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Pretesting and reliability estimation of diet quality assessment tool for Indian adolescents

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***Abstract*---**As dietary tool for assessment of diet quality in Indian adolescents is lacking, there is a need for a standardized one. Our study aimed to develop and standardize Diet Quality Assessment Tool for Indian Adolescents (DQAT-IA). A cross-sectional study was undertaken among school-going adolescents of 13-17 years (n=40; sub set of a sample of 400 on which main study of diet quality assessment was undertaken), residing in rural areas of Aligarh district (India). The DQAT-IA was formulated based on diet adequacy, moderation, diet variety and nutrient intake. The reliability of DQAT-IA was assessed using Cronbach's alpha and split-half method. The mean age of participants was 15.4±1.05 year. Nutrient Adequacy Ratio of energy, dietary fibre, calcium, iron and zinc were inadequate. The mean DQAT-IA sub score for diet variety element was highest (23.6±2.99), followed by moderation (18.0±5.16), nutrient adequacy (15.7±5.01) and food group adequacy (13.1±4.09). Nearly one third of subjects (32.5%) were having healthy diet. Reliability of DQAT-IA was 0.61 by split-half method and by Cronbach's alpha it was 0.50. The DQAT-IA can prove to be a useful measure for examination of diet quality of school-going Indian adolescents, but revision of DQAT-IA items is needed to improve its reliability.

***Keywords*---**Adolescents, Diet quality, Diet Quality Index, Reliability.

Introduction

Worldwide, overweight and obesity prevalence has significantly increased among adolescents over the past few years (Qiu and Hou, 2020). These health problems

may result from excessive food intake in adolescence. Inadequate lifestyle patterns and dietary behaviours adversely affect growth and development in adolescence leading to compromised health in adulthood and reduced expectancy of life. Hence, modifications in lifestyle patterns and dietary habits to reduce the risk of NCDs is the global priority (Bhattarai and Bhusal, 2019). Poor quality of diet is the main contributor to the multiple burdens of malnutrition (micronutrient deficiencies, obesity, overweight and non-communicable diseases) (Dalwood et al, 2020). In India, studies on diet quality of adolescents have unanimously found that their diet quality is not healthy and need an improvement (Shaikh et al, 2016). Studies in Kolkata and New Delhi have revealed that high proportion of adolescents were not following the recommended dietary guidelines (Rathi et al, 2017; Harrell et al, 2015). In addition, their diets were unhealthy characterized by higher servings of refined sugar, dietary fat, red meat, and lower frequency of consumption of whole grains, fruits and vegetables that may contribute to nutrient deficiencies in adolescence (Jain and Kumari, 2020). Although, information related to nutrients and food groups intake among adolescents is easily available, no assessment of the overall quality of diet of Indian adolescents using diet quality indices has been made. Various dietary indices such as Healthy Eating Index and its derivatives have been used to examine the assessment of diet quality (Carvalho et al, 2014), but these indices are based on USDA guidelines and were originally constructed for adults. Existing diet quality indices neither reflect the typical foods consumed by Indian adolescents nor the country's dietary guidelines. There is a dire need for a dietary assessment tool in India for examining the diet quality of Indian adolescents which can be used with ease in community setting. Therefore, this study aimed to conduct a pre-testing survey to develop and standardize an index for assessing the diet quality of Indian adolescents in accordance with Indian dietary guidelines.

Methods

Study design and population

This study was cross-sectional and conducted on 40 adolescents (15 boys, 25 girls) of age 13-17 years. These adolescents were students of one of the schools selected randomly from eight schools in which the main study on diet quality assessment was to be conducted with a statistically calculated sample size of 400. In order to standardize the diet quality index 10% of main sample was used.

The purpose of study was discussed among different classes of the school and those who volunteered and healthy were made a part of the study. The study was conducted among school-going adolescents of class 9^{th} to 12^{th} from private schools of the rural areas of Aligarh district, India with prior permission from the school authority between February and April 2021. All parents signed the informed consent form and filled the questionnaire as per the declaration of Helsinki (2013). The study was conducted in conformity to Ethical Guidelines on Human Subjects (ICMR, 2017) and no invasive data was collected. The researcher explained the purpose and importance of the study to the participants and the parents. Participants whose parents had not responded to the consent letter and

those who were not available at the time of contact for the study or had a major illness were excluded from the study.

