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Development of Food Frequency Questionnaire (FFQ) for the assessment of dietary intake among overweight and obese Saudi young children

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Abstract

Background: Food Frequency Questionnaire (FFQ) is an effective tool for nutritional status assessment. This study had two objectives: (1) to develop a FFQ for habitual dietary intake assessment of children and adolescents with overweight or obesity and (2) to evaluate the reproducibility of this FFQ.

Methods: A cross-sectional study was conducted in the Obesity Clinics at King Khalid University Hospital (KKUH), Riyadh, Saudi Arabia. A final sample of 236 children and adolescents (115/121: M/F; age 6–17 years) was used after they provided a written consent. Their anthropometrics were measured and they completed a 3-day food record (3DFR) questionnaire. We constructed a comprehensive food list based on the most commonly reported food items and portion size reported in 3DFR. This food list was converted to FFQ format using the typically reported portions. FFQ was reduced and developed into final form. The newly developed 74-item FFQ was administered twice over a 4-week period. Reproducibility was explored by comparing the nutrients and food intakes of FFQ1 and FFQ2. All statistical analyses were done on SPSS (version 18.0 (SPSS, Inc., Chicago, IL, USA)).

Results: The newly developed FFQ had 74 food items distributed in 7 food groups. A satisfactory reproducibility of FFQ was achieved. The average correlation coefficients of nutrients and food groups were 0.46 and 0.49, respectively. The average % agreement of nutrients and food groups were 70.1 and 70.9%, respectively.

Conclusion: The newly developed FFQ had 74 food items broadly categorized in 7 food groups and yielded satisfactory reproducibility. We conclude the newly developed FFQ may be a useful tool for further research for dietary assessment of children and adolescents with overweight and obesity in Saudi Arabia.

Keywords: Saudi Arabia, Food Frequency Questionnaire (FFQ), Dietary assessment, Obesity, Overweight, Food intake data

Background

Dietary assessment is important for implementation of programs related to food, nutrition and health promotion for any country [1]. The most common dietary assessment tools include Food Frequency Questionnaire (FFQ), 24-h recall, weighted 3-day food record (3DFR), and dietary history [2]. FFQs, in particular, are main research tools in nutritional epidemiological studies, and

assessing their validity is an important requirement for their use in studies of diet-related disease risk [3–9].

Most of the dietary assessment methods are subjected to considerable limitations by specific errors and biases, hence none of these can be considered as a ‘gold standard’ measure [10–12]. FFQs are often used because they are easier to administer, and cost-effective as compared to dietary records or 24-h recalls [12]. Further, they are also considered to be suitable tools for collection of consistent information on nutrient intake over a long period of time with restricted research resources [4, 10, 13–16]. For cost and feasibility reasons, when relative ranking of food and nutrient intake are sufficient for determination

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of relative risks, FFQs may be advantageous, even if they provide cruder information [16]. However, FFQ needs to be specifically designed and properly validated prior their use [17–19]. This warrants further consideration while designing an FFQ for children, who present greater within-person variability in dietary intake as compared to adults and also their inability to fill in the questionnaire [2, 10, 13–16].

Obesity in childhood causes a number of non-infectious diseases [20–22]. Children with overweight and obesity are more likely to develop metabolic syndrome later in life [22], which may cause cardiovascular diseases [23]. Worrysome is the fact that obesity is increasing worldwide, in both developing and developed countries [24–27]. The World Health Organization (WHO) has projected that 43 million children are obese and/or overweight even in their early preschool years, and more than two third of these children are in the developing countries [28]. Higher prevalence rates have been reported for developed countries like the USA [2, 29, 30]. In relatively less developed societies like Saudi Arabia, the rates are alarming; approximately 26.6% overweight and 10.6% obese in the age group 13–18 years [31]. Other studies found almost the same number in different geographical areas of the Kingdom [20].

Dietary assessment, nutrient intake and eating habits, and pattern of young children and adolescents have established special attention of the research community. This is mainly because of the increasing evidence that support a positive relationship between dietary and nutrient intake during the developing years in young age and the escalating risk of overweight and/or obesity [21]. However, only few studies exist that have specifically designed FFQ for young people with overweight and obesity [7, 8]. While any such a FFQ is essentially missing for Saudi Arabia, where the differences in dietary habits necessitate development of a FFQ, we felt a need to develop one. As far as we know, no FFQ has been developed for children and adolescents with overweight and obesity in Saudi Arabia. In this study, we develop a FFQ to assess food intake in a sample of overweight and obese Saudi children in Riyadh, Saudi Arabia.

Methods

Ethical approval

Ethical approval was obtained from King University Research Board to conduct the study. All participants (or their parent/caregivers) provided written consents of their willingness to participate in the study.

