Dietary patterns and weight status associated with behavioural problems in young children

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Abstract

Objective: To investigate the associations of behavioural problems with dietary patterns and weight status in young children.

Design: We assessed poor social skills and behavioural problems with a seventy-six-item Preschool and Kindergarten Behavior Scale (PKBS) and found three dietary patterns ('Korean healthy', 'animal foods' and 'sweets') in food/food group intake data assessed by an FFQ and analysed using factor analysis. Multiple logistic regression analyses were used to assess the association of diet and weight status with behaviour.

Setting: Pre-schools in the metropolitan areas of Korea.

Subjects: A total of 1458 children (mean age 5·2 (SD 0·9) years) from the Practical Approach for Better Maternal and Child Nutrition and Health Study conducted from 2001 to 2005.

Results: The 'Korean healthy' pattern showed a significant inverse association with poor social skills in the second highest quartile group (OR = 0·42; 95 % CI 0·21, 0·82) compared with the lowest quartile group for boys. For girls, the 'sweets' pattern was associated with a greater risk of poor social skills (OR = 3·41; 95 % CI 1·29, 9·01 at Q4 *v.* Q1) and problem behaviours (OR = 2·80; 95 % CI 1·05, 7·43 at Q4 *v.* Q1). Regarding weight status, both underweight and overweight boys had a higher risk of poor social skills than normal-weight boys.

Conclusions: Dietary patterns and weight status are important indicators for the behaviour of young children. Healthy and unhealthy dietary patterns, under-weight and overweight status, and gender differences should thus be considered for further studies.

Problematic child behaviour has become a critical issue in Korea, where at least one-third of children have been reported to have some type of behavioural problem[1]. According to nationwide studies of 75 643 adolescents in 2011, 42 % suffered from constant depression for more than 2 weeks during the last 12 months and 33 % of them suffered from severe stress. The prevalence of behavioural problems in Korean children is approximately 10 % greater compared with their counterparts in the USA[1,2].

What a person chooses to eat and drink influences the electrochemical activity of the brain and has an impact on that person's behaviour and cognitive functions[3–6]. Early childhood is a time of rapid and dramatic brain development, especially during the pre-school years, when there is a transition from the maternal-selected diet to food more based on the child's selection[3,4]. The impact of diet on the brain has strong and long-lasting effects for children in early childhood[3,4].

Poor nutrition, determined by levels of certain foods or nutrients such as animal products, sugar, glucose and micronutrients (i.e. Fe and thiamin), has an influence on cognition and behaviour in children, although the results are not consistent[3,5,7–12]. Obesity has also been linked to behavioural problems. However, the pattern, degree and direction of these associations are not clear[13–17].

One reason for this inconsistency could be significant associations partly due to chance inter-correlations among many components in the diet. Considering this issue, dietary patterns draw our attention because they provide an overall view of the diet that is not observed when evaluating individual nutrients from foods. The roles of a 'processed' and a 'Western' diet (with high fat and sugar contents) and a micronutrient-rich 'prudent' diet have

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been reported with respect to physical and mental health in children[18–23]. Investigating these dietary patterns further has important implications in public health because this dietary intake is visible and can subsequently be modified. The role of dietary patterns has been suggested in relation to obesity in young children[24]; however, the association between the Korean dietary pattern and behavioural problems in children of pre-school age has not been reported.

Methods

Participants and design

The Practical Approach for Better Maternal and Child Nutrition and Health Study recruited eleven urban pre-schools through multiple-step samplings. From the selected pre-schools, we chose 1724 children whose caregivers agreed to participate in our study from June 2001 to June 2005[24]. For the analyses of the present study, 1458 children with intake variables were selected for identifying dietary patterns. Among them, 1347 children who had complete records of dietary intake, weight, height and behavioural variables were included in the analyses with relation to behaviour.

Dietary intake

Dietary intake for each child was assessed by a validated semi-quantitative FFQ, including 100 food items. These food items were placed into nine non-overlapping categories according to the frequency of consumption (ranging from 'rarely eaten' to 'more than three times per day' during the preceding year) and portion size (small, average or large)[24]. The amount of each food item in the FFQ was converted into grams, from which we calculated the daily intakes of nutrients.

