Assessment of nutrient intakes of picky-eating Chinese preschoolers using a modified food frequency questionnaire

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Original article

Background: **Dietary assessment is crucial for monitoring nutritional status of young children. This study applied a modified Chinese food frequency questionnaire (FFQ) to assess nutrient intakes of young picky-eating Hong Kong children.**

Methods: **Nutrient intakes were obtained by FFQ and 3-day food record (3DFR) in 29 picky-eating children aged 44.8±9.2 months who participated in a randomised controlled trial of a new milk formula.**

Results: **When compared with 3DFR, FFQ over-reported energy intake by 283 kcal (26.5%) at baseline and 237 kcal (21.4%) at end-of-study, and also over-estimated intakes of carbohydrates, proteins and fats. At baseline, FFQ and 3DFR classified 34.4%-65.5% of subjects into the same tertiles for most nutrients. These methods showed weak-to-moderate agreement in measuring most nutrients, with 3DFR showing a trend towards a systematic increase in the differences with increasing nutrient intake.**

Conclusion: **Our FFQ shows promising results for assessing nutrient intakes in picky-eating Chinese preschoolers.**

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Key words: **Chinese; food frequency questionnaire; nutrition; preschooler**

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Introduction

Dietary assessment is crucial for monitoring the nutritional status of children, examining association between diet and health, and identifying dietary factors that are associated with individual clinical conditions. However, measuring diet in very young children is difficult because of the rapid changes in food habits of toddlers, the need to rely on parental report, and the questionable ability of parents to accurately report their children's diet when other caregivers, such as at day care, also feed the child. Food frequency questionnaire (FFQ) reported by parents appears to be a reasonably valid method to collect dietary data in children even in situations when parents do not observe all meals and snacks eaten by their children.[1,2] Most published FFQs were designed and validated in Caucasian populations.[2-8] Population-specific FFQ must be used due to wide variations in dietary habits between different populations. Woo et al[9] developed an FFQ for Chinese adults in Hong Kong, which has subsequently been adapted for use in school-age children and elderly.[10-12] This study adapted the above Chinese FFQ appropriately to reflect the portion sizes typically consumed by young children and applied the modified FFQ to assess nutrient intakes in picky-eating Hong Kong preschool children. A 3-day food record (3DFR) was used as our reference method.

Methods

Subjects and study design

Subjects were Chinese children aged 2-5 years from local kindergartens who participated in a multi-center, randomized controlled trial that studied the efficacy of 4-month treatment with a balanced cow's milk formula.[13] The subjects were reported by parents to have picky-eating behaviour, and with weight-for-height indicator ≤25th percentile according to the World Health Organisation Child Growth Standards (http://www.who.int/childgrowth/en/). Subjects' parents completed FFQ and 3DFR at baseline and 4 months later.

Our FFQ consisted of 262 items categorised into 10 groups: bread/cereals/pasta/rice/noodles, vegetables and legumes, fruits, meat, fish, eggs, milk and dairy products, beverages, dim sum/snacks/fats/oils, and soups. Parents completed this FFQ with the assistance from trained research staff. The options for frequency varied from "never/less than once per month" to "several times a day". Three dimensional food models were provided for parents to aid their estimation of the portion sizes. Our modified FFQ was pilot-tested for readability in five preschool children with allergies before use in this study.

At each time point, the 3DFR covered two weekdays and one weekend. All subjects were instructed to follow their usual diet on those 3 days. Parents were provided with record notebooks and photographic booklets that included colour photographs of common food items and of household measuring units such as differently sized bowls, plates, spoons, cups and glasses to aid the estimation of food portions. Parents were also asked to provide detailed description of each food, including brand name or method of preparation and recipes, whenever possible.

The recording of food intake by 3DFR started 5-7 days after FFQ at baseline, and the sequence was reversed with 3DFR completed 5-7 days ahead of FFQ at 4 months. The Clinical Research Ethics Committee of our University approved this study, and informed written consent was obtained from the parents of the studied children.

