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Original Article

Diet quality is lower among adults with a BMI ≥40 kg m^{-2} or a history of weight loss surgery

Cathy Harbury[a,*], Clare E. Collins[a], Robin Callister[a,b]

[a] Priority Research Centre for Physical Activity and Nutrition, University of Newcastle, Callaghan, NSW Australia
[b] Faculty of Health and Medicine, School of Biomedical Sciences and Pharmacy, University of Newcastle, Callaghan, NSW, Australia

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ABSTRACT

Background: Poor diet is a major public health issue requiring strategies to support improvements. Nutrition knowledge influences eating behaviours, yet few studies have examined relationships with diet quality. The current study aimed to explore relationships between demographic characteristics, nutrition knowledge, and diet quality using the Australian Recommended Food Score (measuring diet variety).
Methods: Adults 18–60 years completed a 210-item survey including questions on demographics, health, nutrition knowledge, and diet. Statistical analysis used chi-square tests, linear and multiple regression, adjusted for covariates.
Results: 480 respondents with a mean (SD) age 39.1 ± 11.6 years (18% male) completed all questions. Overall diet quality scores were high (ARFS 39.5 ± 9 points). Nutrition knowledge ($p < 0.001$) and BMI ($p < 0.001$) were positively associated with ARFS. ARFS scores were higher for those with higher nutrition knowledge scores (ARFS 42 ± 8 points) and of lower BMI (ARFS 40 ± 8 points) compared to those with lower knowledge (ARFS 37 ± 11) and higher BMI (ARFS 35 ± 10 points). Those with BMI ≥ 40 kg·m^{-2} and weight loss surgery reported the lowest diet quality (ARFS 31 ± 10 points).
Conclusion: Diet quality was highest among those with high nutrition knowledge and lower BMI. Those with a BMI ≥ 40 kg·m^{-2}, particularly those with past weight loss surgery reported the lowest diet quality, despite comparable levels of nutrition knowledge. It remains unclear which factors explain the variation in diet quality in the weight loss surgery group and this deserves further attention given the growing popularity of weight loss surgery.

Introduction

High quality diets are associated with lower rates of morbidity and mortality [1,2]. The positive attributes of a high quality dietary pattern were recognised in the “Seven Countries Study” that reported the health benefits of the Mediterranean diet protecting against coronary heart disease, many cancers and inflammatory diseases [3]. This led to examination of dietary patterns in other populations [4] and traditionally such examination has relied on the precise measurement and evaluation of nutrients consumed from all foods. Methodological challenges [5] associated with obtaining accurate dietary intake data have led researchers to develop alternative approaches to assess diet quality. Numerous instruments have been developed, however only a few diet quality indices are effective tools for measuring nutrient adequacy and mortality risk [4].

The predictive ability of a diet quality index is stronger among indices that focus on nutrient-dense, core foods (e.g. wholegrain versus refined grains), that independently score important dietary constituents (e.g. scoring fruits and vegetables separately) and that are culturally appropriate [6]. Aligning with this approach is the Recommended Food Score (RFS) developed for a United States population [2], that has been adapted and validated for use in Australians [7]. The Australian Recommended Food Score (ARFS) does not require quantities consumed and excludes evaluation of energy-dense, nutrient-poor foods. Hence the score avoids some of the error associated with food estimation, such as under-reporting observed in populations with obesity [5]. Points are awarded for the variety of high nutrient-dense foods within each core food group over a usual week. As expected, higher variety scores are positively

* Corresponding author.
E-mail address: cathy.harbury@uon.edu.au (C. Harbury).

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associated with higher nutrient and disease risk biomarkers [7–10]. In this way, diet variety and the presence of nutrients is a proxy for diet quality. A high ARFS indicates a dietary pattern that aligns with the Australian Dietary Guidelines, including consumption of a wide variety of nutritious foods from the five core food groups [1].

Despite the benefits of healthy eating patterns, many Australians continue to consume poor quality diets. This is a finding consistent across Australian studies using different diet indices [11–13] and reflects the findings of National Nutrition Surveys [14]. This is a major public health concern. Strategies are needed to improve the diet quality of some Australians, particularly those who are younger, male and living in lower socioeconomic areas who report diets with lower quality [13]. These groups of Australians also report lower levels of nutrition knowledge [15], as do those who are less educated and individuals with obesity [16]. There may be a role for improving diet quality through improvements in nutrition knowledge since there is evidence that those with higher levels of nutrition knowledge eat healthier compared to those with lower levels of knowledge [15,17,18].

There are few studies of Australian adults that have examined the relationship between nutrition knowledge and diet quality. A better understanding of these associations could support strategies to improve dietary intake. The ARFS [7] is an established [19] and validated diet quality index that focuses on diversity within food groups associated with positive health outcomes in Australians. Therefore the aim of the current study was to explore relationships between demographic characteristics, nutrition knowledge and diet quality using the ARFS [7].

Materials and methods

Study design

Adults 18–60 years were invited to participate in a cross-sectional nutrition survey with study information distributed at medical clinics, through social media and radio interviews. The study design is published elsewhere [16]. In brief, the 30-min 210-item self-administered on-line survey (SurveyMonkey Inc 1999–2016) collected information about demographics, height, weight, health (Medical Outcome Survey Short Form-12) [20], physical activity (International Physical Activity Questionnaire) [21], and dietary intake (ARFS) [19]. Nutrition knowledge was assessed using the Re-examined General Nutrition Knowledge Questionnaire (R-GNKQ) [22] with 96 questions across four domains (dietary guidelines, sources of nutrients, choosing everyday foods, diet–disease relationships) to a maximum score of 96. The R-GNKQ is described elsewhere [16]. Body-mass index (BMI; weight in kilograms divided by the square of height in metres) was categorised according to World Health Organisation criteria. Postcode data were used as a measure of socio-economic status by cross-referencing with the Socio-Economic Indexes for Areas (SEIFA) database [23], a low SEIFA score indicating greater disadvantage. The University of Newcastle Human Research Ethics Committee approved the study and survey completion implied consent.

