

TITLE: Determinants of a dietary pattern linked with greater metabolic risk and its tracking during adolescence

SHORT RUNNING TITLE: Determinants and tracking of a dietary pattern

Keywords : Dietary patterns, food groups, tracking, adolescents, Raine study, social determinants

Abstract word count : 250

Main body word count : 3470

No. of references : 31

No. of tables and figures : 5

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the observational cohort study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

ABSTRACT

Background: While growing evidence suggests that dietary patterns associated with non-communicable diseases in adulthood may develop early in life, when these are established and their determinants, is unclear.

Methods: We examined determinants and tracking of a dietary pattern (DP) associated with metabolic risk and its key food groups, among 860 adolescents in the Western Australian Pregnancy (Raine) Cohort study. Food intake was reported using a Food Frequency Questionnaire (FFQ) at 14 and 17 y. Z-scores for an 'energy dense, high fat, low fibre' DP were estimated by applying reduced rank regression at both ages. Tracking was based on the predictive value (PV) of remaining in the DP z-score or food intake quartile at 14 and 17 y. Early life exposures included: maternal age; maternal pre-pregnancy BMI; parent smoking status during pregnancy; and parent socio-economic position (SEP) at 14 and 17 y. Associations between the DP z-scores, early life factors and SEP were analysed using regression analysis.

Results: Dietary tracking was strongest among boys with high DP z-scores, high intakes of processed meat, low-fibre bread, crisps and savoury snacks ($PV > 1$), and the lowest intakes of vegetables, fruit and legumes. Lower maternal education ($\beta = 0.09$, $p = 0.002$ at 14 y; $\beta = 0.14$, $p < 0.001$ at 17 y) and lower maternal age at birth ($\beta = 0.09$, $p = 0.003$ at 14 y; $\beta = 0.11$, $p = 0.004$ at 17 y) were positively associated with a higher DP z-scores.

Conclusion: An energy-dense, high-fat, low fibre dietary pattern tracks more strongly among adolescent boys who have high scores for this pattern at 14 y of age. These findings highlight target foods and population subgroups for early interventions to improve dietary behaviours.

SIGNIFICANCE

What is already known on this subject?

1. In this cohort, an 'energy dense, high fat, low fibre' dietary pattern during adolescence is linked with greater overall metabolic risk and this dietary pattern tracks over adolescence at the population level; however, individual level tracking of this dietary pattern and its key food groups is unknown.
2. Although many studies have examined the influence of early life and parental factors on children's diet quality and health outcomes, these have not been explored in relation to a dietary pattern specifically linked with metabolic risk factors during adolescence.

What this study adds:

1. Understanding the dietary patterns and their key food groups that are most or least likely to track, assists in identifying nutrition targets for interventions to improve adolescent diet quality
2. Tracking was strongest among low consumers of vegetables, fruits, legumes, high-fibre bread and yogurts, which conferred a higher score for this dietary pattern, particularly among boys.
3. Higher z-scores for this dietary pattern in adolescence were associated with lower maternal age at birth lower levels of maternal education, and paternal smoking.

INTRODUCTION

Growing evidence suggests that diet and lifestyle factors in childhood and adolescence impact on the risk of developing obesity, diabetes and coronary heart disease in adulthood ^(1, 2). Therefore, understanding the stability or tracking of specific childhood dietary patterns that are predictive of adult's health outcomes may provide valuable information for the early prevention of non-communicable disease risk factors. Understanding the determinants of such dietary patterns may provide important information for interventions to improve dietary intakes to specific subgroups at the highest risk of future ill-health.

The concept of tracking in epidemiological studies refers to the consistency of measurements on an individual over a period of time ^(3, 4). Several observational studies have evaluated the tracking of nutrient and single food group intakes between childhood and adulthood ⁽⁵⁻¹⁰⁾. However, few prospective studies have examined the tracking of empirical dietary patterns that summarise total dietary intake and take into account the correlations between foods and nutrients consumed together in a mixed diet, or their key food components, in children and adolescents ^(2, 4, 11, 12).

