍
2. Eating margarine instead of butter (No)	❍	❍	❍
3. Eating protein bars and shakes instead of yogurts, muesli/granola bars and fruits (No)	❍	❍	❍
4. Choosing lower glycemic index (GI) carbohydrates to help regulate appetite (Yes)	❍	❍	❍

Q1.4 If they want to lose weight, athletes should:

- ❍ eat less than 50 grams (1.7 ounces) of carbohydrate per day
- ❍ eat less than 20 grams (0.7 ounces) of fat per day
- ❍ eat less calories/kilojoules than your body needs
- ❍ Not sure

Q1.5 To ensure they meet their energy (kilojoule/calorie) requirements, all athletes should:

- ❍ plan their diet based on their age, gender, body size, sport and training program
- ❍ eat based on their natural hunger and fullness signals
- ❍ eat at least 8000 kilojoules (2000 calories) per day
- ❍ eat more foods that have lots of carbohydrate
- ❍ Not sure

Q1.6 Which is a better recovery meal option for an athlete who wants to put on muscle?

- ❍ A 'mass gainer' protein shake and 3 - 4 scrambled eggs
- ❍ Pasta with lean beef and vegetable sauce, plus a dessert of fruit, yoghurt and nuts
- ❍ A large piece of grilled chicken with a side salad (lettuce, cucumber, tomato)
- ❍ A large steak and fried eggs
- ❍ Not sure

Q1.7 Which is a better recovery meal option for an athlete who wants to lose weight?

- o A side salad with no dressing (lettuce, cucumber, tomato)
- ❍ A pure whey protein isolate (WPI) shake made on water
- ❍ A mixed meal that includes a small-moderate serving of meat and carbohydrate (e.g. small bowl pasta with lean mincemeat and vegetable sauce) plus a large side salad
- ❍ Not sure

Macronutrients

Q2.1 An athlete doing a moderate to high-intensity endurance training program for about two hours should eat…

- ❍ 1 - 3 g carbohydrate per kg (0.016 - 0.048 ounces per lb) body weight per day
- ❍ 5-7 g, increasing up to 10 g/kg with intense training/competition loads 15 - 25% of total daily kilojoule/calorie intake as carbohydrate
- ❍ 75 - 85% of total daily kilojoule/calorie intake as carbohydrate
- ❍ Not sure

Q2.2 Which options have enough carbohydrate for recovery from about 1 hour of high intensity aerobic exercise? Assume the athlete weighs about 70kg and has an important training session again tomorrow.

	Enough	Not enough	Not Sure
1. 1 medium banana (NE)	❍	❍	❍
2. 1 cup cooked quinoa and 1 tin tuna (NE)	❍	❍	❍
3. 1 cup plain yoghurt (NE)	❍	❍	❍
4. 1 cup baked beans on two slices of bread (E)	❍	❍	❍

Q2.3 Which food has the most carbohydrate?

- ❍ 1 cup (168 g/5.6 ounces) boiled rice
- ❍ 2 slices of white sandwich loaf bread
- ❍ 1 medium (150 g/ 5 ounces) boiled potato
- ❍ 1 medium (150 g/5 ounces) ripe banana
- ❍ Not sure

Q2.4 Do you agree or disagree with these statements about fat?

	Agree	Disagree	Not Sure
1. The body needs fat to fight off sickness (A)	❍	❍	❍
2. Athletes should not eat more than 20g of fat per day (D)	❍	❍	❍
3. When we increase the intensity of exercise, the % of fat we use as a fuel also increases (D)	❍	❍	❍
4. When we exercise at a low intensity, our body mostly uses fat as a fuel (A)	❍	❍	❍

Q2.5 Do you think these foods are high in fat?

	Yes	No	Not Sure
Cheddar cheese (Y)	❍	❍	❍
Margarine (Y)	❍	❍	❍
Mixed nuts (Y)	❍	❍	❍
Honey (N)	❍	❍	❍

Q2.6 Do you agree or disagree with the statements about protein?

	Agree	Disagree	Not Sure
1. Protein is the main fuel that muscles use during exercise (D)	❍	❍	❍
2. Vegetarian athletes can meet their protein requirements without the use of protein supplements (A)	❍	❍	❍
3. An experienced athlete needs more protein than a young athlete who is just starting training (D)	❍	❍	❍
4 .The body has a limited ability to use protein for muscle protein synthesis (A)	❍	❍	❍
5. A balanced diet with enough kilojoules/calories (energy) has enough protein for most athletes (A)	❍	❍	❍

Q2.7 Which food has the most protein?

- ❍ 2 eggs
- ❍ 100g (3 ounces) raw skinless chicken breast
- ❍ 30g (1 ounce) almonds
- ❍ Not sure

Q2.8 The protein needs of a 100 kg (220 lb) well trained resistance athlete are closest to:

- ❍ 100g (1g/kg)
- ❍ 150g (1.5g/kg)
- ❍ 500g (5g/kg)
- ❍ They should eat as much protein as possible
- ❍ Not sure

Q2.9 Which of these foods do you think have enough protein to promote muscle growth after a bout of resistance exercise?

	Enough	Not enough	Not Sure
1.100g (3 ounces) chicken breast (E)	❍	❍	❍
2. 300g (1 ounce) Yellow cheese (NE)	❍	❍	❍
3. 1 cup baked beans (NE)	❍	❍	❍
4. 1/2 cup cooked quinoa (NE)	❍	❍	❍

Q2.10 Do you think these foods have all the essential amino acids needed by the body?

	Yes	No	Not Sure
Beef steak (Y)	❍	❍	❍
Eggs (Y)	❍	❍	❍
Lentils (N)	❍	❍	❍
Cow's Milk (Y)	❍	❍	❍

Q2.11 The amount of protein in skim milk compared to full cream milk is:

- ❍ much less
- ❍ about the same
- ❍ much more
- ❍ Not sure

Micronutrients

Q3.1 Do you agree or disagree with these statements on vitamins and minerals?

	Agree	Disagree	Not Sure
1. Calcium is the main component of bone (A)	❍	❍	❍
2. Vitamin C is an anti-oxidant (A)	❍	❍	❍
3.Thiamine (Vitamin B1) is needed to take oxygen to muscles (D)	❍	❍	❍
4. Iron is needed to turn food into usable energy (D) 5. Vitamin D enhances calcium absorption (A) 6. Meat, chicken and fish are good sources of zinc (A) 7. Wholegrain foods are good sources of vitamin C (D) 8. Fruit and vegetables are good sources of calcium (D) 9. Fatty fish is a good source of vitamin D (A) 10. Women who have a monthly period need more iron than men (A) 11. Athletes aged 15 to 24 years need 500 mg of calcium each day (D) 12. A fit person eating a balanced diet can improve their athletic performance by eating more vitamins and minerals from food (D) 13. Vitamins contain energy (kilojoules/calories) (D)	❍	❍	❍

Sports Nutrition

Q4.1 Athletes should drink water to:

- keep plasma (blood) volume stable
- stop dry mouth
- allow proper sweating
- All of the above
- Not sure

Q4.2 Experts think that athletes should:

- drink 50 - 100 ml (1.7 - 3.3 fluid ounces) every 15 - 20 minutes
- suck on ice cubes rather than drinking during practice
- drink sports drinks (e.g. powerade) rather than water when exercising
- drink to a plan, based on body weight changes during training sessions performed in a similar climate
- Not sure

Q4.4 How much sodium (salt) should fluid consumed for hydration purposes (during exercise) contain?

- At least 11 - 25 mmol/L (~ 250 - 575 mg/L)
- At least 4 - 8 mmol/L (~ 90 - 185 mg/L)
- None
- Not sure

Q4.5 Before competition, athletes should eat foods that are high in:

- fluids, fat and carbohydrate
- fluids, fibre and carbohydrate
- fluids and carbohydrate
- Not sure

Q4.6 Do you agree or disagree with the statements on carbohydrate?

	Agree	Disagree	Not Sure
1. Eating carbohydrates when you exercise makes it harder to build strength and muscles (D)	❍	❍	❍
2. In events lasting 60 - 90 minutes, 30- 60 g (1.0 - 2.0 ounces) of carbohydrates should be eaten per hour (A)	❍	❍	❍
3. Eating carbohydrates when you exercise will help keep blood sugar levels stable (A)	❍	❍	❍

Q4.7 Some athletes get a sore stomach if they eat during exercise. What might make stomach pain worse?

- Having energy gels rather than water or sports drinks
- Having small amounts of water at a time
- Having sports drinks with different types of carbohydrates (e.g. fructose and sucrose)
- Not sure

Q4.8 During a competition, athletes should eat foods that are high in:

- Fluids, fibre and fat
- Fluids and protein

- Fluids and carbohydrate
- Not sure

Q4.9 Which is the best snack to have during an intense 90-minute training session?

- A protein shake
- A ripe banana
- 2 boiled eggs
- A handful of nuts
- Not sure

Q4.10 After a competition, athletes should eat foods that are high in?

- Protein, carbohydrate and fat
- Only protein
- Only carbohydrate
- Carbohydrate and protein
- Not sure

Q4.11 How much protein do you think experts say athletes should eat after resistance exercise?

- 0.3g/kg body weight (~ 15 - 25 g [0.53 - 0.88 ounces] for most athletes)
- 1.0 g/kg body weight (~ 50 - 100 g [(1.9 - 2.3 ounces)] for most athletes)
- 1.5g/kg body weight (~ 150 – 130 g [5.3 – 10.6 ounces] for most athletes)
- Not sure

Supplementation

Q5.1 Do you agree or disagree with the statements about vitamin and mineral supplements?

