Original Article

Nutrition education improves serum retinol concentration among adolescent school girls

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Dietary diversification has been identified as a sustainable intervention method in developing countries where subclinical vitamin A deficiency exists. Nutrition education is central to all methods of nutrition intervention including dietary diversification. The paucity of available data currently limits the effective use of nutrition education in national programs in Sri Lanka. We assessed the effect of nutrition education on nutrition related knowledge, food consumption patterns and serum retinol concentrations among 229 adolescent school girls, aged between 15-19 years. Knowledge on nutrition, food consumption patterns and serum retinol concentration was assessed at baseline. Intervention included nutrition education as lecture discussions, interactive group discussions and four different methods of reinforcement. Knowledge, food consumption patterns and serum retinol concentrations were reassessed after a ten week period of intervention. Educational intervention resulted in a significant increase in knowledge (P<0.001) and consumption of local vitamin A rich foods. The percentage of subjects with low serum retinol concentrations (<20µg/dL) decreased from 17% to 4.8%. The effect of nutrition education on serum retinol concentration was highly significant (P<0.001) in subjects with baseline serum retinol concentrations below 20µg/L. Nutrition education was effective in improving knowledge and food consumption patterns among these girls. Effectiveness was of biological significance, as a positive change in serum retinol concentration was observed in subjects with initially low concentrations, and not in subjects with initially normal serum concentrations.

Key Words: serum retinol, nutrition education, adolescents, Sri Lanka

Introduction

The goal of dietary diversification is the achievement of behavioral change in production, selection, preparation and finally consumption, of food. It has been suggested that, to be sustainable, a national program should be based on an information- education- communication (IEC) strategy combined with community mobilization, agricultural inputs, long term promotion, support and follow up.[1] The development of such a national program requires research in the local context in terms of a population's requirements, practicality and effectiveness.

Deficient diets are often lacking in many nutrients. It is noteworthy that a coexistence of more than one micronutrient deficiency has been observed in this study population previously.[2,3] Unlike supplementation, a dietary approach which focuses on the total diet can address a range of nutrient deficiencies. A further benefit, of a dietary approach is its cultural acceptability if carefully designed,[4] with a low possibility of adverse effects. Ghana has identified the need for a transition from capsule distribution to a sustained food based intervention,[5] and Thailand has successfully carried out food based interventions.[6]

Unresolved issues regarding dietary intervention range from those of effectiveness of interventions to problems of bioavailability. A study on weekly supplementation of pregnant women with β-carotene or retinol at levels near those of the recommended dietary allowance, demonstrated a 40% decrease in maternal death rate[7] highlighting that food sources of vitamin A could play an important role in improving vitamin A status. However, it has been shown that when carotenoids are contained within a complex matrix, the matrix has a negative effect on bioavailability of carotenoids.[8] This lays emphasis on the need for education messages to focus on food preparation and diet rather than identifying foods in isolation. During adolescence, when girls experience rapid biological and psychological change, they become more receptive to external influences on diet and lifestyle change compared with adults. Further, they can be used as agents of change in their current and future families. Thus adolescent girls are a suitable target group for the introduction of good dietary practices. In Sri Lanka multiple nutritional deficiencies such as vitamin A, iron and folic acid have been reported [2,3,9,10] among adolescents. Nutritional deficiency during adolescence is likely to be due to increased nutritional requirements for growth and development and blood loss during menstruation.[11]

Girls of low socioeconomic status would have the added disadvantage of a reduced nutrient intake due to both, a low income and level of knowledge on nutrition. It is necessary to develop strategies to improve the nutritional status of adolescent girls as the benefit is two fold: to improve

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educational, physical performance and general health among adolescents and to ensure that they enter pregnancy with a satisfactory nutritional status. Locally adapted community and school based nutrition education has been suggested for improved food practices in Africa.[4] In Sri Lanka nutrition education together with supplementation was effective in improving iron status among school girls.[10] However effectiveness of nutrition education in improving vitamin A status has not been assessed in Sri Lanka. The objective of the present study was to evaluate the effectiveness of dietary diversification through nutrition education in improving serum retinol concentrations of adolescent girls from low socioeconomic groups.