Phases of the study

The present study was completed in two distinct phases. In phase 1 of the study, we developed a FFQ.

In phase 2, the newly developed FFQ was evaluated for reproducibility.

Phase 1: FFQ development

Subjects Subjects for FFQ development phase of the study included Saudi school going children and adolescent with overweight and obesity. Subjects attending the Obesity Clinics at King Khalid University Hospital (KKUH) at the time of present study (March–October, 2014), or those studying in schools of Riyadh, who had attended Obesity Clinics at KKUH in the recent past, were invited to participate in a 3DFR.

Inclusion criteria For the present study, we defined inclusion criteria that were to include children and adolescents (a) of Saudi Arabian ethnicity, (b) of school going age (6 to 17 years), and (c) with a BMI for age \geq 85th percentile according to the new Saudi growth charts [20]. In addition, only those children and adolescents were recruited who had a past 6-month history of no illness and not using any medication on chronic basis that might interfere with the food intake. Initially, 252 children and adolescents (or their parents) gave their consent for participation. However, 16 children and adolescent were excluded from this phase of the study due either to their unsuitability as per the inclusion criteria ($n = 10$) or not providing completed 3DFR questionnaires ($n = 6$). Data could be completed on a final of 236 children and adolescents (115 boys and 121 girls), and their data were included in the final analysis.

Anthropometric measurements Children and adolescents fulfilling the inclusion criteria ($n = 236$) were measured for their body weight and height. Weight was measured with possible minimal clothing on a calibrated scale (Model: 708; Seca, Hamburg, DE), and height was measured on a calibrated stadiometer (Model: 206; Seca, Hamburg, DE). All assessment and measurement were conducted by well-trained dietitians and nurses in the Obesity clinics at KKUH. BMI was calculated as weight (kg)/height (m²) [32].

Dietary data A 3DFR questionnaire was provided to all participants. The 3DFR was a written questionnaire in Arabic with English translation. 3DFR questionnaire contained all possible foods eaten by the children and adolescents. One part of the questionnaire also contained detailed instructions on how to record food intake. The participants were asked to write down all foods they ate in the last six months or so in their major meals and snacks also including water, coffee, tea, or other beverages and fluids. Participants recorded food intake for two work days and one weekend. The 3DFR was filled in by the child/adolescent himself and/or

proxy, who reportedly spent most of the time with the child (usually the mother in this case).

All 3DFR questionnaires were collected and analyzed for completeness by a panel of faculty members and nutrition experts at Nutrition Program, Department of Community Health Sciences, College of Applied Medical Sciences, King Saud University, Saudi Arabia. Only those questioners were included that were complete with unambiguous information. Questioners of 28 subjects were excluded from further analysis because they were incomplete and/or not with clear information.

Construction of the food list Using data of 3DFR forms from 236 subjects, mean intake of each food item was calculated. Nutrients were calculated from mean values of food intakes using the food composition database for Arab countries [33]. The percentage of nutrients was derived [34]. The reported foods were ranked on the basis of their percent nutrient contribution [35]. We were particularly interested in energy and macronutrient intake considering their relevance to obesity [36]. However, we also calculated other nutrients of interest (e.g., fiber, iron, calcium, phosphorus, vitamins A and C, thiamin, riboflavin, niacin, magnesium, potassium, and sodium). The selection of food items for developing the FFQ was performed using the same procedure as adopted by Tokudome and colleagues [37]. In brief, modified contribution analysis was applied to nutrients of interest. Each food item was listed according to the intake amount of nutrient. We then selected food items with up to a 90 cumulative percentage contribution. Furthermore, we performed forward multiple regression analysis, and selected food items with up to a 0.90 cumulative square of the multiple correlation coefficient (cumulative R^2) [37]. Cumulative R^2 can also be interpreted as the proportion of the variance of the dependent variable explained by the independent variables. Finally, we determined food items for FFQ, which were selected by either contribution analysis or multiple regression analysis. The foods contributing to less than three nutrients, with relatively small % contributions, were also excluded. Then, we combined the selected food types using these two methods and overlapping items were excluded. In addition, food types eaten by fewer than 15 subjects were also excluded. Further details on selection of food items can be seen in the section of “**Statistical analysis.**”

We classified 3581 data points, i.e., consumption of various food items reported by study participants in their 3DFR survey and a total of 300 food item codes, covering food intakes on three alternative days of a week including two weekdays and one weekend day. These data were coded into broad food groups appropriate for inclusion on the FFQ according to methods of Block et

al. [34]. For example, 20 different rice types (boiled, boiled, and fried, etc.) were all assigned a single code, “Rice and dishes made with rice.” In this way, all foods mentioned on the three-day food records were coded into 194 food items, which were subsequently ranked in terms of their energy and nutrient contribution.