	Agree	Disagree	Not Sure
1. Vitamin C should always be taken by athletes (D)	❍	❍	❍
2. B vitamins should be taken if energy levels are low (D)	❍	❍	❍
3. Salt tablets should be taken by athletes that get cramps when they exercise (D)	❍	❍	❍
4. Iron tablets should be taken by all athletes who feel tired and are pale (D)	❍	❍	❍

Q5.2 All supplements are tested to make sure they are safe, don't have any contamination.

❍ Agree
❍ Disagree
❍ Not sure

Q5.3 Supplement labels may sometimes say things that are not true.

❍ Agree
❍ Disagree
❍ Not sure

Q5.4 Do you agree or disagree with the statements about supplements?

	Agree	Disagree	Not Sure
1. Creatine makes the brain think that exercise feels easier (D)	❍	❍	❍
2. Caffeine makes muscles able to work harder even without more oxygen (D)	❍	❍	❍
3. Beetroot juice (nitrates) makes muscles feel less sore after exercise (D)	❍	❍	❍
4. Beta-Alanine can decrease how much acid muscles make during intense exercise (A)	❍	❍	❍

Q5.5 Which supplement does not have enough evidence in relation to improving body composition or sporting performance?

❍ caffeine
❍ ferulic acid
❍ bicarbonate
❍ leucine
❍ Not sure

Q5.6 WORLD ANTI-DOPING AGENCY (WADA) bans the use of….

❍ caffeine
❍ bicarbonate
❍ carnitine

- ❍ testosterone
- ❍ Not sure

Alcohol

Q6.1 How much ethanol (pure alcohol) is there in a standard drink?

- ❍ 1 - 2 / 0.03 - 0.06 fluid ounces
- ❍ 8 - 14 g/ 0.3 - 0.6 fluid ounces
- ❍ 30 - 50 g /1.2 - 2.0 fluid ounces
- ❍ Not sure

Q6.2 Which is an example of a "Standard Drink"?

- ❍ 30 - 45 ml/1 - 1.5 fluid ounces of pure spirits
- ❍ One quarter of a bottle (175 ml/ 6 fluid ounces) of red wine
- ❍ A pint (425 ml/ 14 fluid ounces) of full strength beer
- ❍ Not sure

Q6.3 Do you think alcohol can make you put on weight?

- ❍ Yes
- ❍ No
- ❍ Not sure

Q6.4 How many drinks do you think experts say are the most we should have in one day?

- ❍ Two
- ❍ Three
- ❍ Four
- ❍ Not sure

Q6.5 Do you agree or disagree with the statements on alcohol?

	Agree	Disagree	Not Sure
1. If someone does not drink at all during the week, it is okay for them to have five or more drinks on a Friday or Saturday night (Disagree)	❍	❍	❍
2. Drinking lots of alcohol can make it harder to recover from injury (Agree)	❍	❍	❍
3. Alcohol makes you urinate more (Agree)	❍	❍	❍

Q6.6 "Binge drinking" (also referred to as heavy episodic drinking) is defined as:

- ❍ having two or more standard alcoholic drinks on the same occasion
- ❍ having four to five or more standard alcoholic drinks on the same occasion
- ❍ having seven to eight or more standard alcoholic drinks on the same occasion
- ❍ Not sure

Appendix D

Demographic questions for original survey

1. How old are you? (Dropdown list of possible ages)
2. What is your gender? (Tickbox)
    a. Male
    b. Female
    c. Other
3. What country were you born in? (Dropdown list of countries)
4. What is your current post-code/zip code? (Free text)
5. What is your current living situation? (Tickbox)
    a. Alone
    b. With parents
    c. With partner
    d. With other players/athletes
    e. With unrelated adults
6. What is the highest level of education you have obtained? (Dropdown list)
    a. Primary school
    b. I completed/am enrolled high school
    c. I completed/am enrolled in a Diploma or equivalent
    d. University (I completed/am enrolled in a bachelor/undergraduate degree)
    e. University (I completed/am enrolled in a honors/masters degree)
    f. University (I completed/am enrolled in a doctoral degree)
7. Have you ever undertaken any formal studies in human nutrition? This may include a University subject, University course, a specialised course, an online course, or other diploma. (Tickbox)
    a. Yes (please specify)
    b. No
8. Do you play sport? (Tickbox)
    a. Yes If yes, go to question 9
    b. No If no, go to question 16
9. What is the main sport you participate in? (Dropdown list)
    a. Australian Football (AFL)
    b. Basketball
    c. Baseball
    d. Cricket
    e. Cycling
    f. Hockey
    g. Running (Endurance)
    h. Soccer (Football)
    i. Sprinting
    j. Swimming
    k. Triathlon
    l. Other (please specify)
10. What position do you play? (Free text)
11. What is the highest level that you have played the main sport you participate in? (Tickbox)
    a. Local league
    b. State league

c. National league
d. International

12. What Sporting League and Club are you affiliated with? (Free text)
13. For how many years have you been playing the main sport you participate in? (Include primary/elementary school, secondary/high school, university/college) (Dropdown list with possible years)
14. Do the sporting organisation you are part of provide you with access to nutrition education or nutritionist/dietitians? (Tickbox)
    a. Nutrition information only
    b. Nutrition information and access to nutritionist/dietitian
    c. Neither of the above
15. Do you think that the sporting organisations should provide members with access to nutrition information or nutritionists/dietitians? (Tickbox)
    a. Yes, Nutrition information only
    b. Yes, Nutrition information and access to nutritionist/dietitian
    c. Neither of the above
16. On average, how many hours do you train per week? (Including all fitness related activities, at and away from your sporting club) (Dropdown list with possible number)
17. Have any of these individuals ever given you advice regarding your diet? Tick all that apply. (Tickbox)
    a. Athletic trainer/Strength and Conditioning Coach
    b. Coach
    c. Dietitian
    d. Doctor
    e. Family
    f. Friends
    g. Nutritionist
    h. Team-mates
18. Rank up to 3 sources of information you rely on regarding nutrition by placing 1,2, and 3 in the relevant boxes
    a. Academic journal
    b. Athletic trainers/strength and conditioning coach
    c. Coach
    d. Dietitian
    e. Nutritionist
    f. Doctor
    g. Family
    h. Friends
    i. Internet search, please specify websites used
    j. Mass media (magazine, radio, TV)
    k. Social media (Facebook, Twitter)
    l. Team-mates
19. What type of support do/would you find useful, please rank from 1 (most useful) to 5 (least useful)?
    a. Access to nutrition information relevant to healthy eating
    b. Access to nutrition information relevant to sports/training nutrition
    c. Access to group presentations by nutritionists/dietitians
    d. Individuals consultations by nutritionists/dietitians

e. Cooking classes

20. What is your weight in kilograms? (Free text)
21. What is your height in metres? (Free text)
22. Do you follow a specific diet? (e.g. Vegan, Ketogenic) (Tickbox)
    a. Yes (please specify)
    b. No
23. Do you regularly take supplements? (e.g. Multivitamin, Creatine) (Tickbox)
    a. Yes (please specify)
    b. No
24. How would you rate your nutrition knowledge (Tickbox)
    a. Outstanding
    b. Above average
    c. Average
    d. Below average
    e. Poor
25. Do you believe that adhering to a healthy diet is important for athletic performance? (Tickbox)
    a. Strongly agree
    b. Agree
    c. Neither agree or disagree
    d. Disagree
    e. Strongly disagree
26. Are you a university student? (Tickbox)
    a. Yes If yes, go to question 27
    b. No If no, go to next section
27. What degree are you enrolled in? (Free text)

Modifications for wider athlete audience

9. What is the main sport/activity you participate in? (Free text)

10. If you play team sport, what position do you play? Or for other sports/activities, provide detail on the discipline/event type you participate in. (Free text)

11. What is the highest level that you have participated in for the main sport/activity you participate in? (Tickbox)

    a. Local league/club

    b. State league/club

    c. National league/club

    d. International

12. Are you affiliated with a sporting league/club/association? If so, please specify (Free text)

13. For how many years have you been playing the main sport/activity you participate in? (Include primary/elementary school, secondary/high school, university/college) (Dropdown list)

14. Does the sporting organisation/club/association you are part of provide you with access to nutrition information or nutritionists/dietitians? (Tickbox)

a. Nutrition information only
b. Nutrition information and access to nutritionist/dietitian
c. Neither of the above

15. Do you think that the sporting organisations/club/association should provide members with access to nutrition information or nutritionists/dietitians? (Tickbox)

a. Yes, Nutrition information only
b. Yes, Nutrition information and access to nutritionist/dietitian
c. Neither of the above

16. On average, how many hours do you exercise or train for your sport/physical activity per week? (Including all fitness related activities, at and away from your sporting club) (Dropdown list with possible number)

Modifications for staff specific survey

Added

7. Do you currently work as an academic within the field of nutrition or dietetics or sport and exercise science? (Tickbox)

a. Yes (please specify)
b. No

8. How many years have you worked in academia for? (Free text)

9. Do you hold any additional qualifications in the field of Sports Nutrition or Sport Dietetics? (Tickbox)

a. Yes (please specify)
b. No

Removed

19. What type of support do/would you find useful, please rank from 1 (most useful) to 5 (least useful)?
    a. Access to nutrition information relevant to healthy eating
    b. Access to nutrition information relevant to sports/training nutrition
    c. Acess to group presentations by nutritionists/dietitians
    d. Individuals consultations by nutritionists/dietitians
    e. Cooking classes
26. Are you a university student? (Tickbox)
    a. Yes If yes, go to question 27
    b. No If no, go to next section
27. What degree are you enrolled in? (Free text)

Appendix E

Regression analysis assumption testing

Attempt 1 with Complete dataset

A multiple regression is used to predict a continuous dependent variable based on multiple independent variables.