Dietary assessment methods

Our 262-item FFQ incorporated appropriate changes of the initial FFQ[9] to reflect portion sizes typically consumed by young children. Because dietary intake is highly variable at this age, parents were asked to think of their children's diet over the past one month when they filled in such questionnaire. 3DFR based on estimated food intakes covered two weekdays and one weekend. All subjects were instructed to follow their usual diet on those 3 days.

Nutrient calculations

Foods and nutrient intakes obtained from FFQ and 3DFR were computed by the Foodworks nutrient analysis software (Professional version 6; Xyris Software, Highgate Hill, Queensland, Australia), with the addition of some local foods based on food composition tables from China.[14,15]

Statistical analysis

Numerical variables were compared between the two

Table 1. Clinical features of study participants at study baseline and completion

Feature	Baseline (n=29)		End of 4-month study (n=25)	
	N (%) or Mean (SD)	Range	N (%) or Mean (SD)	Range
Boys	14 (48.3)		12 (48.0)	
Age (mon)	44.8 (9.2)	31.1-58.4	48.6 (9.5)*	35.3-62.6
Weight (kg)	12.6 (2.1)	9.1-16.9	13.4 (2.3)*	9.7-19.3
Height (cm)	95.9 (7.7)	82.2-111.0	97.8 (7.2)*	85.5-112.1
BMI (kg/m^2)	13.67 (0.66)	12.19-14.66	13.9 (0.79)	12.29-15.52
BMI z-score	-1.63 (0.72)	-3.12--0.57	-1.29 (0.91)†	-3.44-0.32

BMI: body mass index; SD: standard deviation. *: P<0.001; †: P<0.05, when compared with baseline values (analysed by Wilcoxon signed rank test).

Table 2. Daily absolute intakes of energy and nutrients based on FFQ and 3DFR at baseline (n=29)

Nutrients	FFQ	3DFR	P value‡	Spearman ρ (95% CI)
Energy (kcal)	1351.8 (1011.0-1964.4)	1069.1 (905.4-1259.5)	0.002	0.299 (-0.08, 0.60)
Protein (g)	57.2 (41.1-92.2)	46.9 (37.3-58.6)	0.018	0.351 (-0.02, 0.64)
Total fat (g)	44.3 (29.7-61.6)	35.9 (26.0-43.2)	0.007	0.465 (0.12, 0.72)*
Saturated fat (g)	13.4 (8.5-20.8)	13.1 (10.7-16.7)	0.837	0.392 (0.03, 0.66)*
Polyunsaturated fat (g)	7.9 (6.1-11.3)	4.0 (2.7-5.9)	<0.001	0.521 (0.19, 0.75)†
Monounsaturated fat (g)	16.6 (9.9-20.7)	10.4 (7.9-16.2)	0.003	0.374 (0.01, 0.66)*
Carbohydrate (g)	207.9 (141.3-271.9)	136.2 (121.8-153.5)	0.001	0.095 (-0.29, 0.45)
Sugar (g)	62.4 (43.6-107.7)	49.7 (44.3-67.6)	0.007	0.369 (0.00, 0.65)*
Dietary fibre (g)	10.9 (7.8-19.8)	9.1 (5.6-11.3)	0.013	0.382 (0.02, 0.67)*
Thiamine (mg)	1.4 (0.9-1.9)	1.0 (0.8-1.5)	0.030	0.561 (0.25, 0.78)†
Riboflavin (mg)	1.2 (0.9-1.8)	1.1 (0.9-1.4)	0.061	0.344 (-0.03, 0.64)
Niacin equivalents (mg)	26.3 (17.8-39.5)	22.1 (17.9-27.7)	0.071	0.291 (-0.08, 0.60)
Vitamin C (mg)	94.1 (70.0-177.6)	75.9 (56.0-98.8)	0.006	0.189 (-0.19, 0.53)
Vitamin A (µg)	446.3 (238.5-1025.2)	561.9 (427.0-720.2)	0.905	0.074 (-0.31, 0.43)
Magnesium (mg)	215.1 (144.2-315.4)	160.7 (123.9-196.1)	0.002	0.551 (0.24, 0.77)†
Calcium (mg)	609.6 (385.8-873.0)	459.3 (333.2-600.2)	0.002	0.537 (0.22, 0.76)†
Phosphorus (mg)	898.7 (657.3-1544.3)	746.0 (628.8-941.9)	0.008	0.499 (0.16, 0.74)†
Iron (mg)	11.0 (7.5-17.2)	8.8 (7.0-11.4)	0.007	0.580 (0.28, 0.79)†
Zinc (mg)	7.9 (5.7-11.9)	5.9 (5.2-8.1)	0.002	0.502 (0.17, 0.74)†