Adolescence is a period of major physiological and psychological development and may be a key period in the formation of lifelong dietary habits ^(4, 13). We previously identified an 'energy dense, high fat, low fibre' dietary pattern among adolescents in the Western Australian Pregnancy (Raine) Cohort Study at 14 and 17 y of age ⁽¹⁴⁾. This age span is significant, as it represents a key transition period during adolescence that correlates with major pubertal changes and increases in personal autonomy (e.g. a drivers license may be obtained at 17 y of age in Australia), both of which may affect food choices. This dietary pattern was prospectively associated with greater overall metabolic risk and fasting blood glucose in boys, higher waist circumference in girls and increased insulin resistance in both boys and girls between 14 and 17 y ⁽¹⁵⁾. Tracking coefficients for this dietary pattern

demonstrated moderate tracking between 14 and 17 y in both boys ($r=0.51$; 95% CI: 0.43, 0.58) and girls ($r=0.45$; 95% CI: 0.37, 0.52) ⁽¹⁵⁾, however this summarises tracking at the population level only and does not signify whether dietary pattern scores are consistently high or low in the study population. To help identify targets for interventions to improve dietary patterns in young people, information on dietary pattern tracking at the individual-level, and the determinants of tracking, is needed. For example, understanding the food groups within this pattern that show stronger or weaker tracking, can help to identify dietary targets that may be more or less amenable to change. Similarly, identifying whether tracking is stronger among high or low consumers of key food groups in the pattern, can help to confirm critical timing and population subgroups for intervention. Here, we examine the individual-level tracking of the ‘energy dense, high fat, low fibre’ dietary pattern and its most influential food groups in the Raine Study between 14 and 17 y and evaluate the influences of early life exposures and parental socio-economic factors on the dietary pattern.

METHODS

Full details of the study population have been previously described ⁽¹⁶⁾. In brief, a total of 2900 pregnant women were recruited at 16 to 20 weeks' gestation through public antenatal clinics at King Edward Memorial Hospital and nearby private clinics in Perth, Western Australia, between May 1989 and November 1991. Their 2868 live births have been followed up regularly from birth. This study utilises comprehensive dietary data collected at the 14 and 17 y follow-ups. The human ethics committees of King Edward Memorial Hospital for Women and the Princess Margaret Hospital for Children, Perth, Western Australia approved the recruitment and all protocols for the study. Informed and written consent was provided by study participants or their primary caregiver for all follow-ups.

Dietary assessment

An evaluated semi-quantitative food frequency questionnaire (FFQ) was used to estimate habitual dietary intake over the previous 12 months at 14 and 17 y of age ⁽¹⁷⁾. Completed FFQs were checked by a research nurse and missing or unclear responses were rectified with the adolescents during their physical assessment sessions. Intakes of all 227 food items listed in the FFQ were collapsed into 46 and 47 major food groups at 14 and 17 y, respectively, based on nutrient profiles or culinary usage and their hypothesised contribution to obesity ⁽¹⁴⁾. A food group including alcoholic beverages was added at 17 y.

Dietary patterns

The method used to identify an ‘energy dense, high fat, low fibre’ dietary pattern at 14 and 17 y of age in the Raine Study has been previously described ⁽¹⁴⁾. Briefly, the reduced rank regression (RRR) model included intakes of all predefined major food groups (g/day) as predictor variables and three dietary response variables hypothesised to be associated with obesity risk: dietary energy density (MJ/g food), percentage energy from total fat and fibre density (g fibre/MJ). A total of 1611 participants at 14 y and 1009 participants at 17y had dietary data for the dietary pattern analyses. The ‘energy-dense, high fat and low fibre’ dietary pattern explained the majority of the total variation in all three response variables at 14 and 17 y (58% and 53%, respectively) and matched our hypothesis of a dietary pattern positively associated with obesity ⁽¹⁴⁾. Each individual received a z-score for the dietary pattern discriminating how closely their dietary intake corresponds to the pattern. Intakes of food groups with positive factor loadings increase the individual z-score whereas intakes of food groups with negative factor loadings decrease the z-score. The larger the food group factor loading, the greater the contribution of that food group to the dietary pattern. The factor loadings in **Figure 1** show that the dietary pattern was broadly similar at both ages. The ten key food groups in the ‘energy dense, high fat, low fibre’ dietary pattern were determined as the five food groups having the strongest positive factor loadings (processed meat, chocolate and confectionery, low-fibre bread, crisps and savoury snacks, and fried and roasted potatoes) plus the five food groups with the strongest negative factor loadings (i.e. fresh fruits, vegetables, legumes, high-fibre bread and yoghurts) (Figure 1). Participants were categorised into quartiles of dietary pattern z-scores and quartiles of the ten key food groups (g/d) based on their distribution, at each time point (Supplementary Table 1).