- Focusing on nutrition knowledge percentage score
    - Determine how much of the variation in the dependent variable is explained by the independent variables

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Nutrition knowledge percentage score: 1. Variable 176	Gender (nominal – 2 groups) DICHOTOMOUS Age (continuous) BMI (continuous) Level of education (nominal – 6 levels) POLYTOMOUS Nutrition education/not (nominal – 2 groups) DICHOTOMOUS

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic - should be close to 2 – value =1.803
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	CHECKED Using (a) plot of student residual and unstandardized predicted value = MET (b) partial regression plots – need statistician input on this Age – MET (approximately) BMI – MET (approximately) Have not looked at plots for categorical values as suggested by Laerd. Problematic due to small sample size.
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	MET **There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values.**
Assumption #6	**MET**

Your data must not show multicollinearity	**Checked via Correlation coefficients (no correlations over 0.7 – the highest values returned were .515 and -0.440).** **A**ND Tolerance levels are all greater than 0.1 (the lowest value is 0.778) VIF levels are all less than 10 (highest value is 1.286).
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**Partially MET?** **Not significant outliers were found in the dataset.** Casewise diagnostics were not produced – therefore all values for standardised residuals are less than +/-3. Confirmed by inspection of the studentised deleted residuals – no value higher than +/- 3. **Some high leverage points present.** Checked LEV_1 values – below 0.2 = safe, 0.2-0.5 = risky, 0.5+ = dangerous. 54 =.40673 2 =.37986 33 =.36885 63 = .35146 31 =.25503 64 =.22650 46 =.22575 34 =.20505 36 =.20495 45 =.20486 68 =.20384 **No highly influential points.** Cook's Distance values did not exceed 1 – highest value =0.25847
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**MET** Normal P-P Plot of Regression Standardized Residual Dependent Variable: ScorePerCentAll

Attempt 1 with Complete dataset in Athletes

A multiple regression is used to predict a continuous dependent variable based on multiple independent variables.

- Focusing on nutrition knowledge percentage score
    - Determine how much of the variation in the dependent variable is explained by the independent variables

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Nutrition knowledge percentage score: 2. Variable 176	Gender (nominal – 2 groups) DICHOTOMOUS Age (continuous) BMI (continuous) Level of education (nominal – 6 levels) POLYTOMOUS Nutrition education/not (nominal – 2 groups) DICHOTOMOUS Highest level of sport played (nominal – 4 groups) POLYTOMOUS Team Vs Individual (nominal – 2 groups) DICHOTOMOUS Hours played per week (continuous) Years in sport (continuous)

Assumptions

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic - should be close to 2 – value =2.272
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	CHECKED Using (a) plot of student residual and unstandardized predicted value = MET (b) partial regression plots – need statistician input on this Age – MET (linear relationship) BMI – MET (approximately) Hours played per week – MET (approximately) Years in sport – MET (linear relationship) Have not looked at plots for categorical values as suggested by Laerd. Problematic due to small sample size.
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	MET **There was homoscedasticity, as assessed by visual inspection of a plot of studentized**

	residuals versus unstandardized predicted values.
Assumption #6 Your data must not show multicollinearity	**MET** **Checked via Correlation coefficients (no correlations over 0.7 – the highest values returned were .635 and -0.683).** **A**ND Tolerance levels are all greater than 0.1 (the lowest value is 0.258) VIF levels are all less than 10 (highest value is 3.874).
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**Partially MET** **Not significant outliers were found in the dataset.** Casewise diagnostics were not produced – therefore all values for standardised residuals are less than +/-3. Confirmed by inspection of the studentised deleted residuals – no value higher than +/- 3 (2.75). **ALL but 1 are high leverage points.** Checked LEV_1 values – below 0.2 = safe, 0.2-0.5 = risky, 0.5+ = dangerous. 10 = .16385 **No highly influential points.** Cook's Distance values did not exceed 1 – highest value =0.26571
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**UNSURE?!?!** Normal P-P Plot of Regression Standardized Residual Dependent Variable: ScorePerCentAll

Attempt 2 with Complete dataset in Athletes

A multiple regression is used to predict a continuous dependent variable based on multiple independent variables.

- Focusing on nutrition knowledge percentage score
  - Determine how much of the variation in the dependent variable is explained by the independent variables

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Nutrition knowledge percentage score: 3. Variable 176	Gender (nominal – 2 groups) DICHOTOMOUS Age (continuous)?? BMI (continuous) Nutrition education/not (nominal – 2 groups) DICHOTOMOUS Highest level of sport played (nominal – 4 groups) POLYTOMOUS Team Vs Individual (nominal – 2 groups) DICHOTOMOUS Hours played per week (continuous) Years in sport (continuous)

Highlighted variables removed from this attempt

Assumptions

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic - should be close to 2 – value =2.314
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	CHECKED Using (b) plot of student residual and unstandardized predicted value = MET (b) partial regression plots – need statistician input on this Age – MET (linear relationship) BMI – MET (approximately) Hours played per week – MET (approximately) Years in sport – MET (linear relationship) Have not looked at plots for categorical values as suggested by Laerd. Problematic due to small sample size.
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	MET **There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted**

	values.
Assumption #6 Your data must not show multicollinearity	**MET** **Checked via Correlation coefficients (no correlations over 0.7 – the highest values returned were .635 and -0.404).** **A**ND Tolerance levels are all greater than 0.1 (the lowest value is 0.345) VIF levels are all less than 10 (highest value is 2.903).
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**Partially MET?** **Not significant outliers were found in the dataset.** Casewise diagnostics were not produced – therefore all values for standardised residuals are less than +/-3. Confirmed by inspection of the studentised deleted residuals – no value higher than +/- 3 (2.19481). **ALL but 3 are high leverage points.** Checked LEV_1 values – below 0.2 = safe, 0.2-0.5 = risky, 0.5+ = dangerous. 17=.19701 39=.15911 10=.14788 **No highly influential points.** Cook's Distance values did not exceed 1 – highest value =0.28107
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**UNSURE?!?!** Normal P-P Plot of Regression Standardized Residual Dependent Variable: ScorePerCentAll

ANCOVA testing

- Study design #2
    - Reducing the effect of an extraneous variable
- Post hoc test all pairwise comparison

Assumption	Met/Not Met
One continuous dependent variable	MET NK% score
One categorical independent variable	MET Community group identifier
One continuous covariate variable	MET Age (SQRTage_recode)
Independence of observations	MET
Covariate should be linearly related to the dependent variable and each level of the independent variable	NOT MET Attempted with all transformed age variables
Homogeneity of regression slopes	NOT TESTED

ANCOVA testing will not work with the current sample size.

Linear regression testing

- Athlete subset
- Determine how much of the variation in the dependent variable is explained by the independent variable

Assumption	MET/NOT MET
Dependent continuous variable	MET
Independent continuous variable	MET
Linear relationship between dependent and independent variable	MET
Independence of observations	MET Durbin-Watson statistic = 1.596
No significant outliers	MET No casewise diagnostics generated therefore all values for standardised residuals are less than +/-3.
Homoscedasticity	NOT MET Decreasing funnel
Residuals of the regression line are approximately normally distributed	NOT TESTED

Linear regression testing

- Total dataset
- Determine how much of the variation in the dependent variable is explained by the independent variable

Assumption	MET/NOT MET
Dependent continuous variable	MET
Independent continuous variable	MET
Linear relationship between dependent and independent variable	NOT MET Non-linear relationship between dependent and independent variable.
Independence of observations	NOT TESTED
No significant outliers	NOT TESTED
Homoscedasticity	NOT TESTED
Residuals of the regression line are approximately normally distributed	NOT TESTED

Appendix F

Correct versus incorrect responses by question for the entire cohort (n=71)