FFQ design Based on the data obtained in the previous steps, we constructed our FFQ that contained 74 food items, categorized in seven broad groups as “Cereals and grains” (7 items), “Mixed dishes” (12 items), “Fish, poultry and meat” (11 items), “Beverages” (9 items), “Sweets and confectionery” (13 items), “Dairy products” (6 items), and “Fruits and vegetables” (16 items). The newly developed FFQ was in hard form and contained these entries in columns: (1) names of 74 food items under their corresponding food groups; (2) average portion sizes; and (3) options to respond on food intake frequency.

Frequency of Food Consumption in FFQ Food intake frequency was established taking into consideration the habitual food intake during the previous month [10]. There were four options in the category for frequency of intake, which were (a) “once per day,” (b) “once per week,” (c) “once per month” and (d) “never.” For seasonal food intake, subjects could respond to the frequency of intake at that time. In order to obtain food portion size, we reviewed all reported portions based on 3-day FR and referred to the Arabic food analysis. One or few commonly consumed portion sizes were defined as the units of measurement for each food category. The portion size was based on the medium size.

Pre-testing and pilot testing of the FFQ Several strategies were adopted to test the FFQ and to identify potential difficulties in responding to FFQ questions. For example, feedback from local food experts, stakeholders, and researchers, familiar with local food habits, checked the face validity of FFQ, appropriateness of portion sizes, incorrect description of foods, and they advised if any overweight/obesity-specific local foods were missing from the FFQ food item examples. These nutrition experts consulted had vast experience in cohort studies, National Nutrition Survey of Saudi Arabia, and studies relating to nutrition interventions in Saudi Arabia. Amendments as recommended by these experts were incorporated in the FFQ.

Phase 2: Reproducibility of FFQ

For reproducibility stage of the study, another final sample of 60 children and adolescents with overweight and obesity were selected from three schools in Riyadh city. These children had attended Obesity Clinics at KKHU in the

past 6 months from the time when this study was being undertaken. The same inclusion criteria as mentioned earlier were applied. We collected data using the same FFQ but at two different time points keeping 4 weeks interval between the two administrations. Relative differences in assessment achieved by the FFQ that was administered for the first time (here designated as FFQ1) and administration of the same FFQ (here designated as FFQ2) assessments were calculated. The reproducibility of food intakes from the FFQ1 and FFQ2 were further assessed by cross classification analysis.

Statistical analysis

All statistical analyses were done on SPSS (version 18.0 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics were used to describe socio-demographic characteristics of the study participants. Data were expressed in mean and standard deviations (Std). Means were computed for continuous data and frequencies for categorical variables.

After aggregation of all reported food items, the percentage of people consuming each of the 74 food items over 3-day period (3DFR) was calculated. Foods consumed by < 2% subjects overall and contributing to intake of only one nutrient, which could not be grouped elsewhere, were excluded. Percentage contribution analysis was performed by calculating the contribution of each food item to total daily energy and the selected 15 key nutrients (carbohydrate, protein, fat, fiber, iron, calcium, phosphorus, vitamins A and C, thiamin, riboflavin, niacin, magnesium, potassium, and sodium). A multiple regression analysis was performed with the dependent variable as the average energy intake and nutrient intakes, and the independent variable as the intake of food types. We selected the food types with up to a 0.90 cumulative square of the multiple correlation coefficients (R^2). The correlation coefficients were “de-attenuated” using the within- and between-person components of variation to account for within-person variations caused by day-to-day fluctuations and/or seasonal variations.

Reproducibility of FFQ was evaluated for intakes of energy, 15 nutrients, and 7 food groups. In addition, reproducibility was also evaluated for “consumption

frequency” of the 74 individual food items belonging to these 7 food groups. For reproducibility of FFQ, mean (Std) intakes of food groups and nutrients were calculated for both FFQ1 and FFQ2, administered within a period of 4 weeks. Dietary variables were log transformed when necessary to achieve a normal distribution. Because the log-transformed data showed a normal distribution for energy and all nutrients of FFQ1 and FFQ2, Pearson correlation coefficients were used to compare FFQ1 and FFQ2 as a measure of reproducibility. On the other hand, the log-transformed data did not show a normal distribution for the majority of the food items intake data; therefore, Spearman correlation coefficients were used to compare the food items intake data. We also calculated a ratio of the geometric means to estimate changes in mean intake levels between FFQ1 and FFQ2, and the ratios were multiplied by 100 to be expressed as a percentage, with 100% representing an ideal agreement. To evaluate the joint classification, the intakes of nutrients and food groups estimated by FFQ1 and FFQ2 were classified into quartiles. Agreement analyses were assessed to verify the degree of concordance in classifying subjects among quartiles of the distribution between FFQ1 and FFQ2. The percentages of participants classified in the same quartile, in adjacent quartiles and in opposite quartiles by the two FFQ were analyzed. In the reproducibility study, Student t test was performed to assess the differences between both FFQs. A p value < 0.05 was considered statistically significant at 95% confidence interval.