Measurements and data collection techniques
Demographic and socio-economic variables

A pre-designed and pretested questionnaire was used to interview the subjects to elicit information on demographic variables, like gender, age, occupation of mother etc. Information related to socio-economic variables was asked from parents using Kuppuswamy's socio-economic status scale (Saleem, 2020).

Dietary assessment

Dietary assessment was done using 24 hour diet recall. The diet recall was administered by the trained investigator to ensure the quality of the data. Standardized measuring cups, plates and spoons were used to improve the reliability of food portion size estimation. The trained investigator encouraged the respondents to recall everything that they had eaten and drunk on the previous day. Dietary intake data of the participants were converted into nutrient intake data using validated Nutrition Software of India- 'DietCal- A Tool for Dietary Assessment and Planning' version- 10.0 (Profound Tech Solution; http://dietcal.in/). Daily intake of nutrients such as energy, protein, fat, dietary fibre, retinol, vitamin C, calcium, iron and zinc was calculated using this software. The Nutrient Adequacy Ratio (NAR) was calculated using 24-hour recall data. It was calculated by dividing the subjects' daily intake of nutrients by Recommended Daily Allowance (RDA) (ICMR, 2020). The Mean Adequacy Ratio (MAR) was calculated by dividing the sum of all nutrients by the number of nutrients. Thereafter, subjects were categorized as those having an adequate (≥1.00), fairly adequate (0.66-<1.00) or inadequate (<0.66) NAR for various nutrients (Singh et al, 2015). A value of 1 is considered ideal for both MAR and NAR, it reflects that the individual has taken nutrients in an adequate amount (Meng et al, 2018).

Development of Diet Quality Index for Indian Adolescents (DQAT-IA)

The diet quality index for Indian adolescents was constructed to evaluate the diet quality of adolescents based on Indian dietary guidelines for this age group. It was developed to represent four major elements of diet quality: 1) diet adequacy, 2) moderation, 3) diet variety, 4) nutrient intake. The DQAT-IA comprised fourteen components. The first 5 components of DQAT-IA indicated diet adequacy as described in the dietary guidelines for Indians (ICMR, 2005), which were cereals, pulses, milk and milk products, vegetables and fruits. Components 6 to 8 related to moderation, assessed the intake of dietary elements that contribute to health risk: sugar, fats and oils and sodium. Component 9 examined the variety of food groups in the diet. Seven major food groups (cereals, pulses, milk and milk products, vegetables, fruits, sugar, fats and oils) were selected for measuring diet variety. Components 10 to 14 were the reflection of intake of nutrients such as protein, fibre, retinol, vitamin C and iron. Participants whose diet complied with dietary recommendations for Indian adolescents aged 13-17 years were awarded

the maximum score, whereas those whose dietary intake was not in compliance were awarded the minimum score. The DQAT-IA score ranged between 0 and 120. The total DQAT-IA score was the sum of scores for the four equally weighted index elements. Each element of DQAT-IA was scored between 0 (minimum) and 30 (maximum) points. The first element or "diet adequacy" had 5 components that were each scored between 0 and 6 points. Components assessing moderation were given scores in the range of 0-10 points. In case of sugar, visible fats and oils and sodium, 0 score was given for intake higher or lower than the recommendations. For diet variety components, intake of 1 or more than 1 serving of food per day from each food group was given 30 points. This score was reduced with a decrease in the daily intake of these food groups. A score range of 0-6 was given to components assessing the adequacy of nutrients in the diet of subjects. The maximum possible score for this index was 120, referring to perfect diet quality and lower results reflecting greater deviations from the recommended dietary intakes. Based on statistically calculated tertiles, the maximum possible score (i.e., 120) was subdivided into three categories: which are (i) ≤65: unhealthy diet, (ii) 66-74: moderately healthy, and (iii) ≥75: healthy diet.