	Question	Correct	Incorrect	Not sure
1	Which nutrient do you think has the most energy (kilojoules/calories) per 100 grams (3.5 ounces)?	51(71.8)	19(26.8)	1(1.4)
2	Do you agree or disagree with the following statements about weight loss? - 1. Having the lowest weight possible benefits endurance performance in the long term	55(77.5)	9(12.7)	7(9.9)
3	Do you agree or disagree with the following statements about weight loss? - 2. Eating more protein is the most important dietary change if you want to have more muscle	32(45.1)	35(49.3)	4(5.6)
4	Do you agree or disagree with the following statements about weight loss? - 3. Eating more energy from protein than you need can make you put on fat	51(71.8)	15(21.1)	5(7.0)
5	Do you think the diet changes below are good ways to lose weight? - 1. Swapping carbohydrates/energy dense foods for low-energy foods like vegetables	55(77.5)	15(21.1)	1(1.4)
6	Do you think the diet changes below are good ways to lose weight? - 2. Eating margarine instead of butter	42(59.2)	18(25.4)	11(15.5)
7	Do you think the diet changes below are good ways to lose weight? - 3. Eating protein bars and shakes instead of yogurts, muesli/granola bars and fruits	61(85.9)	4(5.6)	6(8.5)
8	Do you think the diet changes below are good ways to lose weight? - 4. Choosing lower glycaemic index (GI) carbohydrates to help regulate appetite	63(88.7)	4(5.6)	4(5.6)
9	If they want to lose weight, athletes should:	46(64.8)	18(25.4)	7(9.9)
10	To ensure they meet their energy (kilojoule/calorie) requirements, all athletes should:	65(91.5)	6(8.5)	0(0)
11	Which is a better recovery meal option for an athlete who wants to gain weight? Assume they are training in the morning, have already had breakfast, a mid-morning snack. n=38	28 (73.7)	8 (21.1)	2 (5.3)
12	Which is a better recovery meal option for an athlete who wants to lose weight? Assume they are eating an appropriate breakfast and dinner.	45(63.4)	23(32.4)	3(4.2)
13	An athlete doing a moderate to high-intensity endurance training program for about two hours should eat…	30(42.3)	14(19.7)	27(38.0)
14	Which options have enough carbohydrate for recovery from about 1 hour of high intensity aerobic exercise? Assume the athlete weighs about 70 kg and has an important training session again tomorrow. - 1 medium banana	51(71.8)	18(25.4)	2(2.8)
15	Which options have enough carbohydrate for recovery from about 1 hour of high intensity aerobic exercise? Assume the athlete weighs about 70 kg and has an important training session again tomorrow. - 1 cup (168 g/5.6 ounces) cooked quinoa and 1 tin tuna	4(5.6)	63(88.7)	4(5.6)
16	Which options have enough carbohydrate for recovery from about 1 hour of high intensity aerobic exercise? Assume the athlete weighs about 70 kg and has an important training session again tomorrow. - 1 cup plain yoghurt	52(73.2)	13(18.3)	6(8.5

17	Which options have enough carbohydrate for recovery from about 1 hour of high intensity aerobic exercise? Assume the athlete weighs about 70 kg and has an important training session again tomorrow. - 1 cup baked beans and 2 slices toast	63(88.7)	4(5.6)	4(5.6)
18	Which food has the most carbohydrate?	35(49.3)	30(42.2)	6(8.5)
19	Do you agree or disagree with these statements about fat? - 1. The body needs fat to fight off sickness	38(53.5)	23(32.4)	10(14.1)
20	Do you agree or disagree with these statements about fat? - 2. Athletes should not eat more than 20 g of fat per day	42(59.2)	13(18.3)	16(22.5)
21	Do you agree or disagree with these statements about fat? - 3. When we increase the intensity of exercise, the % of fat we use as a fuel also increases	23(32.4)	44(62.0)	4(5.6)
22	Do you agree or disagree with these statements about fat? - 4. When we exercise at a low intensity, our body mostly uses fat as a fuel	40(56.3)	23(32.4)	8(11.3)
23	Do you think these foods are high or low in fat? - Cheddar cheese	66(93.0)	4(5.6)	1(1.4)
24	Do you think these foods are high or low in fat? - Polyunsaturated margarine	47(66.2)	21(29.6)	3(4.2)
25	Do you think these foods are high or low in fat? - Mixed nuts n=70	53(75.7)	17(24.3)	0(0)
26	Do you think these foods are high or low in fat? – Honey n=70	64(91.4)	5(7.1)	1(1.4)
27	Do you agree or disagree with the statements about protein? - 1. Protein is the main fuel that muscles use during exercise	57(80.3)	13(18.3)	1(1.4)
28	Do you agree or disagree with the statements about protein? - 2. Vegetarian athletes can meet their protein requirements without the use of protein supplements	57(80.3)	9(12.7)	5(7.0)
29	Do you agree or disagree with the statements about protein? - 3. An experienced athlete needs more protein than a young athlete who is just starting training	44(62.0)	20(28.2)	7(9.9)
30	Do you agree or disagree with the statements about protein? - 4. The body has a limited ability to use protein for muscle protein synthesis	43(60.6)	16(22.5)	12(16.9)
31	Do you agree or disagree with the statements about protein? - 5. A balanced diet with enough kilojoules/calories (energy) has enough protein for most athletes	58(81.7)	9(12.7)	4(5.6)
32	Which food has the most protein?	47(66.2)	22(31.0)	2(2.8)
33	The protein needs of a 100 kg (220 lb) well trained resistance athlete are closest to:	36(50.7)	19(26.8)	16(22.5)
34	Which of these foods do you think have enough protein to promote muscle growth after a bout of resistance exercise? - 100g (3 ounces) Chicken Breast	69(97.2)	2(2.8)	0(0)
35	Which of these foods do you think have enough protein to promote muscle growth after a bout of resistance exercise? - 30g (1 ounce) Yellow Cheese	49(69.0)	15(21.1)	7(9.9)
36	Which of these foods do you think have enough protein to promote muscle growth after a bout of resistance exercise? - 1 Cup Baked Beans	24(33.8)	44(62.0)	3(4.2)
37	Which of these foods do you think have enough protein to promote muscle growth after a bout of resistance	32(45.1)	31(43.7)	8(11.3)

	exercise? - 1/2 Cup Cooked Quinoa			
38	Do you think these foods contain all the essential amino acids needed by the body? - Beef Steak	39(54.9)	24(33.8)	8(11.3)
39	Do you think these foods contain all the essential amino acids needed by the body? - Eggs	52(73.2)	12(16.9)	7(9.9)
40	Do you think these foods contain all the essential amino acids needed by the body? - Lentils	38(53.5)	26(36.6)	7(9.9)
41	Do you think these foods contain all the essential amino acids needed by the body? - Cow's Milk	31(43.7)	30(42.3)	10(14.1)
42	The amount of protein in skim milk compared to full cream milk is:	43(60.6)	22(30.9)	6(8.5)
43	Do you agree or disagree with these statements on vitamins and minerals? - 1. Calcium is the main component of bone	57(80.3)	9(12.7)	5(7.0)
44	Do you agree or disagree with these statements on vitamins and minerals? - 2. Vitamin C is an anti-oxidant	57(80.3)	7(9.9)	7(9.9)
45	Do you agree or disagree with these statements on vitamins and minerals? - 3. Thiamine (Vitamin B1) is needed to take oxygen to muscles n=70	15(21.4)	29(41.4)	26(37.1)
46	Do you agree or disagree with these statements on vitamins and minerals? - 4. Iron is needed to turn food into usable energy	29(40.8)	29(40.8)	13(18.3)
47	Do you agree or disagree with these statements on vitamins and minerals? - 5. Vitamin D enhances calcium absorption	62(89.3)	2(2.8)	7(9.9)
48	Do you agree or disagree with these statements on vitamins and minerals? - 6. Meat, Chicken and Fish are good sources of zinc	51(71.8)	6(8.5)	14(19.7)
49	Do you agree or disagree with these statements on vitamins and minerals? - 7. Wholegrain foods are good sources of vitamin C	41(57.7)	18(25.4)	12(16.9)
50	Do you agree or disagree with these statements on vitamins and minerals? - 8. Fruit and Vegetables are good sources of calcium	39(54.9)	23(32.4)	9(12.7)
51	Do you agree or disagree with these statements on vitamins and minerals? - 9. Fatty fish is a good source of vitamin D	37(52.1)	21(29.6)	13(18.3)
52	Do you agree or disagree with these statements on vitamins and minerals? - 10. Women who have a monthly period need more iron than men	66(93.0)	1(1.4)	4(5.6)
53	Do you agree or disagree with these statements on vitamins and minerals? - 11. Athletes aged 15 to 24 years need 500 mg of calcium each day	16(22.5)	25(35.2)	30(42.3)
54	Do you agree or disagree with these statements on vitamins and minerals? - 12. A fit person eating a balanced diet can improve their athletic performance by eating more vitamins and minerals from food	16(22.5)	42(59.2)	13(18.3)
55	Do you agree or disagree with these statements on vitamins and minerals? - 13. Vitamins contain energy (kilojoules/calories)	49(69.0)	14(19.7)	8(11.3)
56	Athletes should drink water to:	12(16.9)	57(80.3)	2(2.8)
57	Experts think that athletes should:	44(62.0)	19(26.7)	8(11.3)
58	How much sodium (salt) should fluid consumed for hydration purposes (during exercise) contain?	10(14.1)	32(45.1)	29(40.8)