Early life exposures

Maternal factors during pre-pregnancy and pregnancy, such as maternal body weight and smoking status, may have a direct or indirect (e.g. as a lifestyle marker) influence on the development of offspring obesity and other metabolic risks ⁽¹⁸⁾. In this study, information on early life exposures was collected using detailed questionnaires, including: maternal smoking status (yes/no) at 18 and 34 weeks of gestation; paternal smoking status (yes/no) at 18 weeks of gestation; maternal age at child birth (years); maternal pre-pregnancy weight was self-reported and height was measured at the time of study enrolment (16-20 weeks gestation).

Parental socio-economic position (SEP)

Several studies suggest that parental socio-economic factors are closely associated with children's dietary intake ^(2, 19, 20). Identifying the socio-economic determinants of a dietary intake is important for identifying targeted strategies to improve dietary intakes. Information on parent SEP indicators was measured using a standardised questionnaire at 14 and 17 y. This comprised categories of maternal education represented by years of education attained: <10 years (junior high school), 10-12 years (senior high school), >12 years (higher education), categories of maternal employment status (employed and not-employed), maternal working hours, categories of household income in Australian dollars (<35k, 35-50k, >50-70k, >70-104k and >104k) and categories of family structure (two-parent including those who were married or de facto and single-parent, reflecting those separated, divorced, widowed or never married). For maternal employment status, categories of paid job and unpaid job were treated as employed, while no job was treated as not-employed.

Statistical analyses

Only those participants who completed the FFQ at both ages (n=860) were included in the tracking analysis. Tracking was indicated by using a predictive value for remaining in the same quartile of the dietary pattern z-score or food group intake at 14 and 17 y. It was based on the proportion of individuals who remained in the same quartiles at 14 and 17 years, divided by those who moved into different quartiles between 14 and 17 years. A predictive value of greater than one indicates that more individuals stayed in the same quartiles than moved, while a predictive value of less than one indicates fewer individuals stayed in the same quartile than moved ⁽²¹⁾. As the smallest and largest values are located in the lowest (Quartile 1) and highest quartile (Quartile 4), respectively, greater consideration was given to those participants placed in these extreme quartiles.

To determine the early life and SEP determinants of 'energy dense, high fat, low fibre' dietary pattern z-scores at 14, and at 17 y, univariate linear regression models were firstly used to test each of the early life and SEP variables as likely determinants. Those that showed statistically significant differences across the quartiles of dietary pattern z-scores or with continuous dietary pattern z-scores (at 14 or 17 y) were then included in a multivariable linear regression model to identify the strongest determinants, based on the resulting β coefficients and associated p-values (Supplementary Table 2). These statistical analyses were conducted using STATA (version 12) with an alpha level of 0.05.

RESULTS

Characteristics of early life exposures and parental SES factors

Characteristics of the cohort at 14 and 17 y have been published elsewhere ⁽¹⁵⁾. Table 1 shows that boys and girls had similar early life factors, with the exception of smoking status at 18 weeks of pregnancy, which was more prevalent among the mothers of girls. The prevalence of maternal smoking during pregnancy was high in this study, with almost 30% of mothers smoking in the third trimester. Table 2 shows that (45%) of the mothers in this cohort had more than 12 y of education (completed more than senior high school) and three-quarters were employed when the study adolescents were 14 and 17 y (73%).

Tracking of dietary pattern z-scores and the key food groups

Table 3 shows the predictive values of remaining in either the lowest or highest quartiles for the dietary pattern z-scores and food group intakes for 860 adolescents who completed the FFQ at 14 and 17 y. The dietary pattern scores tracked most strongly for boys who were in the highest quartile at 14 y (predictive value >1 in Quartile 4). Whereas for girls, the predictive values were less than one in both extreme quartiles, suggesting more movement between quartiles and weaker tracking of the dietary pattern between 14 and 17 y.

