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Validity of the Australian Recommended Food Score as a diet quality index for Pre-schoolers

Tracy L Burrows^{1,2}, Kate Collins¹, Jane Watson^{1,2}, Maya Guest^{1,3}, May M Boggess^{3,4*}, Melinda Neve^{1,2}, Megan Rollo^{1,2}, Kerith Duncanson^{1,2,5} and Clare E Collins^{1,2}

Abstract

Background: Diet quality tools provide researchers with brief methods to assess the nutrient adequacy of usual dietary intake. This study describes the development and validation of a pediatric diet quality index, the Australian Recommended Food Scores for Pre-schoolers (ARFS-P), for use with children aged two to five years.

Methods: The ARFS-P was derived from a 120-item food frequency questionnaire, with eight sub-scales, and was scored from zero to 73. Linear regressions were used to estimate the relationship between diet quality score and nutrient intakes, in 142 children (mean age 4 years) in rural localities in New South Wales, Australia.

Results: Total ARFS-P and component scores were highly related to dietary intake of the majority of macronutrients and micronutrients including protein, β -carotene, vitamin C, vitamin A. Total ARFS-P was also positively related to total consumption of nutrient dense foods, such as fruits and vegetables, and negatively related to total consumption of discretionary choices, such as sugar sweetened drinks and packaged snacks.

Conclusion: ARFS-P is a valid measure that can be used to characterise nutrient intakes for children aged two to five years. Further research could assess the utility of the ARFS-P for monitoring of usual dietary intake over time or as part of clinical management.

Keywords: Diet quality index, Food frequency questionnaire, Pre-schoolers, Nutritional adequacy

Background

Diet quality refers to both nutrient adequacy and food variety within healthful food groups, as well as alignment of overall eating patterns with National Dietary Guidelines. Diet quality scores or indices are used to summarize dietary intake into a single numeric variable, which addresses some of the limitations in evaluations of diet-disease relationships based only on single nutrients [1]. However, given the major concerns related to these limitations, it is advisable to keep in mind that findings from food frequency questionnaire based epidemiological studies of diet-disease relationships could have their own limitations. In adults, chronic disease risk factors, including elevated systolic blood pressure, obesity, hyperglycemia,

and both total and disease specific morbidity and mortality, are greater in those with poorer diet quality [2,3].

The validation and reproducibility of diet quality indices in relation to health outcomes in pediatric populations is more challenging to assess for two reasons: first, the time lag to disease development [4], and second, there are fewer indices that have been validated in pediatric populations [5]. Intermediate clinical markers that have been examined previously include BMI [6,7], percentage body fat and waist circumference [6,8], blood pressure [6], micronutrient intakes [9], plasma lipids, inflammation markers, serum iron, vitamin B₁₂ and homocysteine [10,11]. Reviews that examine the relationship between diet quality and health outcomes in children have demonstrated modest associations with asthma and dental caries [6].

To date, only a limited number of studies have sought to validate diet quality indices against nutrient intakes in pediatric populations [12,13]. Huybrechts et al. [12] developed a Diet Quality Index (DQI) for pre-school

* Correspondence: mboggess@asu.edu

³Environmental and Occupational Health and Safety, School of Health Sciences, Faculty of Health and Medicine, The University of Newcastle, Callaghan 2308, NSW, Australia

⁴School of Mathematical and Statistical Sciences, Arizona State University, Tempe 85281, AZ, USA

Full list of author information is available at the end of the article

children and evaluated it for validity ($n = 510$) and reproducibility ($n = 58$). The DQI was shown to positively correlate with a range of macronutrients and micronutrients, and additionally, food frequency questionnaire (FFQ)-based DQI calculations showed moderate agreement with the DQI calculated from a 3 day food record [12].

The authors previously evaluated the performance of the Australian Child and Adolescent Recommended Food Score (ACARFS) compared to nutrient intakes derived from an FFQ in a population ($n = 691$) of children aged 9–12 years [13]. Agreement between ACARFS and nutrient intakes was demonstrated through positive correlations between ACARFS and all vitamins, minerals and total energy intake. However, that evaluation did not include younger children.

Therefore, the aims of this study were to develop a pediatric DQI, the Australian Recommended Food Score for Pre-schoolers (ARFS-P), and evaluate its performance as a measure of diet quality by assessing agreement in pre-schoolers with nutrient intakes derived from a previously validated FFQ [4,14].

Methods

The current study was a cross-sectional evaluation of dietary intake in young children aged 2–5 years ($n = 146$). The data was baseline measures of a randomized control trial, Feeding Healthy Food to Kids (FHFK), conducted in five rural low socioeconomic localities in New South Wales (NSW), Australia, in August 2009 [15,16]. Briefly, parents of young children were recruited from childcare facilities by early childhood health professionals. Inclusion criteria were parents were aged 18 years or older and the child was aged 2–5 years. If more than one child in the family met this criterion, the eldest child within the eligible age range was selected as the study child for consistency and simplicity. Demographic variables collected included child age, gender, Aboriginal or Torres Strait Islander status, child health status, and parental education level. Four children had missing age, leaving a final sample size of $n = 142$. Written informed consent was obtained from all participants' parents prior to their enrolment in the FHFK study. Approval was obtained from Hunter New England (HNE) Human Research Ethics Committee (reference number HREC/08/HNE/403) and the University of Newcastle Human Research Ethics Committee (approval number H-2009-0106).

Assessment of dietary intake AES-P FFQ

Dietary intake was assessed using the Australian Eating Survey Pre-schooler Version (AES-P). Given the age of the pre-schoolers, a caregiver (i.e. parent or guardian) recorded the child's frequency of consumption of a comprehensive 120-item semi-quantitative FFQ. Further details of the development of the AES FFQ have been

published elsewhere [4,14], demonstrating acceptable accuracy for ranking nutrient intakes in children and adolescents 9–16 years of age [14]. The AES-P was previously shown to be a valid estimate of total energy expenditure in children 3 years of age [4], and children 8–11 years of age using doubly labeled water [17].

