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# Adolescent dietary patterns are associated with lifestyle and family psycho-social factors

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## Abstract

*Objective:* Dietary intake during adolescence contributes to lifelong eating habits and the development of early risk factors for disease in adulthood. Few studies have examined the dietary patterns of adolescents and the social and environmental factors that may affect them during this life stage. The present study describes dietary patterns in a cohort of adolescents and examines their associations with socio-economic factors, as well as parental and adolescent risk factor behaviours.

*Design:* A semi-quantitative FFQ was used to assess study adolescents' usual dietary intake over the previous year. Information was collected on family functioning and various socio-economic and risk factor variables via questionnaire. Adolescents visited the study clinic for anthropometric measurements.

*Setting:* The Western Australian Pregnancy Cohort Study (Raine Study), Perth, Western Australia.

*Subjects:* Adolescents (*n* 1631) aged 14 years from a pregnancy cohort study.

*Results:* Factor analysis identified two distinct dietary patterns that differed predominantly in fat and sugar intakes. The 'Western' pattern consisted of high intakes of take-away foods, soft drinks, confectionery, French fries, refined grains, full-fat dairy products and processed meats. The 'healthy' pattern included high intakes of whole grains, fruit, vegetables, legumes and fish. ANOVA showed that the 'Western' dietary pattern was positively associated with greater television viewing and having a parent who smoked, and was inversely associated with family income. The 'healthy' pattern was positively associated with female gender, greater maternal education, better family functioning and being in a two-parent family, and was inversely associated with television viewing.

*Conclusions:* The study suggests that both lifestyle factors and family psycho-social environment are related to dietary patterns in Australian adolescents.

**Keywords**
Adolescents
Diet
Food habits
Factor analysis
Family relations
Risk factors
Cohort studies
Physical activity
Television
Dietary patterns

The diets of children and adolescents are of public health concern due to evidence relating poor nutrition in childhood to subsequent obesity and elevated risks for type 2 diabetes, the metabolic syndrome and CVD[1], all of which are increasing in prevalence[2]. Yet, relating usual dietary intake to health outcomes is challenging, owing to the large number of nutrition variables required to assess intake. The human diet provides a vast array of nutrients, and the effects of dietary intake are complex and multifactorial. Whereas traditional approaches to dietary analyses focus on individual nutrients or foods, an alternative method is to analyse overall dietary patterns using factor analysis, which takes the total diet into consideration. Several advantages in analysing dietary patterns have been highlighted[3]. These include taking account of overall diet, overcoming collinearity between nutrients, and reducing the number of statistical tests required when modelling disease risks[3].

Few studies have examined adolescents' dietary patterns using factor analysis[4–6]. While lower socio-economic status[7], overweight[8], sedentary behaviours[9] and parental smoking[10] have been linked to poorer diet

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quality in children, these have not been widely examined in relation to adolescents' dietary patterns. Identifying factors that influence the dietary patterns of adolescents may assist in targeting at-risk groups and developing strategies to improve dietary intakes.

The Western Australian Pregnancy Cohort Study (Raine Study) has followed children from gestation to adolescence. The present paper reports on dietary patterns in the cohort at 14 years of age and how these patterns correlate with parental and adolescent risk factors, socio-economic circumstances and family functioning. Our hypothesis was that healthier dietary patterns are associated with healthy BMI, higher physical activity levels, less television viewing, higher maternal education, higher family income, two-parent families and better family functioning.

## Methods

### *Subjects*

Details of the Raine Study have been published elsewhere[11]. Briefly, the study commenced with 2900 women recruited from 16 to 20 weeks' gestation through the public antenatal clinic at King Edward Memorial Hospital (KEMH) and nearby private clinics in Perth, Western Australia, from May 1989 to November 1991. A total of 2804 women (97%) had 2868 live births, and these children have been followed up at birth and ages 1, 2, 3, 5, 8, 10 and 14 years. Data collection was approved by the ethics committees of KEMH and Princess Margaret Hospital for Children.

At the 14-year follow-up, 152 (5%) subjects were lost to follow-up, 348 (12%) had withdrawn from the study and thirty-one were deceased, leaving 2337 (81·5%) adolescents eligible for follow-up. Informed consent was obtained from the primary caregiver and the study adolescent. Questionnaires were completed on usual food intake, sociodemographic factors, family functioning and adolescent behaviour, and the adolescent visited the study clinic for anthropometric measurements.