3DFR: 3-day food record; CI: confidence interval; FFQ: food frequency questionnaire. Values are expressed as median (interquartile range). *: P<0.05; †: P<0.01; ‡: Analysed between FFQ and 3DFR by Wilcoxon's signed-rank test.

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dietary assessment methods by Wilcoxon's signed-rank test, whereas the correlations between the two measurements were analysed by Spearman's rank-order correlation coefficients. The agreement between the two dietary assessment methods was analysed by Bland-Altman plots, and the agreement between categorical parameters was examined by kappa coefficients following the classification of absolute nutrient intakes into tertiles. All analyses were performed by SPSS v.17 (SPSS Inc., Chicago, IL, USA), and P values <0.05 were considered to be statistically significant.

Results

Intakes of individual nutrients by FFQ and 3DFR

Twenty-nine subjects (Table 1) returned both FFQ and 3DFR at baseline, and two boys and two girls were lost to follow-up. Table 2 summarizes the daily

Table 3. Daily absolute intakes of energy and nutrients based on FFQ and 3DFR at study completion (n=25)

Nutrients	FFQ	3DFR	P value‡	Spearman ρ (95% CI)
Energy (kcal)	1342.1 (1285.4-1630.8)	1105.4 (969.4-1490.3)	0.002	0.567 (0.23, 0.79)†
Protein (g)	61.2 (45.4-78.0)	53.3 (40.7-68.1)	0.083	0.601 (0.28, 081)†
Total fat (g)	53.3 (39.8-62.6)	35.0 (30.8-45.5)	0.001	0.480 (0.11, 074)*
Saturated fat (g)	13.1 (8.4-16.6)	10.3 (8.0-15.9)	0.088	0.701 (0.43, 0.87)†
Polyunsaturated fat (g)	8.2 (5.2-11.9)	4.0 (2.4-6.3)	<0.001	0.510 (0.14, 0.76)†
Monounsaturated fat (g)	15.2 (10.6-21.4)	9.8 (6.3-15.4)	0.005	0.548 (0.20, 0.78)†
Carbohydrate (g)	179.6 (165.3-197.4)	147.0 (133.6-200.7)	0.002	0.549 (0.20, 0.78)†
Sugar (g)	61.0 (36.0-71.3)	46.0 (26.7-57.3)	0.058	0.563 (0.22, 0.79)†
Dietary fibre (g)	11.3 (7.7-17.0)	8.1 (5.4-13.3)	0.014	0.488 (0.12, 0.75)*
Thiamine (mg)	1.2 (1.0-1.7)	1.1 (0.9-1.5)	0.276	0.369 (-0.03, 0.67)
Riboflavin (mg)	1.3 (1.1-1.8)	1.0 (0.9-1.4)	0.045	0.255 (-0.16, 0.60)
Niacin equivalents (mg)	25.7 (19.4-30.9)	23.1 (17.4-27.9)	0.109	0.534 (0.18, 0.77)†
Vitamin C (mg)	104.5 (80.2-149.9)	65.0 (52.7-91.7)	<0.001	0.647 (0.34, 0.84)†
Vitamin A (μg)	744.6 (530.4-1149.3)	627.0 (428.7-803.0)	0.231	0.485 (0.11, 0.75)*
Magnesium (mg)	219.7 (166.2-284.8)	160.4 (122.1-203.1)	<0.001	0.543 (0.19, 0.78)†
Calcium (mg)	760.8 (591.9-879.7)	579.4 (447.5-707.3)	<0.001	0.375 (-0.02, 0.67)
Phosphorus (mg)	924.1 (804.7-1233.8)	754.8 (678.9-1065.5)	0.013	0.535 (0.18, 0.77)†
Iron (mg)	11.8 (9.8-15.5)	9.9 (8.9-12.1)	0.021	0.595 (0.27, 0.80)†
Zinc (mg)	9.1 (7.3-11.5)	7.8 (6.3-9.8)	0.007	0.781 (0.56, 0.90)†