Caregivers recorded their child's frequency of consumption of a comprehensive, defined list of foods over the previous 6 months. The frequency options ranged from 'never' to '4 or more times per day', to '7 or more glasses per day' for beverages. Questions from the FFQ were grouped categorically into food groups and sub-groups including those energy dense nutrient poor foods now referred to as 'discretionary choices' [18]. Due to the seasonal availability of some fruits, a separate section was included in the FFQ for seasonal fruit. The frequency categories were listed as for other food items, with the question, "when the following fruit is in season, how often do you usually eat it?" to capture the usual consumption of the fruit when it is in season. Seasonal availability was determined by contacting the food markets, Sydney, NSW and obtaining information about the wider availability in other markets and supermarkets during the year, in addition to referring to supermarket literature that indicated the months of the year different seasonal fruit was available.

Pre-school age portion sizes in grams for individual foods items, was derived from the 2007 National Children's Nutrition and Physical Activity Survey, purchased from the Australian Social Science Data Archive at the Australian National University [19]. Nutrient intakes from the AES-P FFQ were computed from the most current food composition database of Australian foods available, the Australian AusNut 2007 database (All Foods) Revision 17 and AusFoods (Brands) Revision 5 [20] to generate individual mean daily macro- and micronutrient intakes. The estimated daily intakes for 20 macro- and micronutrients were calculated using FoodWorks [21] and compared to age-specific nutrient targets. Adequacy of nutrient intake was assessed using Recommended Daily Intake (RDI) and Adequate Intake (AI) targets [22], while intakes exceeding recommendations were defined by Upper Limits (UL) [22] and the 2013 Australian Dietary Guidelines [18].

The Australian Recommended Food Score for Pre-Schoolers ARFS-P

The ARFS-P was designed as a brief, culture specific, food based diet quality tool for young children, focusing on dietary variety within recommended food groups. It was modeled on the Recommended Food Score [23] and the Australian Recommended Food Score (ARFS) [24], and utilizes a subsample of questions from the AES-P FFQ consistent with the 2013 Australian Dietary Guidelines [18]. The ARFS-P includes seventy questions relating

to eight food group components; vegetables (n = 20), fruit (n = 12), meat (n = 7), meat alternatives (i.e. non-meat protein) (n = 6), breads/cereals (n = 12), dairy (n = 10), water (n = 1) and condiments (n = 2). The procedure used to calculate ARFS has been published elsewhere [13]. Briefly, points were awarded for foods consumed according to frequency of consumption, with healthy foods receiving more points (i.e. vegetables, low-fat dairy, whole grains), and point caps on foods that should not be consumed overly often (e.g. meat, whole milk). An ARFS component was only calculated for those responses with not more than one question missing; one child was excluded for this reason. The ARFS total possible score ranges from zero to 73, and the component scores from zero to the number of questions in that component, plus one more possible for vegetables, low-fat dairy, whole grains.

Statistical analysis

Scores were described by medians and interquartile range (IQR) and Fisher's exact test and Wilcoxon rank-sum test were used to compare two age groups in univariate analyses. Groups were younger children (<4 years of age) and older children (≥4 years of age), so that the same RDI, AI and UL values would apply to all participants in a group. Linear regressions were used to estimate the beta-coefficients (which can be thought of as correlations) of ARFS-P scores with FFQ components, whilst controlling for demographic factors. More precisely, agreement was assessed using linear regression models with AES-P FFQ food group, macro and micronutrient intakes as response variables and ARFS-P components as explanatory variables. Demographic variables, age, gender and parent education, were controlled for by being kept in the model if significant (too few participants were Aboriginal or Torres Strait Islander to be able to estimate the effect of race). The total energy intake was included as an explanatory variable if significant. By this we mean that backwards stepwise with $p = 0.05$ for removal was employed to remove variables that added no predictive value to the model. This was followed by adding any variable back in that was significant at the 0.05 level, so that that smallest model with the best predictive ability was identified. Both ARFS-P and FFQ were standardized (subtract mean and divide by standard deviation) so the model coefficient was the beta-coefficient. A square root transform was applied to some variables to improve the normality of the residuals. Kolmogorov-Smirnov tests and normal probability plots were used to assess normality of residuals. Square root transform of response variables was used if necessary to improve residual normality. Statistical significance was at the 5% level. All data manipulation and statistical analysis was undertaken using Stata MP v12 [25].

Results

Table 1 lists demographic characteristics of participants (n = 142) by age group. No significant difference across age groups was found for gender, chronic health conditions or race.

Table 2 reports the percentage of participants that met age specific nutrient RDIs and AIs, and the percentage that exceeded UL for sodium and the percentage energy (%E) from saturated fat, according to their AES-P FFQ reported food intake. Over 75% of participants met recommendations for the majority of macronutrients and micronutrients with the exception of fibre, iron and potassium. In fact, less than 20% met the daily requirement for iron. Only five percent of participants met recommendations in the Dietary Guidelines in Australia of less than 10% of total energy derived from saturated fat, while 81% of younger children and 61% of older children exceeded the recommended upper limit for sodium intake.

Table 3 reports the ARFS-P score, component scores, and macronutrient intake and micronutrient intake descriptive statistics, by age group. The median ARFS-P score was 36 with a minimum of 12 and a maximum of 55, with no significant difference by age. There were no significant differences by age in any component ARFS-P, or macro or micronutrients. Marginal significance ($p < 0.1$) was reached with saturated fat and cholesterol.