Dietary data collection

Diet quality was evaluated using the ARFS, a previously validated a priori defined diet quality score [7]. ARFS measures diet quality as a continuous variable using a subset of 70-items derived from a 120-question semi-quantitative food frequency questionnaire [7]. ARFS is a valid estimate of usual nutrient intakes with strong positive correlations with fibre, vitamin A, beta-carotene, vitamin C (0.53, 95% CI 0.37–0.67) calcium, magnesium and potassium (0.32, 95% CI 0.23–0.40) [7] and is significantly associated with plasma concentrations of total carotenoids ($p < 0.05$) [9]. The score is obtained by summing eight sub-scales scores. The sub-scales evaluate intakes of vegetables, fruit, meat, vegetarian protein sources, grains, dairy foods, water and condiments. The maximum score of 73 requires a daily intake of 2 or more pieces of fruit, 2 or more serves of dairy foods (reduced fat), 4 or more glasses of water and weekly consumption of vegetables eaten on at least 5 nights, 19 vegetable types (excluding hot chips), 11 fruit types, 7 types of animal based protein, 6 types of vegetarian protein sources, 13 types of whole-grains, 8 types of dairy foods, and 2 nutrient-containing sauces or spreads. A higher score reflects higher diet quality and established ARFS rating categories (quartiles) were used: “Outstanding” (47+); “Excellent” (39–46); “Getting There” (33–38); “Needs Work” (<33) [7,19]. The scoring method is described elsewhere [19].

Statistical analysis

Differences in participant characteristics of respondents who completed all 210-items of the survey (completers) and those who did not (non-completers) were examined using chi-square tests. Participants with missing data (non-completers) were excluded from further statistical analysis. The relationships between participant characteristics and ARFS categories and between participant characteristics and total ARFS were examined using Chi-Square test and linear regression model, respectively. Associations between participant characteristics and ARFS sub-scales and total ARFS were examined using multiple regression, adjusted for covariates (age, sex, education, SEIFA decile, BMI, nutrition knowledge, medical, past weight loss surgery and smoking status). Multiple regression assumptions were checked (unusual and influential data, normality of residuals, heteroscedasticity, multicollinearity using Variation Inflation Factor (VIF), non-linearity). The statistical significance was set at $p < 0.05$ and analysis conducted using Stata software, version 13.1 (StataCorp. 2013 College Station, TX: StataCorp LP). Data are presented as mean ± SD.

Results

Participant characteristics

Of 606 respondents who commenced the survey, 79% (n = 480) completed all 210-items (termed “completers”). Characteristics of respondents are summarised in Table 1. The only difference identified between “completers” and “non-completers” were lower nutrition knowledge (R-GNKQ) scores. This is expected as 57 respondents did not answer any R-GNKQ questions and a further 43 respondents did not complete all R-GNKQ questions. Respondents first exited the survey during the collection of demographic data (Supplement 1). Completers had a mean ± SD age of 39.1 ± 11.6 years (range 20–60 years), were mostly female, well educated and had no medical conditions. Completers weight ranged from 46 to 215 kg (mean BMI 29 ± 9 kg m^{-2}, range 18.6–79 kg m^{-2}), with most being overweight (BMI 25–<30 kg m^{-2}) or obese (BMI ≥ 30 kg m^{-2}). Of those completers with a medical condition (43%, n = 207) significantly more had a BMI ≥ 30 kg m^{-2} (49%) compared to those with a BMI 18.5–25 kg m^{-2} (24%) ($P < 0.001$). The majority (66%) of those with a medical condition were being treated with medications. The most common medical conditions were a mental health diagnosis (24%), cardiovascular diseases (23%), musculoskeletal disorders (18%), and diabetes (all types) (7%). Some completers (n = 55, 11%) had previously undergone weight loss surgery (WLS).

Table 1
Demographic characteristics of respondents (n = 606).

Demographic characteristic		“Completers” Group (n = 480)	“Non-completers” Group (n = 126)	p-value
Age (years)[A]	<35	37%	44%	0.379
	35–49	39%	35%	
	50–60	24%	21%	
Sex[A]	Female	82%	78%	0.323
	Male	18%	22%	
SEIFA[a] decile[A]	Low (1–33)	25%	31%	0.410
	Medium (34–66)	38%	32%	
	High (67–100)	37%	27%	
Number of medical conditions diagnosed[A]	None	57%	56%	0.985
	1	20%	20%	
	2	11%	11%	
	3 or more	11%	13%	
Education[B]	High school not completed	5%	8%	0.761
	High school completed	16%	17%	
	Vocational training	28%	25%	
	University degree	51%	51%	
Past weight loss surgery[C]	Yes	11%	11%	0.939
	No	89%	89%	
Smoker[D]	Yes	6%	8%	0.467
	No	94%	92%	
Body mass index ($kg\,m^{-2}$)[E]	18.5–<25	44%	30%	0.224
	25–<30	24%	28%	
	30–<40	18%	13%	
	≥40	11%	9%	
	Not reported	4%	20%	
Score of nutrition knowledge (R-GNKQ[b])[F]	0–24	0%	45%[F1]	<0.001[*]
	25–48	3%	19%[F2]	
	48–72	54%	25%	
	73–96	43%	11%	

Number of non-completers: [A] 0, [B] 6, [C] 10, [D] 12, [E] 16, [F] 100.
[a] Socio-Economic Indexes for Areas [23].
[b] Re-examined General Nutrition Knowledge Questionnaire [22].
[F1] 57 respondents did not answer any R-GNKQ questions.
[F2] 43 respondents did not answer all R-GNKQ questions.
[*] p-values significant at the $p < 0.05$ threshold using Chi Squared test.