Child social-behavioural outcomes

A Korean version of the seventy-six-item Preschool and Kindergarten Behavior Scale (PKBS) was used to measure the problem behaviour and social skills of children[25,26]. The items on the PKBS were composed of two separate scales, each designed to measure separate domains: a thirty-four-item social skills scale and a forty-two-item problematic behaviour scale. Each of these two scales consisted of subscale structures. The social skills scale was composed of the following subscales: social cooperation (twelve items), social interaction (eleven items) and social independence (eleven items). The problem behaviour scale included two broad-band subscales: internalizing behaviours and externalizing behaviours. The internalizing broad-band scale consisted of two narrow-band scales, namely social withdrawal (seven items) and anxiety/somatic problems (eight items); and the externalizing broad-band scale was composed of three narrow-band scales, namely self-centred/explosive

(eleven items), attention problems/overactive (eight items) and anti-social/aggressive (eight items). A four-point Likert scale, ranging from 1 for 'never' to 4 for 'very often', was used to measure each item. Correlation coefficients, for internal consistency and interrelations of PKBS sub-scales for Korean children, ranged from 0·62 to 0·97[26]. In addition to the social skills scale, we used the problem behaviour scale by combining internalizing and externalizing scales due to a high correlation between these two behavioural variables ($r = 0·66$).

Based on our data, we defined the 15th and 85th percentiles as respective cut-off points for the behavioural scores from a statistical point of view, because these points are close to −1 SD and +1 SD. Children with social skills scores lower than the 15th percentile were considered to have a potential risk of poor social skills. For the problem behaviour scale, we identified children receiving scores greater than the 85th percentile as having a potential risk of this behavioural problem. The pre-school teacher responsible for each child completed the PKBS.

Assessment of other variables

The BMI of each child was calculated using his or her height and weight measures assessed by trained graduate students majoring in nutrition. Underweight and overweight status were defined respectively by the 5th and 85th percentiles of BMI for specific age and gender groups based on the Korean paediatric growth standards[27]. Other variables included in data analyses were the child's age, gender and daily nutrient intakes obtained by FFQ assessment, household monthly income (in one of three categories; 1 = less than ≈$US 1700, 2 = ≈$US 1700 to less than ≈$US 4300, 3 = greater than ≈$US 4300), mother's occupational status (1 = simple work, 2 = sales, 3 = office work, 4 = administrative position, 5 = professional, 6 = no job) and pre-school region, as described elsewhere[24]. We divided the maternal occupation variable into two groups (yes/no) and used it in data analyses.

Statistical analysis

In the present study, the dependent variables were the child's behaviours, including social skills and problem behaviour, and the major independent variables were the dietary patterns and weight status. Dietary patterns were identified based on thirty-three foods/food groups from the 100 food variables, adjusting energy intake by the residual method. Using factor analysis with the food/food group intake frequency variables, we developed the 'Korean healthy', 'animal foods' and 'sweets' dietary patterns. We used factor analysis because it has been suggested as a reliable method for dietary pattern analysis and is more commonly used in related studies[28,29].

The 'Korean healthy' dietary pattern indicated a relatively higher intake of vegetables, seaweed, beans, dried and fresh fish, kimchi, potatoes and nuts (Table 1). The 'animal foods' indicated a higher intake of fast foods, organ meat,

Table 1 Factor-loading matrix for the three dietary patterns and their foods or food groups identified in 1458 Korean pre-school children using intake frequency values with adjustment of energy intake, Practical Approach for Better Maternal and Child Nutrition and Health Study, 2001–2005

	'Korean healthy'	'Animal foods'	'Sweets'
Vegetables	0·67	−0·02	0·01
Seaweed	0·53	−0·07	0·03
Beans	0·52	−0·06	−0·13
Fruits	0·49	−0·03	−0·01
Dry fish (anchovy)	0·46	0·01	−0·06
Fresh fish	0·41	0·47	0·03
Kimchi	0·41	−0·08	−0·07
Potato	0·38	0·04	−0·01
Nuts	0·31	0·03	0·03
Sugary foods	0·00	−0·11	0·63
Chocolate	−0·08	−0·09	0·55
Sweet baked goods	−0·11	0·02	0·53
Sweet drinks	−0·14	0·10	0·45
Bread	0·11	0·02	0·34
Ice cream	−0·31	−0·13	0·33
Rice (*bab*)	−0·10	−0·19	−0·44
Fast foods	−0·12	0·60	0·09
Organ meat	0·07	0·59	−0·14
Poultry	0·00	0·51	0·00
Pork	0·06	0·44	−0·05
Beef	0·13	0·43	−0·02
Noodles	−0·14	0·42	0·00
Fish paste	0·16	0·40	0·04
Ramyeon	−0·25	0·33	0·04
Milk	0·14	−0·34	−0·02
Processed fish	0·11	0·26	0·11
Cereals	−0·02	0·05	0·21
Fats	0·25	0·10	0·27
Eggs	0·19	0·04	0·12
Rice cake	0·14	0·05	0·00
Dairy products	0·24	−0·20	0·26
Fruit juice	0·24	−0·09	0·19
Processed meat	−0·15	0·26	0·15