3DFR: 3-day food record; CI: confidence interval; FFQ: food frequency questionnaire. Values are expressed as median (interquartile range). *: P<0.05; †: P<0.01; ‡: Analysed between FFQ and 3DFR by Wilcoxon's signed-rank test.

Table 4. Percentages of subjects classified into the same tertiles and misclassified into opposite tertiles of measured nutrient intakes at baseline and study completion

Nutrients	Baseline, % in tertiles			End of study , % in tertiles		
	Same	Opposite	Kappa (κ_ω)	Same	Opposite	Kappa (κ_ω)
Energy (kcal)	55.1	13.8	0.328*	52.0	8.0	0.279*
Protein (g)	41.3	17.2	0.120	56.0	4.0	0.339*
Total fat (g)	58.6	13.8	0.381†	48.0	4.0	0.219
Saturated fat (g)	44.8	17.2	0.173	52.0	0.0	0.279*
Polyunsaturated fat (g)	48.2	6.8	0.225	44.0	8.0	0.159
Monounsaturated fat (g)	44.8	17.2	0.173	44.0	8.0	0.159
Carbohydrate (g)	34.4	17.2	0.016	36.0	0.0	0.038
Sugar (g)	51.7	20.7	0.278*	56.0	4.0	0.339*
Dietary fibre (g)	51.7	17.2	0.276*	36.0	8.0	0.038
Thiamine (mg)	44.8	6.9	0.174	40.0	12.0	0.099
Riboflavin (mg)	48.2	17.2	0.226	40.0	8.0	0.101
Niacin equivalents (mg)	44.8	17.2	0.173	56.0	4.0	0.339*
Vitamin C (mg)	37.9	20.7	0.068	48.0	12.0	0.219
Vitamin A (μg)	27.5	20.6	-0.086	60.0	8.0	0.399†
Magnesium (mg)	51.6	10.3	0.275*	60.0	8.0	0.399†
Calcium (mg)	44.7	6.9	0.174	48.0	12.0	0.219
Phosphorus (mg)	34.4	10.3	0.020	52.0	8.0	0.279*
Iron (mg)	65.5	6.8	0.482‡	56.0	4.0	0.339*
Zinc (mg)	37.9	6.8	0.071	64.0	4.0	0.459†

*: P<0.05; †: P<0.01; ‡: P<0.005.

absolute intakes of energy and nutrients based on FFQ and 3DFR at baseline. FFQ over-reported the energy intake in our subjects by 283 kcal (26.5%). Generally, medium to high correlations were found in most nutrients (Spearman's rank-order correlation coefficient, ρ>0.29). Table 3 summarizes the daily absolute intakes of energy and nutrients based on FFQ and 3DFR at study completion. FFQ over-reported energy intake by about 237 kcal (21.4%). This method also yielded higher estimates for intakes of many other nutrients. No significant differences were found between the estimates of intakes of other nutrients by these two methods. Medium to high correlations were found between FFQ and 3DFR in all nutrients (ρ>0.35) except riboflavin (ρ=0.255).

Agreement for nutrient intakes by FFQ and 3DFR

Table 4 summarizes the percentages of subjects who were correctly classified and misclassified for nutrient intakes at baseline and study completion. At the baseline, the two methods classified 34.4%-65.5% of subjects into the same tertiles for most nutrients. Gross misclassification (from one extreme tertile to the other extreme) occurred at a median of 17.2% (range: 6.8%-20.7%). FFQ and 3DFR showed weak to moderate agreement (κ_ω) in the measurements of most nutrients (ranged from κ_ω=0.016 for energy intake from carbohydrate to κ_ω=0.482 for iron). At the study completion, FFQ and 3DFR classified 36%-64% of subjects into the same tertile. Gross misclassification occurred at a median of 8.0% (range: 0-12.0%). The two methods again showed weak to moderate agreement for all nutrients (ranged from κ_ω=0.038 for carbohydrate and dietary fibres to κ_ω=0.459 for zinc). The agreement for iron intakes was satisfactory at the baseline and the end of the study.