Diet quality

Overall diet quality scores were high, mean total ARFS 39.5 ± 9 points, with 54% scoring in the two highest ARFS categories (Table 2). Significant differences in total ARFS were found by sex, nutrition knowledge, BMI, number of medical conditions, past WLS and SEIFA decile. There were trends for smoking ($p = 0.051$) and education ($p = 0.059$). This is despite a previous report in which individuals with the highest level of education had a significantly higher level of nutrition knowledge compared to those who had not completed high school ($p < 0.001$) [16]. Diet quality did not differ by age group (Table 2). Females reported higher diet quality scores (ARFS 40 ± 9 points) than males (ARFS 38 ± 9 points) ($p = 0.026$). Those with high nutrition knowledge reported higher diet quality scores (ARFS of 42 ± 8 points) than those with low nutrition knowledge (ARFS 37 ± 11 points) ($p < 0.001$). Those in the lower BMI category (18.5–25 $kg\,m^{-2}$) reported higher diet quality scores (ARFS 40 ± 8) than those in the highest BMI category (BMI ≥ 40 $kg\,m^{-2}$) (ARFS 35 ± 10; $p < 0.001$). Those with no medical condition (ARFS 40 ± 8 points) reported higher diet quality than those with three or more medical conditions (ARFS 36 ± 10 points) ($p = 0.021$). Those with past WLS had a lower diet quality (ARFS 35 ± 9) than those without past WLS (ARFS 40 ± 9; $p < 0.001$) (Table 2). Those in the WLS sub-group (n = 55) with a BMI ≥ 40 $kg\,m^{-2}$ (n = 21) had a lower mean diet quality score (ARFS 31 ± 10) compared to those with a lower BMI (ARFS 37 ± 8; $p = 0.02$) (Table 3) as well as those with a BMI ≥40 $kg\,m^{-2}$ without WLS (n = 32) (ARFS 37 ± 9; $p = 0.046$). There were no significant differences in nutrition knowledge scores across BMI categories for those with or without WLS (Table 3). Evaluation of the independent contribution of each characteristic to explain variation in ARFS using multiple regression further supported the strong associations with sex ($p = 0.023$), nutrition knowledge ($p < 0.001$), BMI category ($p = 0.009$) and WLS ($p = 0.021$). The results did not change by excluding age and education from the multivariable analysis (Table 4).

Variations in ARFS sub-scales

Variation in total ARFS between participants pertained mostly to differences across the vegetable ($p < 0.001$), fruit ($p < 0.001$), and vegetarian protein ($p < 0.001$) sub-scales. Some variation was evident in the grains ($p < 0.001$) and dairy food ($p = 0.025$) sub-scale but not meat protein ($p = 0.086$) (Table 5 and Supplement 2). Key findings included those with the highest nutrition knowledge scoring higher for the vegetable ($p = 0.04$), fruit ($p = 0.02$), vegetarian protein (<0.01), grains ($p = 0.02$) and dairy foods ($p < 0.01$) sub-scales compared to those with the lowest nutrition knowledge. Those with a BMI ≥40 $kg\,m^{-2}$ scored lower on the fruit ($p = 0.04$) and vegetarian protein ($p = 0.04$) sub-scales compared to those in the lowest BMI category. Those who had past WLS had lower sub-scale scores for vegetable ($p < 0.01$) and grains ($p = 0.03$) than those without WLS. Females had higher vegetable ($p < 0.01$) sub-scale scores than males.

Table 2
Total Australian Recommended Food Score (ARFS) and associations with demographics and nutrition knowledge (n = 480).

Participant characteristics		ARFS categories				p-value	Total ARFS (max 73)	
		Needs work (<33)	Getting there (33–38)	Excellent (39–46)	Outstanding (47+)		Mean (SD)	p-value
%		21	24	31	23		39.5 (9.0)	
Age (years)	<35	38	38	35	37	0.958	39.6 (9.0)	0.665
	35–49	39	41	41	37		39.1 (8.9)	
	50–60	24	21	24	26		40.0 (9.2)	
Sex	Female	77	80	83	86	0.425	39.9 (8.8)	0.026**
	Male	23	20	17	14		37.6 (9.4)	
SEIFA[a] decile	Low (1–33)	22	29	26	23	0.365	39.0 (9.2)	0.049**
	Medium (34–66)	44	40	36	32		38.6 (8.9)	
	High (67–100)	34	32	38	45		40.8 (8.8)	
Number of medical conditions diagnosed	None	51	56	61	58	0.069	40.2 (8.8)	0.021**
	1	17	21	22	21		39.5 (8.8)	
	2	12	14	7	14		39.9 (8.3)	
	3 or more	21	10	9	7		36.1 (10.1)	
Education	High school not completed	9	6	3	5	0.473	36.3 (13.5)	0.059
	High school completed	17	15	17	13		38.9 (9.0)	
	Vocational training	32	32	25	26		38.7 (9.3)	
	University degree	43	48	54	56		40.4 (8.1)	
Past weight loss surgery	Yes	22	15	5	6	<0.001*	34.9 (9.0)	<0.001**
	No	78	85	95	94		40.0 (8.8)	
Smoker	Yes	10	7	5	3	0.162	36.3 (9.3)	0.051
	No	90	93	95	97		39.7 (8.9)	
Body mass index ($kg\,m^{-2}$)	18.5–<25	38	43	47	46	0.013*	40.3 (8.1)	<0.001**
	25–<30	19	24	22	30		40.7 (9.3)	
	30–<40	16	21	17	16		38.9 (9.4)	
	≥40	23	10	9	4		34.5 (9.5)	
	Not reported	5	3	5	4		39.5 (9.2)	
Score of nutrition knowledge (R-GNKQ[b])	0–24	0	0	0	0	<0.001*	0 (0)	<0.001**
	25–48	4	3	2	2		36.8 (11.3)	
	49–72	67	64	51	36		37.6 (8.9)	
	73–96	29	32	47	63		42.0 (8.2)	