59	Before competition, athletes should eat foods that are high in:	47(66.2)	22(31.0)	2(2.8)
60	Do you agree or disagree with the statements on carbohydrate? - 1. Eating carbohydrates when you exercise makes it harder to build strength and muscles n=70	64(91.4)	5(7.2)	1(1.4)
61	Do you agree or disagree with the statements on carbohydrate? - 2. In events lasting 60 - 90 minutes, 30-60 g (1.0 - 2.0 ounces) of carbohydrates should be eaten per hour	38(53.5)	11(15.5)	22(31.0)
62	Do you agree or disagree with the statements on carbohydrate? - 3. Eating carbohydrates when you exercise will help keep blood sugar levels stable	55(77.5)	7(9.9)	9(12.7)
63	Some athletes get a sore stomach if they eat during exercise. What might make stomach pain worse?	29(40.8)	27(38.0)	15(21.1)
64	During a competition, athletes should eat foods that are high in:	56(78.9)	12(16.9)	3(4.2)
65	Which is the best snack to have during an intense 90-minute training session?	56(73.2)	12(22.6)	3(4.2)
66	After a competition, athletes should eat foods that are high in:	44(62.0)	25(35.2)	2(2.8)
67	How much protein do you think experts say athletes should eat after resistance exercise?	10(14.1)	43(60.5)	18(25.4)
68	Do you agree or disagree with the statements about vitamin and mineral supplements? - 1. Vitamin C should always be taken by athletes n=70	41(58.6)	14(20.0)	15(21.4)
69	Do you agree or disagree with the statements about vitamin and mineral supplements? - 2. B Vitamins should be taken if energy levels are low n=70	23(32.4)	33(46.5)	14(19.7)
70	Do you agree or disagree with the statements about vitamin and mineral supplements? - 3. Salt tablets should be taken by athletes that get cramps when they exercise n=70	26(37.1)	33(47.1)	11(15.7)
71	Do you agree or disagree with the statements about vitamin and mineral supplements? - 4. Iron tablets should be taken by all athletes who feel tired and are pale n=70	37(52.9)	24(34.3)	9(12.9)
72	All supplements are tested to make sure they are safe, don't have any contamination.	46(64.8)	21(29.6)	4(5.6)
73	Supplement labels may sometimes say things that are not true.	63(88.7)	3(4.2)	5(7.0)
74	Do you agree or disagree with the statements about supplements? - 1. Creatine makes the brain think that exercise feels easier	44(62.0)	9(12.7)	18(25.4)
75	Do you agree or disagree with the statements about supplements? - 2. Caffeine makes muscles able to work harder even without more oxygen	45(63.4)	13(18.3)	13(18.3)
76	Do you agree or disagree with the statements about supplements? - 3. Beetroot juice (nitrates) makes muscles feel less sore after exercise	26(36.6)	20(28.2)	25(35.2)
77	Do you agree or disagree with the statements about supplements? - 4. Beta-Alanine can decrease how much acid muscles make during intense exercise	18(25.4)	17(23.9)	36(50.7)
78	Which supplement does not have enough evidence in relation to improving sporting performance and/or body composition?	12(16.9)	19(32.4)	36(50.7)

79	WORLD ANTI-DOPING AGENCY (WADA) bans the use of….	63(88.7)	4(5.6)	4(5.6)
80	How much ethanol (pure alcohol) is there in a standard drink? n=70	28(40.0)	20(28.6)	22(31.4)
81	Which is an example of a "Standard Drink"? n=70	47(67.2)	19(27.1)	4(5.7)
82	Do you think drinking alcohol can make you put on weight? n=70	69(97.2)	1(1.4)	0(0)
83	How many drinks do you think experts say are the most we should have in one day? n=70	61(87.1)	5(7.1)	4(5.6)
84	Do you agree or disagree with the statements on alcohol? - 1. If someone does not drink at all during the week, it is okay for them to have five or more drinks on a Friday or Saturday night n=70	67(95.7)	3(4.3)	0(0)
85	Do you agree or disagree with the statements on alcohol? - 2. Drinking lots of alcohol can make it harder to recover from injury n=70	68(97.1)	0(0)	2(2.9)
86	Do you agree or disagree with the statements on alcohol? - 3. Alcohol makes you urinate more n=70	68(97.1)	2(2.9)	0(0)
87	"Binge drinking" (also referred to as heavy episodic drinking) is generally defined as: n=70	49(70.0)	17(24.3)	4(5.7)

Appendix G

Data extraction table of included reviews details of dietary assessment, factor assessment, and key findings.

Authors (Year), and Review Registration	Method of dietary assessment	Method of factor assessment	Details of key findings
Nutrition Knowledge			
Boidin et al. (2020) CRD42018083952	3-d diet record (n=12) 7-d diet record (n=1) 72-H recall (n=2) 24H recall (n=6) KIDMED index (n=1) FFQ (n=1) 4-d weighed food record (n=1)	Face-to-face group lectures (8), Individual nutrition counselling (6), Group workshops/activities (4), Mix methods (5)	14/22 studies (n 5 single and n 9 double) reported significant change in at least one nutrition parameter, dietary changes were inconsistent.
Heaney et al. (2011) Not mentioned	24-h recall, 4 food groups servings, 24-h recall FFQ for CA and milk/dairy intake, sport-specific dietary practices, FFQ, 24-h recall & 2-day dietary record, semiqualitative FFQ & diet quality score, Food patterns, 3-D dietary record	NK questionnaires. Self-developed questionnaire (12), Modified existing questionnaire (10), Existing questionnaire (7).	5/9 studies reported a weak, positive association between NK and better dietary intake (r<0.44) 3/9 studies reported a significant association between NK and intake used food-group servings or sport-specific dietary practice questions to assess diet intake. 3/9 articles found no significant correlation and were mainly composed of younger athletes (mean age less than 20 years), including one mixed gender and two all-female samples.
Spronk et al.	3-day dietary	Written	Athletes -

(2014) Not mentioned	record (6) Food patterns questionnaires (1) 43 items FFQ (14) Dietary practices questionnaire (1) 24-H recall (3) Dietary Instrument for Nutrition Education (1) 2-day dietary record (2) Fruit-vegetable-fibre-dietary fat screener (1) 2 x 4d dietary record (1) 2 x 24H recall (1) 3-day frequency intake of seventeen food groups (1)	questionnaire (22), Internet-based collection (1), Interview (3)	5/7 studies - positive association between NK & dietary intake Comparator – 14/22 studies in community samples- positive association between NK and dietary intake, 8/22 found no significant association. 5/22 reported a positive association between NK and a negative dietary attribute.
Body image and body dissatisfaction			
Buckley et al. (2019) CRD42018106470	Measured disordered eating and compensation (11)	Body image questionnaire Figure Rating Scale Eating Disorder Inventory 2 Eating Attitudes Test (EAT-26) 4 x adverse nutrition statements	Three main themes arose from thematic analysis - body dissatisfaction and grief - disordered eating and compensation - long-term influence of sporting culture.

		(validated) (4)	
Weight loss			
Samadi et al. (2019) Not mentioned	Assessment of dietary intake in RWL periods - precise method of assessment is not discussed	Unclear	3/4 studies found reductions in energy, carbohydrates, protein, fat, water, vitamins, and minerals intake prior to athletes competing. 1/4 studies found an increase of energy, carbohydrates, water, and sodium post competition.

Appendix H.

Critical appraisal of included reviews.

Review details	1. Is the review question clear and explicitly stated?	2. Were the inclusion criteria appropriate for the review question?	3. Was the search strategy appropriate?	4. Were the sources and resources used to search for studies adequate?	5. Were the criteria for appraising studies appropriate?	6. Was critical appraisal conducted by two or more reviewers independently?	7. Were there methods to minimize errors in data extraction?	8. Were the methods used to combine studies appropriate?	9. Was the likelihood of publication bias assessed?	10. Were recommendations for policy and/or practice supported by the reported data?	11. Were the specific directives for new research appropriate?	% Score
Boidin et al., 2020	0	1	1	1	1	1	1	1	1	1	1	90.9%
Buckley et al., 2019	1	1	?	1	1	?	1	1	0	1	1	72.7%
Heaney et al., 2011	0	1	0	1	1	1	0	?	0	0	1	45.5%
Samadi et al., 2019	0	0	0	0	0	0	0	?	0	1	1	18.2%
Spronk et al., 2014	0	1	1	1	1	1	1	?	0	1	1	72.7%

Note. 0 = No, 1 = Yes, ? = Unclear.

Appendix I

Crosstabulation results for main outcomes (n=42)

	WC CDRS	PFS FT	BIDQ	MJDF	CvsI CDRS	OAvsI CDRS	PFS Total	PFS FA	PFS FP	%TNK
WC CDRS	1									
PFS FT	-0.120	1								
	0.450									
BIDQ	-0.042	0.206	1							
	0.793	0.191								
MJDF	.387*	-.353*	-.340*	1						
	0.011	0.022	0.028							
CvsI CDRS	-0.140	-0.112	-.441**	-0.124	1					
	0.376	0.478	0.003	0.434						
OAvsI CDRS	0.007	.359*	-0.096	-0.069	0.105	1				
	0.965	0.020	0.546	0.663	0.510					
PFS Total	0.020	.743**	.388*	-0.185	-0.278	0.245	1			
	0.900	0.000	0.011	0.241	0.075	0.118				
PFS FA	0.090	.527**	.428**	-0.093	-0.239	0.291	.864**	1		
	0.570	0.000	0.005	0.558	0.128	0.061	0.000			
PFS FP	-0.111	.512**	0.301	-0.182	-.350*	0.062	.809**	.507**	1	
	0.483	0.001	0.052	0.248	0.023	0.696	0.000	0.001		
%TNK	-0.276	-0.115	-0.105	-0.131	0.222	-0.103	-0.301	-0.150	-.422**	1
	0.077	0.467	0.507	0.408	0.157	0.515	0.053	0.343	0.005	
%GNK	0.004	-0.163	0.012	-0.061	-0.079	-0.271	-0.118	-0.034	-0.175	.581**
	0.980	0.301	0.940	0.703	0.620	0.082	0.456	0.832	0.269	0.000
%SNK	-.326*	-0.050	-0.082	-0.146	0.287	-0.020	-0.293	-0.150	-.415**	.900**
	0.035	0.751	0.607	0.356	0.066	0.901	0.060	0.342	0.006	0.000
ARFS	0.179	-0.173	-0.026	0.191	-0.011	0.014	-0.240	-0.155	-.309*	0.240
	0.258	0.274	0.871	0.226	0.943	0.931	0.126	0.327	0.046	0.126
Fat/kg/bw	0.192	-0.107	-0.303	.778**	-0.030	0.148	-0.030	-0.024	-0.046	-0.156
	0.224	0.499	0.051	0.000	0.851	0.350	0.853	0.882	0.772	0.324
CHO/kg/bw	0.147	-0.198	-0.128	.629**	-0.025	0.006	-0.181	-0.123	-0.232	0.052
	0.352	0.208	0.418	0.000	0.874	0.971	0.252	0.437	0.139	0.743
PRO/kg/bw	0.234	-0.119	-0.220	.708**	-0.049	0.180	-0.054	0.013	-0.081	-0.066
	0.136	0.455	0.162	0.000	0.757	0.254	0.732	0.935	0.608	0.677
PRO% of E	0.031	0.034	-0.108	0.059	0.010	0.076	0.037	0.094	0.062	-0.044
	0.845	0.829	0.495	0.712	0.952	0.632	0.818	0.555	0.695	0.783
CHO% of E	-0.075	0.000	0.128	-0.065	0.027	-0.120	-0.082	-0.069	-0.139	0.193
	0.635	1.000	0.420	0.684	0.863	0.449	0.607	0.665	0.380	0.220
Fats% of E	0.050	0.053	-0.167	0.145	-0.018	0.161	0.141	0.083	0.216	-0.297
	0.751	0.738	0.290	0.359	0.911	0.307	0.374	0.600	0.169	0.056

