Challenges following a personalized diet adhering to dietary guidelines in a sample of Australian university students

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Abstract

Background: Food-based dietary guidelines are designed to support populations to adopt a healthy diet. University students studying nutrition related courses are typically en-route to professional roles, which involve advocating a healthy diet. **Aim:** The present study compared the dietary intake of university students enrolled in a foundation nutrition course against the Australian Dietary Guidelines (ADGs) and Nutrient Reference Values (NRVs); and explored students' experiences of following a 3-day self-determined diet plan adhering to the ADGs/NRVs. **Methods:** Students ($n=115$) initially collected, and subsequently analyzed a 3-day prospective diet record to determine food group/nutrient intake. Individuals then modified their diet to comply with recommendations (ADGs/NRVs) and attempted to implement the diet plan. Challenges associated with meeting the ADGs/NRVs were described in an online survey form. **Results:** Baseline food group and nutrient intakes deviated from the guidelines, with 'lean meats & alternatives' the only group consumed in recommended quantities. Students demonstrated the capacity to plan a modified personal diet adhering to the ADGs food group recommendations. However, when following this, several key challenges to dietary adherence were identified. Challenges were categorized as personal/behavioral factors (e.g. the quantity/type of food) and societal factors (e.g. time, cost, social factors). **Conclusion:** Overall, this study highlights challenges influencing adherence to dietary guidelines in a sample of undergraduate university students. Understanding these factors may help tailor advice to facilitate improved dietary patterns in this population group.

Keywords

nutrition education; dietary intake; dietary guidelines; barriers; challenges

Introduction

Poor dietary behaviors is the largest contributing risk factor to the burden of disease in Australia (Australian Institute of Health and Welfare, 2014). To support Australians to adopt a healthy diet, the National Health and Medical Research Council (NHMRC) developed the Australian Dietary Guidelines (ADGs) (National Health and Medical Research Council, 2013a). The ADGs are informed by Nutrient Reference Values (NRVs) (National Health and Medical Research Council et al., 2006; National Health and Medical Research Council, 2011), which describe recommended daily amounts of nutrients to avoid nutritional deficiency or toxicity, and to decrease the risk of developing diet-related chronic diseases in individuals who are otherwise healthy (National Health and Medical Research Council et al., 2006). The ADGs are also underpinned by reviews of the best available research evidence and significant dietary modelling to ensure nutrient and energy requirements are met for each age and gender group (National Health and Medical Research Council, 2013b).

Despite the availability of dietary guidelines, most Australians do not meet the minimum recommended number of serves/day for any of the five major food groups (Australian Bureau of Statistics, 2016). Indeed, data indicate <4% of the population consume enough vegetables each day, ~10% achieve the recommended intake of dairy & alternatives, and >33% of the population's total daily energy intake is sourced from energy-dense, nutrient-poor 'discretionary foods' (Australian Bureau of Statistics, 2016). Thus, identifying and understanding factors influencing the implementation of and adherence to the ADGs is important and may assist health professionals in the development of strategies to help improve compliance.

Previous studies investigating the implementation of and adherence to dietary guidelines have identified barriers contributing to poor compliance, both in Australia (Welch et al., 2009) and internationally (Kratt et al., 2000; Pomerleau et al., 2005; Siega-Riz and Popkin, 2001). Barriers include external factors such as availability, cost and time, and internal factors such as habits, tastes and preferences (Nicklas et al., 2013; Yeh et al., 2008; Ross and Melzer, 2016; Lappalainen et al., 1997; Ashton et al., 2016). Many of the studies investigating “perceived” barriers to healthy eating have employed survey methodologies to identify key dietary behaviours and examine associations based on sociodemographic and behavioural characteristics (Kearney and McElhone, 1999; Lappalainen et al., 1997; Ross and Melzer, 2016; Worsley and Crawford, 1986; Ashton et al., 2016). Others have used qualitative focus groups in an effort to better understand barriers and facilitators to healthy eating behaviours (Nicklas et al., 2013; Yeh et al., 2008). One of the limitations of these methods is the assumption that participants have previously attempted to follow dietary guidelines or healthy dietary patterns (and can accurately recall their experience). Thus, there is a reliance on individuals’ perceptions of barriers and facilitators of healthy eating rather than employing prospective methods, where individuals attempt to follow a specific dietary plan and report on their experiences. A prospective approach has the potential to provide greater insight into barriers individuals encounter.