Cumulative eiganvalue for the three dietary patterns was 21·8 %.

poultry, pork, beef, processed fish cake, noodles and *ramyeon*. The 'sweets' pattern showed a higher intake of sugary foods, chocolate, sweet baked goods, sweet drinks, bread and ice cream (but a lower intake of rice). In each dietary pattern, we divided the children into four groups according to their dietary pattern scores.

The associations of background characteristics and nutrients with the dietary factor and behaviour scores were evaluated by Pearson correlations and univariate logistic analysis. Multiple logistic regression analyses were used to evaluate the associations of dietary patterns and weight status with behavioural outcomes while minimizing a possible role of family and child characteristics in these associations[30]. Potential confounding variables included pre-school (eleven schools), household monthly income, maternal occupation and the child's age, gender and BMI (only for dietary pattern variables). Except for the child's age, all confounding variables were categorical variables. We included total energy intake as a confounder in analysing the association between weight status and behaviour. Odds ratios and their 95 % confidence intervals were computed to assess the strength of the associations[30]. We performed data analysis using the statistical software package SAS version 9·3.

Results

The mean age of the children was 5·2 years and the proportions of boys and girls were similar (Table 2). The respective percentages of underweight and overweight children were 18·5 % and 16·0 % which indicated a similar level of overweight, but a higher level of underweight in our children, because we used 5th and 85th percentile values based on the Korean child growth standards as cut-off points for underweight and overweight status, respectively (Table 2). About 70 % of the children were from middle-class households and about half of the children had working mothers. Regarding nutrients, 60–95 % of the children met the Korean Dietary Reference Intake for micronutrients[31]. Mean carbohydrate, protein and fat intakes were comparable to the Korean Dietary Reference Intakes. Mean scores for social skills and problem behaviour were similar to those found in another study on Korean children who were selected from the general population[32] (Table 2).

In bivariate analyses, the 'Korean healthy' pattern was positively associated with protein and micronutrients such as Fe, β-carotene, folate and vitamins A, C and E (Table 3). The 'animal foods' pattern was relevant to a greater intake of protein and showed an inverse, but weaker relationship with antioxidant nutrients compared with the 'Korean healthy' pattern. The 'sweets' pattern had a positive relationship with fat intake and negative associations with protein and Fe intakes. Intake of carbohydrate was negatively associated with the dietary patterns because we used energy-adjusted intake variables to identify the dietary patterns. The risk of 'Korean healthy' diet intake was lower in girls than boys and lower among those who were underweight (Table 3). The 'animal foods' pattern was associated positively with age.

Behaviour variables were not associated with nutrient intakes in bivariate analysis (Table 3). The two behavioural problems were lower in older children and showed a lower risk in girls than boys. The poor social skills scale was associated positively with being underweight while the problem behaviour scale showed the opposite relationships. A higher risk of behavioural problems was found in the children who had working mothers (Table 3).

In multivariate analyses, children were divided into four groups (Q1–Q4) for each dietary pattern and two groups (poor *v.* normal behaviour) for each behaviour variable. The 'Korean healthy' dietary pattern showed a significant and inverse association with poor social skills in the second highest group (OR = 0·42; 95 % CI 0·21, 0·82) compared with the lowest intake group for boys (Table 4). For girls, the 'sweets' pattern was positively associated with a greater risk of poor social

Table 2 Background information of the Korean pre-school children, Practical Approach for Better Maternal and Child Nutrition and Health Study, 2001–2005