[a] Socio-Economic Indexes For Areas [23].
[b] Re-examined General Nutrition Knowledge Questionnaire [22].
* p-values significant at the p < 0.05 threshold using Chi squared test.
** p-values significant at the p < 0.05 threshold using linear regression.

Table 3
Scores of diet quality and nutrition knowledge by BMI category and past weight loss surgery.

Participant characteristic	Total ARFS[A] (max score 73)					Total R-GNKQ[B] (max score 96)				
	Past weight loss surgery									
Body mass index ($kg\,m^{-2}$)	Yes		No			Yes		No		
	n	Mean (SD)	n	Mean (SD)	p-value	n	Mean (SD)	n	Mean (SD)	p-value
18.5–<40	34	37.0 (8.0)	393	40.4 (8.7)	0.036*	34	69.9 (9.2)	393	70.8 (11.3)	0.625
≥40	21	31.3 (9.7)	32	36.6 (8.9)	0.046*	21	65.5 (9.1)	32	69.0 (10.5)	0.217
p-value	0.019*		0.018*			0.092		0.368		

[A] Australian Recommended Food Score [7].
[B] Re-examined General Nutrition Knowledge Questionnaire [22].
* p-values significant at the p < 0.05 threshold using linear regression.

Variations in intake across sub-scales

ARFS measures usual variety within key nutrient dense food groups and examining item responses for the six main ARFS sub-scales (vegetables, fruit, protein foods, vegetarian alternatives, grains and dairy foods) provides further insight into eating patterns (Supplement 3). For example, the highest mean sub-scale score was for the vegetable sub-scale, yet from the 19 types of vegetables listed only five were eaten once a week or more by over 80% of respondents; these were carrots (93%), tomatoes (90%), broccoli (88%), lettuce (83%), onions and leek (80%). Similarly, the fruit sub-scale with 22 types of fruit found only six types were eaten at least once per week (when in season) by ~80% of respondents; these were grapes, strawberries, blueberries, bananas, apples and pears. The meat protein sub-scale with seven types of animal-based protein identified that the majority of respondents consumed three types on a weekly basis with the most frequent being chicken (84%), red meat (83%) and canned fish (55%). For the six types of vegetarian protein foods frequently eat by most were eggs (82%) and nuts (69%). Across the six sub-scales, foods eaten less frequently than once a week included: cabbage and brussel sprouts (33%), canned (12%) and dried fruit (28%), fresh fish (47%), pork (38%), prawns and lobster (20%), peanut butter (42%), soybeans and tofu (14%), baked beans (35%), chickpeas, split peas and lentils (48%), muesli (37%),

Table 4
Factors associated with total Australian Recommended Food Score (ARFS) in a cross-sectional nutrition survey of Australian adults (n = 480).

Participant characteristics		β (95% CI)		p-value
				0.552
Age (years)	35–49	1.00	(−1.0, 3.0)	
	50–60	1.15	(−1.2, 3.5)	
Sex	Male	−2.38	(−4.4, −0.3)	0.023*
				0.397
SEIFA[a] decile	Medium (34–66)	−0.62	(−2.7, 1.4)	
	High (67–100)	0.67	(−1.4, 2.8)	
				0.898
Number of medical conditions diagnosed	1	−0.31	(−2.4, 1.8)	
	2	−0.66	(−3.5, 2.1)	
	3 or more	−1.12	(−4.2, 1.9)	
				0.800
Education	High school completed	1.14	(−3.1, 5.4)	
	Vocational training	1.55	(−2.2, 5.3)	
	University degree	1.15	(−2.7, 5.0)	
Past weight loss surgery	Yes	−3.31	(−6.1, −0.5)	0.021*
Smoker	Yes	−2.86	(−6.4, 0.7)	0.111
				0.009*
Body mass index ($kg\,m^{-2}$)	25–<30	0.91	(−1.15, 3.0)	0.386
	30–<40	0.27	(−2.4, 2.9)	0.839
	≥40	−4.16	(−7.2, −1.1)	0.007*
				<0.001*
Score of nutrition knowledge (R-GNKQ)[b]	49–72	1.56	(−3.7, 6.8)	0.561
	73–96	5.53	(0.2, 10.9)	0.043*

Reference categories: age < 35; female; SEIFA decile low (1–33); number of medical conditions diagnosed — none; education — high school not completed; past weight loss surgery — no; smoker — no; BMI 18.5–<25; score of nutrition knowledge - 25 - 48.
[a] Socio-Economic Indexes for Areas [23].
[b] Re-examined General Nutrition Knowledge Questionnaire [22].
* p-values significant at the $p < 0.05$ threshold using multiple regression.

cooked porridge (43%), breakfast cereal (44%), cous cous, burghul, and quinoa (38%). From a full range of dairy foods lowest daily intakes were reported for yoghurt (49%), cottage and ricotta cheese (10%).