Results

Table 1 shows the baseline characteristics of the study subjects. Study subjects were not significantly different with respect to mean age, BMI and monthly family income (p , for all trends > 0.05). All subjects were obese (BMI 27–33 kg/m²).

Table 2 shows the top three foods according to their percent energy contribution from each of the seven food groups. As can be seen, “Bread” ranked on the top for percent energy contribution (11.2%) followed by foods in other food groups; “Rice Kabsa” (8.3%), “Boiled lamb”

Table 1 Characteristics of children and adolescents of the FFQ development phase of the study ($n = 236$) and FFQ reproducibility phase of the study ($n = 60$)

	Subjects of FFQ development study ($n = 236$)	Subjects of FFQ reproducibility study ($n = 60$)	p value ¹
Age (years)	14.8 (3.1)	14.3 (4.2)	0.131
BMI (kg/m ²)	31.35(6.8)	30.9 (7.2)	0.091
% number of subjects according to monthly family income (US dollars)			
< 2000 US dollars	5.9%	4.7%	0.071
2000–10,000 US dollars	26.6%	27.1%	0.112
> 10,000 US dollars	67.5%	68.2%	0.112

¹ p value from Student's t test (continuous variable) and from chi-square tests (categorical variables)

Table 2 List of three food items and their foods groups that constitutes the FFQ

Food Groups	Food items	% contribution
Cereals	Bread	11.2
	Biscuits chocolate	5.5
	Tea biscuits	0.7
Mixed Dishes	Rice Kabsa	8.3
	Chicken burger with cheese	4.9
	Cheese sandwich	4.2
Fish, poultry and meat products	Boiled lamb	4.3
	Poached chicken	3.5
	Fried chicken	2.6
Beverages	Aerated cola drink	1.9
	Canned unsweetened juice	1.4
	Lemon drink gaseous	0.7
Sweets and confectionary	Croissant Fatayer	2.8
	Cake	1.1
	Pastries (Fatayer) chees or labnah	1.1
Dairy Products	Full-fat cow's milk	1.9
	Cream cheese	1.6
	Ice cream pillow	0.5
Fruits and vegetables	Potato chips	6.3
	Dates	2.1
	Diyafa seeds	0.4

(4.3%), “*Crossiant Fatayer*” (2.8%) “Dates” (2.1%) and “Carbonated cola drink” (1.9%) from food groups. The percent contribution of energy for other food items ranged from 0.16% (Thyme bread) to 0.65% (Corn flakes) in the food group of cereal; 0.27% (Meat sandwich) to 2.28% (Chicken shawarma) in the food group of “Mixed dishes”; 0.16% (Sausage) to 2.04% (Roast beef/Mortadella) in the food group of “Fish, poultry and meat products” 0.16% (Instant coffee) to 0.55% (Minutes milk) in the food group of “Beverages”; 1.7% (Honey) to 0.63% (Doughnuts jam) in the food group of “Sweets and confectionery”; 0.16% (Milk shake) to 0.32% (Full fat yogurt) in the food group “Dairy products”; 0.10% (Vegetable soup) to 0.38% (Thyme) in the food group of “Fruits and vegetables.”

The top 13 food types ranked according to R^2 values are listed in Table 3. “Chicken burger with cheese” had the highest R^2 value for energy and “Poached chicken” had the highest R^2 value for protein. Similarly, “Bread” and “Dates” were ranked at the top for carbohydrate and “Boiled lamb” and “Chicken burger with cheese” were ranked at the top for fat, based on the highest R^2 value.

We excluded overlapping items and obtained 80 food types. We then combined the selected food items and finally obtained 74 food types (Table 4). A food item was excluded based on the criteria if it had been eaten by fewer than 15 subjects. The final 74 food items were categorized as Cereals and Grains (7 items), Mixed dishes (12 items), Fish, poultry and meat (11 items), Beverages (9 items), Sweets (13 items), Dairy products (6 items), and Fruits and vegetables (16 items).