Table 1 Demographic characteristics of study population of pre-schoolers, by age group

| | All n = 142 | Younger < 4 yrs n = 76 | Older ≥ 4 yrs n = 66 | P |
|---|----------------|------------------------------|----------------------------|------|
| Gender | | | | |
| Female | 66 (46%) | 40 (53%) | 26 (39%) | |
| Male | 76 (54%) | 36 (47%) | 40 (61%) | 0.13 |
| Chronic Health Condition | | | | |
| Yes | 4 (3%) | 3 (4%) | 1 (2%) | |
| No | 138 (97%) | 73 (96%) | 65 (98%) | 0.62 |
| Aboriginal/ Torres Strait Islander | | | | |
| Yes | 5 (4%) | 3 (4%) | 2 (3%) | |
| No | 137 (96%) | 73 (96%) | 64 (97%) | 1.00 |
| Parent Education | | | | |
| Did not complete Year 10 | 3 (2%) | 1 (1%) | 2 (3%) | |
| Completed year 10 | 37 (26%) | 16 (21%) | 21 (32%) | |
| Completed Year 12 | 25 (18%) | 19 (25%) | 6 (9%) | |
| Commenced Higher Education Degree | 14 (10%) | 6 (8%) | 8 (12%) | |
| Completed Higher Education Degree | 42 (30%) | 20 (26%) | 22 (33%) | |
| Completed Post Graduate Course | 21 (15%) | 14 (18%) | 7 (11%) | 0.07 |

Table 2 Comparison of nutrient intakes, as assessed by the Australian Eating Survey Pre-schooler Version (AES-P) Food Frequency Questionnaire, to Australian Recommended Dietary Intakes (RDI), Adequate Intake (AI) and upper limit (UL), by age group

| Intake per day | Younger < 4 yrs (n = 76) | | | Older ≥ 4 yrs (n = 66) | | |
|-------------------------------|--------------------------|---------|-----------|------------------------|---------|-----------|
| | RDI/AI | Mean | Meeting | RDI/AI | Mean | Meeting |
| Meeting ¹ | | | | | | |
| Protein (g) | 14 | 57.23 | 100% | 20 | 53.13 | 100% |
| Fibre (g) | 14 | 16.13 | 62% | 18 | 15.9 | 44% |
| Vitamin A (µg) | 300 | 784.39 | 99% | 400 | 735.54 | 97% |
| Thiamine (mg) | 0.5 | 1.4 | 99% | 0.6 | 1.37 | 99% |
| Riboflavin (mg) | 0.5 | 2.27 | 100% | 0.6 | 2.16 | 100% |
| Niacine equiv (mg) | 6 | 25.52 | 100% | 8 | 24.26 | 100% |
| Folate (µg) | 150 | 223.91 | 89% | 200 | 222.95 | 77% |
| Vitamin C (mg) | 35 | 84.14 | 97% | 35 | 79.92 | 96% |
| Calcium (mg) | 500 | 1014.41 | 96% | 700 | 945.23 | 87% |
| Iron (mg) | 9 | 7.84 | 22% | 10 | 7.97 | 18% |
| Magnesium (mg) | 80 | 246.59 | 100% | 130 | 239.72 | 100% |
| Phosphorus(mg) | 460 | 1151.03 | 100% | 500 | 1073.8 | 100% |
| Potassium(mg) | 2000 | 2379.39 | 68% | 2300 | 2188.1 | 54% |
| Zinc (mg) | 3 | 7.72 | 100% | 4 | 7.3 | 99% |
| Exceeding | UL | Mean | Exceeding | UL | Mean | Exceeding |
| Sodium(mg) ¹ | 1000 | 1329.39 | 82% | 1400 | 1342.27 | 61% |
| %E Saturated fat ² | 10 | 16.83 | 95% | 10 | 15.95 | 95% |

¹Nutrient Reference Values for Australia and New Zealand [22].

²Australian Dietary Guidelines [18].

Also in Table 3 is the %E from nutrient dense and discretionary choice components, as assessed by the AES-P FFQ, by age group. The median %E from nutrient dense food was 70.5%, and 29.5% from discretionary choices, with no significant difference by age. However, older children did obtain significantly higher %E from grains and sweetened cereals than their younger counterparts, and marginally so for packaged snacks.

Assessment of Agreement between AFRS-P and AES-P FFQ nutrients and food groups

Table 4 demonstrates that total ARFS-P and the ARFS-P components were significantly related to AES-P FFQ intake of the majority of macro and micronutrients. Total ARFS-P was positively related to protein ($\rho = 22\%$ CI_{95%} 14-30), cholesterol ($\rho = 27\%$ CI_{95%} 15-40), fibre ($\rho = 12\%$ CI_{95%} 3-22), vitamin A ($\rho = 40\%$ CI_{95%} 26-54), β -carotene ($\rho = 58\%$ CI_{95%} 44-71), niacine equivalents ($\rho = 20\%$ CI_{95%} 10-30), folate ($\rho = 14\%$ CI_{95%} 2-26), vitamin C ($\rho = 44\%$ CI_{95%} 31-58), calcium ($\rho = 16\%$ CI_{95%} 4-29), magnesium ($\rho = 16\%$ CI_{95%} 9-24), phosphorus ($\rho = 13\%$ CI_{95%} 6-21), potassium ($\rho = 27\%$ CI_{95%} 19-35) and zinc intake ($\rho = 17\%$ CI_{95%} 10-25), while negatively related to carbohydrate ($\rho = -10\%$ CI_{95%} -16- -5).

Table 4 also demonstrates that total ARFS-P was significantly related to eating patterns. It was positively

related to total consumption of nutrient-dense foods, as well as food sub-groups including vegetables, fruit, meat and meat alternatives. In contrast, total ARFS-P was negatively related to total consumption of discretionary choices, and subgroups such as confectionary, sugar sweetened drinks, packaged snacks and take-away foods. Figure 1 displays these beta-coefficients between total ARFS-P and AES-P FFQ reported intake, together with their 95% confidence intervals.