In studies employing prospective methods, emphasis is often on consumption of specific food groups (i.e. fruit and vegetables) rather than adherence to entire dietary guidelines (John and Ziebland, 2004; Anderson et al., 1998). In a study examining barriers to eating a healthy diet (in a UK population group) and using semi-structured qualitative interviews, Macdiarmid *et al.*(2013) identified key barriers to be social and cultural in

nature (i.e. time pressures, convenience, lack of motivation to cook) rather than lack of skills or knowledge about healthy eating. However, all of the meals in this study were prepared for (and possibly delivered to) participants, reducing the ecological validity as factors such as access, availability, time and cost are removed. Thus, further research is required to determine barriers for adhering to dietary guidelines in a real-world context, particularly amongst specific population groups.

University students are one population group at risk of not meeting dietary guidelines (Deliens et al., 2016). Previous research indicates university students exhibit poor eating behaviours (Mann and Blotnick, 2016; Strawson et al., 2013), which exist irrespective of tertiary studies in nutrition (Strawson et al., 2013). While food-related behaviours developed during early adulthood may have a lasting impact on the long-term health (Deliens et al., 2016; Nelson et al., 2008), tertiary nutrition courses are often undertaken by future physicians, nurses, dietitians and public health professionals, whose role will involve advocating for healthy dietary behaviours. Thus, strategies facilitating improved adherence to dietary guidelines in university nutrition students may impact on personal health and facilitate the development of competence that supports advocating for improved dietary patterns in others.

The present study was an opportunistic exploration of food intake data and experiences following a planned 3-day diet adhering to the ADGs/NRVs (collected as part of an experiential learning assessment item) in a group of university students undertaking an undergraduate nutrition course. The study aimed to compare students current dietary intakes (of food groups and nutrients) against the ADGs/NRVs, and explore student-perceived barriers to eating a personalised diet compliant with the ADGs/NRVs.

Methods

Participants

The present study was conducted using data collected as part of a major assessment item in a second year undergraduate nutrition course. The course is taken by students from a diverse range of three and four year health-related degrees (e.g. Nutrition and Dietetics, Exercise Science, Nursing, Psychology, Public Health, Medical Science). The study was approved by the University's Human Research Ethics Committee (GU: 2016/791) and students provided written informed consent. The course had a total of 197 students enrolled. However, $n=49$ (25%) did not provide written informed consent, $n=7$ (4%) did not submit all required components of the assessment item, and a further $n=26$ (13%) had obvious and substantial errors (either over or under reporters, i.e. energy intake values $<2,500$ kJ or $>20,000$ kJ and did not accurately reflect information provided in food photos) in their dietary analysis and were excluded from the final analysis. The final sample was 115 students; a recruitment rate of 58%.

Procedures

The assessment item for the nutrition course incorporates the experience, reflection, conceptualization and active experimental aspects of experiential learning (Briers, 2005; Kolb, 1984; Yardley et al., 2012). Students attended 2×60 min tutorials in Week 2 of trimester (6th – 11th March, 2017), where they were taught how to monitor and analyze dietary intake. The tutorials were delivered by three academics/Accredited Practicing Dietitians (APDs). In the first tutorial, students were trained to keep a diet record including a detailed description of food/beverages consumed (i.e. weight, cooking method, brand, volume) and digital images of each item (captured using a smartphone

camera). Methodology of this nature has demonstrated good reliability and validity for assessing dietary intake in adult populations (Ngo et al., 2009). In the second tutorial, students were taught how to calculate food group/nutrient intakes; which involved categorizing items into food groups, calculating intake as the number of food group ‘serves’ consumed and using dietary analysis software (FoodWorks® Version 8, Xyris Software, Brisbane, Australia) to estimate nutrient intake.

Students kept a detailed written record of the food/beverages (including dietary supplements) they consumed for three pre-determined consecutive *mid-week* days (Tuesday to Thursday) in Week 3 (14th – 16th March, 2017) of trimester (Baseline Diet). They then conducted analyses of their Baseline Diet to determine food group/nutrient intake and modified this to comply with recommended intakes from the ADGs/NRVs (Modified Diet). Individuals attempted to implement their Modified Diet over 3 *mid-week* days in Week 10 of trimester (9th – 11th May, 2017). Food records and accompanying images, and results from food group/nutrient analysis of diets were submitted as part of course assessment. Other demographic information (i.e. age, weight, height, gender); an estimated daily energy requirement (EER, calculated in FoodWorks® from NRV equations); and any specific dietary requirements followed (e.g. lactose free, gluten free, paleo etc.) was also obtained. Individual food intake was analyzed by each student using the Australian-specific nutrient analysis software (FoodWorks® Version 8, Xyris Software, Brisbane, Australia) described in the second tutorial. Data was pooled by the researchers for further analysis.