Table 5 shows mean daily nutrient intakes and Pearson correlation coefficients between nutrients intake estimated by FFQ1 and FFQ2. Measurements of iron, vitamin C, and thiamin differed by more than 20% (22.6, 20.6, and 25.3%, respectively) between the two FFQs. Measurements for most of the remaining nutrients differed only < 5% (Table 5). Adjustment for total energy intake did not affect these observations but only slightly. Highly significant correlation coefficients were observed for most of the nutrients ranging from 0.33 (fiber) to 0.61 (magnesium and potassium). The average correlation coefficients were 0.47 (crude) and 0.46 (energy-adjusted). According to classification into quartiles of nutrient intakes estimated by FFQ1 and FFQ2, the percentage of agreement ranged from 64.3% (Magnesium) to 79.4% (Niacin). The average % agreement for nutrients was 70.1%.

Table 6 shows reproducibility of the FFQ for food group intake. Food items in food groups “Cereals and grains” and “Fish, poultry and meat” were slightly overestimated by FFQ1 (2.3% and 3.8%, respectively). Food items in the rest of food groups were overestimated by FFQ2 to as less as < 10%, except food items in “Mixed dishes” and “Dairy products,” overestimated by FFQ2 > 10%. The correlation coefficients of food groups intakes between FFQ1 and FFQ2 showed relatively wider range than that observed for nutrients and ranged from 0.36 (“Beverages”) to 0.62 (“Fish, poultry and meat”). When adjusted for energy, correlation coefficients of food group intakes did not change largely. According to classification into quartiles of food group intakes estimated by FFQ1 and FFQ2, the percentage of agreement ranged from 65.1% (“Fruits and vegetables”) to 85.6% (“Fish, poultry, and meat”); the average being 72.7% for all food groups.

Reproducibility of FFQ for “consumption frequency” of the 74 food items was also investigated (Additional file 1). The mean “consumption frequency” slightly differed between FFQ1 and FFQ2, ranging from 0.2% (Apricot and Cream desserts) to 11.3% (Bread). Generally, FFQ2 overestimated the mean consumption frequency of individual food items. The percentage of agreement for “consumption frequencies” of 74 food items were generally very high ranging from 65.8% (Orange) to 77.1% (Eggs) with an average of 70.9%.

Table 3 A list of top food items ranked according to R^2 values

Nutrient	Rank	Food type	Cumulative R^{2a}
Energy	1	Chicken burger with cheese	0.12
	2	Bread	0.2
	3	Boiled lamb	0.26
	4	Biscuits covered with full chocolate	0.33
	5	Potato chips	0.4
	6	Poached chicken	0.45
	7	Smoked beef (mortadella)	0.5
	8	Dates	0.53
	9	Cake	0.57
	10	Instant coffee with milk	0.62
	11	Diyafa seeds	0.64
	12	Samosas with meat	0.65
	13	Black olive	0.67
	14	Rice kabsa	0.69
Protein	1	Poached chicken	0.32
	2	Chicken burger with cheese	0.44
	3	Bath roast	0.51
	4	Roast beef (mortadella)	0.54
	5	Bread	0.57
	6	Instant coffee with milk	0.6
	7	Potato chips	0.62
	8	Broasted (fried chicken)	0.66
	9	Diyafa seeds	0.67
	10	Cocoa powder with whole milk (cappuccino)	0.69
	11	Liver Sandwich	0.69
	12	Cheese Sandwich	0.72
	13	Pizza	0.72
Carbohydrates	1	Bread	0.19
	2	Dates	0.26
	3	Aerated cola drink	0.36
	4	Cake	0.42
	5	Lemon drink gaseous	0.48
	6	Cheese sandwich	0.52
	7	Rice kabsa	0.61
	8	Baklava	0.61
	9	Potato chips	0.68
	10	Biscuits covered with full chocolate	0.72
	11	Biscuit with dates	0.74
	12	Samosas meat	0.75
	1	Boiled lamb	0.24
2	Chicken burger with cheese	0.4	
3	Potato chips	0.49	

Table 3 A list of top food items ranked according to R^2 values (Continued)

Nutrient	Rank	Food type	Cumulative R^{2a}
	4	Black olive	0.56
	5	Biscuits covered with full chocolate	0.63
	6	Roast beef (mortadella)	0.69
	7	Diyafa seeds	0.71
	8	Minutes milk	0.72
	9	Coconut	0.73
	10	Cream cheese	0.75
	11	Falafel	0.76
	12	Broasted (fried chicken)	0.79
	13	Sandwich mixed	0.8

^aData are based on cumulative R^2 values in a stepwise regression analysis of a food frequency questionnaire

Spearman's correlation coefficients were generally higher than the Cohen's kappa. Spearman's coefficient ranged from 0.492 (eggs) to 0.92 (full-fat yogurt) and Cohen's kappa coefficients ranged from 0.54 (potato chips) to 0.81 (full-fat yogurt).