Discussion

The current study found that diet quality, as measured using the ARFS, was strongly and positively associated with greater nutrition knowledge and a BMI in the healthy range, in a broad sample of Australian adults. Individuals with a high level of nutrition knowledge had the highest overall diet quality reflecting a more varied weekly pattern of eating across the five food groups, which is more closely aligned to the Australian Dietary Guidelines [1]. Similarly, those with a healthy BMI had higher diet quality, particularly in relation to their variety of fruit, and vegetarian sources of protein.

Novel aspects of this study were the investigation of different categories of obesity and the inclusion of a substantial number of individuals with a history of WLS. Those with a BMI ≥ 40 $kg\,m^{-2}$ had a lower diet quality of the BMI groups studied but diet quality was even lower for individuals who previously had WLS. No differences in nutrition knowledge were identified for these two groups, despite our previous report that people with obesity (BMI ≥ 30 $kg\,m^{-2}$) have lower levels of nutrition knowledge [16]. This is an important finding as it suggests that the knowledge measured was not sufficient to support the adoption of higher quality diets for these individuals, unlike those with lower weight and without WLS. It is unclear if these differences in diet quality were due to individuals choosing not to apply their nutrition knowledge or whether challenges are experienced in its application. Nutrition knowledge is an integral component of nutrition literacy, however it remains unclear which aspects of knowledge inform specific nutrition decisions or influence dietary behaviours. The role of nutrition knowledge and its impact on nutrition literacy, which is recognised as a complex construct, has received limited research attention to date [15,24]. After WLS, it is plausible that interpreting and adapting the nutrition guidelines to a new food landscape requires the development of new food skills. For these individuals, if education and nutrition knowledge are not drivers for high quality diets then exploring the multidimensional construct of nutrition literacy may hold more merit.

Two systematic reviews [25,26] have examined the relationship between diet quality and obesity. Asghari et al. reviewed 36 studies, ten of these had prospective designs and 26 had cross-sectional designs. The ten studies in developed countries that used indices based on dietary guidelines tended to report significant and positive associations between obesity and diet quality. In contrast, most studies conducted in developing countries did not find this association [25]. Salehi-Abargouei et al. [26] found no association between diet quality and BMI status (overweight, obesity) from 16 cross-sectional studies across four continents (Asia, Africa, North America and South America). The authors attributed this to a lack of homogenous study design. Across studies, the methods used to measure dietary intake data, evaluate diet quality and define obesity, varied. For example, the method to collect dietary intake data varied between 24-h recall and food frequency questionnaire, with only one study using a food frequency questionnaire that had previously been assessed for reliability and validity. Most studies used their own method to score diet diversity and how foods were grouped for each method tended to vary. In one study obesity was defined as a BMI ≥ 25 $kg\,m^{-2}$. The authors concluded that there was a need for well-designed prospective studies.

Previous Australian studies have reported low diet quality in individuals with obesity using several different diet quality indices [11,27–29]. O'Brien et al. [29] used the ARFS to evaluate change in diet quality for an online weight loss intervention and reported

Table 5

Factors associated with Australian Recommended Food Score (ARFS) sub-scales in a cross-sectional nutrition survey of Australian adults.