### *FFQ*

A semi-quantitative FFQ developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Adelaide, Australia[12] was used to assess study adolescents' usual dietary intake over the previous year. The FFQ was modified to include foods typically eaten by adolescents, such as popular snacks and beverages, but excluded alcohol. The frequency of consumption in relation to standard serving sizes was estimated for 212 individual foods, mixed dishes and beverages. Consumption frequencies included never, rarely, number of times per month, number of times per week and number of times per day. Respondents were asked to record if their typical serving size differed in relation to an example serving size measured in household units (cups, spoons, slices, etc.), which was based on weighed diet records collected in previous work[13]. Other information was collected about foods often eaten but not included in the FFQ, cooking methods, fat types, and whether or not low-fat versions and fresh, frozen or canned foods were consumed. This FFQ was able to correctly rank most nutrient intakes when compared with a 3 d food diary in this cohort (GL Ambrosini, HN de Klerk, TA O'Sullivan *et al.*, unpublished results) and has been previously applied in this cohort at 8 years of age[14].

Adolescents may have a limited knowledge of food names and compositions, and may lack the conceptualisation skills necessary to complete an FFQ independently[15]. Therefore the FFQ was posted to the primary caregiver for completion in association with the study adolescent. FFQ responses were checked by a research nurse at the time of physical assessment to clarify missing responses. All FFQ data were entered twice and verified by CSIRO. Estimated daily intakes of foods were provided by CSIRO using Australian food composition data[16]. All 212 foods were merged into thirty-eight food groups devised a priori (Table 1).

### *Covariates*

Height and weight were measured using standard calibrated equipment. BMI was calculated as weight divided by the square of height ($kg/m^2$) and assessed using gender-specific BMI-for-age percentile cut-offs recommended for children and adolescents by the US Centers for Disease Control and Prevention[17]. Adolescents with a BMI lower than the (age- and gender-specific) 5th percentile were considered underweight, those with BMI between ≥5th and <85th percentile were considered to have a healthy weight, those with BMI between ≥85th and <95th percentile were considered at risk of overweight and adolescents with BMI >95th percentile were considered overweight[18].

Levels of physical activity were determined by the adolescents' self-report of how many times they exercised enough to become out of breath or sweat outside school hours and excluded compulsory school physical education requirements. Adolescents could select from five categories ranging from exercising once a month or less through to exercising every day. An ordinal variable was created to identify those who exercised out of school hours at low (exercising ≤1 time/month), medium (exercising 1–3 times/week) and high (exercising ≥4 times/week) levels. The number of hours per day the adolescent spent viewing television and videos was used as a measure of sedentary behaviour. Whether or not the adolescent had smoked in the past four weeks (yes, no, never) was also recorded.

To provide a measure of family functioning, the primary caregiver completed the General Functioning Scale (GFS) from the McMaster Family Assessment Device[19].