	%GNK	%SNK	ARFS	Fat/kg/bw	CHO/kg/bw	PRO/kg/bw	PRO% of E	CHO% of E	Fats% of E
WC CDRS									
PFS FT									
BIDQ									
MJDF									
CvsI CDRS									
OAvsI CDRS									
PFS Total									
PFS FA									
PFS FP									
%TNK									
%GNK	1								
%SNK	0.194	1							
	0.219								
ARFS	0.208	0.195	1						
	0.185	0.215							
Fat/kg/bw	-0.158	-0.133	0.145	1					
	0.317	0.400	0.361						
CHO/kg/bw	-0.023	0.052	0.256	.512**	1				
	0.883	0.745	0.101	0.001					
PRO/kg/bw	-0.204	-0.007	0.205	.811**	.449**	1			
	0.196	0.965	0.192	0.000	0.003				
PRO% of E	-0.142	0.005	-0.054	0.190	-.408**	.539**	1		
	0.371	0.977	0.732	0.227	0.007	0.000			
CHO% of E	0.093	0.178	0.013	-0.300	.565**	-.306*	-.733**	1	
	0.559	0.260	0.933	0.053	0.000	0.049	0.000		
Fats% of E	-0.142	-0.291	-0.170	.453**	-.430**	0.238	.501**	-.878**	1
	0.370	0.062	0.283	0.003	0.004	0.129	0.001	0.000	

Note. WC CDRS, Weight Change Contour Drawing Rating Scale score. PFS FT, Power of Food Scale Food Tasted Subscale score. BIDQ, Body Image Disturbance Questionnaire score. MJDF, Megajoules of energy intake with dietary fibre. CvsI CDRS, Current versus Ideal Contour Drawing Rating Scale score. OAvsI CDRS, Opposite Average versus Ideal Contour Drawing Rating Scale score. PFS Total, Power of Food Scale Total score. PFS FA, Power of Food Scale Food Available Subscale score. PFS FP, Power of Food Scale Food Present Subscale score. %TNK, Percent score of Total Nutrition Knowledge. %GNK, Percent score of General Nutrition Knowledge. %SNK, Percent score of Sport Nutrition Knowledge. ARFS, Australian Recommended Food Score. Fat/kg/bw, Fat intake grams per kilogram of body weight. CHO/kg/bw, Carbohydrate intake grams per kilogram of body weight. PRO/kg/bw, Protein intake grams per kilogram of body weight. PRO% of E, Protein percentage of total energy intake. CHO% of E, Carbohydrate percentage of total energy intake. Fats% of E, Fat percentage of total energy intake.

Appendix J

Multiple Regression Analysis

Used to predict a continuous dependent variable based on multiple independent variables.

Determine how much of the variation in the dependent variable is explained by the independent variables

Attempt 1

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
4. ARFS
5. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ Food Available
	  ○ Food Present
	  ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	DOES NOT MEET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.576) Savin and White table suggests that the upper limit for this many variables should be 2.386
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	

Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	
Assumption #6 Your data must not show multicollinearity	
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 2

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
6. ARFS
7. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ ~~Food Available~~
	  ○ ~~Food Present~~
	  ○ ~~Food Tasted~~
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ ~~GNK~~
	  ○ ~~SNK~~
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumptions

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	DOES NOT MEET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.652) Savin and White table suggests that the upper limit for this many variables should be 1.876
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	
Assumption #6 Your data must not show multicollinearity	
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	

Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 3

Using only individuals with acceptable reporting of KJwithDF according to the Goldberg cut-off

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
8. ARFS
9. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ Food Available
	  ○ Food Present
	  ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.033) Savin and White table suggests that the upper limit for this many variables should be 2.907
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) relationships in partial plots appear to be linear b) appears to be linear
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**Correlations** **Had correlations greater than 0.7 for PFS and subcategories and macronutrient information** **VIF for CHO% 16.934 exceeds the maximum requirement of 10**
Assumption #7	

There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 4

Using only individuals with acceptable reporting of KJwithDF according to the Goldberg cut-off

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
10. ARFS
11. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ ~~Food Available~~
	  ○ ~~Food Present~~
	  ○ ~~Food Tasted~~
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, ~~carbohydrate, and fat percent of energy~~
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.811) Savin and White table suggests that the upper limit for this many variables should be 2.363
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) relationships in partial plots appear to be linear b) appears to be linear
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**Correlations** **Had correlations greater than 0.7 for GNK** **VIF did not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	

Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 5

Using only individuals with acceptable reporting of KJwithDF according to the Goldberg cut-off

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
12. ARFS
13. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ ~~Food Available~~
	  ○ ~~Food Present~~
	  ○ ~~Food Tasted~~
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ ~~GNK~~
	  ○ ~~SNK~~
	• Macronutrient balance
	  ○ Protein, ~~carbohydrate, and fat percent of energy~~
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.870) Savin and White table suggests that the upper limit for this many variables should be 2.098
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) relationships in partial plots appear to be linear b) appears to be linear
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**MET** **No correlation exceeded 0.7** **VIF did not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**MET** **Outliers - No residuals greater than +/- 3** **One high leverage point – over 0.5 (case 8)**

	Highly influential points – none (no values over 1) **As the high leverage point does not appear to be a highly influential point, this case will not be removed.**
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**Histogram and Normal P-P plot indicate an approximately normal distribution, which is appropriate as regression analysis is fairly robust to issues with normality.**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.509[a]	.259	-.053	8.667	1.870

a. Predictors: (Constant), Proportion of energy from Fats, CurrentidealCDRS, WeightchangeCDRS, OppositeaverageidealCDRS, PercentTNK, Proportion of energy from Protein, BIDQmean, AveragePFStotal

b. Dependent Variable: Australian recommended food score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	499.181	8	62.398	.831	.587[b]
	Residual	1427.247	19	75.118		
	Total	1926.429	27			

a. Dependent Variable: Australian recommended food score

b. Predictors: (Constant), Proportion of energy from Fats, CurrentidealCDRS, WeightchangeCDRS, OppositeaverageidealCDRS, PercentTNK, Proportion of energy from Protein, BIDQmean, AveragePFStotal

$F(8, 19) = 0.831$, $p = 0.587$

Attempt 6

Using only individuals with acceptable reporting of KJwithDF according to the Goldberg cut-off

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
1. ARFS
2. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ Food Available
	  ○ Food Present
	  ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	NOT MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.252) Savin and White table suggests that the upper limit for this many variables should be 2.229
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	
Assumption #6 Your data must not show multicollinearity	
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors)	

are approximately normally distributed	

Attempt 7

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
3. ARFS
4. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ Food Available
	  ○ Food Present
	  ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	NOT MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.464) Savin and White table suggests that the upper limit for this many variables should be 2.694
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) relationships in partial plots appear to be linear b) appears to be linear
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**MET** **Correlation between total PFS and subgroups exceeded 0.7 and TNK vs. SNK and protein to carbohydrate and carbohydrate to fats.** **VIF for CHO% and Fats% exceeded 10**

Assumption #7 There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 8

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
14. ARFS
15. KJwithDF
	Continuous variables
	• CDRS score
	• PFS score
	  ○ Total
	  ○ ~~Food Available~~
	  ○ ~~Food Present~~
	  ○ ~~Food Tasted~~
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ ~~GNK~~
	  ○ ~~SNK~~
	• Macronutrient balance
	  ○ Protein, ~~carbohydrate,~~ and fat percent of energy
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.331) Savin and White table suggests that the upper limit for this many variables should be 1.847/1.970
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) relationships in partial plots appear to be linear b) appears to be linear
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**MET** **No correlation exceeded 0.7** **VIF did not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**MET** **Outliers - No residuals greater than +/- 3** **No high leverage points (highest value 0.343)** **Highly influential points – none (no values over 1)**

Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**Histogram and Normal P-P plot indicate an approximately normal distribution, which is appropriate as regression analysis is fairly robust to issues with normality. The Normal Q-Q plot appears to be largely normally distributed.** **There is some slight variation in normality which is appropriate as regression analysis is fairly robust to issues with normality.**

Multiple Regression Analysis

Used to predict a continuous dependent variable based on multiple independent variables.