Participant characteristics		Vegetables (max score 21)		Fruit (max score 12)		Meat protein (max score 7)		Vegetarian protein (max score 6)		Grains (max score 13)		Dairy foods (max score 11)		Water (max score 1)		Condiments (max score 2)	
p-value		<0.001*		<0.001*		0.086		<0.001*		<0.001*		0.025*		0.073		0.071	
		β (95% CI)	p	β (95% CI)	p	β (95% CI)	p	β (95% CI)	p	β (95% CI)	p	β (95%CI)	p	β (95% CI)	p	β (95% CI)	p
Age (years)			0.01*		0.03*		0.08		0.42		0.03*		0.52		0.09		<0.01
	35–49	1.3 (0.4, 2.1)		0.2 (−0.5,0.8)		0.3 (0.0, 0.7)		0.0 (−0.3, 0.3)		−0.6 (−1.1,0.0)		0.0 (−0.5,0.5)		−0.1 (−0.2, 0.0)		0.0 (−0.2, 0.1)	
	50	1.1 (0.1, 2.1)		1.0 (0.2,1.7)		0.5 (0.0, 0.9)		0.2 (−0.2, 0.6)		−0.8 (−1.4,−0.2)		−0.3 (−0.8,0.3)		−0.1 (−0.2, 0.0)		−0.3 (−0.6, −0.1)	
Sex	Male	−1.5 (−2.4, −0.6)	<0.01*	−0.4 (−1.1,0.2)	0.19	−0.1 (−0.5,0.3)	0.72	−0.1 (−0.4, 0.2)	0.64	−0.2 (−0.7,0.3)	0.50	−0.2 (−0.7,0.3)	0.54	0.0 (−0.1, 0.1)	0.83	0.0 (−0.2, 0.2)	0.70
SEIFA[A] decile			0.49		0.19		0.67		0.83		0.49		0.67		0.53		0.67
	Medium (34–66)	−0.1 (−0.9,0.8)		−0.2 (−0.9, 0.4)		0.1 (−0.3, 0.5)		0.0 (−0.3, 0.4)		−0.2 (−0.8,0.3)		−0.2 (−0.7,0.3)		0.0 (−0.1, 0.1)		−0.1 (−0.2,0.1)	
	High (67–100)	0.4 (−0.5,1.3)		0.3 (−0.4, 1.0)		0.2 (−0.2, 0.6)		0.1 (−0.2, 0.4)		−0.5 (−0.5,0.6)		−0.2 (−0.7,0.3)		0.0 (−0.1,0.1)		−0.1 (−0.3,0.1)	
No.of medical conditions diagnosed			0.80		0.54		0.80		0.89		0.58		0.51		0.05		0.05
	1	0.4 (−0.5,1.3)		−0.4 (−1.1,0.3)		0.1 (−0.3, 0.5)		0.0 (−0.4, 0.3)		−0.1 (−0.7,0.4)		−0.2 (−0.7, 0.3)		0.0 (−0.1, 0.2)		−0.1 (−0.3, 0.1)	
	2	0.1 (−1.0,1.3)		−0.2 (−1.1, 0.7)		0.0 (−0.5, 0.5)		−0.1 (−0.6, 0.3)		−0.2 (−1.0, 0.5)		0.2 (−0.4, 0.9)		−0.1 (−0.3, 0.0)		−0.3 (−0.6, −0.1)	
	3 or more	−0.2 (−1.5,1.1)		−0.6 (−1.6, 0.4)		−0.2 (−0.8, 0.4)		−0.1 (−0.6, 0.3)		−0.6 (−1.3, 0.2)		0.4 (−0.4, 1.1)		0.1 (0.0, 0.3)		0.0 (−0.3, 0.3)	
Education			0.57		0.49		0.44		0.37		0.67		0.39		0.70		0.62
	High school complete	1.0 (−0.8, 2.8)		1.0 (−0.4, 2.4)		−0.3 (−1.0, 0.5)		−0.2 (−0.9, 0.4)		−0.6 (−1.7, 0.5)		0.1 (−0.9, 1.2)		0.0 (−0.2, 0.2)		0.1 (−0.3, 0.5)	
	Vocational training	1.1 (−0.5,2.7)		0.8 (−0.4, 2.0)		0.1 (−0.6, 0.8)		0.0 (−0.5, 0.6)		−0.3 (−1.3, 0.7)		−0.3 (−1.2,0.6)		−0.1 (−0.3, 0.1)		0.2 (−0.2, 0.5)	
	University degree	0.9 (−0.7,2.6)		0.6 (−0.7, 1.8)		0.1 (−0.6, 0.8)		−0.2 (−0.8, 0.4)		−0.5 (−1.5, 0.5)		0.1 (−0.9, 1.0)		0.0 (−0.2, 0.2)		0.2 (−0.2, 0.6)	
Past weight loss surgery	Yes	−1.8 (−3.0,−0.6)	<0.01*	−0.7 (−1.6, 0.2)	0.12	−0.1 (−0.6, 0.4)	0.84	−0.3 (−0.7, 0.1)	0.18	−0.8 (−1.5,−0.1)	0.03*	0.5 (−0.2, 1.2)	0.13	−0.1 (−0.2, 0.1)	0.34	−0.1 (−0.3,0.2)	0.58
Smoker	Yes	−1.3 (−2.8,0.2)	0.09	−0.8 (−2.0, 0.3)	0.16	−0.6 (−1.3, 0.0)	0.05	−0.3 (−0.7, 0.1)	0.51	0.2 (−0.7, 1.1)	0.90	−0.5 (−1.3,0.4)	0.29	0.0 (−0.2, 0.2)	0.94	−0.1 (−0.4, 0.3)	0.71
Body mass index ($kg\,m^{-2}$)			0.12		0.04*		0.87		0.04*		0.10		0.11		0.67		0.11
	25–<30	0.4 (−0.5,1.2)		0.1 (−0.6,0.8)		0.0 (−0.4, 0.4)		0.0 (−0.3, 0.3)		−0.2 (−0.7,0.3)		0.5 (0.0, 1.0)		0.0 (−0.1,0.1)		0.2 (0.0, 0.3)	
	30–<40	0.1 (−1.0,1.2)		−0.4 (−1.2, 0.5)		0.2 (−0.3, 0.7)		0.0 (−0.4, 0.4)		0.1 (−0.5,0.8)		0.1 (−0.6, 0.7)		−0.1 (−0.2, 0.1)		0.3 (0.0, 0.5)	
	≥40	−1.2 (−2.4,0.1)		−1.3 (−2.2,−0.3)		0.0 (−0.6, 0.5)		−0.6 (−1.1,−0.2)		−0.8 (−1.6, −0.0)		−0.4 (−1.1, 0.4)		−0.1 (−0.3, 0.1)		0.2 (0.0, 0.5)	
Score of nutrition knowledge (R-GNKQ)[B]			0.04*		0.02*		0.17		<0.01*		0.02*		<0.01*		0.15		0.44
	49–72	0.5 (−1.7,2.8)		0.3 (−1.4, 2.0)		0.5 (−0.5, 1.5)		0.2 (−0.6, 1.0)		0.5 (−0.8, 1.9)		−0.6 (−1.9, 0.7)		0.3 (0.0, 0.6)		−0.2 (−0.7, 0.3)	
	73–96	1.4 (−0.8,3.7)		1.1 (−0.7, 2.8)		0.7 (−0.3, 1,7)		0.8 (0.0, 1.6)		1.1 (−0.3, 2.5)		0.2 (−1.1, 1.5)		0.3 (0.0, 0.6)		−0.1 (−0.6, 0.4)	

Reference categories: age < 35; female; SEIFA decile low (1–33); number of medical conditions diagnosed — none; education — high school not completed; past weight loss surgery — no; smoker — no; BMI 18.5–<25; score of nutrition knowledge - 25 - 48.