**Table 1** Food groups included in the factor analysis

| Food group | FFQ items |
|---|---|
| Whole grains | Wholemeal, mixed-grain or high-fibre sliced bread, oatmeal, muesli, bran, wheat germ, other wholegrain breakfast cereals |
| Refined grains | White bread or rolls, refined breakfast cereals, crumpets, muffins, crispbread, crackers, salted biscuits, rice, noodles, pasta |
| Red meats | Beef, lamb, pork, puréed meat dishes, schnitzel, offal, mince dishes, hamburger patty (without bun) |
| Processed meat | Sausages, frankfurters, bacon, ham, fritz-devon, salami |
| Poultry | Roast or boiled chicken |
| Meat-based mixed dishes | Stew, casserole, Chinese meat and vegetables, curry, goulash |
| Take-away foods | Hamburger with bun, pizza, fried chicken, sausage roll, meat pie, savoury-filled pastry |
| Fried fish | Fried fish, battered fish |
| Other fish | Steamed, grilled or canned fish, other seafood |
| Fried potatoes | Hot chips (French fries), potato gems (pommes noisettes) |
| Potato | Boiled, mashed, roasted, canned or dried potato, potato salad |
| Yellow or red vegetables | Carrots, pumpkin, capsicum |
| Other vegetables | Beetroot, courgette, sweet corn, mushrooms, olives, celery, turnip, swede, onion, cucumber, mixed vegetables |
| Legumes | Haricot, lima, broad or green beans, peas, baked beans, lentils |
| Cruciferous vegetables | Cabbage, Brussels sprouts, broccoli, cauliflower, coleslaw |
| Leafy green vegetables | Silverbeet, lettuce |
| Tomato | Fresh and cooked tomato |
| Fresh fruit | Orange, apple, banana, fruit salad, berries, melons, peach, plum, nectarine, apricot, grapes, pineapple, avocado |
| Canned fruit | Fruit canned in syrup or juice |
| Dried fruit | Sultanas, raisins, currants, other dried fruit |
| Cakes, biscuits, sweet pastries | Fruit loaf, sweet bun, doughnut, croissant, biscuits, cake, fruit pie or pastry, steamed pudding |
| Low-fat dairy products | Reduced-fat milk, skimmed milk, flavoured milk, Sustagen, low-fat yoghurt, low-fat cheese, cottage cheese |
| Full-fat dairy products | Whole milk, cream, ice cream, full-fat yoghurt, full-fat cheese, thick shakes |
| Soya milk | Soya milk |
| Milk-based dishes | Milk pudding, mornay dishes, custard |
| Confectionery | Chocolate, chocolate-covered bars, lollies, toffees, icy poles |
| Added sugar | Honey, jam, marmalade, spooned sugar |
| Crisps | Crisps, corn chips |
| Nuts | Peanuts, other nuts (salted and unsalted) |
| Sauces | Mayonnaise, salad cream, thick sauces e.g. brown sauce |
| Soups | Canned soup, packet soup, homemade soup |
| Eggs | Fried, boiled, scrambled egg, omelette |
| Tea, coffee | Tea, herbal tea, coffee, coffee substitute, decaffeinated coffee |
| Soft drinks | Coca cola, mineral water, other soft drinks, cordial, fruit drink (≤35 % fruit juice) |
| Mineral water (plain) | Spring water |
| Juice | Pure fruit juice, vegetable juice |
| Saturated spreads | Butter, butter/margarine blend, lard, table margarine |
| Unsaturated spreads | Canola or other monounsaturated fat margarine, polyunsaturated margarine, low-fat spreads |

The GFS consists of twelve questions on problem solving, family communication, affective responsiveness and behaviour control with responses recorded on a four-point Likert scale. Higher GFS scores represent better family functioning and scores were categorised into quartiles. The GFS has been shown to be reliable and reproducible[20,21].

The primary caregiver provided sociodemographic information including the mother's (or primary caregiver's) highest level of education (≤10 years, 11 years or ≥12 years), family income, and whether or not the adolescent lived in a single-parent household (yes or no). Information was also collected from the primary caregiver about their current smoking status (yes or no).

### *Statistical analyses*

Some energy intakes reported in the FFQ were outside the range of what would be expected in this age group. We excluded subjects with energy intakes <3000 or >20 000 kJ/d, which is similar to cut-offs applied in a US study using an FFQ in adolescents[22].

Factor analysis was used to reduce the food group intakes measured by the FFQ into a smaller number of underlying factors or dietary patterns that could explain variations in dietary intake. The Kaiser–Meyer–Olkin measure of sampling adequacy indicated that the food group data were suitable for factor analysis (KMO = 0·80)[23]. Using PROC FACTOR in the SAS for Windows statistical software package version 9·1·3 (SAS Institute Inc., Cary, NC, USA), we conducted a factor analysis including all food groups (g/d; Table 1). The factor solution was limited to those factors with an eigenvalue >1 and the scree plot was used to identify the number of factors to retain[24–26]. Foods failing to load on any factor ($r < 0{\cdot}10$) were removed from the analysis (soya milk, tea, coffee, saturated and unsaturated spreads). After applying varimax rotation to improve the separation of factors, two major dietary patterns were identified. Food groups having a factor loading with an

absolute value of 0·30 or more were considered important contributors to each dietary pattern. All adolescents received a score for both dietary patterns, which was calculated by the PROC FACTOR procedure and measured on the *Z*-score scale. Separate factor analyses were initially conducted for males and females; however, as there was little difference in dietary patterns, the results from combined analyses are given.