Reliability and statistical analysis

Analyses were performed with the IBM SPSS program, version 20.0 (IBM Co., Armonk, NY, USA). Mean, standard deviation (SD), and percentage were used to express the results. Student's t-test was employed to evaluate the significant difference between the mean intake of food groups and recommended dietary allowances. Karl Pearson's correlation coefficient was used to compute the correlation between diet quality scores and nutrient intakes. A p-value of less than 0.05 was considered statistically significant. The reliability of DQAT-IA was assessed using Cronbach's alpha and split-half method. A Cronbach's alpha coefficient of 0.5 or above is considered sufficient to indicate good internal reliability between index components (Tuckman, 1999). Spearman Brown coefficient value of 0.7 or higher is considered desirable to predict the split-half reliability (Wang et al 2015).

Results

Subject characteristics

A total of 40 students (37.5% male and 62.5% female), with a mean age of 15.40± 1.05 years, participated in this study. The mean ages of males and females were 15.56±0.63 and 15.56±1.22 years, respectively. A higher percentage of girls (23%) belonged to joint families than boys (18%). Distribution of subjects according to religion showed that the majority of them were Hindus (98%). Concerning eating habits, more than half (65%) of the subjects reported eating dairy products with plant foods; 29% ate eggs, dairy products with vegetarian food (not chicken or fish). Nearly a quarter of the heads of the family (26%) obtained high school education and majority of mothers (96%) were involved in household work, not engaged in any paid activity. Nearly half of subjects' head of family (45%) were agricultural workers from which 53.3% were those whose family income per month was <RS 6323.

Intake of food groups and nutrients

Nutrient intakes derived through adolescents' diets are depicted in table 1. Intake of protein, fat, vitamin C was found to be higher than their respective RDA in most of the adolescents. In contrast, intake of iron among all the subjects was lesser than the RDA and lowest intake of iron observed among subjects was 6.16 mg/day. The energy intake ranged from 1049.05 to 2943.11 kcal/day and protein intake ranged between 31.13 and 94.14 g/day. Total fat intake was higher in majority of subjects. Concerning micronutrients, intake of calcium was found to be higher than the RDA in most of boys (13-17 years), whereas most of girls (13-17 years) had lesser intake of calcium than the RDA. Both boys and girls consumed inadequate amount of retinol, iron and zinc and both genders achieved the required intake of vitamin C (more than 100%). NAR for energy was fairly adequate (NAR ≥0.66) for 65% of the adolescents, over 90% of the subjects were observed to have fairly adequate NAR for protein, fat, vitamin C and iron. Zinc was a deficient nutrient in most diet with only 15% subjects having NAR of zinc between 0.66 to 1.00. MAR results are different by gender that boys (1.12) had higher MAR than girls (0.95). MAR was found to be 1.02 which indicate overall nutrient adequacy in the diet. The Karl Pearson's correlation coefficient between diet quality scores and nutrient intakes showed that correlation was significant and positive for energy (r=0.520, p=0.001), protein (r=0.782, p=0.000), retinol (r=0.774, p=0.000), vitamin C (r=0.420, p=0.007), calcium (r=0.430, p=0.006), iron (r=0.485, p=0.001) and zinc (r=0.607, p=0.000); while it was negative for visible fat (r=-0.026, p=0.876) and sodium (r=-0.003, p=0.987).

Table 1
Mean daily intake of nutrients of adolescents (13-17years)

Nutrients	Gender	Age group (years)	RDA	Daily intake (Mean±SD)	NAR
Energy (kcal/d)	Girls	13-15	2400.0	1407.43±467.96	0.58±0.19
		16-17	2500.0	1916.65±487.88	0.76±0.19
	Boys	13-15	2860.0	2039.93±511.67	0.68±0.17
		16-17	3320.0	2440.22±608.91	0.80±0.22
Protein (g/d)	Girls	13-15	43.2	43.34±16.36	1.00±0.38
		16-17	46.2	55.87±18.12	1.01±0.33
	Boys	13-15	44.9	62.83±19.97	1.39±0.44
		16-17	55.4	75.02±13.01	1.63±0.28
Total Fat (g/d)	Girls	13-15	40.0	57.71±26.93	1.41±0.69
		16-17	35.0	80.55±30.68	2.02±1.08
	Boys	13-15	45.0	85.57±30.29	1.90±0.67
		16-17	50.0	117.65±45.67	2.40±1.00
Dietary fibre (g/d)	Girls	13-15	36.0	26.57±4.68	0.73±0.12
		16-17	38.0	29.39±9.36	0.78±0.24
	Boys	13-15	43.0	27.00±5.93	0.61±0.13
		16-17	50.0	35.67±8.98	0.71±0.17
Retinol (µg/d)	Girls	13-15	890.0	210.07±135.49	0.23±0.15
		16-17	860.0	202.23±114.10	0.23±0.13

