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Identification of a dietary pattern associated with greater cardiometabolic risk in adolescence

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Abstract *Background and aims:* Energy dense, high fat, low fibre diets may contribute to obesity in young people, however their relationships with other cardiometabolic risk factors are unclear. We examined associations between an 'energy-dense, high-fat and low-fibre' dietary pattern (DP) and cardiometabolic risk factors, and the tracking of this DP in adolescence.
Methods and results: Data was sourced from participants in the Western Australian Pregnancy (Raine) Cohort Study. At 14 and 17 y, dietary intake, anthropometric and biochemical data were measured and z-scores for an 'energy dense, high fat and low fibre' DP were estimated using reduced rank regression (RRR). Associations between DP z-scores and cardiometabolic risk factors were examined using regression models. Tracking of DP z-scores was assessed using Pearson's correlation coefficient.

A 1 SD unit increase in DP z-score between 14 and 17 y was associated with a 20% greater odds of high metabolic risk (95% CI: 1.01, 1.41) and a 0.04 mmol/L higher fasting glucose in boys (95% CI: 0.01, 0.08); a 28% greater odds of a high-waist circumference (95% CI: 1.00, 1.63) in girls. An increase of 3% and 4% was observed for insulin and HOMA (95% CI: 1%, 7%), respectively, in boys and girls, for every 1 SD increase in DP z-score and independently of BMI. The DP showed moderate tracking between 14 and 17 y of age ($r = 0.51$ for boys, $r = 0.45$ for girls).
Conclusion: An 'energy dense, high fat, low fibre' DP is positively associated with cardiometabolic risk factors and tends to persist throughout adolescence.

Abbreviations: CVD, cardiovascular diseases; RRR, reduced rank regression; DP, dietary pattern; Raine, Western Australian Pregnancy (Raine) Cohort; FFQ, food frequency questionnaire; BMI, body mass index; WC, waist circumference; HOMA, insulin resistance; y, years; CSIRO, Commonwealth Scientific and Industrial Research Organisation; CDC, Center for Disease Control; IOTF, International Obesity Task Force; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; PWC-170, physical working capacity 170; PCA, principal component analysis.

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Introduction

There is growing evidence that cardiometabolic risk factors, namely obesity, high systolic blood pressure, dyslipidaemia, impaired glucose tolerance and vascular abnormalities, develop early in life and track during growth and development and into adulthood [1–3]. Early identification and understanding of these risk factors are essential, so that appropriate interventions can be targeted to children and adolescents to minimise the risk of developing cardiovascular diseases (CVD) in later life.

Diet is a modifiable risk factor for CVD in adulthood and is therefore, likely to be important for early CVD risk factors in childhood [4,5]. A number of studies have examined prospective relationships between single food groups and cardiometabolic risk factors in children and adolescents [6–8]. However, foods and nutrients are not consumed in isolation. Interest in overall dietary patterns (DP) has peaked over the last decade, as these consider all food and nutrient intakes and may account for the cumulative and interactive effects of foods and nutrients eaten together. To date, few studies have examined empirically derived DPs in relation to cardiometabolic risk factors among adolescents [9–13]. Furthermore, little is known about how DPs track from childhood to adulthood [14,15]. Understanding how DPs track over the life course may be useful in improving dietary intakes and related health outcomes.

Dietary energy-density, fibre and fat are associated with CVD risk in adults [13,16–18] and adiposity in children [12]. In this study, we hypothesised that a DP specifically characterised as energy-dense, high in fat, and low in fibre would be prospectively associated with obesity and other cardiometabolic risk factors, and would track between 14 and 17 years (y) of age in adolescents from the Western Australian Pregnancy (Raine) Study.

Methods

Study population

Details of the Raine Study have been described elsewhere [19]. In brief, the original cohort comprised of 2900 pregnant women who were recruited into a trial at King Edward Memorial Hospital (Perth, Western Australia) to examine ultrasound imaging from 1989 to 1991. A total of 2868 babies born to 2804 mothers who remained with the study formed the Raine cohort and were followed up at regular intervals after birth. The present analysis uses data collected at the 14 (n = 1857) and 17 (n = 1709) y follow ups, when comprehensive dietary and cardiometabolic data were collected. Ethical approval for the study was obtained from the ethics committees of King Edward Memorial Hospital and Princess Margaret Hospital for Children. Written informed consent was obtained from all adolescents and their parent or guardian.

Dietary assessment

A validated semi-quantitative food frequency questionnaire (FFQ) was administered at 14 and 17 y of age to estimate habitual dietary intake over the previous year and has been described elsewhere [20]. Of the 1857 and 1709 adolescents who participated in the 14 and 17 y follow ups, 1611 (87%) and 1009 (60%) completed the (FFQ), respectively. At 14 y of age, the FFQ was completed with assistance from a parent or caregiver. The FFQ collected information on usual frequency of consumption and serving sizes (in household units) of 227 food and beverages; at 17 y of age the FFQ included alcoholic beverages, increasing the number of items to 232. The selected frequency of consumption for each food was converted to a daily intake and linked with Australian Food Composition Tables to calculate average daily nutrient intakes, by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australia [21]. Intakes of all food and beverages were then collapsed into 46 (47 at 17 y, including alcohol) predefined food groups based on nutrient profiles or culinary usage, and their hypothesized contribution to diet-disease relationships (Supplementary Table 1). All FFQs were checked by a research nurse and, missing and unclear responses were corrected with the adolescent at the time of their physical assessment.

Dietary misreporting, particularly under-reporting is common among adolescents [22]. Dietary misreporting was estimated using a standardised equation at 14 and 17 y of age, as previously described [22]. Rather than excluding dietary misreporters, a categorical variable indicating plausible, under- and over-reporting was included as a potential confounder in statistical models.

Dietary patterns

Reduced rank regression (RRR) is a data-dimension reduction technique that identifies DPs that are potentially relevant for the aetiology of disease by including *a-priori* knowledge e.g. biomarkers or nutrient intakes. Identification and evaluation of an energy-dense, high fat, low fibre DP using RRR at 14 y in this cohort has been previously described [23]. Briefly, the RRR model included intakes of all predefined food groups (Supplementary Table 1) as predictor variables, and intakes of dietary energy density (DED) from food, the proportion of total energy from total fat (%E fat) and fibre density as response variables. These three response variables were chosen because of their links with obesity and other cardiometabolic risk factors [12,24]. DED was calculated by dividing total food energy (kJ) by total food weight in grams (g), excluding beverages. Beverages were excluded from the calculation of DED because they may disproportionately influence total dietary energy density values [25]. Beverages were defined as high and low-fat milk, sugar-sweetened beverages, low-energy beverages, fruit juice, hot and powdered drinks, water and alcoholic drinks. However, to account for their potential contribution to the DP, beverages were included