Variable	n	Mean	SD	Meeting % KDRI†
Age (years)	1461	5·2	0·9	
Nutrient				
Energy (kJ)	1478	6667	2729	51
Carbohydrate (% of energy)	1478	57·4	7·1	
Protein (% of energy)	1478	15·1	2·4	
Fat (% of energy)	1478	27·5	5·7	
Fe (mg)	1478	10·5	5·3	87
β-Carotene (μg)	1478	2676	2100	
Folate (μg)	1478	217·6	139·1	61
Vitamin A (μg RE)	1478	745·7	455·5	95
Vitamin C (mg)	1478	98·8	77·3	89
Vitamin E (mg)	1478	8·7	5·6	59
Behaviour				
Social skills	1320	107·3	16·9	
Problem behaviour	1317	72·2	22·1	
	n	%		
Gender				
Girl	708	48·1		
BMI				
Underweight	273	18·5		
Overweight	235	16·0		
Household income				
Less than $US 1700	400	28·0		
$US 1700 to less than $US 4300	925	64·7		
Greater than $US 4300	104	7·3		
Maternal occupation				
Yes	759	51·4		

KDRI, Korean Dietary Reference Intake; RE, retinol equivalents.
†References are the EER (estimated energy requirement) for energy and the EAR (estimated average requirement) for other nutrients based on the KDRI.

Table 3 Univariate associations of dietary patterns and behavioural problems with background information variables among Korean pre-school children, Practical Approach for Better Maternal and Child Nutrition and Health Study, 2001–2005

	n	'Korean healthy' r	'Animal foods' r	'Sweets' r	n	Poor social skills r	Problem behaviour r
Nutrient							
Energy (kJ)	1458	0·00	0·00	0·00	1320	−0·02	−0·01
Carbohydrate	1458	−0·13**	−0·30**	−0·11**	1320	0·00	0·02
Protein	1458	0·44	0·32**	−0·22**	1320	−0·05	−0·05
Fat	1458	−0·02**	0·24**	0·23**	1320	0·01	−0·01
Fe	1458	0·26**	0·02	−0·09**	1320	−0·01	−0·02
β-Carotene	1458	0·53**	−0·06*	−0·05*	1320	−0·03	−0·04
Folate	1458	0·43**	−0·07*	−0·05	1320	−0·01	0·00
Vitamin A	1458	0·42**	−0·06*	0·00	1320	−0·03	−0·04
Vitamin C	1458	0·37**	−0·08**	0·01	1320	−0·01	0·00
Vitamin E	1458	0·19**	0·27**	0·03	1320	−0·01	−0·02
Age	1458	0·04	0·11**	−0·03	1320	−0·18**	−0·10**

	n	OR†	95 % CI	OR†	95 % CI	OR†	95 % CI	n	OR‡	95 % CI	OR‡	95 % CI
Gender												
Boy	752	1·00	–	1·00	–	1·00	–	688	1·00	–	1·00	–
Girl	701	0·77	0·63, 0·95	0·92	0·75, 1·14	0·91	0·74, 1·12	632	0·46	0·33, 0·63	0·34	0·24, 0·48
BMI												
Normal	962	1·00	–	1·00	–	1·00	–	907	1·00	–	1·00	–
Underweight	257	0·66	0·50, 0·87	0·80	0·61, 1·06	1·03	0·79, 1·36	186	3·41	2·56, 4·54	0·62	0·40, 0·97
Overweight	234	0·81	0·61, 1·08	0·84	0·63, 1·12	1·22	0·91, 1·62	227	0·94	0·65, 1·36	0·93	0·61, 1·41
Household income												
Less than $US 1700	390	1·00	–	1·00	–	1·00	–	359	1·00	–	1·00	–
$US 1700 to less than $US 4300	916	0·84	0·66, 1·08	0·99	0·78, 1·26	1·06	0·83, 1·34	829	0·70	0·50, 0·98	1·05	0·74, 1·48
Greater than $US 4300	104	0·78	0·51, 1·20	1·34	0·87, 2·07	0·84	0·55, 1·30	97	0·83	0·45, 1·53	1·17	0·64, 2·16
Maternal occupation												
No	709	1·00	–	1·00	–	1·00	–	657	1·00	–	1·00	–
Yes	749	1·16	0·95, 1·43	0·95	0·77, 1·17	1·02	0·83, 1·25	663	1·47	1·09, 2·00	1·35	1·00, 1·83

*$P < 0.05$, **$P < 0.01$ for Pearson correlation coefficients using continuous variables.
†Dietary pattern variables were divided into two groups based on median values.
‡Behavioural variables were divided into poor (15 % of the children) and normal (85 % of the children) groups.