Materials and methods

Subjects

The study sample discussed in this paper was a subsample from a larger study in an urban (N = 576) and a rural (N = 339) area on iron status of adolescent girls (15-19 years) from low socioeconomic groups, following iron supplementation and educational intervention.[10] All girls included were post menarche. Subjects who tested positive on a faecal worm egg count by the Kato Katz quantitative technique[12] were excluded from the present study. Two hundred and twenty nine girls for whom paired data on serum retinol was available were included in the present analysis.

Study design

The study was interventional in design and all girls received nutrition education. The girls were assessed for level of knowledge, food consumption practices and serum retinol concentration before delivery of the nutrition education programme and after a ten week period of intervention.

Baseline data collection

A pre-tested multiple choice question paper was administered to assess baseline knowledge on nutrition. The question paper was based on the following topics: the common nutritional deficiencies in Sri Lanka, the consequences of anaemia, the consequences of vitamin A deficiency, population groups at increased risk of developing these deficiencies, the common iron rich foods in their area, the common vitamin A rich foods in their area. Scoring for the paper was out of a maximum of 100 marks. A pre-tested interviewer administered food frequency questionnaire was used to assess food consumption patterns (Table 1 contains the list of foods). This questionnaire included Sri Lankan foods rich in retinol, carotenoids and other micronutrients.

A sample of venous blood (10ml) was collected under safe and sterile conditions between 8.00am and 10.00 am, for laboratory assessment of serum retinol concentration and for estimation of iron status[10] and haemoglobin concentration at baseline. Height was measured using a standardized height scale to the nearest 0.01metre. Weight was measured using a Salter (UK) scales to the nearest 0.05kg and the Body Mass Index (BMI) was calculated.

Table 1. List of foods included in the food frequency questionnaire

Dark green leaves (the subject filled in two types of leaves most commonly eaten)
Carrots
Yellow sweet potato
Pumpkin
Dhal
Mung
Cowpea
Eggs
Meat (the subject filled in two types of meat most commonly eaten)
Small fish
Big fish
Tinned fish
Dried fish
Mango
Papaw
Other frequently eaten fruit (the subject filled in two types of fruit most commonly eaten)
Milk
Yoghurt
Curd
Ice-cream

Development of educational tools and approach

In order to develop effective nutrition education tools and identify the most appropriate education approach for this community, formative discussions were carried out and characteristics of the study population were investigated. Qualitative data were collected from discussions held among a sample of adolescent girls comparable to the study population in age and socioeconomic status (the formative group; N = 10). Food selection and preparation practices, factors that currently limit adequate consumption of food, knowledge related to nutrition and attitudes towards gaining knowledge and changing behavior accordingly, were explored.

Qualitative data used in designing the education material, in choosing the mode of delivery and in designing the questionnaire on knowledge, is presented below. Recipes that increase the content and bioavailability of carotenoids/vitamin A and iron and factors limiting food consumption were identified through the discussions. Three common recipes were identified for the preparation of dark green leaves. In these preparations bioavailability of vitamin A and iron are increased due to the addition of oil, animal protein and lime. Cooking pumpkin, carrot and yellow sweet potato with coconut milk or oil were identified as methods of preparation in which bioavailability of carotenoids would be increased. High cost was a limiting factor in the availability of sources of preformed vitamin A such as eggs, dairy products and animal products.

Perceptions on home gardening were investigated among the formative group. Of those who had limited land for home garden cultivation, some had vegetables and fruits in tins and pots while others believed that they had inadequate space for vegetable cultivation although they had flowers in tins and pots. The lack of interest for vegetable and fruit cultivation was due to a lack of understanding of the link between health and adequate consumption of foods rich in specific nutrients.

Key issues that influence the willingness to change nutrition related behavior were identified through a study of attitudes towards education among the formative group. Most girls expressed that they would like to know whether they had vitamin A deficiency, and said that they would be willing to make a behavioral change to correct the deficiency if identified. Among those who did not wish to know whether they had a deficiency, most were willing to try to make a behavioral change. All girls wanted to learn about nutrition and food.

While a few adolescents felt that "since the meals were prepared by an adult they could not change it", most girls felt that "since they were receiving the information from school, the adult concerned would be happy to receive and act according to the information". In this community the younger generation is more educated than the older generation. Thus adolescent girls could be used as agents of change of their families.

