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RESEARCH ARTICLE

DEVELOPMENT AND EVALUATION OF HEALTHY EATING INDEX FOR ADOLESCENTS (HEIA).

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Abstract

Background:- Healthy Eating Index (HEI) is used to measure dietary quality of Americans. So far no attempt has been made in India to develop such systems in Indian context.

Objective:- Development and validation of Healthy Eating Index for Adolescents (HEIA) in Indian context which measures congruity of dietary patterns with previously established 'Dietary Guidelines for Indians'.

Design:- Socio-economic status, 24-hour dietary recall (3 day) and anthropometric data was collected from 478 school children aged 8-15 years. HEIA was developed and validated based on psychometric properties.

Results:- HEIA comprised of 10 dietary components. HEIA assessed and scored quality of relative proportion of foods consumed. Religion, nutritional status and dietary habits had significant effect on mean HEIA scores. Mean HEIA scores were positively correlated to mean energy, protein calcium and iron intakes. Multiple-regression analysis revealed 36% of total variation in mean HEIA scores was exerted by calcium, protein, iron, energy intakes and age together. Analysis of the psychometric properties of HEIA showed its components conformed to the dietary guidelines. HEIA uncoupled dietary quality with dietary quantity. Eight of ten components explained 90% of variance in HEIA scores. HEIA was found to be reliable multidimensional tool for measuring diet quality.

Conclusion:- HEIA is a simple, valid and reliable tool for measuring dietary quality of school children. General population can be trained to evaluate quality of their own diets using HEIA. It should be used in conjunction with simple behaviour-change communication messages to bring about positive behavioural changes amongst populations.

Introduction:-

'Adolescence is an age of opportunity for children, and a pivotal time to build on their development in the first decade of life, to help them navigate risks and vulnerabilities, and to set them on a path to fulfilling their potential'[1].

Healthy eating patterns in childhood and adolescence promote optimal health, growth, and intellectual development[2]. The quality of children's and adolescents' diet is of importance because the poor eating habits established in this stage continue till later stages of life. These habits are the major contributing factors to related health and nutrition outcomes.

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Most of the countries have developed or are developing National Food Based Dietary Guidelines (FBDG). In addition to the dietary guidelines, there has also been a call in the research and policy communities to develop simple indicators to measure diet quality. Simple dietary assessment tools like Healthy Eating Index[3] can be used by the adolescents to assess the quality of their dietary intakes.

Previous studies have suggested a dual burden of malnutrition amongst adolescents in urban Indian cities. As well as dietary inadequacies have been highlighted by many investigators, but so far no attempt has been made to evolve a system to assess the dietary inadequacies/practices of school children in India unlike western countries, where people have developed and validated the HEI to assess the quality of diet. Healthy Eating Index (HEI) is being used by United States Department of Agriculture since 1989 to assess the dietary quality of Americans. HEI provides a measure of overall dietary quality based on major dietary components.

Thus, the hypothesis for the present study stated that HEIA developed based on dietary guidelines for Indians may be used to effectively assess the dietary quality of adolescents.

The **major objective** of the present study was to develop and evaluate the Healthy Eating Index for Adolescents in Indian context. The specific objectives were as follows:

- To review the socio-economic profile of the school children enrolled for the study.
- To assess the nutritional status of the children in selected schools by anthropometric measurements and perform biochemical estimations on a subsample.
- To assess the 3 day dietary intake of all the subjects using 24 hour Dietary Recall method.
- To develop a Healthy Eating Index for adolescents in the Indian context.
- To review the dietary quality of the study subjects with the help of the developed Healthy Eating Index.
- To assess the validity of Healthy Eating Index as a tool for assessing dietary quality.

Methods and Materials:-

Baseline data collection:-

Two urban schools were randomly selected and all the students (N=478) studying in std. V^{th} to IX^{th} were enrolled for the study. Written informed consent was obtained from all the parents as well as from all the participating children for the study and hemoglobin analysis was conducted only on the children whose parents consented for the same. Students were given an option of participating in the study even if they did not consent for hemoglobin analysis. Ethical clearance was obtained for the study the clearance no. being: F.C.Sc/ FND/ME/90

Baseline data collection on anthropometric measurements (Height and weight), socioeconomic status and 24- hour dietary recall (3 day) was carried out on all the subjects. To assess the prevalence of malnutrition, indices namely, BMI for age z scores[4] (BAZ), Height for age z scores (HAZ)[4] and Weight for age z scores (WAZ)[5] were calculated. Information on the socio-economic profile of the subjects was collected using a pre-tested structured questionnaire.