The food groups/nutrients analysed in the Baseline/Modified Diets were: fruit; vegetables and legumes/beans (‘veg.’); breads, cereals and grains (‘bread/cereal’); lean meats and poultry, fish, eggs, tofu, nuts and seeds and legumes/beans (‘meat/alts.’); milk,

yoghurt, cheese and/or alternatives ('dairy/alts.');

discretionary choices ('discretionary food');

unsaturated fats and oils ('fats/oils');

energy; carbohydrate (CHO); protein; fat; alcohol; water; calcium; iron and sodium. Dietary intakes were compared against recommendations from the ADGs/NRVs. Macronutrient intakes were compared against the Acceptable Macronutrient Distribution Ranges (AMDRs), which indicate the proportion of dietary energy that should be derived from each nutrient (CHO=45-65% EER; protein=15-25% EER; fat=20-35% EER). Calcium and iron intake were compared against the Recommended Dietary Intake (RDI). Water and sodium were compared against the Adequate Intake (AI) and Suggested Dietary Target (SDT), respectively.

After implementation of the Modified Diet, participants provided a written response to a single open-ended question via an online survey form to “*describe challenges in following the modified dietary plan (both food- and non-food related)*”.

Data analysis

All statistical procedures were completed using IBM SPSS Statistical Software, Version 24.0 (SPSS Inc., Chicago, IL). Dietary intake was investigated using quantitative methods. Each participants' 'total intake' (i.e. food groups, macronutrient, micronutrient, energy and water intake per day of the Baseline/Modified Diet) was determined and compared against their ADGs/NRVs recommendations. 'Total intake' and 'intake compared to ADGs/NRVs' were non-normally distributed (Shapiro-Wilk test $P's > 0.05$); hence, Friedman and Mann-Whitney U tests were used to compare dietary intakes over time (i.e. between Day 1-3) and by gender, respectively. Food groups, macronutrients, micronutrients, energy and water intakes in the Baseline and Modified Diets did not differ significantly by time (i.e. Day 1-3) (all $P's > 0.05$). Therefore, these values were averaged

across the 3-day observation period. Data are presented as the median and inter-quartile range (IQR). Statistical significance was accepted as $P < 0.05$. Responses to open-ended questions were investigated using mixed methods.

Qualitative data were handled specifically using content analysis (Bengtsson, 2016). Responses were condensed into smaller text units describing the main challenges students encountered in their attempt to adhere to the dietary recommendations. A single investigator coded the units inductively and organized the codes into categories; each category referred to a particular challenge. Categories are expressed by frequency (i.e. the number of participants referring to each challenge). Those frequently described (i.e. >5 student responses) were examined to identify sub-categories. Codes from 10% of transcripts and categories/subcategories were reviewed by two other investigators with qualitative research experience to identify any variations and reach consensus.

Results

Participant Characteristics

Complete data was available for 115 participants ($n=37$ males, $n=78$ females; age: 22 ± 5 y; BMI: 22.8 ± 3.3 kg/m²; values are Mean $\pm$ SD). An independent samples *t*-test indicated no difference in age between genders (Males: 22.3 ± 5.7 y; Females: 21.7 ± 3.9 y; $t(113)=0.601$, $p=0.549$). In total, $n=20$ individuals reported restricted dietary patterns (i.e. vegetarian, vegan, lactose free, gluten free, other food allergies). Except for two cases (one lactose free and one vegetarian), all restricted dietary patterns were reported by females.

Baseline Diet Intakes

Dietary intakes from Baseline Diet records are displayed in Tables 1 and 2, with gender comparisons provided. Both males and females consumed fewer servings of fruit, veg., dairy/alts. and bread/cereal than recommended in the ADGs. Females also consumed less meat/alts than recommended. The proportion of dietary energy derived from protein and fat was within the AMDR for both genders. However, energy derived from CHO was below the lower AMDR level for both genders. Both males and females consumed less water and calcium compared to the NRVs. Females also consumed less iron; while males consumed more sodium than recommended. Females who adhered to a vegetarian/vegan diet ($n=11$, 10%) consumed higher levels of iron, but were still below the NRVs.

INSERT TABLE 1 HERE

INSERT TABLE 2 HERE

Modified Diet Plans

Students demonstrated the ability to plan a Modified Diet adhering to the ADGs food groups recommendations. Planned intakes of water, calcium and sodium, as well as the proportion of dietary energy derived from protein and fat were consistent with NRV recommendations. For females, the planned iron intake was still lower than the NRV recommendation. The proportion of energy from CHO was also below the lower AMDR limit (i.e. 1%) for both genders.