	Boys	13-15 16-17	930.0 1000.0	394.39±220.05 492.80±190.82	0.42±0.23 0.49±0.19
Vitamin C (mg/d)	Girls	13-15 16-17	66.0 68.0	99.18±48.51 131.29±159.53	1.32±0.67 1.87±2.27
	Boys	13-15 16-17	72.0 82.0	103.33±34.79 101.53±22.65	1.72±1.00 1.45±0.32
Calcium (mg/d)	Girls	13-15 16-17	1000.0 1050.0	605.92±197.63 707.84±344.99	0.60±0.19 0.67±0.32
	Boys	13-15 16-17	1000.0 1050.0	1075.14±532.48 1554.32±582.91	1.07±0.53 1.48±0.55
Iron (mg/d)	Girls	13-15 16-17	30.0 32.0	10.90±2.34 11.65±3.68	0.36±0.07 0.36±0.11
	Boys	13-15 16-17	22.0 26.0	11.48±2.43 15.19±3.11	0.51±0.11 0.58±0.11
Zinc (mg/d)	Girls	13-15 16-17	12.8 14.2	6.08±1.31 7.22±1.99	0.42±0.09 0.49±0.13
	Boys	13-15 16-17	14.3 17.6	7.68±1.58 9.00±1.46	0.53±0.11 0.63±0.10

Table 2 shows the intake of different food groups according to recommended dietary intake. The mean intakes of all food groups were below recommended levels for all except sugar and milk and milk products in boys (13-17 years) and roots and tubers in girls (13-15 years). The average daily intakes of roots and tubers were higher than the recommended dietary intake (RDI) in adolescent girls aged 13-15 years, whereas consumption of cereals, pulses, green leafy vegetables, other vegetables, roots and tubers, fruits and fats was lower than RDI in adolescent boys (13-15 years). Overall consumption of milk and milk products was found to be higher in boys than their girl counterparts. The deficit in the consumption of all food groups except cereals and roots and tubers was higher among girls, compared with boys (16-17 years). Adolescent boys aged 13-15 years had a greater percentage of inadequate intakes of cereals, pulses, green leafy vegetables, other vegetables and fats and oils, compared to adolescent boys aged 16-17 years. The intake of food groups (cereals, pulses, green leafy vegetables, fruits) was significantly different than RDI in most of girls (13-17 years), whereas, the intake of roots and tubers, other vegetables and sugar was not significantly different than RDI in most of boys (13-17 years).

Table 2
Mean daily intake of different food groups of adolescents

Food Groups	Gender	Age group (years)	RDI	Daily intake (g) (Mean±SD)	Percent of RDI	p-value
Cereals and millets	Girls	13-15 16-17	330	163.59±70.81 172.64±67.06	49.57 52.31	0.00* 0.00*
	Boys	13-15 16-17	420 450	151.26±67.39 172.00±43.09	36.01 38.22	0.00* 0.00*
Pulses	Girls	13-15 16-17	60 75	20.59±41.94 14.57±20.13	34.31 19.42	0.03* 0.00*