Three consecutive days dietary recalls were recorded and the researcher then visited the households to get details of the exact amounts of ingredients consumed. The data obtained was later analysed for the amount of energy, protein, fats, calcium and iron intakes and also for evaluation of dietary quality using Healthy Eating Index for Adolescents (HEIA).

Haemoglobin estimation (using cyanmethaeoglobin method) was performed on a sub-sample of 61 subjects who got a written consent from their parents.

Development and Evaluation Strategy for Healthy Eating Index for Adolescents:-

HEIA, in the present study, evaluated food consumption pattern against the recommendations made in *'Dietary Guidelines for Indians'*[6]. HEIA consisted of 10 dietary components encompassing all the dietary aspects as laid down in the dietary guidelines.

Evaluation of content validity examines qualitatively the extent to which an index represents the variety of attributes that make up diet quality. The key recommendations applicable to adolescents were used from 'Dietary guidelines for Indians- 2010'. These recommendations were linked to related components of HEIA for establishing content validity.

Construct and criterion validity measure how well the index measures diet quality. This is done in four different ways.

Firstly, to evaluate construct validity it was observed whether the index gave maximum scores to menus developed by nutrition experts, to illustrate high diet quality. For this sample diet menus given by experts were used.

Secondly, to establish concurrent validity, HEIA should distinguish between groups with known differences in diet quality for example under nourished and well nourished.

Thirdly, HEIA should be able to assess diet quality independent of diet quantity, as measured by diet's energy value. Because nutrient intake is positively correlated with energy intake, a diet quality index could lead to an overrating of high calorie diets. To evaluate this independence, Pearson correlations of the HEIA total and components scores with the energy intake were seen.

Fourthly, the underlying structure of the index was examined through principal component analysis (PCA). On the basis of the correlations among the components, the PCA was used to determine the number of independent factors that compromise the HEIA. The main objective of PCA was to find out whether one or more than one factor accounted for the systematic variation observed in the data.

HEIA was checked for one form of reliability, internal consistency, the degree to which multiple components within an index measure the same underlying, unidimensional, latent construct, by using Cronbach's coefficient alpha. This statistic is mathematically equivalent to the average of the correlations among all possible split-half combinations of the 10 components of HEIA, and thus captures any systematic variation underlying the dietary components that are measured.

Also to get an understanding of the inter component relationships among components, inter component correlations were observed.
Data was analyzed using Microsoft excel (2010), Epiinfo Version 7 and Statistical Package for Social Sciences (SPSS) Version 17.

Results:-

Development of Healthy Eating Index for Adolescents (HEIA):-

HEIA comprised of 10 dietary components, each representing a different aspect of diet quality (Table 1.1). Each of the 7 components except total vegetables, Green/yellow/orange vegetables and Solid fat and added sugars (SOFAAS) had a scoring range of 0 to 10. Total vegetables and Green/yellow/orange vegetables had a maximum score of 5 each, while SOFAAS had a maximum score of 20. Higher intakes for components other than SOFAAS, Total oil and Total sugar reflected higher intakes of those components whereas higher scores for SOFAAS, Total oil and Total Sugar reflected lower intakes. Thus, the most desirable intake of a component was given the maximum score. Minimum score was allotted to the most undesirable intake.

The overall HEIA scores were the simple sum of the scores from the 10 components. Total HEIA scores over 80 implied a "Good" diet. Scores between 51 to 80 indicated a "need for improvement" and scores below 51 indicated a "poor diet".

Table 1.1:- Individual Components of Healthy Eating Index for Adolescents (HEIA)

Components	Maximum Score	Minimum score
Total Grains	10	0
Total pulses/Meat , Fish & Poultry	10	0
Total Vegetables	5	0
Total Green, Yellow & Orange vegetables	5	0
Total Fruits	10	0
Total Milk	10	0
Total Oil	10	0
Total Sugar	10	0
Variety	10	0
SOFAAS	20	0
Total Score	**100**	**0**

Assessment of Dietary Quality of the Subjects According to the Healthy Eating Index for Adolescents (HEIA):-

For the study subjects mean overall HEIA score was 63.34 ± 5.2 with no significant difference in scores for the three days. Mean score for boys was slightly higher than girls. However, this difference was not significant between the sexes.