Challenges Adhering to Modified Diet

Eight categories emerged from students' descriptions of challenges encountered in adhering to dietary recommendations. Four 'food related' challenges were identified: (1)

consuming the volume of food advised (i.e. due to large serving sizes); (2) increasing intake of certain food groups/nutrients; (3) decreasing intake of certain food groups/nutrients; and, (4) applying the ADGs (i.e. serving sizes and food group classifications). Four ‘non-food related’ challenges were also identified: (1) time commitment; (2) additional cost of purchasing food/groceries; (3) inflexibility of the meal plan; and, (4) managing social situations involving food. Challenges are detailed below; with supporting quotes from participants indicated in Table 3.

Food Related Challenges

Thirty-two participants (28%) indicated the quantity of food (based on the amount required to meet the recommended ADGs food groups) was too great to consume, and in some cases, was reportedly associated with adverse gastro-intestinal (GI) symptoms (i.e. abdominal pain/bloating). The large quantity of bread/cereal recommended was viewed as particularly problematic. Participants reported feeling “too full” to finish meals and/or snack items, or even “force feeding” themselves to comply with the serving recommendations. The frequency of this response did not differ significantly by gender ($P>0.05$). A comparatively small group of individuals ($n=5$, 4%, predominantly male), identified feeling hungry between meals as a challenge in adhering to the dietary recommendations.

Forty-eight participants (42%) reported difficulty increasing their intake of certain food groups/nutrients to comply with nutrient recommendations. Included food groups/nutrients were bread/cereal ($n=16$, 14%), veg. ($n=11$, 10%), iron ($n=7$, 6%) and dairy ($n=7$, 6%). With regard to bread/cereal, individuals cited the number of serves recommended was much larger than what they typically consumed and GI symptoms (i.e.

abdominal pain/bloating) as barriers to increasing intake. Difficulty increasing veg. intake was also partly due to the large number of serves recommended. Others cited an underlying dislike of vegetables and the large amount of time/effort required to prepare/cook vegetables as barriers to intake. Female participants reported difficulty consuming sufficient iron. Individuals cited the high RDI as the primary reason for this challenge. Those who had difficulty increasing dairy intake were often lactose intolerant or vegan; those who were not, failed to specify a reason for having difficulty increasing their intake. Females were more likely to report difficulty increasing their intake of bread/cereal ($\chi^2=5.724$, $P=0.019$) and iron ($\chi^2=3.536$, $P=0.095$) than males. The frequency of reporting difficulty increasing veg. and dairy intake did not differ significantly by gender ($P>0.05$).

Twenty-four participants (21%) reported difficulty decreasing their intake of certain food groups/nutrients to comply with recommendations. Discretionary food ($n=13$, 11%) and sodium ($n=7$, 6%) were frequently identified. With regard to discretionary food, individuals cited the pleasant taste and the high availability/low cost as barriers to decreasing intake. Difficulty decreasing sodium intake was also related to taste preferences, although one individual also cited cultural factors (i.e. Chinese cuisine having a high sodium content) as a barrier. The frequency for reports of difficulty decreasing discretionary food and sodium intake did not differ significantly by gender (all $P's>0.05$).

Participants reported having difficulty applying the ADGs in a real-life context ($n=7$, 6%). Specifically, individuals indicated estimating serving sizes of foods/ingredients and determining food group classifications were sometimes challenging.

Non-Food Related Challenges

Fifty-five participants (48%) indicated adhering to the nutrient recommendations was time-consuming, and finding time to complete the associated activities, i.e. shopping for food (often looking for very specific items), preparing/planning meals and eating during the day, was a challenge. Participants indicated completing paid work, university work and social/recreational activities restricted the amount of time available for these tasks.

Nineteen participants (17%) indicated adhering to the nutrient recommendations increased the cost of purchasing food/groceries. The added cost was typically attributed to the large amount of food recommended in the guidelines, the need to purchase a wide variety of ingredients, difficulty anticipating the cost of specific products during meal planning (and subsequently, having to make adjustments to the plan “on-the-go” if certain items were too expensive and/or alternate items were discounted) and the need to purchase more expensive nutrient-fortified products to achieve recommended micronutrient intakes (e.g. iron).

Eleven participants (10%) had difficulty managing social situations involving food, with reports of turning down invitations to attend social events because they felt it would be impossible to adhere to nutrient recommendations under these circumstances, either because of “temptation” to consume discretionary food or because suitable alternatives would not be available.

Seventeen participants (15%) simply disliked the inflexibility of having a diet plan, i.e. not having the freedom to eat what and when they liked. Participants indicated it was difficult to anticipate the type of food they would “feel like eating” on a given day, and if they were to deviate from the diet plan (i.e. as a consequence of wanting something else to eat or increased/decreased hunger), it was difficult to adapt the diet “on-the-go” to

compensate for the nutritional impact of the change. The frequency with which these non-food related challenges were reported did not differ significantly by gender (all P 's>0.05).