Discussion

The importance of consuming a large variety of nutritious foods is recognized within national food guidelines [18]. The ARFS-P was developed to reflect the food behaviors and eating habits recommended in such guidelines. The use of brief tools is convenient for clinicians and allows for rapid individualized feedback and early interventions targeting improvements in diet quality. This is important given recent reviews of diet quality indices in children suggesting healthier diet patterns are associated with cognition, behavior, and anthropometric factors [6,7]. Associations between diet quality indices and short and long term health outcomes, such as blood pressure, asthma, blood lipids, inflammation factors and dental caries, has also been recognized [6].

Table 3 The Australian Recommended Food Scores for Pre-schoolers (ARFS-P) and Australian Eating Survey Pre-schooler Version (AES-P) Food Frequency Questionnaire (FFQ) nutrients, and % energy from nutrient-dense and discretionary choices, by age (*includes one for adequate water intake)

| ARFS-P (total possible score) | All (n = 142) | | Younger < 4 yrs (n = 76) | | Older ≥ 4 yrs (n = 66) | | P |
|---------------------------------|---------------|-------------|--------------------------|-------------|------------------------|-------------|------|
| | Median | IQR | Median | IQR | Median | IQR | |
| Total (73)* | 36 | (29–42) | 35 | (29–42) | 36 | (29.5–41.5) | 0.97 |
| Vegetables (21) | 11 | (8–15) | 11 | (8–16) | 11.5 | (9–14) | 0.91 |
| Fruit (12) | 8 | (6–10) | 8 | (6–10) | 8 | (5.5–9.5) | 0.67 |
| Meat (7) | 2 | (2–3) | 2 | (2–3) | 2 | (2–3) | 0.84 |
| Meat alternatives (6) | 2 | (1–2) | 1 | (1–2) | 2 | (1–3) | 0.78 |
| Grains (13) | 6 | (4–7) | 6 | (4–7) | 6 | (4–7) | 0.62 |
| Dairy (11) | 5 | (4–6) | 5 | (4–6) | 5 | (4–6) | 0.84 |
| Condiments (2) | 1 | (1–2) | 1 | (1–2) | 2 | (1–2) | 0.31 |
| AES-P FFQ macronutrients | | | | | | | |
| Energy (kJ) | 5216 | (4647–6242) | 5226 | (4656–6379) | 5182 | (4577–5944) | 0.43 |
| Protein (g) | 53.79 | (47–63) | 54.6 | (48.0–63.9) | 52.58 | (44.7–60.1) | 0.14 |
| Saturated fat (g) | 23.25 | (17–28) | 24.44 | (19.6–28.7) | 21.18 | (16.5–26.9) | 0.06 |
| Cholesterol (mg) | 161.7 | (126–206) | 167.3 | (137–209) | 155.9 | (121–200) | 0.09 |
| Carbohydrate (g) | 150.0 | (130–177) | 148.7 | (129–181) | 152.0 | (133–175) | 0.93 |
| Sugars (g) | 88.09 | (72.9–109) | 87.79 | (73.7–110) | 88.2 | (69.9–106) | 0.73 |
| Fibre (g) | 15.33 | (12.4–18.0) | 15.27 | (11.7–18.6) | 15.37 | (12.9–17.8) | 0.91 |
| AES-P FFQ micronutrients | | | | | | | |
| Vitamin A (µg) | 745.0 | (604–891) | 768.5 | (620–914) | 715.8 | (594–878) | 0.25 |
| Retinol (µg) | 339.5 | (225–439) | 359.2 | (238–482) | 314.1 | (210–415) | 0.08 |
| β-carotene (µg) | 2497 | (1773–3049) | 2580 | (1676–3145) | 2353 | (184–2818) | 0.65 |
| Thiamine (mg) | 1.28 | (1.0–1.6) | 1.28 | (1.0–1.7) | 1.28 | (1.0–1.5) | 0.96 |
| Riboflavin (mg) | 2.12 | (1.7–2.6) | 2.29 | (1.7–2.6) | 2.11 | (1.6–2.5) | 0.38 |
| Niacine equivalent (mg) | 23.75 | (20.9–27.4) | 24.01 | (20.9–28.5) | 23.71 | (20.8–27.1) | 0.60 |
| Folate (µg) | 211.2 | (182–255) | 211.2 | (176–261) | 210.2 | (184–241) | 0.95 |
| Vitamin C (mg) | 78.12 | (59.9–100) | 78.12 | (63.2–102) | 78.69 | (59.6–98.3) | 0.73 |
| Calcium (mg) | 963.2 | (746–1167) | 988.9 | (828–1179) | 889.9 | (711–1093) | 0.10 |
| Iron (mg) | 7.72 | (6.1–8.9) | 7.51 | (6.1–8.9) | 7.91 | (6.2–8.7) | 0.62 |
| Magnesium (mg) | 227.5 | (202–277) | 227.5 | (202–278) | 227.5 | (202–275) | 0.69 |
| Potassium (mg) | 2208 | (1897–2618) | 2311 | (1931–2700) | 2132 | (1869–2494) | 0.14 |
| Phosphorus (mg) | 1109 | (900–1292) | 1121 | (956–1304) | 1073 | (869–1220) | 0.15 |
| Sodium (mg) | 1279 | (1052–1594) | 1279 | (1029–1603) | 1287 | (1097–1559) | 0.69 |
| Zinc (mg) | 7.36 | (6.3–8.5) | 7.67 | (6.4–8.7) | 7.14 | (6.2–8.1) | 0.16 |
| % Energy from | | | | | | | |
| Saturated Fat | 17 | (14.0–19.0) | 17 | (14.0–19.0) | 16 | (13.5–18.0) | 0.12 |
| Nutrient dense | 71 | (63–79) | 72 | (64–81) | 70.5 | (62.5–79) | 0.29 |
| Vegetables | 5 | (3–7) | 5 | (3–7) | 5 | (4–7) | 0.78 |
| Fruit | 10 | (7–15) | 12 | (8–16) | 10 | (7–13.5) | 0.30 |
| Meat | 7 | (5–9) | 7 | (5–9) | 7 | (5–9.5) | 0.77 |
| Meat alternatives | 1 | (1–3) | 1 | (1–3) | 1 | (1–3) | 0.74 |
| Grains | 18 | (14–21) | 16 | (13–20) | 19 | (15–22) | 0.03 |
| Dairy | 28 | (22–35) | 29 | (22–36) | 26.5 | (21.5–32.5) | 0.10 |