An age and sexwise analysis shows that boys had overall higher scores than girls at all ages except between at 9, 11 and 13 years of age. Total HEIA scores showed a gradual increase between 7 to 10 years (64.2) followed by a drop in the total scores at 11 years of age (63.1). However, these scores again showed an increase at 12 years (65.7) followed by a decline in total score as age advanced. Oldest age group had the lowest scores (60.8) irrespective of the sex. However, these differences were not significant as shown by Analysis of Variance (ANOVA).

Mean HEIA scores were significantly correlated ($p<0.01$, 2 tailed) with mean energy, protein, calcium and iron intakes of the subjects.

Analysis of Variance (ANOVA) revealed that religion had a significant effect on the mean HEIA scores of the study subjects with 'Christians' having the highest scores followed by 'Hindus'. Although, type of family and family size had no significant effect on mean HEIA scores, but the scores were higher for subjects with smaller families.

There was no significant effect of PCI, education of parents or working status of mother on the mean HEIA scores. Dietary habits (Vegetarian/ Non-vegetarian / Ovo-vegetarian) had a significant effect on the mean HEIA scores. Mean HEIA scores were significantly higher in vegetarians ($p<0.001$) and non- vegetarians ($p<0.01$) as compared to ovo-vegetarians.

Almost all the subjects (99%) needed improvement in their diets. None of the subjects were consuming diet of a good quality. There was no significant difference between the sexes with regard to diet quality.

As the nutritional status of these subjects improved there was an increase in their mean HEIA scores. Subjects having WAZ and HAZ scores <-2SD had almost similar HEIA scores which were also the lowest. A significant difference was seen between the mean HEIA scores of subjects according to their WAZ ($p<0.005$) and HAZ ($p<0.05$) scores. BAZ scores did not have any significant effect on the mean HEIA scores.

HAZ scores were significantly correlated ($p<0.01$) to the mean HEIA scores while WAZ and BAZ scores had no significant correlation with the mean overall HEIA scores. However, analysis of Variance (ANOVA) showed a significant effect of WAZ ($p<0.05$) and HAZ ($p<0.005$) scores on the mean overall HEIA scores.

On comparing the diet quality of anemic and non anemic subjects it was found that the mean HEIA score for non anemic subjects (63.2) was higher than the anemic subjects (62.7). However, the difference in their mean HEIA scores was not found to be significant.

Multiple regression analysis was carried out to find out the factors exerting an independent effect on the mean HEIA scores. Five factors exerted an independent effect on mean HEIA scores (Table 1.2). The first factor to enter the equation was calcium intake of the subjects. Alone, it explained for 27.3% of the variation in HEIA score. The next factor was protein intake, which also exerted an independent effect on mean HEIA scores and accounted for 4.3% of the variation seen in HEIA scores. The third factor which had a significant and independent effect on HEIA scores was age. Age accounted for 3.3% of the variation in the scores. Iron intake and the dietary habits of the subjects were the fourth and the fifth factors to enter the equation, respectively. Both accounted for 1.5% of the total variation observed in the mean HEIA scores. The five factors together accounted for 36% of the total variation seen in the mean HEIA scores.

Table 1.2:- Mean HEIA score according to the nutritional status3.

Nutritional Status (N=478)	**Total HEI scores Mean±SD**	**'t' value**	**'F' value**
WAZ			
<-2 SD (n=24)	60.39 ±4.73	2.88***	2.30*
≥-2 SD (n=454)	63.50 ± 5.19		
HAZ			
<-2 SD (n=12)	59.82 ± 5.52	2.39*	2.88***
≥-2 SD (n=466)	63.44 ± 5.17		
BAZ			
<-2 SD (n=47)	62.31 ± 4.97	1.43	1.33
≥-2 SD (n=431)	63.46 ±5.22		

*significant at p<0.05
***significant at p<0.005

Evaluation of the Psychometric Properties of the Healthy Eating Index for Adolescents (HEIA):-
Validity:-
Content Validity:-
All the components of the dietary guidelines for Indians, which relate to diet quality, were reflected in HEIA. By design HEIA did not cover physical activity, body weight management, water intake, food safety, cooking methods and healthy eating habits (Table 1.3).

Table 1.3:- HEIA Components mapped to Dietary Guidelines for Indians.