Mean factor scores for both dietary patterns were examined according to gender and categories of BMI-for-age, physical activity level, parental smoking, adolescent smoking, hours of television watched, total energy intake, and other social and economic variables, using ANOVA for unbalanced designs (PROC GLM) in SAS. *P* values comparing mean factor scores within each category were adjusted for multiple comparisons using the Dunnett–Hsu method. All statistical tests were considered significant at $P < 0{\cdot}05$.

## Results

A total of 1857 (79·5 % of traced) adolescents responded to the 14-year follow-up, of whom 1631 completed the FFQ. Those who either did not respond or did not complete the FFQ were significantly ($P < 0{\cdot}05$) more likely to have a parent who smoked (32 % *v.* 22 %) and lower maternal education (45 % *v.* 37 % with ≤10 years of schooling) than those who completed the FFQ, while all other covariates were similar (data not shown). Eighteen respondents were excluded due to implausible energy intakes, leaving data from 1613 FFQ for the factor analysis. A summary of the covariate data is shown for girls and boys who completed the FFQ in Table 2. Not all of the covariate data were available for every subject who completed the FFQ.

The factor analysis identified two major dietary patterns that explained 84 % of the variance in dietary intakes

**Table 2** Cohort characteristics, FFQ completers: 14-year follow-up of the Western Australian Pregnancy Cohort Study (Raine Study), Perth, Western Australia

| | | Girls | | Boys | | |
|---|---|---|---|---|---|---|
| | Total* | *n* | % | *n* | % | *P*† |
| *n* | 1613 | 787 | 49 | 826 | 51 | |
| BMI-for-age | 1418 | | | | | |
| Underweight | | 14 | 2 | 28 | 4 | 0·918 |
| Healthy weight | | 502 | 73 | 521 | 71 | |
| At risk of overweight | | 113 | 16 | 101 | 14 | |
| Overweight | | 59 | 9 | 80 | 11 | |
| Physical activity | 1415 | | | | | |
| High | | 170 | 25 | 292 | 40 | <0·0001 |
| Medium | | 440 | 64 | 387 | 53 | |
| Low | | 79 | 11 | 47 | 7 | |
| Television or video watching (h/d) | 1413 | | | | | |
| None | | 12 | 2 | 9 | 1 | 0·012 |
| <1 | | 125 | 18 | 96 | 13 | |
| 1 to 2 | | 228 | 33 | 234 | 33 | |
| >2 to 3 | | 231 | 34 | 284 | 39 | |
| >3 | | 92 | 13 | 102 | 14 | |
| Single-parent family | 1603 | | | | | |
| No | | 608 | 78 | 652 | 79 | 0·428 |
| Yes | | 174 | 22 | 169 | 21 | |
| Mother's education | 1572 | | | | | |
| 12 years or more | | 343 | 45 | 364 | 45 | 0·486 |
| 11 years | | 126 | 17 | 163 | 20 | |
| 10 years or less | | 292 | 38 | 284 | 35 | |
| Annual family income ($AUD) | 1613 | | | | | |
| ≤25 000 | | 112 | 14 | 117 | 14 | 0·110 |
| 25 001–35 000 | | 101 | 13 | 77 | 9 | |
| 35 001–50 000 | | 122 | 15 | 128 | 16 | |
| 50 001–70 000 | | 154 | 20 | 156 | 19 | |
| 70 001–104 000 | | 164 | 21 | 193 | 23 | |
| >104 000 | | 134 | 17 | 155 | 19 | |
| Quartile of General Functioning Scale‡ | 1554 | | | | | |
| ≤25 | | 169 | 22 | 186 | 23 | 0·929 |
| 26–28 | | 191 | 25 | 180 | 23 | |
| 29–33 | | 210 | 28 | 243 | 30 | |
| 34–39 | | 187 | 25 | 188 | 24 | |
| Parent smoker | 1600 | | | | | |
| No | | 597 | 76 | 655 | 80 | 0·047 |
| Yes | | 188 | 24 | 163 | 20 | |

*Excludes eighteen subjects who had extreme energy intakes (some categories do not add up to total number of males and females because of missing values).
†*P* value for $\chi^2$ test.
‡Based on the McMaster Family Assessment Device[19].