Among boys, a high intake of foods positively loaded onto the dietary pattern, particularly processed meat, low-fibre bread, crisps and savoury snacks, showed stronger tracking than low intakes (Table 3). This indicated that high consumers were more likely to remain high consumers whereas, low consumers were more likely to move to different quartiles. By comparison, girls showed much weaker tracking for high intakes of foods positively loaded onto the dietary pattern (predictive values <1 in Quartile 4). Girls' tracking was also weak among low consumers of these foods (with the exception of low processed

meat intakes, which tracked strongly for girls). However, girls appeared more likely to remain low consumers than high consumers of these foods, than boys.

The strongest tracking for any food groups was seen among boys who were low consumers of foods negatively loaded onto the pattern (vegetables, fruit, legumes, high-fibre bread and yoghurts); positive predictive values ranged from 1.14 for legumes to 1.92 for yoghurts (Table 3). By comparison, tracking of these food groups was weaker and more mixed for girls however, the predictive values suggest that like boys, tracking was stronger for girls who were low consumers of these food groups, than high consumers (Table 3).

Determinants of an ‘energy dense, high fat, low fibre’ dietary pattern

Since there were few differences in early life and SEP characteristics between girls and boys (Table 1 and 2), the regression analysis was not stratified by gender. Univariate analyses indicated maternal age at child birth, paternal smoking (18 weeks gestation), maternal smoking (34 weeks gestation), maternal education, and family structure as having significant associations with dietary pattern z-scores (Supplementary Table 1). Maternal smoking status at 18 weeks gestation was strongly correlated with maternal smoking status at 34 weeks gestation, therefore only the latter was included in the multiple regression model, indicative of a sustained smoking during pregnancy. Maternal BMI, employment status, working hours, and annual household income were not associated with dietary pattern z-scores.

Multiple regression analysis indicated that a greater maternal age at birth was associated with a lower dietary pattern z-score ($\beta = -0.09$ at 14 y and $\beta = -0.11$ at 17 y, $p < 0.05$) (Table 4). Adolescents whose fathers smoked during their gestation had, on average, a 0.10 SD unit ($p = 0.049$) higher dietary pattern z-score at 14 y than those whose fathers did not smoke. Maternal smoking at 34 weeks gestation was not a significant determinant of the adolescent dietary pattern z-score at 14 or 17 y (Table 4).

Adolescents whose mothers had up to 12 years of education had a significantly higher dietary pattern z-score at 14 y and 17 y of age than adolescents whose mothers received more than 12 y of education (Table 4). Family structure was not a significant determinant of the adolescent's dietary pattern score at 14 or 17 y (Table 4).

DISCUSSION

These findings illuminate several aspects of dietary pattern tracking in this adolescent cohort, including the contributions of different food groups that are helpful for guiding interventions to improve dietary intakes in young people.

Individual scores for an energy dense, high fat, low fibre dietary pattern tracked most strongly for boys with the highest scores. Whereas, tracking of the dietary pattern was less evident among girls and among boys with low scores for this pattern.

Food group analyses showed that tracking was the strongest among boys who consumed low intakes of ‘healthy’ foods (vegetables, fruit, legumes, high-fibre bread and yoghurts) negatively associated with the energy-dense, high fat, low fibre dietary pattern. This was only partly reflected among girls who were low consumers (fruit and yoghurt only). However, high intakes of these ‘healthy’ food groups appeared less likely to track than low intakes in both boys and girls (predictive values all <1) indicating less stability in healthier dietary habits. High intakes of some foods positively associated with the dietary pattern (processed meat, low-fibre bread, crisps and savoury snacks) tracked to 17 years, but again this was observed in only boys. Taken together, this indicates that interventions aimed specifically at engaging adolescent boys may be needed. Given that low intakes of ‘healthy foods’ are most likely to be maintained (at least among adolescent boys in this study) interventions to address this may be more successful if introduced at younger ages. However, studies investigating the drivers of poor dietary choices among adolescent boys may be needed to further guide decisions on interventions in this group.