INSERT TABLE 3 HERE

Discussion

Overall, students' baseline food group and nutrient intakes deviated considerably from the guidelines, confirming concerns about the poor eating behaviours of university/college students. Students demonstrated the capacity to plan a personal diet complying with the ADGs Food Groups recommendations. However, when attempting to adhere to their dietary plan several key challenges were identified, including personal/behavioural and societal factors.

In regard to their Baseline Diet, students typically consumed less than the recommended daily number of serves for all food groups, with the exception of males consuming adequate quantities of meats/alts. For instance, 12% of participants achieved recommended intake of veg. serves, 12% met dairy/alts., 16% consumed sufficient bread/cereal, and 30% met recommended fruit intake. Similar proportions are observed amongst the broader Australian population (Australian Bureau of Statistics, 2016).

Participants' water and micronutrient intakes were similarly inadequate; with most individuals under-consuming iron, calcium and water (or, in the case of sodium, exceeding the UL) compared to NRV recommendations (National Health and Medical Research Council et al., 2006). Females in this study consumed ~56% of the recommended daily value of iron, with ~6% consuming adequate iron to meet the RDI. When adhering to a vegetarian or vegan diet, average iron intakes fell to ~43% of the

RDI, with only one participant (who supplemented) achieving the RDI. Despite the Modified Diet forecasting a larger intake of iron, this remained below (-3.3 mg) recommendations. Thus, despite undertaking a tertiary-level nutrition course, many females in the present study were unable to develop a dietary plan meeting their recommended iron requirement; demonstrating the challenges of translating nutrient-based recommendations and a need for more educational resources providing dietary plans consistent with the ADGs and NRVs.

Previous studies have identified a variety of barriers decreasing adherence to dietary guidelines (Kratt et al., 2000; Pomerleau et al., 2005; Siega-Riz and Popkin, 2001; Welch et al., 2009). However, as participants in these investigations are often required to identify “barriers” without first experiencing a “healthy diet”, this evidence is limited. Having implemented the ADGs, participants in the present study reported the large quantity of food recommended was a significant barrier to adherence, resulting in reports of adverse GI symptoms (e.g. abdominal pain/bloating). While GI disturbance may be related to specific food components such as increased fibre intake (Marlett et al., 2002), which may take >3 days to become accustomed to, the fact participants felt satiated when adhering to nutrient recommendations was positive. Particularly as this satiation suppressed the desire to consume discretionary foods. The present data also highlights a need to consider the feasibility of dietary guidelines, to ensure recommendations are both beneficial and achievable.

The present investigation also identified several food group/nutrient recommendations were particularly challenging to achieve. Participants reported difficulty increasing their intake of bread/cereal, iron and dairy to recommended levels, and decreasing sodium intake. Females in particular indicated difficulty meeting

bread/cereal and iron requirements. Participants' experiences of increasing veg. intake and limiting discretionary foods were mixed. Understanding the challenges affecting dietary adherence at the level of individual food groups (and nutrients) may help inform the development of targeted public health interventions (initially) prioritising the most achievable recommendations, before moving on to more challenging components.

Participants cited societal issues as barriers to adopting a healthy diet. Indeed, several individuals stated adhering to the guidelines was time-consuming, with the associated activities (e.g. shopping, preparing meals and eating) proving a challenge. Time barriers have previously been identified in young adults (Munt et al., 2017), who may prioritise other activities (e.g. University work, paid employment and social/recreational events) over health-behaviours (Ashton et al., 2016; Deliens et al., 2014). Participants in this study did not clearly indicate why the 3-day dietary plan was more "time consuming" than their Baseline Diet. However, the Modified Diets did include fewer pre-prepared or "convenience-type foods".

Participants in this study also stated the increased cost of purchasing food and groceries was a significant barrier to dietary adherence; an observation consistent with evidence demonstrating healthier diets (i.e. rich in fruit and vegetables) are typically more expensive than diets rich in processed foods (Rao et al., 2013). In Australia, the median income of employed university students (18-24 y) is approximately \$331/week (Australian Bureau of Statistics, 2013); 21.0% of (domestic) undergraduate students have an income less than \$192/week (Bexley et al., 2013). Evidence suggests individuals need to spend approximately \$60/week on food to comply with current recommendations (Ketings et al., 2009). Hence, healthy eating would represent a substantial proportion of many students' weekly income. Individuals attributed the added costs to the need to

purchase a wide variety and large quantity of food (and nutrient-fortified alternatives) and difficulty anticipating the cost of certain items when planning the diets. Indeed, participants in the present study stated, to decrease the cost of healthy eating, they needed to spend time comparing prices across several vendors. Collectively, these data demonstrate a need to identify dietary patterns that are nutrient-rich, affordable, yet time-efficient to support university students in adopting healthy eating behaviours. The present data suggest university students may respond to interventions providing structured plans (i.e. detailed plan outlining meals, ingredients and cooking methods) to follow.