The formative discussions were facilitated by a young adult, to assess the feasibility of using young adult educators in the main study. The girls expressed that a person closer to their age would be more sensitive to their needs. The girls were receptive and a relaxed and informal atmosphere could be generated. In designing the education programme, methods of education and reinforcement that were practical to be used in field settings were selected. The education messages, the mode of delivery of the messages, the visual aids and the questionnaires were pre-tested in a comparable group of adolescent girls and modifications were made where necessary.

Content and delivery of the education programme

Delivery of the education programme

The first encounter was in the form of a lecture discussion of 30 minutes duration using flip charts as visual aids followed by a further 15 minutes discussion time, during which the educator answered questions from the participants. This first meeting was used to generate a rapport between the participants and the educator. Posters, which were replicas of the visual aids, were displayed by the participants in the school in a place identified by the students and staff. Trained young adults were used as educators in this study. Separation of the education exposures from the main school curriculum was expected to make the girls more conducive to behavior change than to mere acquisition of knowledge. That the education was perceived by them as a pleasurable and relaxed experience was shown by their anticipation to meet the educators another time even after the education was completed. The approach used by the educator when delivering the education was to help the girls feel that they are the agents of positive change for the whole family. Since the education was delivered in an interactive manner, negative attitudes exhibited by the participants could be discussed and solutions found at the level of the group.

Possible influencing factors

These girls did not receive any additional nutrition education messages outside our intervention, from school, during the period of study. The school curriculum includes information on the need for a balanced diet for health and on food groups. Nutrition related information included in the school curriculum prior to and during the period of intervention was noted in order to prevent any conflict of messages given. There were no other nutrition education messages received by these girls from school during the period of study. Monitoring of factors from outside school, that may influence nutrition knowledge of the subjects were not carried out at an individual level. However, national education programmes addressing these issues were not conducted through the mass media during this period. There were no major changes in environmental conditions affecting food availability. Foods selected for promotion were those available throughout the year.

Content of the education programme

The central theme of education was to identify adolescent girls as a vulnerable group to developing nutritional deficiencies and that increased vulnerability is due to increased nutritional demand during adolescence coupled with inadequate intake. In particular, the importance of maintaining a satisfactory vitamin A, iron and protein energy status was discussed. The next segment of the discussion focused on the consequences of deficiencies of these nutrients during adolescence, pregnancy and in early childhood. That they are the future mothers who need an adequate nutritional status to maintain health was also emphasized. As future mothers of their new family they can ensure good nutri-tion for their children if they are willing to use this information to positively change their behavior. Much emphasis was placed on the fact that "little changes can make a big difference".

In delivering food based information to improve nutritional status, the following information was emphasised. The importance of an adequate total diet in terms of protein and energy. Highlighting cheap vitamin A and iron rich foods in their diet (eggs and small fish as good value for money, and dark green leaves, and yellow fruits) was coupled with selecting combinations of foods and recipes that would enhance bioavailability of these nutrients. Three preparations identified at the formative stage for dark green leaves were promoted. Cooking with coconut oil or milk was encouraged rather than prolonged boiling. Thus the information required to effectively diversify the diet within the economic constraints faced and accounting for cultural sensitivities was given in a practical way in order to empower these girls.

Reinforcement

Reinforcement was designed in four different forms. Reinforcement in the form of further education sessions was at two and five weeks after the first session and was carried out as interactive group discussions. The second form of reinforcement was the posters that were displayed in the school. Between the first and second education sessions each subject was given a potted *Centella asiatica* (Gotukola) plant as the third form of reinforcement. This had three aims. The first was to reinforce the fact that this commonly eaten plant has both vitamin A and iron and that the common method of preparation contains enhancers of vitamin A (oil) and iron (vitamin C). The second was to emphasize that dark green leaves can be easily

grown in pots or tins even where land availability is low. The third was to act as a reminder of the education and to stimulate discussion around it in their homes. Between the last education session and the end of the intervention period groups of girls were given boards and coloured pens and asked to make their own posters including what they thought were important education messages. This was the final form of reinforcement.

Laboratory methods

Serum retinol concentration was estimated by reverse phase high performance liquid chromatography (HPLC) using the protocol recommended by the International Vitamin A Consultative Group with modifications as indicated below. A C18 column was used as the solid phase and a methanol: water (97:3) mixture as the mobile phase.[13] An internal standard (retinyl acetate) was added to the sample and subjected to the same extraction process. The standard curve was generated from fresh standards prepared on each day of analysis. Control samples and serum samples were run in duplicate. Haemoglobin concentration was estimated in duplicate for each sample by the cyanmethaemoglobin method.[14]

Post intervention assessment

The same multiple choice question paper and food frequency questionnaire were used at the end of the ten week period of intervention. A sample of venous blood was collected under the same conditions as at baseline. Serum retinol concentration was measured by the same method.