Despite evidence of dietary tracking for extreme quartiles of intake, many adolescents did not maintain their positions between the two time-points, suggesting that adolescent dietary intake is also subject to change, thus providing opportunities for effective interventions to promote healthier dietary patterns. The less consistent tracking observed for

girls in this study suggests that they may be more amenable to improving their dietary intakes than boys.

Few studies have reported the tracking of food group intakes according to high and low levels of consumption in young people. Patterson *et al.* reported the tracking of high intakes of selected food groups between 9 and 15 years of age among 273 children in the European Youth Heart Study ⁽²¹⁾. The predictive values for high intakes of vegetables (0.55), fruit (0.76), sweets and chocolate (0.43), crisps and chips (0.22) were comparable to those reported here (indicating weak tracking; gender-specific results were not reported), despite relying on a single 24 hour dietary recall at each time point, and inclusion of a younger group of children and longer follow up ⁽²¹⁾. A similar set of food groups was tracked between 7 and 15 years of age in the UK Avon Longitudinal Study of Parents and Children (ALSPAC), with findings similar to ours. The strongest tracking was observed in children who had the lowest intakes of ‘healthy foods’ (fruit, vegetables, high fibre bread, legumes, high-fibre breakfast cereals), in comparison with high consumers of these foods and both high and low consumers of ‘unhealthy’ food groups (e.g. chocolate and confectionery, low-fibre bread, processed meat, cakes and biscuits) ⁽²⁾.

Of the maternal factors examined in this study, only lower maternal education and age at child birth were associated with scores for the dietary pattern at 14 and 17 y of age. Higher maternal education has been shown as one of the key factors associated with knowledge about nutrition and health, and good diet quality in children ⁽²²⁻²⁴⁾. Children’s eating habits and food preferences are modelled on parents’ personal preferences, attitudes, knowledge and understanding of the importance of healthy dietary intakes ⁽²⁴⁾. An analysis in ALSPAC found that lower scores for an ‘energy dense, high fat, low fibre’ dietary pattern at ages five, seven and 13 were observed in children whose mothers had a higher education level ^(2, 20). This is

consistent with our findings and in other studies that have used empirical methods to identify similar dietary patterns in child cohorts ^(19, 25-28).

‘Unhealthy’ dietary patterns have been observed in children and adolescents of younger mothers ^(19, 29-31). Diets of young women may be different from those of older women, possibly because older women may have had more opportunity to gain greater nutrition knowledge or experience in meal planning and food preparation. In the Southampton Women’s Study (SWS), infants with higher scores for an ‘infant guidelines’ dietary pattern characterised by high consumption of fruit, vegetables, and home-made foods, were more likely to have older mothers compared to those who had lower scores for this dietary pattern ($p < 0.001$) ⁽¹⁹⁾. In the same study, mothers of infants having higher scores for an ‘adult food’ dietary pattern characterised by high intakes of bread, savoury snacks, biscuits and chips were more likely to be younger rather than older mothers ⁽¹⁹⁾. Two analyses conducted at different time points in the ALSPAC cohort concluded that ‘healthy’ dietary patterns were associated with higher maternal age, whereas children of younger mothers were associated with ‘unhealthy’ dietary patterns ^(27, 29).

In our study, higher scores for an ‘energy dense, high fat, low fibre’ dietary pattern in participants at 14 y was weakly linked to paternal smoking habits. This suggests that fathers’ health behaviours, not only mothers’, may be associated with their child’s diet quality. A cross-sectional analysis among Raine Study adolescents at 14 y reported a significantly higher ‘Western’ dietary pattern score (based on factor analysis) in adolescents whose parents smoked; conversely adolescents with non-smoking parents had a higher score for a ‘Healthy’ dietary pattern ⁽²⁸⁾.

The strengths of our study include a large sample size, analysis of a range of maternal and paternal factors as potential determinants of the dietary pattern associated with greater metabolic risk in adolescents. However, some limitations must be acknowledged. The

estimation of self-reported dietary intakes using a FFQ is not without limitations; however it provides important information on the composition of the diet, which is exploited here by the empirical dietary pattern analysis. The dietary pattern identified using a FFQ in this study cohort has shown moderate reliability when evaluated against a 3-day food record among adolescents at 14 y ⁽¹⁴⁾. Nonetheless, residual error and dietary misreporting cannot be ruled out as the FFQ was completed by study respondents' parents at 14 y and at 17 y, the respondents reported their own dietary intakes. Other limitations related to the derivation of the dietary patterns using RRR including measurement and correlated errors inherent to the dietary assessment method have been discussed previously ⁽¹⁵⁾.