Dietary Guidelines – Key recommendations	HEIA Components	Comment
Eat variety of foods to ensure a balanced diet	• Total Grains • Total pulse/ meat, fish and poultry • Total vegetables • Total green, yellow and orange vegetables • Total fruits • Total Milk • Total oil • Total Sugar • Variety • SOFAAS	HEIA assesses intake of all the food groups. It also includes 'Variety' to ensure use of all major foods in the diet. SOFAAS component covers all the additional calories consumed in the form of extra sugar and fat.
Eat plenty of vegetables and fruits	• Total vegetables • Total green, yellow and orange vegetables • Total fruits	These components cover the recommended intakes for vegetables and fruits for HEIA.
Ensure moderate use of edible oils and animal foods and very less use of ghee/ butter/ vanaspati	• Total oil • SOFAAS	A score of 8 is given to total oil component meeting the requirements whereas a score of 10 is given to an intake of 20% less than the requirement. Additional fat intakes apart from edible oil are counted as SOFAAS. Higher intakes results in lower scores for total oil and SOFAAS components.
Overeating should be avoided to prevent overweight and obesity		HEIA does not measure energy intakes because it assesses quality rather than quantity. Also higher intakes than requirements for Total oil, Total Sugar and SOFAAS results in lower scores.

Exercise regularly and be physically active to maintain ideal body weight		HEIA does not include physical activity. Measures of physical activity can be used along with HEIA.
Ensure the use of safe and clean foods		By design HEIA does not address food safety.
Practice right cooking methods and healthy eating habits		HEIA does not include healthy eating habits and methods of cooking.
Drink plenty of water and take beverages in moderation		HEIA does not cover water intake.
Minimize the use of processed foods rich in salt, sugar and fats	• Total Oil • Total Sugar • SOFAAS	Higher intakes of the mentioned components yield a lower score thus discouraging the use of higher amounts of fats and sugars. By design HEIA does not cover salt intake.

Construct and Criterion Validity:-

This was carried out in four ways-

1. The scores based on balanced diets for adolescents according to portion sizes were the highest as these plans were used to formulate HEIA (Table 1.4). The HEIA score for the sample diet plan for boys by 'Dietary guidelines for Indians'[6], was low as the total grains, total pulse, total oil and total sugar scores were a little lower. However, all the diets were ranked of a good quality.

Table1.4:- Quality of sample diets as per HEIA.

Components	**Balanced Diet (NIN) Boys (13-15y)**	**Balanced Diet (NIN) Girls (13-15y)**	**Sample Diet Plan (NIN) Boys (13-15y)**	**Sample Diet Plan (NIN) Girls (13-15y)**
Total Grains	10	10	8	9
Total pulse/Meat Fish & Poultry	10	10	8	10
Total Vegetables	5	5	5	5
Total Green, Yellow & Orange vegetables	5	5	5	5
Total Fruits	10	10	10	10
Total Milk	10	10	10	10
Total Oil	8	8	9	10
Total Sugar	10	10	7	10
Variety	10	10	10	10
SOFAAS	20	20	20	20
Total Score	**98**	**98**	**92**	**99**

2. Differences in 3-day HEIA scores between undernourished (WAZ<-2SD) and well nourished (WAZ>-2SD) subjects are shown in Table 1.5. Three of the ten components were significantly higher for the well nourished subjects. Mean total HEIA score for undernourished subjects (60.39) was significantly lower ($p<0.005$) than the score for the well nourished subjects (63.5). Although there were certain exceptions like total pulses, total oil and SOFAAS score which were higher for the undernourished subjects.

Table1.5:- Mean Total HEIA and individual component score according to the Nutritional Status.

Components	**Score (Mean ± SE)**	
	Undernourished (N=24)	**Well nourished (N=454)**
Total Grains	6.31± 0.3	6.64± 0.09
Total pulse /Meat , Fish & Poultry	6.71± 0.68	5.85± 0.13
Total Vegetables	1.69±0.24	2.67± 0.06***
Total Green, Yellow & Orange vegetables	0.21± 0.12	0.51± 0.04
Total Fruits	0.97± 0.43	1.01± 0.11
Total Milk	2.04± 0.45	3.73± 0.09***

Total Oil	9.67+ 0.17	9.47+ 0.04
Total Sugar	9.68+ 0.19	9.81+ 0.03
Variety	3.28+ 0.31	4.03+ 0.08*
SOFAAS	19.83+ 0.12	19.78+ 0.05
Total Score	60.39+ 0.97	63.5+ 0.24***

*significant at p<0.05
***significant at p<0.005

3. The correlations between each of the HEIA component scores and energy intake are shown in Table 1.6.The components with the highest positive correlations with energy were the milk score (0.5) and the variety score (0.35). The component scores with the highest negative correlation were the SOFAAS score (-.41) and the oil score (-.35). HEIA was able to uncouple diet quality with diet quantity which can be seen by the low correlations of the total and component scores with energy (Table1.6).