Discussion

This paper describes the process of development of a FFQ and evaluation of its reproducibility for Saudi Arabian children and adolescent with overweight and obesity. Dietary assessment of this population is invaluable to understand the role of nutrition in chronic diseases so that preventive strategies can be implemented.

In many epidemiological studies, FFQs originally developed for adults are used to assess habitual food intake in children [38, 39] as only a few studies have published data of reproducibility of FFQ in children [40–45]. In contrast, the food list in our FFQ was developed specifically for children and adolescents with overweight and obesity, using a data-based approach. Such a FFQ is more likely to provide representative dietary data for Saudi school aged children. Willett et al. [46] used stepwise regression analysis to develop the list of foods to include in their FFQ. The current study used a similar approach but instead of including individual foods as the independent variables in the regression analysis, we used food groups. The advantage of using this approach is that the number of items in the food list is lower, making the FFQ easier and less costly to apply and more likely to avoid producing fatigue in respondents which could occur when a longer list of foods is used.

In our FFQ, we included 74 food items (Table 4). The number of food items listed in FFQ is likely to differ widely. For example, Cade et al. [3], in their review, found a range of 5–350 food items on various questionnaire forms. For example, the FFQ developed by Na and Lee

Table 4 Food groups and food items of FFQ

Food group (no. of food items)	Food items
Cereals and grains (7)	Bread, Macaroni, Corn Flex, Popcorn, Homs, Falafel, Biscuits
Fish, poultry and meat (11)	Eggs, Sausage, Fried Fish, Roast Beef, Chicken Soup, Tuna With Oil, Fried Chicken, Kofta Kebab Meat, Poached Chicken, Grilled Chicken, Boiled Lamb
Mixed dishes (12)	Chicken Burger, Applied Eggs (Mutabiq), Rice Kabsa, Cheese Sandwich, Egg Sandwich, Petza, Samosas Meat, Sandwich Meat, Chicken Shawarma, Sandwich Mixed, Meat Burger, Liver Sandwich
Beverages (9)	Concentrated Orange Syrup, Canned Unsweetened Juice, Minutes Milk, Fresh Orange Juice, Aerated Cola Drink, Apple Juice, Coca Powder With Whole Milk (Cappuccino), Instant Coffee, Grape Juice
Sweets and baked goods (13)	Pastries (Fatayer), Honey, Mxid Sweets, Sugar, Basbousa, Croissant Fatayer, Biscuit With Dates, Baklava, Cake, Doughnuts Jam, Cream Desserts Konafa Cream, Sweet Dumpling
Dairy products (6)	Cream Cheese, Full-Fat Yogurt, Full-Fat Cow's Milk, Low-Fat Cow's Milk, Ice Cream Pillow, Milk Chake
Fruits and vegetables (16)	Fresh Tomatoes, Grape Leaves, Orange, Watermelon, Apricot, Coconut, Vegetable Soup, Dates, Vegetables Cooked, Fava Beans, Nuts Variety Potato Chips, Thyme, Black Olive, Green Salad Mixed, Boiled Potatoes

[47], Date et al. [48], Tokudome et al. [37], and Kobayashi et al. [17] had 128, 122, 102, and 75 food items, respectively. In brief, most of the FFQs developed so far have between 100 and 150 items [46, 49, 50]. Increasing the number of food items in a FFQ may cause an overestimation of nutrient intake [17, 37]. However, whether increasing the number of food items in a FFQ may increase the burden on the respondent is still not much clear and

needs further investigation. Also, the question whether the length of a FFQ should be adjusted according to the age of the respondents (e.g., children vs adult) merits to be investigated in future research studies.

Results of the present study on reproducibility show good applicability of the newly developed FFQ among children and adolescents with overweight and obesity. The average of reproducibility coefficient for nutrients in

Table 5 Mean daily nutritional intake and Pearson Correlation Coefficients among children and adolescents ($n = 60$)