Figs. 1 and 2 are Bland-Altman plots for the agreement in selected nutrients by FFQ and 3DFR. There was a trend towards a systematic increase in the differences between FFQ and 3DFR with increasing intake. Our observed differences suggested that participants both under-reported and over-reported nutrient intakes with FFQ compared with 3DFR.

Discussion

Vereecken and colleagues[8] compared food intakes by a 77-item FFQ with an online 3DFR in 216 Belgian-Flemish preschool children. At the group level, they identified good agreement for energy, fat and protein

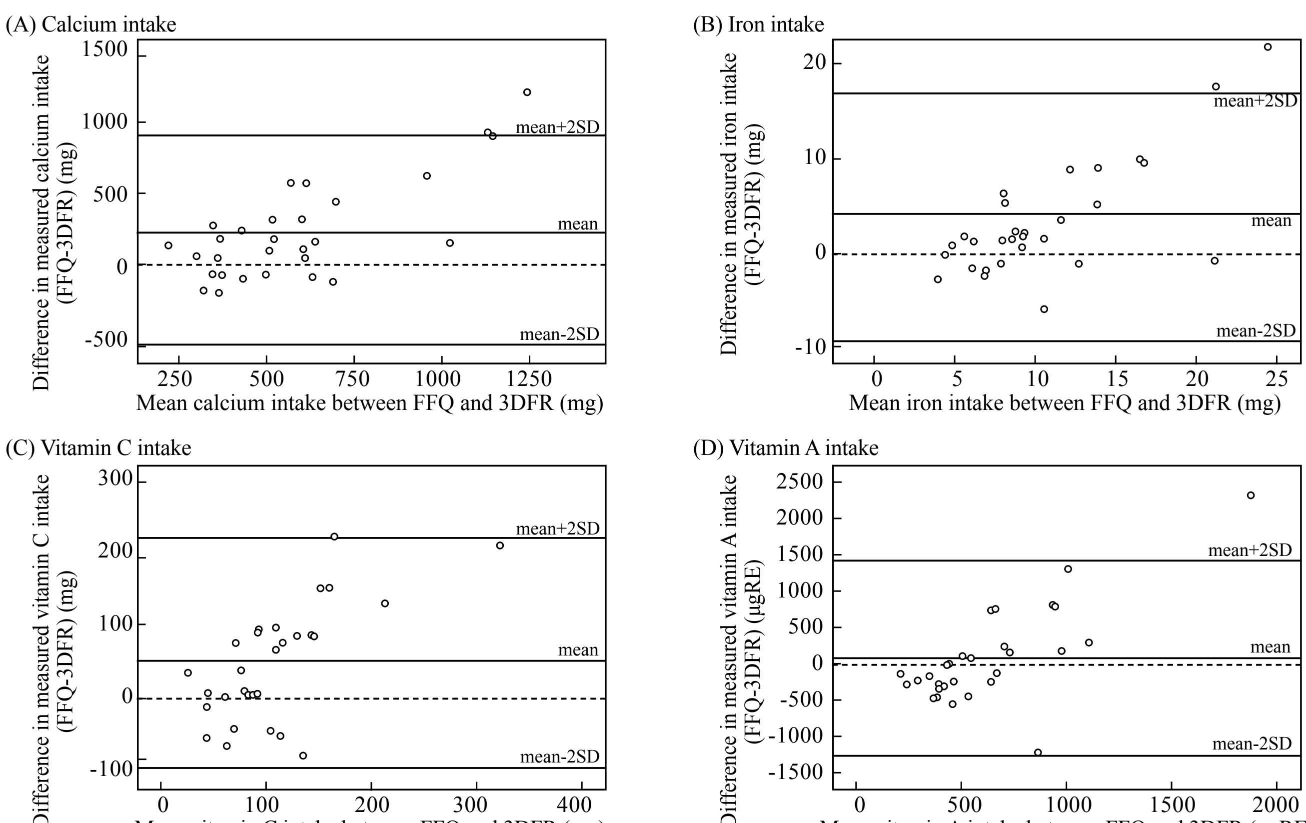

Fig. 1. Bland-Altman plots for the agreement between FFQ and 3DFR at baseline for assessing intakes of (A) calcium; (B) iron; (C) vitamin C; and (D) vitamin A.