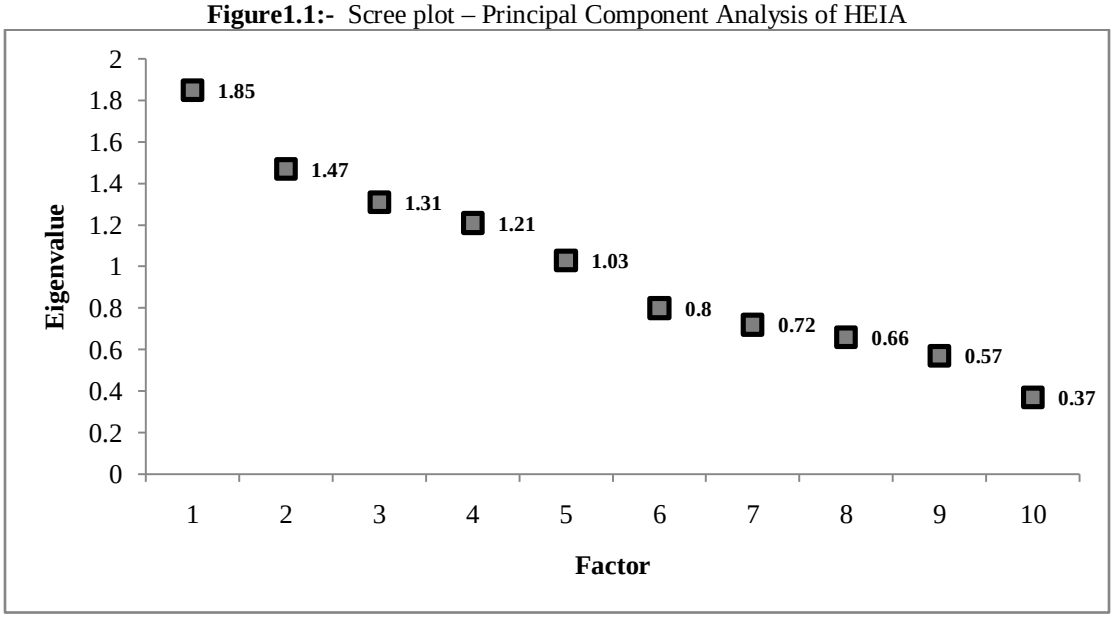
Table1.6:- Correlations of 3-day HEIA components and total score and energy intake.
*significant at 0.05 level (2- tailed)
**significant at 0.01level (2- tailed)

Component	Total Grains	Total pulse /Meat , Fish & Poultry	Total Vegetables	Total Green, Yellow & Orange vegetables	Total Fruits	Total Milk	Total Oil	Total Sugar	Variety	SOFAAS	Total Score	Energy Intake
Total Grains	1											
Total pulse /Meat , Fish & Poultry	-0.02	1										
Total Vegetables	0.11*	-0.25**	1									
Total Green, Yellow & Orange vegetables	0.11*	0.01	0.2**	1								
Total Fruits	-0.09*	-0.12**	-0.00	-0.01	1							
Total Milk	0.08	-0.17**	0.24**	0.05	0.08	1						
Total Oil	-0.17**	-0.14**	0.06	0.09*	-0.11*	-0.12**	1					
Total Sugar	0.06	0.08	-0.15	0.01	-.28**	-0.03	0.06	1				
Variety	-0.09*	0.12**	0.30**	0.08	0.25**	0.43**	-0.21**	-0.04	1			
SOFAAS	-0.18**	-0.02	-0.06	-0.23**	-0.01	0.01	0.05	0.00	0.06	1		
Total Score	-0.13**	-0.02**	0.14**	0.11*	-0.05	0.12*	-0.24**	-0.08	0.44**	-0.10*	1	
Energy Intake	0.19**	0.10*	0.29**	0.22**	0.13**	0.50**	-0.35**	-0.02	0.32**	-0.41**	0.44**	1

4. The scree plot from the Principal Component Analysis (PCA) showed that multiple factors form HEIA. The plot shows the amount of variance each principal component or factor contributes. Around 69% of the variance is explained by the first five components and 90% by the first eight components. The optimal number of factors is the place where the curve forms a flat horizontal line. Figure 1.1 shows that the flat line appears between six and eight factors.