Conclusions for practice

Tracking an energy-dense, high fat, low fibre dietary pattern that is associated with greater metabolic risk in adolescence has provided insights that may guide interventions to improve the dietary intakes of young people, to reduce their risk of non-communicable disease in adulthood. Adolescents, particularly boys, who have established poor dietary intakes by the age of 14 y are most likely to continue these into later adolescence. Early interventions aimed at engaging boys to increase their intakes of fruit, vegetables and other healthful food groups, deserve particular consideration. The observed associations between lower maternal education, younger maternal age at birth and paternal smoking, highlight subgroups of the population who may benefit the most from early interventions to help establish healthy dietary patterns in childhood. Research examining other social and environmental determinants of dietary choice in young people is warranted, to inform wider public health action to improve population dietary intakes.

Abbreviations

3-day FR	Three day food record
ALSPAC	Avon Longitudinal Study of Parents and Children
BMI	Body mass index
CHD	Coronary heart disease
CVD	Cardiovascular diseases
DP	Dietary pattern
FFQ	Food frequency questionnaire
PV	Predictive value
Raine	Western Australian Pregnancy (Raine) Cohort
RRR	Reduced rank regression
SES	Socio-economic status
SWS	Southampton Women's Study
y	Years

Acknowledgements

We are extremely grateful to all the Raine study participants and their families and the Raine Study team. We also wish to acknowledge the National Health and Medical Research Council of Australia for their funding contributions to the Raine study over the last 20 years, the Telethon Kids Institute at the University of Western Australia for long term support of the study and the Commonwealth Scientific and Industrial Research Organization for use of the FFQ.

Funding sources

This work was supported by a program grant from the Medical Research Council (grant number U105960389) and research grants from the National Health and Medical Research Council of Australia, the National Heart Foundation of Australia, and Beyond Blue Cardiovascular Disease and Depression Strategic Research Program. The first author was supported by a PhD studentship from the Ministry of Higher Education, Malaysia and Universiti Putra Malaysia. Management funding for the Raine Study was provided by the University of Western Australia, the Telethon Kids Institute, the Raine Medical Research Foundation, the Faculty of Medicine, Dentistry and Health Sciences of the University of Western Australia, the Women's and Infants Research Foundation and Curtin University.

Disclosures

All authors declare no competing interests.