[A] Socio-Economic Indexes For Areas [23].

[B] Re-examined General Nutrition Knowledge Questionnaire [22].

* p-values significant at the p < 0.05 threshold using multiple regression.

baseline scores. Adults (n = 309) with a mean age of 41.6 ± 10.2 years who were overweight or obese (BMI 32 ± 4 kg m^{-2}) had a mean baseline total ARFS of 32 ± 4, which falls in the bottom quartile of scores. In the current study, all groups of participants reported higher diet quality scores, except for the participants who had undergone past WLS (ARFS 31 ± 10). These low diet quality scores in individuals with obesity, and particularly more severe obesity, warrant further investigation. This is the first study to examine and describe the diet quality of those with a BMI ≥ 40 kg m^{-2} and the lower mean total ARFS scores were unexpected. At a higher BMI both resting and total daily energy expenditures may be higher [30] and this higher energy requirement creates an opportunity to consume a greater variety of healthy and nutrient dense foods, however this consumption pattern was not evident in our study. As identified previously [31,32], the relationship between diet quality and BMI depends on the energy density of foods consumed. As the ARFS only include nutrient-dense core-foods in the scoring, many of which have a lower energy density, it is plausible that individuals with obesity are maintaining their body mass with higher intakes of energy dense, nutrient-poor foods. In the current study, this is further supported by the findings that those with a higher BMI were also consuming lower varieties of fruit and vegetarian protein compared to individuals with a healthy BMI. Given that high fruit and vegetable consumption can protect against weight gain over time [33–35] and a higher ARFS score of vegetables has been associated with lower health care costs [10] promoting higher variety of these foods is recommended.

There are several limitations in the current study that require acknowledgement. The sample was not representative of the general community with 51% educated to a university level and 39% living in the most advantaged areas. There is the possibility of selection bias given that the statistical analysis only included those who completed all 210-items to investigate the relationship between nutrition knowledge and diet quality, which means the results presented are potentially “best-case”. These participants dedicated 30 min to undertake the survey suggesting an interest in nutrition and this may explain the overall high level of diet quality. For those who had undergone WLS recruitment may have been biased towards those with lower diet quality as these individuals may have participated in the hope of receiving advice or information. Also, the current study relied on self-report data, although response patterns appear credible with intakes of some vegetables being similar to those reported in a national nutrition survey [14]. A key strength was the use of a validated, reliable tool to evaluate diet quality that has been used in previous Australian studies [19,27,29,35] facilitating comparison with previous research.

Australian researchers have investigated interventions aimed at improving individual diet quality with promising results [19,29]. Similar survey items in the current study have been administered on-line to a large sample (n = 93,252) of Australians who were provided with brief, specific feedback on how to improve their diet quality [19]. Those respondents who scored in the lowest “needs work” category were able to change their usual eating pattern over seven months and achieve the greatest improvements in diet quality and more optimal nutrient profiles [7,27]. Furthermore, findings from a weight loss RCT found that increasing ARFS score by ten points over time, which equates to ten different core foods being consumed at least once per week, is associated with greater weight loss by an average of 1% over a 12-week period compared to the control group [29]. For those with a low ARFS this is a realistic nutrition target.

Implications for practice

The current study reminds clinicians that for some individuals, current levels of nutrition knowledge are not sufficient to achieve high quality diets. Encouraging a higher diet variety is a simple, positive and powerful message, and likely more welcome than messages of restriction. Insights gained about the different consumption patterns of those within different BMI categories identifies potential for higher variety of vegetables, all fruit types (fresh, tinned and dried), vegetarian protein sources (tofu, legumes), grains including oats, cous cous, burghul, quinoa and dairy foods such as yoghurt, cottage and ricotta cheese. It is encouraging that this study recruited mostly individuals who were overweight or obese and this participation suggests these individuals have a high interest in nutrition. Clinicians should feel confident that this group of individuals would welcome discussions that are focused on empowering dietary change.

Conclusions

Significant differences in diet quality were identified related to participant nutrition knowledge and BMI category. The current study found that individuals with lower nutrition knowledge and with the highest BMI’s reported the lowest diet quality. In addition, those with a BMI ≥ 40 kg m^{-2} and those who had previously undergone WLS had the poorest diet quality compared to all other groups, despite nutrition knowledge being comparable to other groups. In this preliminary finding it remains unclear which factors explain the variation in diet quality in the WLS sub-group. There is a need for further investigation in this area, particularly given the growing popularity of WLS and that those undergoing surgery commonly do so with the goal of improving health outcomes. Exploring the multidimensional construct of nutrition literacy holds promise.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.orcp.2018.10.003.