	Mean (Std)		% Diff. ²	p value ³	Correlation coefficient		% Agree. ⁶
	FFQ1 ¹	FFQ2 ¹			r^4	$r_{adj.}^5$	
Energy (kcal)	2066 (650)	2106 (655)	1.9	0.345	0.41	–	65.4
Protein (gm)	0070 (32.1)	72 (32.2)	2.9	0.325	0.46	0.44	71.1
Fat (gm)	64.4(33.5)	68.14(33.7)	5.8	0.215	0.39	0.40	68.2
Carbohydrates (gm)	229 (93.1)	259 (93.7)	.8.7	0.412	0.51	0.53	72.1
Fiber (gm)	9.49 (4.89)	8.32(4.9)	–12.3	0.275	0.33	0.34	69.4
Iron (mg)	14.6 (7.6)	11.3(8.2)	–22.6	0.021*	0.56	0.57	75.3
Calcium (mg)	412.5(234)	415.2(250)	0.7	0.512	0.37	0.38	69.7
Phosphorus (mg)	877.3(360)	866.3(385)	–1.3	0.412	0.41	0.39	68.6
Vitamin A (μ g)	490.2(425)	492.5(454.8)	0.5	0.415	0.49	0.50	71.1
Vitamin C (mg)	40.7 (35.5)	49.1(38)	20.6	0.175	0.48	0.49	68.5
Thiamine (mg)	0.79 (0.58)	0.59(0.6)	–25.3	0.001**	0.51	0.53	73.5
Riboflavin (mg)	1.44 (0.85)	1.23 (1.2)	–14.6	0.181	0.56	0.51	68.8
Magnesium (mg)	8.79 (14.9)	8.45(17.4)	–3.9	0.412	0.61	0.63	64.3
Potassium (mg)	1043(781)	1121(913.8)	7.5	0.311	0.61	0.58	64.9
Sodium (mg)**	1137(612)	1098(715)	–3.4	0.345	0.43	0.44	71.2
Niacin (mg)	6.56 (7.28)	6.16(8.5)	–6.1	0.125	0.45	0.41	79.4
Average	–	–	–	–	0.47	0.46	70.1

¹FFQ1 and FFQ2: The same FFQ was firstly administered at baseline (FFQ1) and secondly (FFQ2) after 4 weeks

²(Value derived from FFQ-value derived from 3-day food record)/(value derived from 3-day food record) \times 100

³ p value from paired t test; * and **, respectively, denote 'significant' and 'highly significant'

⁴Coefficient correlation after nutrient crude intake were log-transformed

⁵Coefficient correlation after nutrient crude intake adjusted for total energy intake

⁶Overall percentage of children and adolescents in the same or adjacent quintiles; all correlation coefficients were statistical significant, $p < 0.01$

Table 6 Mean daily food groups intake and Pearson correlation coefficients among children and adolescents ($n = 60$)

Food group (number of items)	Mean (Std)		% Diff. ₂	p value ³	Correlation coefficient		% Agree. ⁶
	FFQ1 ¹	FFQ2 ¹			r^4	$r_{adj.}^5$	
Cereals and grains (g/day)	433 (189)	423 (166)	- 2.3	0.31	0.61	0.65	84.3
Fish, poultry and meat (g/day)	264 (68)	254 (73)	- 3.8	0.211	0.62	0.61	85.4
Mixed dishes (g/day)	122 (56)	152 (59)	24.6	0.001*	0.46	0.43	69.5
Beverages (ml/day)	1520 (788)	1560 (801)	2.6	0.412	0.36	0.33	65.7
Sweets and baked goods (g/day)	122 (56)	129 (66)	5.7	0.315	0.61	0.56	71.2
Dairy products (g/day)	67 (56)	77 (51)	14.9	0.251	0.44	0.47	68.0
Fruits and vegetables (g/day)	122 (86)	131 (78)	7.4	0.216	0.48	0.41	65.1
Average					0.51	0.49	72.7

¹FFQ1 and FFQ2: The same FFQ was firstly administered at baseline (FFQ1) and secondly (FFQ2) after 4 weeks

²(Value derived from FFQ-value derived from 3-day food record)/(value derived from 3-day food record) \times 100

³ p value from paired t test: * denotes 'highly significant'

⁴Coefficient correlation after nutrient crude intake were log-transformed

⁵Coefficient correlation after nutrient crude intake adjusted for total energy intake

⁶Overall percentage of children and adolescents in the same or adjacent quintiles; all correlation coefficients were statistically significant, $p < 0.01$