	Boys	13-15 16-17	75 90	17.75±28.09 33.85±60.34	23.66 37.61	0.00* 0.10NS
Green leafy vegetables	Girls	13-15 16-17	100	26.91±71.20 12.80±41.94	26.91 12.80	0.03* 0.00*
	Boys	13-15 16-17	100	- 20.00±40.00	- 20.00	- 0.00*
Other vegetables	Girls	13-15 16-17	200	138.32±134.83 188.21±157.02	69.16 94.10	0.23NS 0.76NS
	Boys	13-15 16-17	200	151.05±135.01 188.52±92.87	75.52 94.26	0.25NS 0.79NS
Fruits	Girls	13-15 16-17	100	31.25±69.57 31.81±64.31	31.25 31.81	0.02* 0.00*
	Boys	13-15 16-17	100	84.54±129.25 68.00±108.94	84.54 68.00	0.70NS 0.54NS
Roots and tubers	Girls	13-15 16-17	100 200	129.11±89.85 136.41±99.81	129.11 68.20	0.39NS 0.01*
	Boys	13-15 16-17	150 200	117.16±67.13 100.4±120.32	78.10 50.20	0.10NS 0.13NS
Sugar	Girls	13-15 16-17	25	21.25±15.75 20.00±12.50	85.00 80.00	0.52NS 0.11NS
	Boys	13-15 16-17	20 30	28.63±25.89 30.00±16.95	143.15 100.00	0.29NS 1.00NS
Milk and milk products	Girls	13-15 16-17	500	352.18±141.45 434.11±227.43	70.43 86.82	0.02* 0.25NS
	Boys	13-15 16-17	500	796.36±432.94 1094.00±571.03	159.27 218.80	0.04* 0.08NS
Fats and oils	Girls	13-15 16-17	40 35	21.40±15.85 27.90±18.08	53.50 79.71	0.00* 0.12NS
	Boys	13-15 16-17	45 50	15.33±9.99 32.35±33.54	34.06 64.70	0.00* 0.30NS

*$p<0.05$, NSnon-significant

Reliability estimation and diet quality assessment using Diet Quality Assessment Tool for Indian Adolescents (DQAT-IA)

The mean DQAT-IA score was 70.5; it ranged from 46.0 to 95.0. Male participants achieved a mean DQAT-IA score of 72.6 (SD 11.0) and the mean score was 69.2 (SD 11.8) for female participants. The mean DQAT-IA sub score for diet variety elements was highest, with a range from 20 to 30, followed by the mean sub score of moderation, nutrient adequacy and food group adequacy (table 3). Regarding the food group adequacy category, the majority of students (90%) had a

consumption of cereals lower than the Indian guidelines (10 to 15 servings/day). Only 10% of adolescents met the recommended levels of pulses intake. Milk was consumed regularly by more than half of the subjects (55%) as per recommendation (5 servings/day). Most of the adolescents (95%) were not consuming green leafy vegetables as per recommended dietary intake (RDI). Nearly half of the subjects reported an intake of roots and tubers and other vegetables as per the recommendations (1 to 2 servings/day). A quarter of participants (25%) achieved fruits goals (1 serving/day). According to the moderation category, only 35.0% and 12.5% of adolescents achieved sugar (6 servings/day) and fat (9 servings/day) goals, respectively. Sodium intake was 2g/day in 20.0% of the subjects. Regarding the diet variety category, only 3.0% of subjects daily consumed one or more than one serving from each food group; 57.5% missed only one food item and 35.0% missed two food items per day. According to the nutrient adequacy category, more than half of the subjects (62.5%) achieved the protein goal. A large proportion of the population reported intake of vitamin C ≥100% the recommendation and 72.5% and 35.0% of adolescents reported intake of fibre and vitamin A over 50% of the recommendation, respectively. Over 52.5% of students' iron intakes were below 50% of the Indian RDI. Following the assessment of diet quality by DQAT-IA, total score was calculated for each subject.

Based on statistically calculated tertiles, more than one-third of subjects (35%) were having a moderately healthy diet. About one-third of subjects (32.5%) fell in the healthy category. Moreover, more girls (40%) as compared to boys (20%) were consuming unhealthy diet. Only 20% of boys followed unhealthy diet. More than a quarter of total girls (28%) were having healthy diet. The Cronbach's alpha coefficient was 0.50, which indicated that the DQAT-IA components had fair internal reliability in measuring diet quality. Reliability statistics of this tool was 0.61 by the split-half method, which is considered lower.