Table 4 Association between dietary patterns and behavioural problems in Korean pre-school children by gender using multivariate logistic analysis, Practical Approach for Better Maternal and Child Nutrition and Health Study, 2001–2005

	Poor social skills, ref. = low				Problem behaviour, ref. = low			
	OR	95 % CI	P Wald	P trend	OR	95 % CI	P Wald	P trend
'Korean healthy'								
Boys								
Q1	1·00	–	0·03	0·13	1·00	–	0·35	0·23
Q2	1·12	0·66, 1·92			1·16	0·69, 1·96		
Q3	0·42	0·21, 0·82			0·72	0·41, 1·27		
Q4	0·83	0·47, 1·48			0·81	0·46, 1·42		
Girls								
Q1	1·00	–	0·79	0·52	1·00	–		
Q2	1·51	0·66, 3·45			0·99	0·42, 2·30	0·99	0·73
Q3	1·41	0·62, 3·21			0·89	0·38, 2·07		
Q4	1·38	0·59, 3·20			0·88	0·37, 2·09		
'Animal foods'								
Boys								
Q1	1·00	–	0·88	0·76	1·00	–	0·82	0·62
Q2	0·92	0·51, 1·66			0·84	0·48, 1·47		
Q3	1·16	0·64, 2·11			1·02	0·58, 1·79		
Q4	1·01	0·55, 1·88			1·09	0·62, 1·91		
Girls								
Q1	1·00	–	0·29	0·36	1·00	–		
Q2	1·12	0·57, 2·49			0·59	0·25, 1·41	0·21	0·14
Q3	1·39	0·68, 2·81			0·91	0·43, 1·92		
Q4	1·86	0·96, 3·36			0·41	0·16, 1·04		
'Sweets'								
Boys								
Q1	1·00	–	0·82	0·68	1·00	–	0·99	0·88
Q2	1·2	0·67, 2·14			1·05	0·60, 1·82		
Q3	0·97	0·52, 1·80			1·11	0·63, 1·96		
Q4	1·22	0·68, 2·22			1·03	0·58, 1·81		
Girls								
Q1	1·00	–	0·06	0·01	1·00	–	0·22	0·04
Q2	2·39	0·87, 6·60			1·93	0·68, 5·44		
Q3	3·36	1·29, 8·80			2·24	0·83, 6·04		
Q4	3·41	1·29, 9·01			2·80	1·05, 7·43		

ref., referent category.
Respective numbers of children belonging to the low *v.* high groups of the poor social skills and problem behaviour scores were 475 *v.* 112 and 453 *v.* 132 for boys and 504 *v.* 56 and 511 *v.* 47 for girls.
Adjusted for household income, maternal occupation, pre-school, child's age, sex and BMI, and total energy intake.

Table 5 Association between weight status and behavioural problems in Korean pre-school children by gender using multivariate logistic analysis, Practical Approach for Better Maternal and Child Nutrition and Health Study, 2001–2005

	Poor social skills, ref. = low			Problem behaviour, ref. = low		
	OR	95 % CI	P Wald	OR	95 % CI	P Wald
Boys			<0·01			0·44
Normal	1·00	–		1·00	–	
Underweight	2·03	1·19, 3·45		0·72	0·40, 1·30	
Overweight	1·86	1·11, 3·10		1·14	0·68, 1·88	
Girls			0·57			0·34
Normal	1·00	–		1·00	–	
Underweight	0·87	0·39, 1·94		1·40	0·66, 2·95	
Overweight	0·64	0·27, 1·49		0·64	0·27, 1·49	

ref., referent category.
Respective numbers of children belonging to the low *v.* high groups of the poor social skills and problem behaviour scores were 532 *v.* 129 and 518 *v.* 141 for boys and 553 *v.* 60 and 561 *v.* 52 for girls.
Adjusted for household income, maternal occupation, pre-school, child's age and gender, and total energy intake.

skills (OR = 3·41; 95 % CI 1·29, 9·01 at Q4 *v.* Q1) and problem behaviour (OR = 2·80; 95 % CI 1·05, 7·43 at Q4 *v.* Q1). The 'animal food' pattern had no association with behavioural problems.