**Table 3** Dietary patterns and their factor loadings: 14-year follow-up of the Western Australian Pregnancy Cohort Study (Raine Study), Perth, Western Australia

| | Factor loading | |
|---|---|---|
| | 'Healthy' pattern | 'Western' pattern |
| Yellow or red vegetables | 0·56 | 0·12 |
| Leafy green vegetables | 0·49 | 0·00 |
| Tomato | 0·49 | 0·00 |
| Cruciferous vegetables | 0·48 | 0·27 |
| Other vegetables | 0·66 | 0·22 |
| Fresh fruit | 0·48 | −0·02 |
| Legumes | 0·43 | 0·19 |
| Whole grains | 0·39 | −0·12 |
| Fish, steamed, grilled or tinned | 0·33 | 0·05 |
| Take-away foods | −0·20 | 0·53 |
| Confectionery | −0·14 | 0·46 |
| Red meat | 0·14 | 0·46 |
| Refined grains | 0·03 | 0·42 |
| Processed meats | −0·02 | 0·41 |
| Potato, fried e.g. French fries | −0·25 | 0·39 |
| Crisps | −0·22 | 0·39 |
| Soft drinks | −0·18 | 0·37 |
| Cakes, biscuits | 0·10 | 0·34 |
| Potato, not fried | 0·21 | 0·34 |
| Sauces and dressings | 0·13 | 0·34 |
| Full-fat dairy products | 0·00 | 0·30 |
| Soups | 0·26 | 0·26 |
| Canned fruit | 0·26 | 0·11 |
| Meat dishes | 0·26 | 0·15 |
| Dried fruit | 0·23 | 0·00 |
| Mineral water | 0·23 | −0·05 |
| Low-fat dairy products | 0·22 | −0·10 |
| Eggs | 0·20 | 0·24 |
| Juices | 0·19 | −0·02 |
| Nuts | 0·17 | −0·02 |
| Added sugar | 0·13 | 0·21 |
| Milk dishes | 0·13 | 0·20 |
| Fish, fried or battered | 0·02 | 0·23 |
| Poultry | 0·01 | 0·29 |
| Variance | 4·28 | 2·89 |
| % variance | 50 | 34 |
| Mean | 0 | 0 |
| SD | 0·89 | 0·87 |
| Min | −2·12 | −2·07 |
| Median | −0·1 | −0·13 |
| Max | 5·01 | 4·74 |

(Table 3). Items loading on the first dietary pattern included wholegrain cereals, fresh fruit, legumes, steamed, grilled or canned fish and all vegetables except potatoes. Scores for the first dietary pattern were strongly correlated with intakes of fibre, folic acid and most micronutrients, and inversely correlated with energy from total fat, saturated fat and refined sugar (Table 4); therefore this pattern was labelled 'healthy'. Items loading on the second pattern included take-away foods, red meats, processed meats, full-fat dairy products, fried potatoes ('hot chips' or 'French fries'), refined cereals, cakes and biscuits, confectionery, soft drinks, crisps, sauces and dressings (Table 3). This pattern showed moderate positive correlations with most nutrients except vitamin C and folic acid and strong correlations with intake of energy, total fat, saturated fat, cholesterol and refined sugar (Table 4). This pattern was labelled the 'Western' pattern as it was similar to that described in other published factor analyses[24,27].

The ANOVA results are based on 1321 subjects who completed the FFQ and for whom all covariate data were available. Taking all of the potential confounding factors in Table 2 into consideration, girls had significantly higher scores for the 'healthy' pattern, and the 'healthy' pattern was positively associated with increasing maternal education and better family functioning (Table 5). Mean scores for the 'healthy' pattern decreased with increasing hours of television watching, and were lower where a parent smoked and in single-parent families. Mean 'Western' pattern scores increased significantly with greater television viewing times and where a parent smoked. Adolescents from families in the highest income group had significantly lower mean scores for the 'Western' pattern, as did adolescents from single-parent families.

Adolescents reporting high levels of physical activity had higher 'healthy' pattern and lower 'Western' pattern scores; however, this was not statistically significant. There were no relationships between adolescent smoking status and either dietary pattern. No significant relationships were found between the two dietary patterns and BMI-for-age; however, a U-shaped relationship was suggested for the 'Western' pattern, whereby underweight and overweight adolescents had higher 'Western' pattern scores. In addition, adolescents 'at risk of overweight' appeared to have higher mean 'healthy' pattern scores after adjusting for total energy intake. This remained when the criteria developed by Cole *et al.* were used to identify overweight subjects[28]. After adjusting for all variables, those in the highest quartile for the 'Western' pattern score had significantly lower scores for the 'healthy' pattern, and vice versa.