our study was 0.46 (Table 5), higher than reported by Vioque et al. (0.42) [51], but lower than that reported by Kobayashi et al. (0.50) [45] for Japanese children of 6 years of age. These differences may be due to differences of age of the study participants and also the length of period to examine reproducibility. As an example, children participating in the studies of Vioque et al. [51] and Kobayashi et al. [45] were younger as compared to those in our study (respectively, 4–5 years, 6 years, and 6–17 years). Also, both these studies [45, 51] used 6 months duration between the administration of FFQ1 and FFQ2 as compared to 1 month duration in our study. Correlation coefficients reported for repeated administrations of FFQs may generally range from 0.50 to 0.70 for nutrient intakes in adult populations. However, in populations of children and adolescents, the correlations tend to be lower. For example, Rockett et al. [52] reported correlations of 0.41 for total fat in a population of children aged 9 to 18 years using the Harvard Youth/Adolescent questionnaire. They reported a correlation of 0.51 for a 45-item fruit and vegetable questionnaire in fourth- and fifth-grade students, using a 1-month interval between administrations. Other studies reported variable correlation coefficients. For example, a study in the USA on 51 children, who were 4–5 grade students, reported correlation coefficient for 1 year reproducibility of a FFQ from 0.26 (Vegetables) to 0.40 (Fruit juice) [53]. The study of Vioque et al., on 169 children aged 4–5 years conducted in Spain reported correlation coefficients of reproducibility for 6 months ranging from 0.05 (white meat) to 0.73 (dairy products) [51], whereas our analysis show correlation coefficients of 0.33 (Beverages) to 0.65 (Cereals and grains) (Table 6). Other studies [41, 52] reported higher correlation coefficients of reproducibility for relatively shorter period (2 to 4 weeks). These

differences in correlation coefficients of reproducibility may be largely due to the differences in time between the administrations of the two FFQs [51]. Overall, our FFQ of our showed satisfactory reproducibility and relatively higher percent agreement for most nutrients and food groups, and therefore, it may be considered a reliable dietary assessment tool in children and adolescents aged 6–17 years with overweight and obesity in Saudi Arabia.

The mean daily intakes estimated for most nutrients and food items were higher in FFQ2 than FFQ1 in our study. However, generally the differences were smaller and significant only for a few nutrients (fiber, iron, vitamin C, thiamin, and riboflavin) and food items (e.g., Mixed dishes, Dairy products). These results of the current study show no major changes in children's diet during the study period. While some studies have shown higher nutrients intakes in FFQ1 [42, 51], generally, most of the studies have shown no large and significant differences in nutrients and food intakes between FFQ1 and FFQ2 [51, 54]. In the present study, we also investigated correlation coefficients of reproducibility of "mean consumption frequencies" of 74 food items (Additional file 1). Generally, higher mean "consumption frequencies" were noted for majority of food items in FFQ2. We find only one published report on European children, aged 2 to 9 years, where the FFQ gave reproducible estimates of the consumption frequency of 43 food items from 14 food groups in European children [55]. Our data on relatively higher "consumption frequencies" of food items in FFQ2 are in close agreement to findings of this report [55]. Nevertheless, for more generalization of the results, we may need more data from diverse geographical regions with different eating patterns and habits. This, in general, may be a potential area of further investigations as food consumption frequencies have potential health effects [56].

This study had some strengths: firstly, relatively high participation rate, complete data collection by trained personals, using a variety of all possible tools for the estimation of intake amount and portion size. Secondly, food groups designed included beverages, which affect energy intake [57]. Thirdly, we used 3DFR method instead of 24 DR for making a list of foods that to be included in the FFQ. This helped in gathering diverse information extended over a week time including both the work and week days. Finally, almost comparable number of male and female (115/121) subjects participated, which may increase the generalizability of the study [58]. The present study had one limitation. We used the Arabic food composition tables for nutrients calculation in the current study as Saudi Arabia does not have its own food composition database. There may be some variations as this database was estimated for the whole Arab region. However, careful calculation of nutrients from food intakes might have minimized any possible biases.

Conclusions

In conclusion, FFQ are reliable dietary assessment tools as widely reported in the literature. The development and reproducibility of FFQ for Saudi children and adolescents with overweight and obesity in the current study is a useful tool that other researchers in the region can adapt and use to suit their needs. We anticipate that this newly developed FFQ is a feasible tool for its convenience, especially if self-administered for use in large populations; large temporal catchment (months to years) and, hence, robust to the effect of seasonal variations; relatively high degree of reliability in ranking subjects across each food item; and feasibility and low cost for large scale epidemiological studies.

Additional file

Additional file 1: Table S1. Mean food consumption frequencies among children and adolescents ($n = 60$). (DOCX 24 kb)

Abbreviations

3DFR: 3-day food record; BMI: Body mass index; FFQ: Food frequency questionnaire; KKUH: King Khalid University Hospital; WDR: Weighed dietary records; WHO: World Health Organization

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Availability of data and materials

The data may be released for the reviewers and editor not for public due to the policy of the authors and university.

Authors' contributions

AA conceived the idea, developed design of study, and wrote the proposal for grant. ARA collected the data. IA and MA analyzed the data and wrote the draft manuscript. SR, MFB, BAB, and MA helped in the review of manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Ethical approval was obtained from King University Research Board to conduct the study. All participants provided written consents of their willingness to participate in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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