Determine how much of the variation in the dependent variable is explained by the independent variables

Attempt 9

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
16. KJwithDF
	Continuous variables
	• ARFS
	• CDRS score
	• PFS score
	    ○ Total
	    ○ Food Available
	    ○ Food Present
	    ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	    ○ TNK
	    ○ GNK
	    ○ SNK
	• Macronutrient balance
	    ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.688) Savin and White table suggests that the upper limit for this many variables should be 2.297
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) Appears to have a roughly linear relationship b) Appear to have a roughly linear relationship

Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET** **No obvious funnelling**
Assumption #6 Your data must not show multicollinearity	**Does not meet** - **Average PFS has correlations above 0.7 with subgroups** - **TNK with SNK** - **Protein with CHO** - **CHO with Fat** **VIF** - **CHO% and Fat% above 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Attempt 10

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
17. KJwithDF
	Continuous variables
	• ARFS
	• CDRS score
	• PFS score
	  ○ Total
	  ○ ~~Food Available~~
	  ○ ~~Food Present~~
	  ○ ~~Food Tasted~~
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ ~~GNK~~
	  ○ ~~SNK~~
	• Macronutrient balance
	  ○ Protein, ~~carbohydrate,~~ and fat percent of energy
	• Weight fluctuation scores

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.497) Savin and White table suggests that the upper limit for this many variables should be 1.799
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET a) Appears to have a roughly linear relationship b) Appear to have a roughly linear relationship
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET** **No obvious funnelling**
Assumption #6 Your data must not show multicollinearity	**MET** **Correlation – does not exceed 0.7** **VIF – does not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**SRE – does not exceed 3** **LEV – does not exceed 0.5** **COO – Does not exceed 1**
Assumption #8	**Appears to be roughly normally distributed**

You need to check that the residuals (errors) are approximately normally distributed	**according to the histogram, normal p-p plot, and the normal q-q plot. Regression analysis is fairly robust to issues with normality, therefore, this should be appropriate.**

F (8, 33) = 2.288, p = 0.045

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	97922051.360	8	12240256.420	2.288	.045[b]
	Residual	176525805.012	33	5349266.819		
	Total	274447856.371	41			

a. Dependent Variable: KJwithDF

b. Predictors: (Constant), Proportion of energy from Fats, CurrentidealCDRS, WeightchangeCDRS, Australian recommended food score, AveragePFStotal, BIDQmean, PercentTNK, Proportion of energy from Protein

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.597[a]	.357	.201	2312.84820	1.497

a. Predictors: (Constant), Proportion of energy from Fats, CurrentidealCDRS, WeightchangeCDRS, Australian recommended food score, AveragePFStotal, BIDQmean, PercentTNK, Proportion of energy from Protein

b. Dependent Variable: KJwithDF

R^2 for the overall model was 35.7% with an adjusted R^2 of 20.1%, a

Not very strong correlation. R squared – close to one is better. Less than 0.5

Attempt 11

Use only participants with acceptable KJ intake according to the Goldberg cutoff.

Dependant variable (AKA outcome, target, criterion variable)	Other variables

Dietary intake – RUN TWICE:
1. KJwithDF
	Continuous variables
	• ARFS
	• CDRS score
	• PFS score
	  ○ Total
	  ○ Food Available
	  ○ Food Present
	  ○ Food Tasted
	• BIDQ score
	• A-NSKQ score
	  ○ TNK
	  ○ GNK
	  ○ SNK
	• Macronutrient balance
	  ○ Protein, carbohydrate, and fat percent of energy
	• Weight fluctuation scores

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.013) Savin and White table suggests that the upper limit for this many variables should be 2.297
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	Does not meet a) Appears to have non-linear relationship b) Appear to have a roughly linear relationship
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET** **No obvious funnelling**
Assumption #6 Your data must not show multicollinearity	**Does not meet** - **Average PFS has correlations above 0.7 with subgroups**

	- **TNK with SNK** - **Protein with CHO** - **CHO with Fat** **VIF** - **CHO% and Fat% above 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	

Univariate analysis

Stepwise

Variables

MJwithDF

CHO/kg, BIDQmean, WeightchangeCDRS, FoodTastedPFS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.661[a]	.438	.424	1.96441
2	.726[b]	.528	.503	1.82321
3	.770[c]	.593	.560	1.71524
4	.804[d]	.646	.608	1.61988

a. Predictors: (Constant), CHOperkg

b. Predictors: (Constant), CHOperkg, BIDQmean

c. Predictors: (Constant), CHOperkg, BIDQmean, WeightchangeCDRS

d. Predictors: (Constant), CHOperkg, BIDQmean, WeightchangeCDRS, FoodTastedPFS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	120.091	1	120.091	31.120	.000[b]
	Residual	154.357	40	3.859		
	Total	274.448	41			
2	Regression	144.808	2	72.404	21.782	.000[c]
	Residual	129.640	39	3.324		
	Total	274.448	41			
3	Regression	162.650	3	54.217	18.428	.000[d]
	Residual	111.798	38	2.942		
	Total	274.448	41			
4	Regression	177.360	4	44.340	16.898	.000[e]
	Residual	97.088	37	2.624		
	Total	274.448	41			

a. Dependent Variable: MJwithDF

b. Predictors: (Constant), CHOperkg

c. Predictors: (Constant), CHOperkg, BIDQmean

d. Predictors: (Constant), CHOperkg, BIDQmean, WeightchangeCDRS

e. Predictors: (Constant), CHOperkg, BIDQmean, WeightchangeCDRS, FoodTastedPFS

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.353	.922		4.724	.000
	CHOperkg	1.200	.215	.661	5.579	.000
2	(Constant)	6.729	1.221		5.511	.000
	CHOperkg	1.123	.202	.619	5.574	.000
	BIDQmean	-.915	.336	-.303	-2.727	.010
3	(Constant)	6.946	1.152		6.030	.000
	CHOperkg	1.058	.191	.583	5.527	.000
	BIDQmean	-.918	.316	-.304	-2.908	.006
	WeightchangeCDRS	.745	.302	.257	2.463	.018
4	(Constant)	9.190	1.443		6.369	.000
	CHOperkg	.984	.184	.542	5.360	.000
	BIDQmean	-.834	.300	-.276	-2.778	.009
	WeightchangeCDRS	.730	.286	.252	2.555	.015
	FoodTastedPFS	-.719	.304	-.238	-2.368	.023

a. Dependent Variable: MJwithDF

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	WeightchangeCDRS	.256[b]	2.246	.030	.338	.981
	FoodTastedPFS	-.276[b]	-2.418	.020	-.361	.963
	BIDQmean	-.303[b]	-2.727	.010	-.400	.981
2	WeightchangeCDRS	.257[c]	2.463	.018	.371	.981
	FoodTastedPFS	-.243[c]	-2.265	.029	-.345	.950
3	FoodTastedPFS	-.238[d]	-2.368	.023	-.363	.949

a. Dependent Variable: MJwithDF

b. Predictors in the Model: (Constant), CHOperkg

c. Predictors in the Model: (Constant), CHOperkg, BIDQmean

d. Predictors in the Model: (Constant), CHOperkg, BIDQmean, WeightchangeCDRS

Univariate analysis

Stepwise

Variables

MJwithDF

CHO/kg, LogBIDQmean, WeightchangeCDRS, FoodTastedPFS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.661[a]	.438	.424	1.96441
2	.737[b]	.543	.520	1.79311
3	.779[c]	.606	.575	1.68623
4	.807[d]	.652	.614	1.60720

a. Predictors: (Constant), CHOperkg

b. Predictors: (Constant), CHOperkg, LogBIDQmean

c. Predictors: (Constant), CHOperkg, LogBIDQmean, WeightchangeCDRS

d. Predictors: (Constant), CHOperkg, LogBIDQmean, WeightchangeCDRS, FoodTastedPFS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	120.091	1	120.091	31.120	.000[b]
	Residual	154.357	40	3.859		
	Total	274.448	41			
2	Regression	149.054	2	74.527	23.179	.000[c]
	Residual	125.394	39	3.215		
	Total	274.448	41			
3	Regression	166.400	3	55.467	19.507	.000[d]
	Residual	108.048	38	2.843		
	Total	274.448	41			
4	Regression	178.874	4	44.718	17.312	.000[e]
	Residual	95.574	37	2.583		
	Total	274.448	41			

a. Dependent Variable: MJwithDF

b. Predictors: (Constant), CHOperkg

c. Predictors: (Constant), CHOperkg, LogBIDQmean

d. Predictors: (Constant), CHOperkg, LogBIDQmean, WeightchangeCDRS

e. Predictors: (Constant), CHOperkg, LogBIDQmean, WeightchangeCDRS, FoodTastedPFS

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	WeightchangeCDRS	.256[b]	2.246	.030	.338	.981
	FoodTastedPFS	-.276[b]	-2.418	.020	-.361	.963
	LogBIDQmean	-.331[b]	-3.001	.005	-.433	.966
2	WeightchangeCDRS	.254[c]	2.470	.018	.372	.981
	FoodTastedPFS	-.226[c]	-2.103	.042	-.323	.935
3	FoodTastedPFS	-.221[d]	-2.198	.034	-.340	.934

a. Dependent Variable: MJwithDF

b. Predictors in the Model: (Constant), CHOperkg

c. Predictors in the Model: (Constant), CHOperkg, LogBIDQmean

d. Predictors in the Model: (Constant), CHOperkg, LogBIDQmean, WeightchangeCDRS

Variables

MJwithDF

Fat/kg, CHO/kg, PRO/kg, ARFS

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	fatperkg	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	CHOperkg	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: MJwithDF