## Discussion

The present analysis of 14-year-old adolescents has identified two main dietary patterns that correspond closely with those observed in large studies of US adults: a 'prudent' or 'healthy' pattern and a 'Western' pattern[24,27,29,30]. In adults, these two dietary patterns have reportedly explained 20–37 % of the total variation in food intakes[24,29,30], whereas in the present study of Australian adolescents, they explained over 80 %. This suggests that the dietary intakes in this adolescent cohort may be narrow and possibly limited, compared with adults.

Very few studies have used factor analysis to examine the dietary patterns of adolescents. A Spanish study reported four patterns based on a factor analysis of FFQ data collected in a population-based survey of 3534 young people aged 2 to 24 years[4]. The four patterns explained 54 % of the variation in intakes and included a

**Table 4** Pearson correlation coefficients (*r*) between dietary pattern scores and nutrient intakes: 14-year follow-up of the Western Australian Pregnancy Cohort Study (Raine Study), Perth, Western Australia

| Nutrient | 'Healthy' pattern* | 'Western' pattern* |
|---|---|---|
| Energy | 0·28 | 0·77 |
| Protein | 0·42 | 0·66 |
| Total fat | 0·13 | 0·80 |
| Saturated fats | 0·03† | 0·75 |
| Monounsaturated fats | 0·11 | 0·81 |
| Polyunsaturated fats | 0·31 | 0·49 |
| Cholesterol | 0·23 | 0·63 |
| Total carbohydrates | 0·30 | 0·66 |
| Starch | 0·19 | 0·68 |
| Refined sugar | −0·10 | 0·66 |
| Fibre | 0·75 | 0·36 |
| Total vitamin A | 0·52 | 0·34 |
| Vitamin C | 0·48 | 0·19 |
| Vitamin E | 0·33 | 0·40 |
| Total folic acid | 0·74 | 0·28 |
| Thiamin | 0·38 | 0·42 |
| Riboflavin | 0·40 | 0·37 |
| Niacin | 0·46 | 0·59 |
| Vitamin $B_6$ | 0·59 | 0·45 |
| Vitamin $B_{12}$ | 0·31 | 0·47 |
| Ca | 0·33 | 0·31 |
| Fe | 0·48 | 0·59 |
| Zn | 0·46 | 0·63 |
| % energy from protein | 0·28 | −0·18 |
| % energy from fat | −0·25 | 0·31 |
| % energy from saturated fats | −0·33 | 0·28 |
| % energy from monounsaturated fats | −0·27 | 0·31 |
| % energy from polyunsaturated fats | 0·17 | <−0·01† |
| % energy from total carbohydrates | 0·09 | −0·21 |
| % energy from starch | −0·14 | −0·07 |
| % energy from refined sugar | −0·34 | 0·27 |

*All correlations are significant ($P<0·05$) except †.

'snacky' pattern positively loaded for biscuits, buns, sweets, salted snacks, soft drinks and nuts, and a 'healthy' pattern high in fish, vegetables and fruit. Among the 2159 14–24-year-olds, the 'snacky' pattern was inversely associated with age and mother's education, and positively associated with television viewing time. The 'healthy' pattern was positively associated with higher maternal education and female gender.

Two other studies conducted factor analyses combining dietary intakes with adolescent behaviours, although both studies used limited dietary assessment. A Dutch study of children aged 12–16 years conducted a factor analysis of fruit, vegetables, soft drinks and sweets intake, breakfast eating, physical activity, computer and television use, and addictive behaviours (tobacco, marijuana and alcohol use)[31]. Four separate behaviour patterns were identified: 'addictive', 'sweets consumption', 'health-enhancing' and 'sedentary', explaining 51% of the variance. The 'health-enhancing' pattern loaded strongly for fruit and vegetable intake and physical activity, whereas the 'sweets consumption' pattern loaded positively for soft drink and sweets consumption. The 'sedentary' pattern loaded moderately for soft drink consumption and television watching. None of the dietary variables loaded on the 'addictive' pattern. These results suggest that sedentary behaviours may be associated with high consumption of soft drinks, and that healthy eating and physical activity are correlated, but sweets and soft drink consumption and addictive behaviours may be independent of these patterns. Similarly in a US study of 36 284 adolescents, factor analysis was conducted using a single variable representing unhealthy eating and measurements of various behaviours[5]. In boys, unhealthy eating was positively associated with a 'risk-taking behaviours' pattern (delinquency, drug use, high-risk sexual activity) and was inversely associated with an 'exercise' pattern. In girls, unhealthy eating was positively correlated with a pattern representative of poorer academic outcomes and high drop-out risk. For both boys and girls, unhealthy eating was negatively correlated with a 'health-promoting behaviours' pattern (teeth brushing and seat belt use).