Table 3 The Australian Recommended Food Scores for Pre-schoolers (ARFS-P) and Australian Eating Survey Pre-schooler Version (AES-P) Food Frequency Questionnaire (FFQ) nutrients, and % energy from nutrient-dense and discretionary choices, by age (*includes one for adequate water intake) (Continued)

| | | | | | | | |
|-------------------------------|----|---------|----|---------|------|-----------|------|
| Discretionary choices | 29 | (21–37) | 28 | (19–36) | 29.5 | (21–37.5) | 0.29 |
| <i>Sweetened drinks</i> | 2 | (1–4) | 2 | (0–4) | 2.5 | (1–5) | 0.19 |
| <i>Packaged snacks</i> | 4 | (1–7) | 3 | (1–6) | 4 | (2–7) | 0.09 |
| <i>Confectionary</i> | 3 | (2–5) | 4 | (2–5) | 3 | (2–5) | 0.81 |
| <i>Baked sweet products</i> | 5 | (3–8) | 5 | (3–7) | 4.5 | (3–8) | 0.92 |
| <i>Take-away</i> | 5 | (3–6) | 5 | (3–7) | 4 | (3–6) | 0.59 |
| <i>Condiments</i> | 2 | (1–4) | 2 | (1–3) | 3 | (1–4) | 0.14 |
| <i>Processed Meats</i> | 1 | (1–2) | 1 | (1–2) | 1 | (1–2.5) | 0.51 |
| <i>Sweet breakfast cereal</i> | 8 | (5–11) | 7 | (5–10) | 9 | (7–11.5) | 0.01 |

This study is novel in applying this approach to assess diet quality in a pre-school population. We have previously validated this diet quality scoring method, which uses a food-based approach in an older pediatric population aged 9–16 years [13]. While diet quality scores have been constructed for use in children, recent reviews have highlighted the need for additional studies in more diverse population samples with analyses adjusted more fully for potential confounders [6,7] and a specific need for further studies in children under the age of five years [6,7,26]. The ARFS-P was calculated from intakes of whole foods rather than nutrient intakes, making this method of interest when information about usual food intake, as opposed to nutrients, is sought or when feedback to individuals about their food patterns would be useful.

While few DQIs have been developed specifically for use with toddler populations [27], findings from this study are similar to other diet quality validation studies in toddlers, including the FFQ DQI developed for pre-schoolers in which significant correlations were found between their DQI and nutrients such as protein, fibre, calcium and zinc [12], as we did in this study ($r = 0.220$, $p < 0.001$; $r = 0.125$, $p = 0.008$; $r = 0.164$, $p = 0.011$; $r = 0.173$, $p < 0.001$; respectively). However, we found a strong relationship between ARFS-P and β -carotene where they did not; differences such as these are not surprising since they used Pearson's correlations that do not allow for controlling for influences of, for instance total energy and age. Other validation studies of diet quality scores, such as the Healthy Eating index [28], found strong relationships with dietary intake, including fibre, folate and vitamin C, as did we ($r = 0.125$, $p = 0.008$; $r = 0.141$, $p = 0.018$; $r = 0.441$, $p < 0.001$; respectively).

Strategies to enhance diet quality need to focus on increasing the variety of nutrient-dense foods in a child's diet, and reducing consumption of discretionary choices. Results of the current study indicate that each of the ARFS component scores were low compared to the total

maximum point available, particularly for sub-scales of fruit and vegetables. This suggests that increasing the variety of fruit and vegetables consumed regularly could be important areas to target improvements in diet quality. Other areas, in descending order, could include lean meat and vegetarian protein alternatives. This suggests that public health messages targeting increases in the variety amongst healthful foods that are consumed each week, could offer a new approach to nutrition promotion.

This study found that ARFS-P scores were highly related to both nutrient intakes and consumption patterns of children aged two to five years. The sensitivity of this DQS is demonstrated by its ability to detect significant changes in macronutrient and micronutrient intake per unit change in ARFS-P. By way of example, the positive beta-coefficient of β -carotene with total ARFS-P means that an increase in total ARFS-P corresponds to an increase in pre-schooler β -carotene intake, on average. A similar trend was evident when considering intake of food groups and ARFS-P. Consequently the use of the ARFS-P was valid in assessing the eating patterns and nutrient intakes of the study population. Marginal significance was reached with saturated fat and cholesterol, providing some evidence that younger children may have been consuming more saturated fat and cholesterol than their older counterparts.

Strengths and limitations

Anthropometric data, such as weight, were not obtained from this population, since the primary outcome measure of the FHFK randomized controlled trial was changes to dietary intake. As a consequence, the relationship between weight status and ARFS-P could not be explored. However, unpublished data collected in 2008 as part of the Before School Screening program for 4–5 year olds ($n = 571$) in the same study locations suggested that rates of overweight and obesity were higher than the NSW average [29], with 26.8% of children overweight or obese