REFERENCES

1. Kaikkonen J, Mikkilä V, Magnussen C et al. Does childhood nutrition influence adult cardiovascular disease risk?--insights from the Young Finns Study. *Ann Med*. 2013;45:120-128.
2. Ambrosini G, Emmett P, Northstone K et al. Tracking of a dietary pattern associated with increased adiposity in childhood and adolescence. *Obesity* 2014;22:458-466.
3. Deshmukh-Taskar P, Nicklas TA, Morales M et al. Tracking of overweight status from childhood to young adulthood: The Bogalusa Heart Study. *Eur J Clin Nutr*. 2006;60:48-57.
4. Mikkilä V, Rasanen L, Raitakari O et al. Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. *Br J Nutr*. 2005;93:923 - 931.
5. Boulton TJC, Magarey AM, Cockington RA. Tracking of serum lipids and dietary energy, fat and calcium intake from 1 to 15 years. *Acta Paediatr*. 1995;84:1050-1055.
6. Welten D, Kemper H, Post G et al. Longitudinal development and tracking of calcium and dairy intake from teenager to adult. *Eur J Clin Nutr*. 1997;51:612-618.
7. Twisk JWR, Kemper HCG, van Mechelen W et al. Tracking of risk factors for coronary heart disease over a 14-year period: A comparison between lifestyle and biologic risk factors with data from the Amsterdam Growth and Health Study. *Am J Epidemiol*. 1997;145:888-898.
8. Resnicow K, Smith M, Baranowski T et al. 2-year tracking of children's fruit and vegetable intake. *J Am Diet Assoc*. 1998;98:785-789.
9. Lien N, Lytle L, Klepp K. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Prev Med*. 2001;33:217 - 226.
10. Wang Y, Bentley ME, Zhai F et al. Tracking of dietary intake patterns of chinese from childhood to adolescence over a six-year follow-up period. *J Nutr*. 2002;132:430-438.
11. Cutler G, Flood A, Hannan P et al. Major patterns of dietary intake in adolescents and their stability over time. *J Nutr*. 2009;139:323 - 328.
12. Li J, Wang Y. Tracking of dietary intake patterns is associated with baseline characteristics of urban low-income African-American adolescents. *J Nutr*. 2008;138:94-100.
13. Skinner J, Bounds W, Carruth B et al. Predictors of children's body mass index: A longitudinal study of diet and growth in children ages 2-8 y. *Int J Obes*. 2004;28:476-482.
14. Appannah G, Pot G, O'Sullivan T et al. The reliability of an adolescent dietary pattern identified using reduced-rank regression: Comparison of a ffq and 3 d food record. *Br J Nutr*. 2014;112:609-615.
15. Appannah G, Pot G, Huang R et al. Identification of a dietary pattern associated with greater cardiometabolic risk in adolescence. *Nutr Metab Cardiovasc Dis*. 2015;25:643-650.
16. Newnham JP, Evans SF, Michael CA et al. Effects of frequent ultrasound during pregnancy: A randomised controlled trial. *Lancet*. 1993;342:887-891.
17. Ambrosini G, Klerk Nd, O'Sullivan T et al. The reliability of a food frequency questionnaire for use among adolescents. *Eur J Clin Nutr*. 2009;63:1251-1259.
18. Reilly J, Armstrong J, Dorasty A et al. Early life risk factors for obesity in childhood: Cohort study. *Br Med J*. 2005;330:1357.
19. Robinson S, Marriott L, Poole J et al. Dietary patterns in infancy: The importance of maternal and family influences on feeding practice. *Br J Nutr*. 2007;98:1029-1037.
20. Johnson L, Mander AP, Jones LR et al. Energy-dense, low fiber, high-fat dietary pattern is associated with increased fatness in childhood. *Am J Clin Nutr*. 2008;87:846-854.

21. Patterson E, Warnberg J, Kearney J et al. The tracking of dietary intakes of children and adolescents in Sweden over six years: The European Youth Heart Study. *Int J Behav Nutr Phys Act.* 2009;6:91.
22. Leary SD, Smith GD, Rogers IS et al. Smoking during pregnancy and offspring fat and lean mass in childhood. *Obesity* 2006;14:2284-2293.
23. Xie B, Gilliland FD, Li Y-F et al. Effects of ethnicity, family income, and education on dietary intake among adolescents. *Prev Med.* 2003;36:30-40.
24. Wardle J. Parental influences on children's diet. *Proc Nutr Soc.* 1995;54:747-758.
25. Aranceta J, Perez Rodrigo C, Ribas L et al. Sociodemographic and lifestyle determinants of food patterns in Spanish children and adolescents: The enkid Study. *Eur J Clin Nutr.* 2003;57:S40-S44.
26. Craig L, McNeill G, Macdiarmid J et al. Dietary patterns of school-age children in Scotland: Association with socio-economic indicators, physical activity and obesity. *Br J Nutr.* 2010;103:319 - 334.
27. Northstone K, Emmett P. Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *Eur J Clin Nutr.* 2005;59:751-760.
28. Ambrosini G, Oddy W, Robinson M et al. Adolescent dietary patterns are associated with lifestyle and family psycho-social factors. *Public Health Nutr.* 2009;12:1807 - 1815.
29. Smithers LG, Brazionis L, Golley RK et al. Associations between dietary patterns at 6 and 15 months of age and sociodemographic factors. *Eur J Clin Nutr.* 2012;66:658-666.
30. Northstone K, Emmett P. The associations between feeding difficulties and behaviours and dietary patterns at 2 years of age: The ALSPAC cohort. *Matern Child Nutr* 2012;doi: 10.1111/j.1740-8709.2012.00399.x.
31. Bell LK, Golley RK, Daniels L et al. Dietary patterns of Australian children aged 14 and 24 months, and associations with socio-demographic factors and adiposity. *Eur J Clin Nutr.* 2013;67:638-645.