The present population-based study highlights potential roles for family factors and parent behaviours in influencing dietary patterns. The 'healthy' dietary pattern was positively associated with better family functioning, independent of family income and maternal education. Other studies have shown poor family functioning to be associated with obesity in adolescents[32,33]; however, this has not been demonstrated conclusively at a population level[34]. Adolescents from single-parent families had lower scores for both the 'healthy' and the 'Western' patterns, which suggests that their diets are neither overtly 'healthy' nor 'Western'. Parenting styles may explain some of these differences; single parents have been shown to exercise more control when shopping for food to avoid food rules at home[35]. Finally, adolescents with a parent who smoked had significantly higher 'Western' pattern scores, which corresponds with other studies that have found smoking to be associated with poor diet[36] and that parental risk factor behaviours may be associated with poorer diet quality in their adolescent children[10].

Adolescent overweight and obesity is a problem globally and in Australia, where approximately one-quarter of Australian adolescents are either overweight or obese[37]. Yet, our study failed to show any clear association between either dietary pattern and BMI. This may be due to energy intake being positively associated with higher scores for both dietary patterns. Alternatively, residual confounding related to physical activity or other factors not measured in the study may have a greater moderating effect on BMI than the dietary pattern. However, longer television viewing times were associated with a more 'Western' style diet, while adolescents with a more 'healthy' diet watched less television. Other studies have found television viewing to be associated with higher consumption of soft drinks[4,9,31] and fried foods[9].

Our study has some limitations. Factor analysis, as a statistical technique, requires some arbitrary decisions and subjective interpretation of factors. We used criteria similar to those reported by other dietary pattern studies

**Table 5** Mean factor scores adjusted for risk factor and socio-economic variables*: 14-year follow-up of the Western Australian Pregnancy Cohort Study (Raine Study), Perth, Western Australia