Table 4 Beta-coefficients relating intakes as assessed by the Australian Eating Survey Pre-schooler Version (AES-P) Food Frequency Questionnaire (FFQ), and the Australian Recommended Food Score for Pre-schoolers (ARFS-P) components of standardized ARFS component in linear regression model of standardized FFQ nutrient, adjusted for total FFQ energy and demographics age, gender and education (n = 142)

| | ARFS-P Total | ARFS-P Veg | ARFS-P Fruit | ARFS-P Meat | ARFS-P Altern. | ARFS-P Grains | ARFS-P Dairy | ARFS-P Condmnt |
|---------------------------------|-----------------|---------------|-----------------|----------------|-------------------|------------------|-----------------|-------------------|
| AES-P FFQ Macronutrients | | | | | | | | |
| <i>Protein (g)</i> | 0.220** | 0.176** | 0.132** | 0.263** | | | 0.191** | |
| <i>Saturated fat (g)</i> | | | | | | | | |
| <i>Cholesterol (mg)</i> | 0.271** | 0.195** | 0.185** | 0.382** | 0.195** | 0.127 | | -0.156* |
| <i>Carbohydrate (g)</i> | -0.104** | -0.100** | | -0.128** | | -0.052 | -0.057 | |
| <i>Sugars (g)</i> | | | | -0.073 | | | -0.093* | |
| <i>Fibre (g)</i> | 0.125** | 0.121* | 0.173** | | 0.091 | | -0.082 | |
| AES-P FFQ Micronutrients | | | | | | | | |
| <i>Vitamin A (µg)</i> | 0.399** | 0.442**T | 0.326** | 0.287** | | | | |
| <i>Retinol (µg)</i> | | | | 0.187*T | | | | |
| <i>β-carotene (µg)</i> | 0.578**X | 0.622**X | 0.469**X | 0.246**X | | 0.235**X | | |
| <i>Thiamine (mg)</i> | | | | | | | | 0.246**T |
| <i>Riboflavin (mg)</i> | | | 0.133 | | | | | 0.199** |
| <i>Niacine equivalent (mg)</i> | 0.171**T | 0.123* | 0.138** | 0.152** | | | 0.158** | 0.147** |
| <i>Folate (µg)</i> | 0.141* | 0.138* | 0.165** | | | | | 0.105 |
| <i>Vitamin C (mg)</i> | 0.441** | 0.444** | 0.517** | 0.251** | | | | |
| <i>Calcium (mg)</i> | 0.164* | 0.145* | 0.111 | 0.125E | | | 0.156* | |
| <i>Iron (mg)</i> | | | | | | | | |
| <i>Magnesium (mg)</i> | 0.164** | 0.126** | 0.133** | | | 0.083* | | |
| <i>Potassium (mg)</i> | 0.273**M | 0.271**M | 0.281**M | 0.163**E | | | | |
| <i>Phosphorus (mg)</i> | 0.132** | 0.110** | 0.068E | 0.130**E | | | 0.149** | |
| <i>Sodium (mg)</i> | | | -0.103* | -0.083 | | | 0.194** | 0.176** |
| <i>Zinc (mg)</i> | 0.173** | 0.174** | 0.137** | 0.154** | | | 0.092* | |
| % Energy from | | | | | | | | |
| <i>Saturated Fat</i> | | | | | | | -0.149X | |
| Nutrient dense Foods | | | | | | | | |
| <i>Vegetables</i> | 0.485** | 0.476** | 0.511** | 0.355** | 0.178* | 0.231** | | -0.170* |
| <i>Fruit</i> | 0.518** | 0.637** | 0.348** | 0.232** | 0.170* | 0.208** | | |
| <i>Meat</i> | 0.306**X | 0.277**X | 0.537** | | | | | -0.207*X |
| <i>Meat alternatives</i> | 0.276**X | 0.244**X | 0.214*X | 0.535** | | | | |
| <i>Grains</i> | 0.316**T | 0.198*T | 0.170*T | | 0.673** | 0.279**T | | |
| <i>Dairy</i> | | | | -0.171*X | | | | |
| Discretionary Choices | | | | | | | | |
| <i>Sugar sweetened drinks</i> | -0.484** | -0.476** | -0.509** | -0.355** | -0.177* | -0.231** | | 0.171* |
| <i>Packaged snacks</i> | -0.333**T | -0.272** | -0.302**T | | | -0.192*T | | |
| <i>Confectionary</i> | -0.379** | -0.284** | -0.409** | -0.187*T | -0.249**T | -0.271**T | | |
| <i>Baked sweet products</i> | -0.199*X | -0.223**X | | -0.209*X | | -0.152X | | |
| <i>Take-away</i> | -0.354**X | -0.328**X | -0.149X | -0.162X | -0.199*X | -0.188*X | | |

Table 4 Beta-coefficients relating intakes as assessed by the Australian Eating Survey Pre-schooler Version (AES-P) Food Frequency Questionnaire (FFQ), and the Australian Recommended Food Score for Pre-schoolers (ARFS-P) components of standardized ARFS component in linear regression model of standardized FFQ nutrient, adjusted for total FFQ energy and demographics age, gender and education (n = 142) (Continued)

| | | | | | |
|------------------------|----------|-----------|---------|----------|----------|
| Condiments | | -0.256**X | | 0.258**X | |
| Processed Meats | -0.195*X | -0.199*X | -0.159X | -0.178*X | -0.203*X |
| Sweet breakfast cereal | | | -0.143X | -0.172*X | -0.147X |

Only beta-coefficients with P < 0.10 are shown; *5% significance, **1% significance. (T) square root transform was applied, (M) gender significant in model, (E) parent education significant in model, (X) energy not significant in model. Shaded values indicate a negative relationship.

(27.3% male, 26.3% female). Despite a previous study suggesting that the FFQ was relatively accurate when assessing total energy intake at the group level [4], over and under-reporting of dietary intake and physical activity level were not assessed in the current study. The relatively small sample from rural locations reduces the generalizability and hence results should be interpreted with caution.

The effect of parental bias must also be considered when interpreting results as a caregiver completed the AES-P on their child's behalf. This may exacerbate the over reporting bias already associated with the use of an FFQ [30] and may increase the chance that the data is incomplete or that intake has been underestimated [31]. Future studies should consider obtaining dietary intake

reports from both parents, or where appropriate, with the child present to try to reduce reporting biases [32,33].

Some limitations of calculating and using ARFS to determine usual diet quality have been previously published [13], including that the national nutrient databases used in this study does not accurately reflect population consumption of folate as fortification of breads, cereals and cereal products is not accounted for within the database, hence results obtained for FFQ folate intake are likely to be lower than true intake.