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.531	.519	1.79413
2	.796[b]	.633	.615	1.60613

a. Predictors: (Constant), fatperkg

b. Predictors: (Constant), fatperkg, CHOperkg

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	145.691	1	145.691	45.261	.000[b]
	Residual	128.757	40	3.219		
	Total	274.448	41			
2	Regression	173.841	2	86.921	33.695	.000[c]
	Residual	100.607	39	2.580		
	Total	274.448	41			

a. Dependent Variable: MJwithDF

b. Predictors: (Constant), fatperkg

c. Predictors: (Constant), fatperkg, CHOperkg

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.738	1.001		2.736	.009
	fatperkg	5.243	.779	.729	6.728	.000
2	(Constant)	1.763	.943		1.868	.069
	fatperkg	3.776	.827	.525	4.565	.000
	CHOperkg	.689	.208	.380	3.303	.002

a. Dependent Variable: MJwithDF

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	CHOperkg	.380[b]	3.303	.002	.468	.711
	PROperkg	.194[b]	1.147	.259	.181	.408
	Australian recommended food score	.109[b]	1.002	.323	.158	.989
2	PROperkg	.228[c]	1.521	.136	.240	.406
	Australian recommended food score	.048[c]	.482	.632	.078	.952

a. Dependent Variable: MJwithDF

b. Predictors in the Model: (Constant), fatperkg

c. Predictors in the Model: (Constant), fatperkg, CHOperkg

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Dietary intake: 18. KJwithDF	Continuous variables ○ Food Tasted • BIDQ score (Log) • Macronutrient balance ○ ~~Protein,~~ carbohydrate, ~~and fat~~ /kg • Weight fluctuation scores

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.022)
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET c) Appears to have a roughly linear relationship d) Appear to have a roughly linear relationship
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**Questionable – may have some funneling**
Assumption #6 Your data must not show multicollinearity	**MET** **Correlation – does not exceed 0.7** **VIF – does not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**SRE – does not exceed 3** **LEV – does not exceed 0.5** **COO – Does not exceed 1**
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**Appears to be normally distributed according to the histogram, normal p-p plot, and the normal q-q plot. Regression analysis is fairly robust to issues with normality, therefore, this should be appropriate.**

Results of model

Descriptive Statistics

	Mean	Std. Deviation	N
MJwithDF	9.2083	2.58725	42
WeightchangeCDRS	.07	.894	42
FoodTastedPFS	2.9619	.85453	42
CHOperkg	4.0473	1.42671	42
LogBIDQmean	.3223	.16997	42

Correlations

		MJwithDF	WeightchangeCDRS	FoodTastedPFS	CHOperkg	LogBIDQmean
Pearson Correlation	MJwithDF	1.000	.343	-.393	.661	-.441
	WeightchangeCDRS	.343	1.000	-.047	.139	-.033
	FoodTastedPFS	-.393	-.047	1.000	-.192	.201
	CHOperkg	.661	.139	-.192	1.000	-.185
	LogBIDQmean	-.441	-.033	.201	-.185	1.000
Sig. (1-tailed)	MJwithDF	.	.013	.005	.000	.002
	WeightchangeCDRS	.013	.	.383	.190	.418
	FoodTastedPFS	.005	.383	.	.111	.101
	CHOperkg	.000	.190	.111	.	.121
	LogBIDQmean	.002	.418	.101	.121	.
N	MJwithDF	42	42	42	42	42
	WeightchangeCDRS	42	42	42	42	42
	FoodTastedPFS	42	42	42	42	42
	CHOperkg	42	42	42	42	42
	LogBIDQmean	42	42	42	42	42

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	LogBIDQmean, WeightchangeCDRS, FoodTastedPFS, CHOperkg[b]	.	Enter

a. Dependent Variable: MJwithDF

b. All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.807[a]	.652	.614	1.60720	2.022

a. Predictors: (Constant), LogBIDQmean, WeightchangeCDRS, FoodTastedPFS, CHOperkg

b. Dependent Variable: MJwithDF

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	178.874	4	44.718	17.312	.000[b]
	Residual	95.574	37	2.583		
	Total	274.448	41			

a. Dependent Variable: MJwithDF

b. Predictors: (Constant), LogBIDQmean, WeightchangeCDRS, FoodTastedPFS, CHOperkg

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	8.666	1.351		6.414	.000	5.928	11.403					
	WeightchangeCDRS	.722	.284	.249	2.546	.015	.147	1.296	.343	.386	.247	.980	1.020
	FoodTastedPFS	-.668	.304	-.221	-2.198	.034	-1.284	-.052	-.393	-.340	-.213	.934	1.070
	CHOperkg	.962	.183	.531	5.261	.000	.592	1.333	.661	.654	.510	.925	1.081
	LogBIDQmean	-4.427	1.525	-.291	-2.903	.006	-7.517	-1.337	-.441	-.431	-.282	.937	1.067

a. Dependent Variable: MJwithDF

Univariate analysis

Stepwise

Variables – BIDQ mean

MJwithDF, CurrentidealCDRS, AveragePFS, FoodAvailablePFS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.444[a]	.197	.177	.15417
2	.575[b]	.331	.297	.14253
3	.673[c]	.452	.409	.13064

a. Predictors: (Constant), FoodAvailablePFS

b. Predictors: (Constant), FoodAvailablePFS, MJwithDF

c. Predictors: (Constant), FoodAvailablePFS, MJwithDF, CurrentidealCDRS

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.234	1	.234	9.836	.003[b]
	Residual	.951	40	.024		
	Total	1.184	41			
2	Regression	.392	2	.196	9.651	.000[c]
	Residual	.792	39	.020		
	Total	1.184	41			
3	Regression	.536	3	.179	10.468	.000[d]
	Residual	.649	38	.017		
	Total	1.184	41			

a. Dependent Variable: LogBIDQmean

b. Predictors: (Constant), FoodAvailablePFS

c. Predictors: (Constant), FoodAvailablePFS, MJwithDF

d. Predictors: (Constant), FoodAvailablePFS, MJwithDF, CurrentidealCDRS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.120	.069		1.742	.089
	FoodAvailablePFS	.077	.025	.444	3.136	.003

2	(Constant)	.376	.112		3.368	.002
	FoodAvailablePFS	.065	.023	.376	2.819	.008
	MJwithDF	-.024	.009	-.372	-2.792	.008
3	(Constant)	.371	.102		3.619	.001
	FoodAvailablePFS	.052	.022	.297	2.376	.023
	MJwithDF	-.025	.008	-.383	-3.131	.003
	CurrentidealCDRS	-.044	.015	-.357	-2.903	.006

a. Dependent Variable: LogBIDQmean

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	MJwithDF	-.372[b]	-2.792	.008	-.408	.966
	CurrentidealCDRS	-.345[b]	-2.539	.015	-.377	.954
	AveragePFStotal	.045[b]	.153	.879	.025	.238
2	CurrentidealCDRS	-.357[c]	-2.903	.006	-.426	.953
	AveragePFStotal	-.204[c]	-.718	.477	-.116	.216
3	AveragePFStotal	-.403[d]	-1.542	.131	-.246	.204

a. Dependent Variable: LogBIDQmean

b. Predictors in the Model: (Constant), FoodAvailablePFS

c. Predictors in the Model: (Constant), FoodAvailablePFS, MJwithDF

d. Predictors in the Model: (Constant), FoodAvailablePFS, MJwithDF, CurrentidealCDRS

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Dietary intake: 19. LogBIDQMean	Continuous variables • Food Available PFS • MJwithDF • CurrentidealCDRS

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 1.880)
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET e) Appears to have a roughly linear relationship f) Appear to have a roughly linear relationship
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**DOES NOT** **Correlation – does not exceed 0.7** **VIF – does not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**SRE – does not exceed 3** **LEV – does not exceed 0.5** **COO – Does not exceed 1**
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**Appears to be normally distributed according to the histogram, normal p-p plot, and the normal q-q plot. Regression analysis is fairly robust to issues with normality, therefore, this should be appropriate.**

Dependant variable (AKA outcome, target, criterion variable)	Other variables
Dietary intake: 20. mJwithDF	Continuous variables • Macronutrient balance ○ Protein, carbohydrate, and fat /kg

Assumptions – attempt 1

Assumption #1: You have **one dependent variable** that is measured at the **continuous** level	MET
Assumption #2: You have **two or more independent variables** that are measured either at the **continuous** or **nominal** level.	MET
Assumption #3 You should have independence of observations (i.e., independence of residuals)	MET CHECKED Using Durbin-Watson statistic (should be close to 2 and we got a value of 2.345)
Assumption #4 There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	MET g) Appears to have a roughly linear relationship h) Appear to have a roughly linear relationship
Assumption #5 Your data needs to show homoscedasticity of residuals (equal error variances)	**MET**
Assumption #6 Your data must not show multicollinearity	**DOES NOT** **Correlation – does not exceed 0.7** **VIF – does not exceed 10**
Assumption #7 There should be no significant outliers, high leverage points or highly influential points	**SRE – does not exceed 3** **LEV – does not exceed 0.5** **COO – Does not exceed 1**
Assumption #8 You need to check that the residuals (errors) are approximately normally distributed	**Appears to be normally distributed according to the histogram, normal p-p plot, and the normal q-q plot. Regression analysis is fairly robust to issues with normality, therefore, this should be appropriate.**