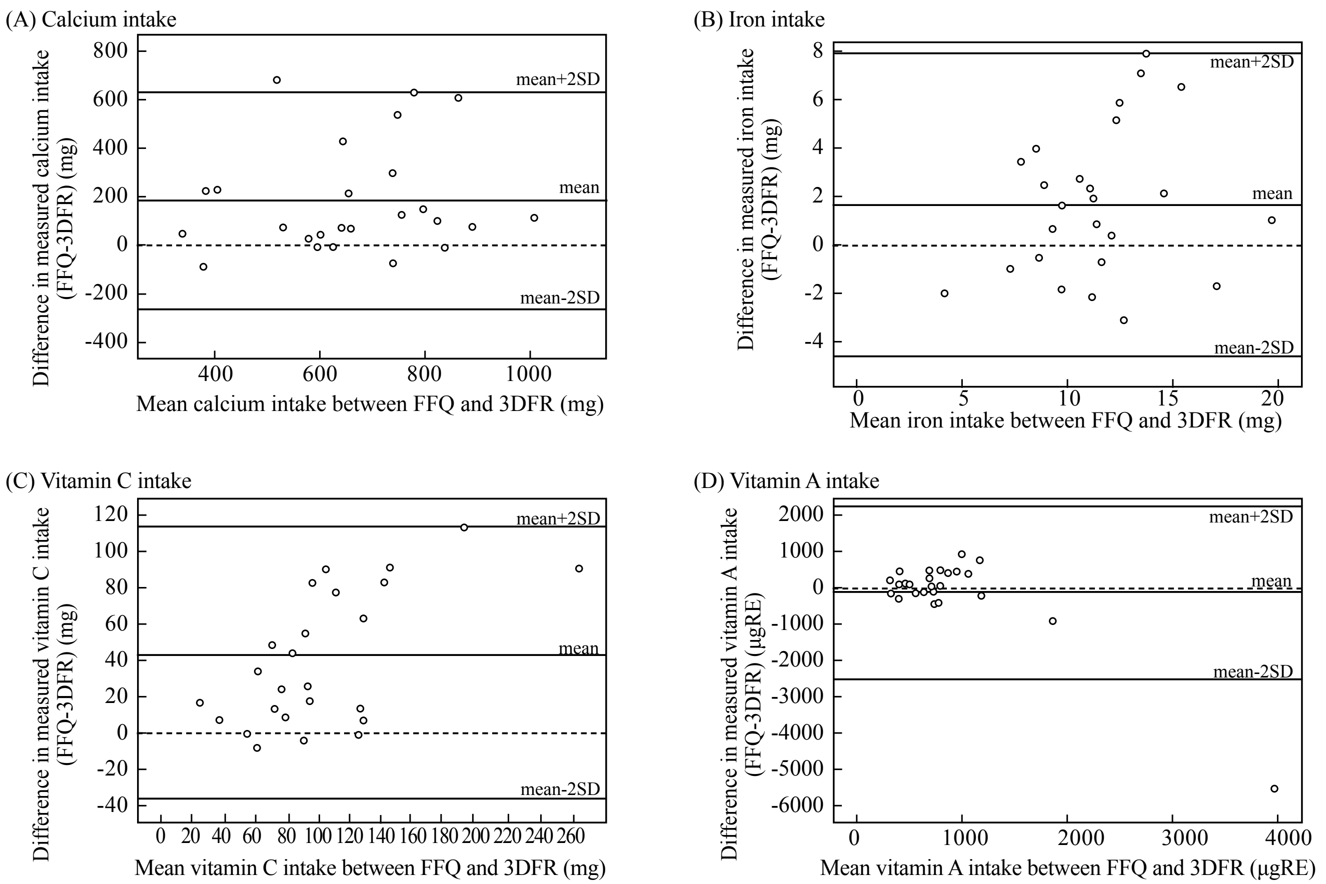

Fig. 2. Bland-Altman plots for the agreement between FFQ and 3DFR at the end of 4-month study for assessing intakes of (A) calcium; (B) iron; (C) vitamin C; (D) vitamin A.