Implications for research and practice

The ARFS-P allows for the rapid measurement of diet quality of children aged 2–5 years in a single continuous variable. It was derived from a validated FFQ for young

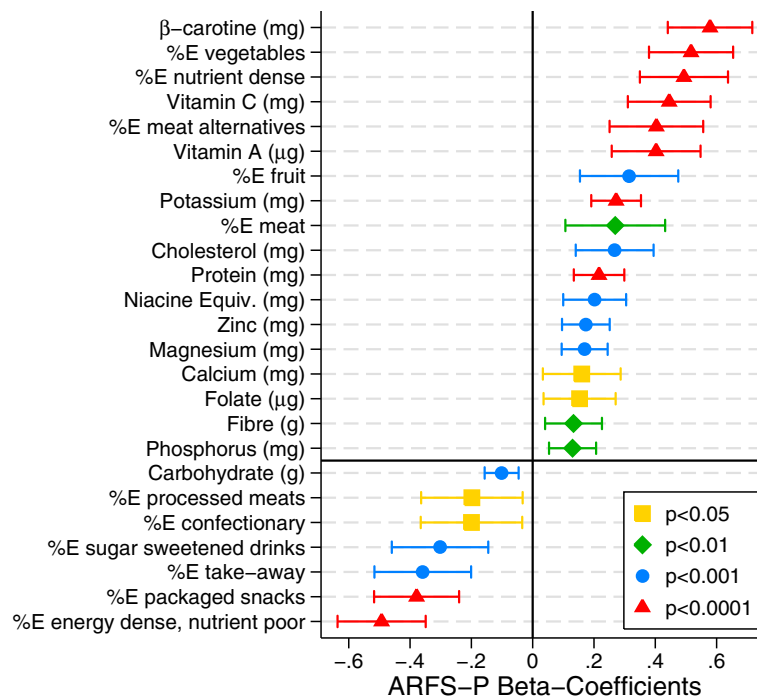


Figure 1 Significant beta-coefficients of ARFS-P component of AES-P nutrients and %E from food groups, controlling for total energy consumption, age, gender and parent education, as estimated by linear regression modelling, with 95% confidence intervals.

children, and provides researchers the opportunity to use an independent measure of intake, or calculated secondarily, from the AES-P FFQ. Its calculation is less onerous than methods that require derivation of nutrient based sub-scales. This means that the provision of feedback based on overall score can potentially be in real-time.

Based on the finding in the current study, the ARFS-P method for scoring diet quality could be applied to other FFQs, in other populations, age groups, and in other settings. This could include testing its use as a self-monitoring tool or within clinical practice. If validated in these settings it would be a convenient tool that could be used by a variety of health professionals to assess and monitor dietary patterns.

Conclusions

In conclusion, the ARFS-P is a brief dietary index that assesses usual diet quality, food variety and the nutritional adequacy of dietary intakes of Australian pre-schoolers. It was a valid tool that can be used to characterize nutrient intake as well as eating patterns. Future research should examine whether the ARFS-P can be used to target improvements in diet quality within interventions and/or population health approaches aimed at optimizing the dietary patterns of young children.

Abbreviations

DQI: Diet Quality Index; FFQ: Food Frequency Questionnaire; ACARFS: Australian Child and Adolescent Recommended Food Score; ARFS: Australian Adolescent Recommended Food Score; ARFS-P: Australian Adolescent Recommended Food Score for Pre-schoolers; HNE: Hunter New England; FHFK: Feed Healthy Food to Kids; NSW: New South Wales; AES: Australian Healthy Eating Survey; AES-P: Australian Healthy Eating Survey Pre-schooler version; RDI: Recommended Daily Intake; AI: Adequate Intake; UL: Upper Limits; %E: Percent energy.

Competing interests

This study was conducted at the University of Newcastle, Callaghan NSW, Australia. All authors declare that they have no conflicts of interest or financial interests or affiliations with institutions, organizations or companies mentioned in the manuscript. CEC was supported by an Australian National Health and Medical Research Council Career Development Research Fellowship. MMB was supported by a Faculty of Health and Medicine, University of Newcastle Visiting Scholar Grant. KC was supported by a Summer Scholarship from the Australasian Child and Adolescent Obesity Research Network (ACAORN).

Authors' contributions

KC, JW, TB, MN, MR, KD and CEC conceived of the study, and participated in its design and data collection and entry. MG and MMB participated in the design of the study, data collection and performed the statistical analysis. All authors contributed to the preparation of the manuscript. All authors read and approved the final manuscript.

Author details

¹Nutrition and Dietetics, School of Health Sciences, Faculty of Health and Medicine, The University of Newcastle, Callaghan 2308, NSW, Australia.

²Priority Research Centre in Physical Activity and Nutrition, Faculty of Health, The University of Newcastle, Callaghan 2308, NSW, Australia. ³Environmental and Occupational Health and Safety, School of Health Sciences, Faculty of Health and Medicine, The University of Newcastle, Callaghan 2308, NSW, Australia. ⁴School of Mathematical and Statistical Sciences, Arizona State University, Tempe 85281, AZ, USA. ⁵Hunter New England Local Health District, Forster 2428, NSW, Australia.