References

[1] National Health and Medical Research Council. Australian dietary guidelines. Canberra, Australia: NHMRC; 2013.
[2] Kant A, Schatzkin A, Graubard B, Schairer C. A prospective study of diet quality and mortality in women. JAMA 2000;283(16):2109–15.
[3] Menotti A, Kromhout D, Blackburn H, Fidanza F, Buzina R, Nissinen A. Food intake patterns and 25-year mortality from coronary heart disease: cross-cultural correlations in the Seven Countries Study. Eur J Epidemiol 1999;15:507–15.
[4] Wirt A, Collins C. Diet quality — what is it and does it matter? Public Health Nutr 2009;12(12):2473–92.
[5] MacDiarmid J, Blundell J. Dietary under-reporting: what people say about recording their food intake. Eur J Clin Nutr 1997;51:199–200.
[6] Waijers P, Feskens E, Ocke M. A critical review of predefined diet quality scores. Br J Nutr 2007;97:219–31.
[7] Collins C, Burrows T, Rollo M, Boggess M, Watson J, Guest M, et al. The comparative validity and reproducibility of a diet quality index for adults: the Australian recommended food score. Nutrients 2015;7(2):785–98.
[8] Kant A, Graubard B. A comparison of three dietary patterns indexes for predicting biomarkers of diet and disease. J Am Coll Nutr 2005;24(4):294–303.
[9] Ashton L, Williams R, Wood L, Schumacher T, Burrows T, Rollo M, et al. Comparison of Australian Recommended Food Score (ARFS) and plasma carotenoid concentrations: a validation study in adults. Nutrients 2017;9(888).
[10] Patterson A, Hure A, Burrows T, Jackson J, Collins C. Diet quality and 10-year healthcare costs by BMI categories in the mid-age cohort of the Australian Lon-

gitudinal Study on Women's Health. J Hum Nutr Diet 2018 https://doi.org/10.1111/jhn.12556.

[11] Zarrin R, Ibiebele T, Marks G. Development and validity assessment of a diet quality index for Australians. Asia Pac J Clin Nutr 2013;22(2):177–87.

[12] Arabshahi S, van der Pols J, Williams G, Marks G, Lahmann P. Diet quality and change in anthropometric measures: 15-year longitudinal study in Australian adults. Br J Nutr 2011;107:1376–85.

[13] McNaughton S, Ball K, Crawford D, Mishra G. An index of diet and eating patterns is a valid measure of diet quality in an Australian population. J Nutr 2008;138:86–93.

[14] Australian Bureau of Statistics. Australian health survey: consumption of food groups from the Australian Dietary Guidelines. Canberra: Commonwealth of Australia; 2016.

[15] Spronk I, Kullen C, Burdon C, O'Connor H. Relationship between nutrition knowledge and dietary intake. Br J Nutr 2014;111:1713–26.

[16] Harbury C, Callister R, Collins C. Nutrition "fat facts" are not common knowledge. Health Promot J Austr 2017;(00):1–6.

[17] Wardle J, Parmenter K, Waller J. Nutrition knowledge and food intake. Appetite 2000;34(3):269–75.

[18] Spronk I, Heaney S, Prvan T, O'Connor H. Relationship between general nutrition knowledge and dietary quality in elite athletes. Int J Sport Nutr Exerc Metab 2015;25:243–51.

[19] Williams R, Rollo M, Schumacher T, Collins C. Diet quality scores of Australian adults who have completed the Healthy Eating Quiz. Nutrients 2017;9(880).

[20] Ware J, Sherbourne C. The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. Med Care 1992;30(6):473–83.

[21] Craig C, Marshall A, Sjostrom M, Bauman A, Booth M, Ainsworth B, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;(August):1381–95.

[22] Spendlove J, Heaney S, Gifford J, Prvan T, Denyer G, O'Connor H. Evaluation of general nutrition knowledge in elite Australian athletes. Br J Nutr 2011;107(12):1871–80.

[23] Brian P. In: Australian Bureau of Statistics, editor. Socio-economic indexes for areas (SEIFA) 2011. Commonwealth of Australia; 2013.

[24] Velardo S. The nuances of health literacy, nutrition literacy, and food literacy. J Nutr Educ Behav 2015;47:385–9.

[25] Asghari G, Mirmiran P, Yuzbashian E, Azizi F. A systematic review of diet quality indices in relation to obesity. Br J Nutr 2017;117:1055–65.

[26] Salehi-Abargouei A, Akbari F, Bellissimo N, Azadbakht L. Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies. Eur J Clin Nutr 2016;70:1–9.

[27] Collins C, Young A, Hodge A. Diet quality is associated with higher nutrient intake and self-rated health in mid-aged women. J Am Coll Nutr 2008;27(1):146–57.

[28] McNaughton S, Dunstan D, Ball K, Shaw J, Crawford D. Diet quality is associated with diabetes and cardio-metabolic risk factors. J Nutr 2009;139:734–42.

[29] O'Brien K, Hutchesson M, Jensen M, Morgan P, Callister R, Collins C. Participants in an online weight loss program can improve diet quality during weight loss: a randomized controlled trial. Nutr J 2014;13(82).

[30] Das S, Saltzman E, McCrory M, Hsu L, Shikora S, Dolnikowski G, et al. Energy expenditure is very high in extremely obese women. J Nutr 2004;134(6):1412–6.

[31] McCrory M, Fuss P, McCallum J, Yao M, Vinken A, Hays N, et al. Dietary variety within food groups: associations with energy intake and body fatness in men and women. Am J Clin Nutr 1999;69:440–7.

[32] Ledikwe J, Blanck H, Khan L, Serdula M, Seymour J, Tohill B, et al. Low-energy density diets are associated with high diet quality in adults in the United States. J Am Diet Assoc 2006;106:1172–80.

[33] He K, Hu F, Colditz G, Manson J, Willet W, Liu S. Changes in intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women. Int J Obes 2004;28:1569–74.

[34] Vioque J, Weinbrenner T, Castello A, Asensio L, de la Hera G. Intake of fruits and vegetables in relation to 10-year weight gain among Spanish adults. Obesity 2008;16:664–70.

[35] Aljadani H, Patterson A, Sibbritt D, Hutchesson M, Jensen M, Collins C. Diet quality, measured by fruit and vegetable intake, predicts weight change in young women. J Obes 2013;2013:10. Article ID 525161 https://doi.org/10.1155/2013/525161.