| | 'Healthy' pattern | | | 'Western' pattern | | |
|---|---|---|---|---|---|---|
| | Mean score | *P*† | *P* for trend‡ | Mean score | *P*† | *P* for trend‡ |
| Gender | | | | | | |
| Male | −0·1125 | | | 0·0198 | | |
| Female | 0·1130 | <0·0001 | <0·0001 | 0·0732 | 0·1153 | 0·1153 |
| BMI-for-age | | | | | | |
| Underweight | −0·0900 | | | 0·0718 | | |
| Healthy weight | −0·0247 | 0·9270 | | −0·0126 | 0·5518 | |
| At risk of overweight | 0·1021 | 0·2948 | | 0·0389 | 0·9396 | |
| Overweight | 0·0317 | 0·6118 | 0·1144 | 0·0879 | 0·9922 | 0·1946 |
| Physical activity | | | | | | |
| High | 0·0688 | | | 0·0058 | | |
| Medium | −0·0010 | 0·2058 | | 0·0207 | 0·8824 | |
| Low | −0·0580 | 0·5444 | 0·1895 | 0·1130 | 0·1495 | 0·2118 |
| Television or video watching (h/d) | | | | | | |
| None | 0·2896 | | | −0·1536 | | |
| <1 | 0·0057 | 0·2137 | | −0·0002 | 0·3705 | |
| 1 to 2 | −0·1234 | 0·0484 | | 0·0942 | 0·0991 | |
| >2 to 3 | −0·1278 | 0·0459 | | 0·1194 | 0·0652 | |
| >3 | −0·0427 | 0·1402 | 0·0526 | 0·1727 | 0·0297 | 0·0114 |
| Single-parent family | | | | | | |
| No | 0·0799 | | | 0·0965 | | |
| Yes | −0·0793 | 0·0186 | 0·0186 | −0·0036 | 0·0348 | 0·0348 |
| Maternal education | | | | | | |
| 12 years or more | 0·0890 | | | 0·0039 | | |
| 11 years | 0·0184 | 0·4340 | | 0·0770 | 0·1743 | |
| 10 years or less | −0·1067 | 0·0006 | 0·0014 | 0·0585 | 0·2673 | 0·1767 |
| Annual family income ($AUD) | | | | | | |
| ≤25 000 | 0·1693 | | | 0·0945 | | |
| 25 001–35 000 | 0·0253 | 0·3596 | | 0·2053 | 0·2788 | |
| 35 001–50 000 | −0·0673 | 0·0324 | | 0·0688 | 0·9897 | |
| 50 001–70 000 | −0·0468 | 0·0627 | | 0·0422 | 0·8431 | |
| 70 001–104 000 | −0·0063 | 0·1779 | | −0·0223 | 0·2173 | |
| >104 000 | −0·0726 | 0·0508 | 0·1288 | −0·1095 | 0·0124 | 0·0003 |
| Family functioning score§ | | | | | | |
| ≤25 | −0·0799 | | | 0·0918 | | |
| 26–28 | −0·1042 | 0·9659 | | 0·0499 | 0·6807 | |
| 29–33 | 0·0392 | 0·1367 | | 0·0496 | 0·6429 | |
| 34–39 | 0·1459 | 0·0019 | 0·0004 | −0·0053 | 0·0924 | 0·2234 |
| Parent smokes | | | | | | |
| No | 0·0598 | | | −0·0215 | | |
| Yes | −0·0593 | 0·0376 | 0·0376 | 0·1145 | 0·0007 | 0·0007 |
| Western pattern score (quartile) | | | | | | |
| 1 | 0·2959 | | | – | | |
| 2 | 0·1484 | 0·0697 | | – | – | |
| 3 | −0·1228 | <0·0001 | | – | – | |
| 4 | −0·3203 | <0·0001 | <0·0001 | – | – | – |
| Healthy pattern score (quartile) | | | | | | |
| 1 | – | | | 0·2090 | | |
| 2 | – | – | | 0·0596 | 0·0025 | |
| 3 | – | – | | 0·0356 | 0·0004 | |
| 4 | – | – | – | −0·1183 | <0·0001 | <0·0001 |
| Energy intake (kJ/d) | | | | | | |
| 3286–7466 | −0·5439 | | | −0·7451 | | |
| 7467–9341 | −0·2196 | <0·0001 | | −0·2649 | <0·0001 | |
| 9341–11 346 | 0·1535 | <0·0001 | | 0·1945 | 0·0002 | |
| 11 352–19 769 | 0·6110 | <0·0001 | <0·0001 | 1·0014 | <0·0001 | <0·0001 |

*Mean factor scores calculated using an ANOVA model adjusting for all variables in the table, based on 1321 subjects.
†Probability that mean factor score is equal to that of the reference level (adjusted for multiple comparisons using the Dunnett–Hsu method).
‡Test for trend in mean factor score across category levels.
§Based on the McMaster Family Assessment Device[19].

to enable study comparisons[24,27]. Dietary patterns identified using factor analysis have been shown to be reliable in adults[38–40] but, to our knowledge, have not been tested for reliability in adolescent populations. We acknowledge the limitations of FFQ in regard to individual measurement error; however, the FFQ remains one of the most practical dietary methods for epidemiological studies and the FFQ used in the present study has been evaluated in this cohort (GL Ambrosini, HN de Klerk, TA O'Sullivan *et al.*, unpublished results).

The strengths of the Raine Study are that it is population-based and has collected a broad range of health data. Our response fraction for FFQ completion (70 %) was favourable, given the age of respondents and FFQ length. Non-responders differed slightly and this must be considered if wanting to apply these findings to other populations; however, respondents were well distributed across most socio-economic indicators. Although the present analysis was cross-sectional, future longitudinal analyses are planned and data collection for the 17-year follow-up has commenced.

Our study of dietary patterns suggests that adolescent dietary intake is dependent on factors related to the family, whereby parental health behaviours (smoking), family functioning, family structure (single- *v.* two-parent families), maternal education and family income are important influences. Further, poorer dietary habits in adolescents are associated with more television viewing. The identification of dietary patterns in this cohort will be useful for future longitudinal analyses of diet and various health outcomes including metabolic syndrome, CVD and mental health.

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