Participants in this study rarely indicated a lack of knowledge or skill reduced their ability to adhere to nutrient recommendations; consistent with previous evidence indicating poor knowledge of healthy eating or a lack of cooking skills are the least common barriers to dietary change (Macdiarmid et al., 2013). However, individuals in the present study reported having difficulty applying the ADGs. Specifically, estimating serving sizes and determining food group classifications were the challenges. The ADGs are designed specifically to provide nutrition advice to health-professionals, policy-makers and the general public (National Health and Medical Research Council, 2013a). However, evidence to support the usability of dietary guidelines is limited and the work completed tends to suggest individuals are at risk of misinterpreting recommendations (Brown et al., 2011). In the USA, a study evaluating consumers' understanding of the MyPyramid food guidance system revealed that few individuals could correctly categorise foods into food groups, and estimating serving sizes of fruit and vegetables was "confusing" (Britten et al., 2006). Evaluation of consumers' ability to use/apply the ADGs is essential to ensure the general public have access to high-quality evidence-based nutrition advice they understand and can implement for themselves.

Finally, individuals reported having difficulty managing social situations involving food, which may have influenced adherence to the ADGs. Social factors have been an issue identified in previous studies investigating barriers to healthy eating (Macdiarmid et al., 2013; Ashton et al., 2016; John and Ziebland, 2004; Munt et al., 2017). However, the importance of “social circumstances” as a barrier to dietary adherence may have been underestimated in the present study, as participants implemented the Modified Diet on weekdays. Social events involving eating and drinking are most likely to occur on weekends (Thompson et al., 1986; Yang et al., 2014). When attempting to change dietary habits, it is important to ensure recommendations do not lead to social exclusion, particularly amongst young adults. Thus, challenges associated with adherence to dietary guidelines in a context where social circumstances are likely to be greater (i.e. on weekends) should be explored further.

Limitations

The present study is not without limitations. Firstly, the 3-day diet records students collected for their Baseline Diet did not include a weekend day. Thus, the data may not provide an accurate reflection of actual dietary behaviors. In addition, close to half of all eligible students did not participate, either through lack of completing informed consent, incomplete submissions of assessment components, or because they were excluded based on reduced confidence in their ability to analyze dietary intake data accurately. Therefore, the reported perceived challenges in adhering to dietary guidelines are based on the most motivated students in the course. Thus, findings may not be generalizable to the broader university student population.

Conclusions

Overall, this study provides insight into challenges affecting adherence to dietary guidelines in university students. Given widespread concerns regarding poor eating behaviours of this population group, health professionals can use these findings to help tailor advice facilitating improvement in dietary patterns. There is also a need for more educational resources translating the ADGs and NRVs from their focus on individual food items/nutrients into examples of meals or complete dietary patterns reflecting real-world dietary intake.

Authors' contributions

CI and DM formulated the research question(s), designed the study methodology, collected and analyzed data and wrote the article. BD and SK contributed to formulating the research question(s), study design and writing the article. All authors critically revised the manuscript and approved the final version of the paper.

Availability of data and materials

Data set and materials are available upon written request to the corresponding author.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

The study was approved by the Griffith University human research ethics committee (GU: 2016/791).

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Table 1. Average 3-day intake of ADGs food groups in the Baseline Diet ($n=115$)

	Total Intake		Recommended Intake	
	Males	Females	Males	Females
Fruit	0.7 (1.3)	1.3 (1.3)*	2.0	2.0
Vegetables	2.7 (2.0)	3.2 (2.1)	6.0	5.0
Meats & Alternatives	3.0 (2.8)	2.2 (1.7)*	3.0	2.5
Dairy & Alternatives	1.3 (0.7)	1.3 (1.1)	2.5	2.5
Bread, Cereals & Grains	4.3 (2.7)	3.3 (2.3)*	6.0	6.0
Discretionary	1.3 (2.7)	2.0 (1.8)	-	-
Fats & Oils	1.7 (1.7)	1.0 (1.3)	-	-

Intakes are expressed as the number of food group ‘serves’ consumed per day, in accordance with the ADGs(National Health and Medical Research Council, 2013a). Total intake values are Median (IQR).

* indicates a significant difference ($p<0.05$, Mann-Whitney Test) from male participants (Nb. ADGs do not recommend a specific level of discretionary food or fats/oils intake).