Table 3
Diet Quality Assessment Tool for Indian Adolescents (DQAT-IA) scores and components

Components	Score range	Mean±SD
Dietary adequacy	30	15.77±5.01
Cereals	0-6	2.25±1.86
Pulses	0-6	1.50±2.01
Milk and milk products	0-6	4.57±1.64
Green leafy vegetables	0-2	0.17±0.49
Roots and tubers	0-2	1.45±0.63
Other vegetables	0-2	1.35±0.69
Fruits	0-6	1.87±2.57
Moderation	30	18.00±5.16
Sugar	0-10	6.37±3.87
Fats and oils (visible)	0-10	3.87±3.25
Sodium	0-10	7.75±3.52
Diet variety	30	23.62±2.95
Nutrient adequacy	30	15.77±5.01
Protein	0-6	4.87±1.45

Iron	0-6	1.50±1.64
Vitamin C	0-6	4.95±1.71
Retinol	0-6	1.20±1.65
Fibre	0-6	3.22±1.55

Discussion

The results of nutrient adequacy reveal that NAR of energy was inadequate. These findings were consistent with the results of a study conducted among rural adolescent girls (Malhotra and Passi, 2007). The food intake, in the present study, was low particularly with respect to cereals and pulses. This could be a possible reason for the inadequate energy in the diets. The majority of adolescents had an adequate intake of fat which was contributed by higher consumption of fatty foods. Our findings, akin to the previous study (Gupta et al, 2018) inferred that there was an inadequate intake of energy on the one hand and intake of high calorie food on the other hand. Protein intake was adequate in most of the participants. This has been contributed by the high intake of milk and milk products as the main source of protein. Male participants had a high intake of protein as compared to female counterparts. This difference is more related to the portion size consumed between girls and boys. These findings were inconsistent with a study conducted among adolescents in Assam, India, where protein intake was low (Konwar et al, 2019). With regards to micronutrients intake, findings indicate that adolescents had inadequate consumption of calcium, iron and zinc. In line with research, a study conducted among adolescents in Telangana, South India, reported a low intake of micronutrients including iron and zinc (Madhari et al, 2020). Consumption of fruits and vegetables particularly green leafy vegetables was found to be inadequate in the present study, which could have led to deficient micronutrients intake. The mean intakes of milk and milk products in all the boys were much higher than the recommended, whilst the intake of pulses was lower than the recommended among all the subjects. It can be stated that the higher contribution to total protein intake came from milk and milk products followed by pulses.

We developed a diet quality index (DQI-IA) which comprised 16 components to assess adherence to the dietary guidelines for Indian adolescents. In the present study, diet quality scores ranged between 0 to 120, whereas the mean score was found to be 70.5. The average DQI-IA score was higher than the mean scores observed in adolescent girls consuming lacto-vegetarian diet (Chiplonkar and Tupe, 2010), which may be due to scoring given to different dietary patterns. In concordance with results from other studies (Cheng et al, 2016; Tek et al, 2011), it was found that the DQI-IA scores positively correlated with essential nutrients and vitamins namely protein, calcium, iron, vitamin C, zinc and vitamin A and negatively with fat and sodium intakes. This reflects that the DQI-IA scores increase when there is a decrease in intakes of fat and sodium. It was demonstrated that most participants who fell in the unhealthy diet category had a low intake of food and poor food choices high in total fat, sugar and sodium. These results signify that a high intake of fat, sodium and salt decreases DQI-IA scores. While in contrast, participants who consumed adequate food groups and made food choices that incorporated variety in the diet had high DQI-IA scores and were categorised under the healthy diet category.

Reliability estimation of DQAT-IA depicted that Cronbach's alpha coefficient for the total score was found to be 0.50. A validation study by Wong et al, (2013), showed that Cronbach's alpha value of NADQI-A was 0.51, which indicated fair internal consistency in assessing quality of diet. Tuckman (1999) suggested that a value of 0.50 or higher is considered acceptable Cronbach's alpha for tools based on assessment of attitudes. A lesser number of questions, poor interrelatedness between items and heterogenous constructs can cause low value of Cronbach's alpha coefficient. Split-half reliability of DQAT-IA was 0.61 which was considered lower. A value of >0.7 is generally considered as acceptable for split-half reliability (Wong et al, 2015). In the validation study by Chamoli et al, (2019) among school children, split-half reliability of DQIIC was found to be 0.85, which is higher to what was observed in our study.

In conclusion, the present study reveals dietary inadequacy of the participants particularly in respect of energy, calcium, iron, dietary fibre and zinc. Nearly one-third of participants were having unhealthy diets therefore diet quality of adolescents needs to be improved. The DQI-IA may be a useful tool in evaluating the diet quality of Indian adolescents, but modification of DQAT-IA items is required in order to enhance its reliability.

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