Both overweight and underweight boys had a higher risk of poorer social skills than normal-weight boys (Table 5). The problem behaviour scores did not differ according to weight status for both genders.

Discussion

We found that the 'Korean healthy' pattern was associated with pro-social behaviours in boys, while the 'sweets' pattern was associated with anti-social behaviours in girls. For weight status, both underweight and overweight boys had a higher risk of poor social skills than normal-weight boys.

Our findings support the results of other studies on Western children suggesting a considerable role of dietary patterns on behaviour in children[15,18–23]. In a prospective cohort study, a poor diet, similar to the 'sweets' dietary pattern in the present study, at 3 years of age was negatively related to intelligence quotient at 8·5 years of age, while the opposite association was found for a better diet similar to our 'Korean healthy' dietary pattern[20]. The magnitude of this association was greater in the poor diet than in the better diet[20]. In other studies, children with a higher intake of the Western diet, a combination of the 'animal foods' and 'sweets' dietary patterns, also had a greater risk of anti-social behaviours[15,18,22].

One potential reason for the association between diet and behaviour is the nutrient content of the diet. The 'Korean healthy' pattern is an antioxidant-rich diet that includes vitamins A, C and E, β-carotene and folate (Table 2). Antioxidant nutrients protect against oxidative stress and cell damage from free radicals, preserving neural functions[3–5]. Similar to antioxidant nutrients, folic acid is required for neurotransmitters[3,10]. Maternal folate status during early pregnancy has been reported to have an inverse association with emotional problems in the offspring in a large-scale cohort study[33].

Another important finding is a negative role of the 'sweets' pattern in behavioural problems for girls. Sweet foods are relevant to sucrose that could produce a rapid rise of blood glucose, which in turn induces a rapid fall to a level that disrupts brain function[11,34]. Less sugar from fruit snacks and/or lower vitamin C intake has been reported to have a positive association with the risk for attention-deficit hyperactivity disorder in school-aged Korean children[35], although the adverse influence of sugar is not clear[34].

Glucose may need a shorter period of time to respond to human body needs than micronutrients[34]. The 'Korean healthy' pattern related to micronutrients suggests a relative long-term effect of nutrition on health compared with the 'sweets' pattern associated with glucose. These interpretations imply that chronic rather than acute response to nutrition would be meaningful in behaviour for boys while the opposite response would be important for girls according to the context of the Korean diet. However, this suggestion is limited because a simple sugars intake variable was not available in our data.

We found a 'U' shape in the relationship between weight status and behaviour. Besides obesity, being underweight presented a higher level of poor social behaviour in boys. Accumulating evidence suggests an important role of obesity on problematic behaviours, although the results are not consistent in terms of the direction of the association and/or gender[3,13,14,16]. One of the reasons could be that being underweight limits exposure to the external environment and induces lethargy in young children, which could then weaken their pro-social behaviour[36].

A gender difference in the association between weight and behaviour requires attention. Previous studies have suggested a gender difference in adolescents but not children of pre-school age[36]. To our knowledge, our study is the first one to show the importance of weight status and gender in relation to behaviour in young children.

The present study has both limitations and strengths. The Korean version of the PKBS we used is not a diagnostic instrument. We assessed children with behavioural problems based on a statistical point of view rather than clinical considerations. It was a cross-sectional study of free-living children, thus evidence linking dietary pattern and weight status with behaviour may be inconclusive because unmeasured or unexamined variables (such as environmental pollution, parenting style, physical activities and genetic factors) could partly explain the outcome[37].

One of the strengths of the present study is that the examination of dietary patterns can overcome the problem of inter-correlations from many dietary components. Furthermore, the study is the first to present the importance of a Korean-style healthy diet on the behaviour of young children. The associations between the type of behaviour (e.g. pro- v. anti-social behaviours) and dietary patterns (healthy v. unhealthy diets) are meaningful because of a lack of related research for young children. Further research, such as a cohort study, may be needed to confirm our findings.

Conclusion

In conclusion, our analyses suggest that dietary patterns and weight status are important for the behaviour of young children. Healthy and unhealthy dietary patterns, underweight and overweight status, and gender differences should be considered for further studies.

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