Table 2. Average 3-day intake of energy, macronutrients, micronutrients and water in the Baseline Diet (*n*=115)

	Total Intake			Recommended Intake		
	Males	Females	Females (V/V)	Males	Females	Females (V/V)
Energy (MJ)	9.1 (2.8)	6.9 (1.7)*		12.7 (3.3)	9.6 (1.3)	
Protein (g)	122 (44)	84 (36)*				
CHO (g)	195 (75)	169 (63)*				
Fat (g)	78 (32)	63 (32)*				
Protein (% EER)	23 (5)	20 (6)*		15-25	15-25	
CHO (% EER)	37 (5)	40 (11)*		45-65	45-65	
Fat (%EER)	35 (9)	33 (12)		20-35	20-35	
Alcohol (g)	0 (0)	0 (0)		-	-	
Water (L·d⁻¹)	2.3 (1.4)	2.5 (1.7)		3.4	2.8	
Iron (mg·d⁻¹)	13.3 (5.9)	10.0 (4.2)*	13.7 (10.2)	8.0	18.0	32.4
Calcium (mg·d⁻¹)	802 (414)	748 (340)		1000	1000	
Sodium (mg·d⁻¹)	2671 (1104)	1861 (1056)*		2000	2000	

MJ: Mega-joules, g: grams, mg: milligrams; Total intake excludes 1 vegetarian male. Females (V/V) includes iron intake data for vegetarian/vegan participants only (all other vegetarian/vegan data are incorporated with the female population. All 'Total Intake' values are Median (IQR). 'Recommended Intake' values for energy (estimated energy requirement, EER) are Median (IQR) calculated from participants age, gender, height, weight and PAL data. 'Recommended Intake' values for micronutrients are AI for water, RDI for calcium and iron (+80% for Females(V/V)), and SDT for sodium in accordance with NRVs. 'Recommended Intake' values for macronutrients are acceptable macronutrient distribution ranges (AMDR). * indicates a significant difference ($p<0.05$, Mann-Whitney Test) from male participants (Nb. NRVs do not recommend a specific alcohol intake).

Table 3. Food and non-food related categories and sub-categories (with supporting quotes) emerging from the students' descriptions of the *challenges* encountered in adhering to the dietary recommendations.

Food Related Categories/Sub-Categories	
(1) Consuming the quantity of food recommended:	
	P983 (F, 24 y): <i>"There were days were I did not have some snacks or only ate half the serving size I originally planned, as I didn't want to over eat or make myself feel full, bloated or sick"</i>
	P840 (F, 26 y): <i>"I would not eat some of the planned meals, as I was physically too full to eat them"</i>
	P271 (F, 21 y): <i>"I regularly skipped foods throughout the 3 day period as I was too full to consume the diet planned. Eating six serves of grains per day was impossible due to such a large quantity"</i>
	P042 (F, 20 y): <i>"To meet the ADGs, I had to have a lot more meals in a day than I normally would. I had to force some foods down in order to keep up with my meal plan and this made me feel uncomfortable and too full"</i>
	P819 (F, 22 y): <i>"The amount of food I had to eat was much more than I would normally. I often didn't feel hungry for my next meal and occasionally felt too full to eat some of my planned snacks"</i>
(2) Increasing intake of certain food groups/nutrients:	
2a. Breads, Cereals & Grains	P343 (F, 19 y): <i>"Increasing the serves of bread/cereal was a challenge. The planned intake was a substantial change from my normal intake and I find that I feel bloated when consuming grains, as a result I tend to avoid them"</i>
	P901 (F, 22 y): <i>"Consuming 7 serves of bread/cereal was difficult as there was a large difference (4.5 serves) between my usual intake and this recommendation"</i>
2b. Vegetables	P750 (F, 19 y): <i>"I find it difficult to maintain an adequate vegetable intake as I am not fond of its taste. And cooking vegetables involves time and effort"</i>
	P935 (F, 21 y): <i>"Usually, I only eat vegetables at dinner time, making it extremely challenging to consume the right amount"</i>
	P467 (F, 19 y): <i>"I found it quite difficult to consume 5 serves of Veg. I attempted to do this by having vegetables for snacks, such as carrots, and including as many vegetables in my meals as I could"</i>
	P389 (M, 19 y): <i>"I found that even when consuming a salad with a variety of different vegetables, some of these only contributed to a small portion of the total vegetable intake, thus making it difficult to achieve the requirements"</i>
	P549 (F, 20 y): <i>"I didn't realize that even though I was consuming vegetables, they were not up to the standard of 1 serving size, some actually only calculating to half a serve"</i>
2c. Iron	P873 (F, 19 y): <i>"Another challenge I faced was meeting the RDI for iron. I was able to meet the EAR across all days but failed to reach the RDI"</i>
	P359 (F, 23 y): <i>"I found it quite challenging to increase my iron intake without overconsuming meat and alternatives"</i>
2d. Dairy	P622 (F, 36 y): <i>"My lactose intolerance also inhibited my ability to stick to the guidelines especially when it came to the dairy and alternatives sector of my food intakes"</i>
(3) Decreasing intake of certain food groups/nutrients:	
3a. Discretionary	P773 (M, 25 y): <i>"The most challenging thing was combating my craving for foods outside the diet plan. I wanted to eat pizza very badly"</i>
	P980 (F, 19 y): <i>"When I went grocery shopping, I often saw tasty-looking discretionary foods being discounted at very low prices. It was tempting to purchase and consume them"</i>
	P722 (F, 21 y): <i>"One of the biggest things I wanted to focus on was reducing my intake of discretionary foods. I have been known to consume high amounts of sugary foods, especially while I'm studying. It was challenging to control my cravings, however I did quite well. I underestimated the ability of fruits and yoghurts to satisfy those cravings"</i>
3b. Sodium	P511 (F, 21 y): <i>"I planned to reduce my sodium intake by cutting out added table salt. I followed this recommendation for the first day but food didn't taste as nice without salt. By the third day I was putting my usual amount on everything"</i>
	P156 (M, 19 y): <i>"The cuisine of my culture (Chinese) is often high in salt content, and my family prefer meals which are highly savory and are high in salt"</i>
(4) Applying the ADGs (i.e. serving sizes and food group classifications):	