intake but an overestimation of carbohydrates (5.6%) and dietary fibre (13.3%) and an underestimation of calcium (9%). Our FFQ significantly overestimated energy, carbohydrate, fat and dietary fibre compared with 3DFR at both the baseline and the end of 4-month follow-up (Tables 1 and 2). Such overestimation may be explained by recall bias of parents and their choice of food items. If a particular food contains more than one item under the FFQ food list, it is possible for parents to report those items and overestimate the relevant nutrient intakes.

Calcium intake is crucial for the long-term bone health of young children. Taylor et al[16] compared calcium intake from a 35-item short calcium FFQ with that from a 4-day diet record. They concluded that the short calcium FFQ would not be appropriate for determining calcium intake of young children because it overestimated actual calcium intakes. A subsequent study found that FFQ underestimated preschool children's calcium intake (838 by 3DFR and 777 by FFQ).[17] More than 50% of our picky-eating subjects took lower calcium than the US age-specific RDA (800 mg/day; Table 1). In addition, although we found moderate correlation for calcium intakes between FFQ and 3DFR (Spearman's rank-order correlation coefficient, $\rho>0.537$), our FFQ overestimated calcium intake when compared with 3DFR at the baseline (median, 609.6 mg/day *vs.* 459.3 mg/day) and the end of the study (median, 760.8 mg/day *vs.* 579.4 mg/day).

Rogers et al[18] investigated the long-term implications of nutritional assessments throughout childhood in over 3000 British girls. Diet was assessed by FFQ at 3 and 7 years of age, and by 3DFR at 10 years. They found intakes of total and animal protein as well as polyunsaturated fatty acids at 3 and 7 years to be positively associated with earlier age at menarche. Such results may alter the lifetime risks of breast cancer and osteoporosis, thus supporting the importance of using either FFQ or food diary to assess nutrient intakes in preschool children.

This study has several limitations. Bland-Altman plots revealed wide limits of agreement of the differences in nutrient intakes between FFQ and 3DFR. This observation could be explained by the small number of subjects being recruited. Our results need to be confirmed in larger studies. Besides, the subjects had subnormal body weight (BMI z-scores -0.57 to -3.12) and abnormal eating behaviours, so this study could not reflect dietary intakes in healthy children. Our participants had picky-eating behaviour. A good agreement of the tools in our subjects might not be generalisable to the general preschool population. In addition, our FFQ should ideally be validated against doubly-labelled water.[19,20] Because of time and financial constraints, however, we consider it acceptable to compare FFQ with food record as in many published studies.[2-8,18,20]

In conclusion, our modified FFQ is an acceptable method for assessing intakes of energy, macronutrients and selected vitamins and minerals in picky-eating Chinese preschoolers. This method is more useful in assigning overall ranking than assessing the actual nutrient intakes. Our findings also need to be confirmed in larger community-based cohorts.

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Ethical approval: This study was approved by Clinical Research Ethics Committee of The Chinese University of Hong Kong (reference CRE-2009.637-T).

Competing interest: The randomized controlled clinical trial for the balanced milk formula was sponsored by Shanghai Wyeth Nutritional under protocol number 9061A1-4000. However, the sponsor was not involved in the design of this study, collection and analysis of data and the preparation of this manuscript.

Contributors: Kwok FY and Ho YY collected anthropometric and nutritional data and helped in data analyses; Chow CM participated in the study design and collected clinical data; So CY administered food questionnaires; Leung TF designed the study, collected, analyzed and interpreted data and wrote the manuscript.

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