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References

1. Nicklas T: Assessing diet quality in children and adolescents. *J Am Diet Assoc* 2004, **104**:1383–1384.
2. Kant A: Indexes of overall diet quality: A review. *J Am Diet Assoc* 1996, **96**:785–791.
3. Wirt A, Collins C: Diet quality - what is it and does it matter? *Public Health Nutr* 2009, **12**:2473–2492.
4. Collins C, Burrows T, Truby H, Morgan P, Wright I, Davies P, Callister R: Comparison of energy intake in toddlers assessed by food frequency questionnaire and total energy expenditure measured by the doubly labeled water method. *J Acad Nutr Diet* 2013, **113**:459–463.
5. Burrows T, Martin R, Collins C: A systematic review of the validity of the dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc* 2010, **110**:1501–1510.
6. Lazarou C, Newby P: Use of dietary indexes among children in developed countries. *Adv Nutr* 2011, **2**:295–303.
7. Smithers L, Golley R, Brazionis L, Lynch J: Characterizing whole diets of young children from developed countries and the association between diet and health: a systematic review. *Nutr Rev* 2011, **69**:449–467.
8. Lazarou C, Panagiotakos DB, Spanoudis G, Matalas A-L: E-KINDEX: a dietary screening tool to assess children's obesogenic dietary habits. *J Am Coll Nutr* 2011, **30**:100–112.
9. Hurley K, Oberlander S, Merry B, Wroblewski M, Klassen A, Black M: The healthy eating index and youth healthy eating index are unique, nonredundant measures of diet quality among low-income African American adolescents. *J Nutr* 2009, **139**:359–364.
10. Kleiser C, Mensink G, Scheidt-Nave C, Kurth B: HuSKY: a healthy nutrition score based on food intake of children and adolescents in Germany. *Br J Nutr* 2009, **102**:610–618.
11. Royo-Bordonada M, Gorgojo L, Ortega H, Martín-Moreno J, Lasunción M, Garcés C, Gil A, Rodríguez-Artalejo F, de Oya M: Greater dietary variety is associated with better biochemical nutritional status in Spanish children: The Four Provinces Study. *Nutr Metab Cardiovasc Dis* 2003, **13**:357–364.
12. Huybrechts I, Vereecken C, De Bacquer D, Vandevijvere S, Van Oyen H, Maes L, Vanhauwaert E, Temme L, De Backer G, De Henauw S: Reproducibility and validity of a diet quality index for children assessed using a FFQ. *Br J Nutr* 2010, **104**:135–144.
13. Marshall S, Watson J, Burrows T, Guest M, Collins C: The development and evaluation of the Australian child and adolescent recommended food score: a cross-sectional study. *Nutr J* 2012, **11**:96.
14. Watson J, Collins C, Sibbritt D, Dibley M, Garg M: Reproducibility and comparative validity of a food frequency questionnaire for Australian children and adolescents. *Int J Behav Nutr Phys Act* 2009, **6**:62.
15. Duncanson K, Burrows T, Collins C: Study protocol of a parent-focused child feeding and dietary intake intervention: the feeding healthy food to kids randomised controlled trial. *BMC Public Health* 2012, **12**:564–575.
16. Duncanson K, Burrows T, Collins C: Effect of a Low-Intensity Parent-Focused Nutrition Intervention on Dietary Intake of 2-to 5-Year Olds. *J Pediatr Gastroenterol Nutr* 2013, **57**:728–734.
17. Burrows T, Truby H, Morgan P, Callister R, Davies P, Collins C: A comparison and validation of child versus parent reporting of children's energy intake using food frequency questionnaires versus food records: Who's an accurate reporter? *Clin Nutr* 2012, **32**:613–618.
18. Australian Government Publishing Service: *Eat for Health: Australian Dietary Guidelines*; 2013.
19. Commonwealth Scientific Industrial Research Organisation (CSIRO): *2007 Australian National Children's Nutrition and Physical Activity Survey - Main Findings*; 2008. ISBN ISBN: 1-74186-756-8.
20. Food Standards Australia New Zealand: *AUSNUT 2007 Australian Food, Supplement & Nutrient Database 2007*; 2008.
21. Xyris Software (Australia) Pty Ltd: *FoodWorks Professional Version 3.02.581*. 2004.
22. Australian Government Publishing Service: *Nutrient Reference Values for Australian and New Zealand including Recommended Dietary Intakes*. ; 2006.
23. Kant A, Schatzkin A, Graubard B, Schairer C: A prospective study of diet quality and mortality in women. *JAMA* 2000, **283**:2109–2115.
24. Collins C, Young A, Hodge A: Diet quality is associated with higher nutrient intake and self-related health in mid-aged women. *J Am Coll Nutr* 2008, **27**:146–157.

25. StataCorp LP: *Stata MP, version 12*; 2012.
26. Magarey A, Watson J, Golley R, Burrows T, Sutherland R, McNaughton S, Denney-Wilson E, Campbell K, Collins C: **Assessing dietary intake in children and adolescents: Considerations and recommendations for obesity research.** *Int J Pediatr Obes* 2011, **6**:2–11.
27. Collins C, Duncanson K, Burrows T: **A systematic review investigating associations between parenting style and child feeding behaviours.** *J Hum Nutr Diet* 2013, doi:10.1111/jhn.12192.
28. Manios Y, Kourlaba G, Kondaki K, Grammatikaki E, Biribilis M, Oikonomou E, Roma-Giannikou E: **Diet quality of preschoolers in Greece based on the Healthy Eating Index: the GENESIS study.** *J Am Diet Assoc* 2009, **109**:616–623.
29. Hardy L, King L, Bauman A, Espinel P: *NSW Schools Physical Activity and Nutrition Survey (SPANS) 2010 Full Report*; 2010.
30. Kourlaba G, Kondaki K, Grammatikaki E, Roma-Giannikou E, Manios Y: **Diet quality of preschool children and maternal perceptions/misperceptions: the GENESIS study.** *Public Health* 2009, **123**:738–742.
31. Baranowski T, Sprague D, Baranowski J, Harrison J: **Accuracy of maternal dietary recall for preschool children.** *J Am Diet Assoc* 1991, **91**:669–674.
32. Eck L, Klesges R, Hanson C: **Recall of a child's intake from one meal: are parents accurate?** *J Am Diet Assoc* 1989, **89**:784–789.
33. Sobo E, Rock C: **"You Ate All That!?: Caretaker-Child Interaction during Children's Assisted Dietary Recall Interviews.** *Med Anthropol Q* 2001, **15**:222–244.

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