- P610 (F, 21 y): *“In the past, I have never thought about how many serves of a particular food group I would be consuming in a given meal. For instance, knowing how much of a pumpkin was one serve of vegetables and the best way to measure this proportion (cups/g/kg/small/medium etc.) was definitely challenging”*
- P602 (F, 21 y): *“The guidelines did not include every single food item, so I found it challenging to know exactly how much of certain ingredients to use”*

Non-Food Related Categories/Sub-categories

(1) Time commitment:

- 1a. Shopping** P938 (M, 22 y): *“I spent more time than I usually would trying to find specific brands or types of products when grocery shopping”*
- 1b. Preparing meals** P108 (F, 22 y): *“The second challenge, was cooking for every meal. I found myself in the kitchen a lot, cooking constantly”*
P501 (F, 20 y): *“To prepare each meal for the day and cook each dinner was a chore. My time is very limited with full time university and part time work; every hour is spent working on either one, hence the time involved in preparing and cooking each meal was borrowed”*
- 1c. Eating** P955 (M, 19 y): *“Work and university commitments made it hard to follow the dietary plan. Ordinarily, I would skip meals to allow more time for these commitments”*
P532 (F, 19 y): *“I don’t usually pack food for the time I am on campus. I find myself skipping meals instead.”*

(2) Additional cost of purchasing food/groceries

- 2a. Large amounts** P154 (F, 26 y): *“I found that my grocery bill was a lot more than what I would usually spend at the supermarket. This was due to having to purchase almost double the amount of food that I would normally consume”*
- 2b. Wide variety** P813 (M, 20 y): *“I tried varying the different meat and vegetables in lunch/dinner, but this was hard as I didn’t want to spend too much money on different ingredients, when I can buy bulk and use the same thing again and again”*
- 2c. Anticipated cost** P921 (M, 20 y): *“Another challenge was having to purchase the correct foods to follow the dietary plan, as the foods that I intended to buy exceeded the expected cost”*
- 2d. Fortified products** P505 (F, 19 y): *“Due to financial restraints, I could not purchase the iron-enriched Wonder whole-meal bread. Instead, I bought bread that was discounted”*

(3) The inflexibility of the meal plan

- P500 (F, 20 y): *“The most challenging aspect I encountered was having to follow such a structured/detailed plan, I felt pressured and restricted as to what I was eating. Usually, I have the freedom to make whatever I feel like, however, on the plan I felt forced to make my food that it became almost a chore”*
- P002 (F, 19 y): *“I found following the diet plan reasonably difficult, as sometimes I didn’t feel like what I had planned, wasn’t hungry or I was hungrier than anticipated”*

(4) Managing social situations involving food

- P901 (F, 22 y): *“I went out for dessert one of the nights I was following this plan and didn’t allow myself to indulge. It makes it socially awkward to go out and not be able to eat anything with your friends”*
- P819 (F, 22 y): *“One night I was invited to a friend’s house for dinner but had to turn down the invitation, as this would have meant eating a meal not in my diet plan. This would be a real barrier to following a more long-term plan”*