Another way of finding out the number of factors is an Eigenvalue greater than 1. The scree plot shows that at least five factors are there in HEIA with eigenvalue more than 1. Thus, the PCA showed that no single linear combination of components of HEIA accounted for a significant proportion of the co-variation in dietary patterns of the subjects.

Figure1.1:- Scree plot – Principal Component Analysis of HEIA



Reliability:-

Test retest and inter-rater reliability is the most widely recognized forms of reliability. HEIA was developed to be identical for identical diets or practices that are recalled, recorded and coded the same way. The test retest measurement error in this case could be attributed to respondent recall

or data collection and processing. Inter-rater reliability was not needed as no judgment was required for scoring. Thus, these two reliabilities were perfect.

Cronbach's coefficient alpha is a measure of internal consistency of an index. For HEIA, the Cronbach's coefficient alpha was-0.017. The Cronbach's Alpha was expected to be low because diet quality is known to be a complex and multidimensional construct. Also because there is no consistency in individuals meeting all the dietary standards used to assess diet quality. Therefore, internal consistency was not a necessary characteristic of HEIA.

The component score most highly correlated with the total HEIA score were variety (0.44) other positively correlated components were vegetables (0.14 and 0.11) and milk (0.12). Six of the component scores had low negative correlations with the total score ranging from-.22 to -.02.

Discussion:-

As tools similar to HEIA have not been developed in India, the discussion is mainly based on studies carried out in other countries. Mean HEIA scores were higher for boys than girls in the present study. Females had higher mean HEI scores as compared to males as shown by Center for Nutrition Policy and Promotion (CNPP) surveys[3;7-10](Table 1.7). This was explained by a higher intake of nutrients by boys as compared to girls in the present study.

The mean scores were almost consistent or increased between the ages of 9 to 12 years and then decreased as age advanced. This can be explained by lower mean nutrient intakes by these groups. CNPP surveys indicate the highest scores were obtained by children and as age advanced the mean total HEI scores declined[3,7,8].

Various socio demographic factors have shown an influence on the HEIA scores in the present study. CNPP survey conducted in 2005 has shown that although the mean HEI scores were higher for higher income group subjects but the difference found was not significant[9]. This supports the findings of the present study where subjects with per capita income of Rs. 5000 or more had higher HEIA scores. Lin[10] also reported of no significant difference between the mean HEI scores of school age children with regards to income level.

CNPP survey considered education level and found mean HEI scores to be higher in well educated subjects[3,7,8]. The present study took education level of the parents into consideration and reported higher education of parents had

positive effects on the mean HEIA scores of the subjects. Education may be a predictor of people's ability to translate nutrition guidance information into better dietary practices[11].

Table 1.7:- Comparison of Total HEI scores in other studies v/s HEIA scores in present study

Study/ Year	Author/ Place	Mean Total HEI Scores		
		Males	Females	Total
Present Study, 2013	Vadodara, India	63.4	63.2	63.3
HEI – 1989, 1995	Kennedy et al, USA (3)	62	65.6	63.8
HEI – 94 -96, 1998	Bowman et al, USA (7)	62.9	64.4	63.6
HEI-99-00, 2002	Basiotis et al, USA (8)	63.2	64.5	63.8
HEI 2005, 2011	Ervin B, USA(12)	54.8	60.3	57.2

Conclusion and policy implications for healthier dietary practices:-

In order to bring a change in the dietary practices, it is very important to assess their quality first. Healthy Eating Index for Adolescents (HEIA) was found to be a valid and reliable tool in assessing the dietary quality of the subjects. There is need to develop new tools like HEIA for all age groups and implement it at population levels, to see the degree of conformation to the dietary guidelines.

Another implication to be drawn from the present study is that with a little information general population can also be trained to evaluate the quality of their own diets using HEIA. Steps should be made in this regard as to make these tools more accessible to the population.

Thus, to conclude simple dietary tools like HEIA - to assess the diet quality should be used along with simple behaviour change communication (BCC) messages to bring about positive behavioural changes amongst populations.

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Conflict of interest:-

The above paper was presented at the 45th National Conference of Nutrition Society of India, NIN, Hyderabad, India between 21-22 Nov. 2013 and was awarded Young Scientist Award (Senior) in Community Nutrition

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