Statistical analysis

Data were entered and analysed on SPSS for Windows Version 11.0. The effects of intervention and the significance of the effects were assessed using the paired t-test. The significance of the changes in food data were assessed by the Chi^2 test using the EPI INFO statistical package Version 6. The baseline data and the effects of intervention were not significantly different between urban and rural groups and hence the data were pooled for analysis as one intervention group.

Ethical clearance

The study was approved by the Ethical Review Committee of the Faculty of Medicine, University of Colombo, Sri Lanka. Written informed consent was obtained from the Ministry of Education, principals of respective schools, each participant and their parent/guardian, prior to recruitment.

Results

Baseline assessment

Locally available foods rich in preformed vitamin A and carotenoids consumed by these girls were eggs, pumpkin, dark green leafy vegetables (DGLV), papaya and mango. The consumption pattern of foods at baseline is given in Table 3. The mean height of these girls was 1.54±0.06m, and the mean weight was 42.1±6.94kg (Table 2) with a mean BMI of 17.7±2.36 kg/m^2. Mean serum retinol concentration in this population was 31.3±12.3µg/dl at baseline. Mean haemoglobin (Hb) concentration was 129.5 ± 12.8g/L. Thirty nine girls (17%) had serum retinol concentrations <20µg/dl indicating marginal or low deficiency. Seven of these girls (3.1%) were also anaemic (Hb <120g/L). Only three subjects (1.3%) had very low vitamin A status indicated by a serum retinol concentration of <10 µg/dl (Table 4) and their mean concentration was 7.67 ± 1.95µg/dl.

Table 2. Baseline nutritional status of the study sample

Nutritional status	*N*	mean	SD
Height (m)	215	1.54	0.06
Weight (Kg)	215	42.1	6.94
BMI (Kg/m^2)	215	17.7	2.37
Serum retinol (µg/dl)	229	31.4	12.3
Haemoglobin (g/L)	224	129.5	12.7

Table 3. Frequency of consumption of local foods containing vitamin A or provitamin A following nutrition education

Foods	Subjects who consumed foods > twice per week			
	Baseline (*N*=204)		Post intervention (*N*=212)	
	N	%	*N*	%
Egg	79	38.7	98	46.2
DGLV †	18	8.82	42	19.8**
Carrots	49	24.0	72	33.9*
Pumpkin	15	7.35	35	16.5**
Mango	45	22.1	69	32.5*
Papaya	25	12.3	37	17.5

†DGLV=dark green leafy vegetables;*P<0.05 by chi^2 test. ** P<0.005 by chi^2 test.

Table 4. Knowledge scores and serum retinol concentration following nutrition education

	Baseline			Post intervention	
	N	mean	SD	mean	SD
Knowledge scores †					
All subjects	195	61.3	10.7	67.3	13.8**
Serum retinol (µg/dl)					
All subjects	229	31.4	12.3	33.4	13.2*
≥20 µg/dl	190	34.6	10.9	34.6	12.9
<20 µg/dl	39	15.7	3.16	27.8	12.9**
10-19.9 µg/dl	36	16.3	2.17	28.3	13.1**
< 10 µg/dl	3	7.67	1.95	22.2	12.9

† Knowledge score was out of a total of 100 marks. Paired data for knowledge was available for 195 girls. * P<0.05 by paired t-test. ** P<0.001 by paired t-test.

Post intervention assessment

Education resulted in a significant (P<0.001) increase in knowledge on nutrition (Table 4). Their initial mean education score increased significantly (P<0.001) from 61.3 (SD=10.65) to 67.3 (SD=13.77). A significantly greater percentage of girls consumed dark green leafy vegetables (DGLV), pumpkin (P<0.005), carrot and mango (P<0.05) more than twice per week. Consumption of egg and papaya increased following intervention although it did not reach statistical significance (Table 3). The number of subjects with low serum retinol concen-

trations (<20 µg/dl) reduced from 39 (17%) to 11 (4.8%) after intervention. A significant (P<0.05) mean increase in serum retinol concentration was observed in the total population. The impact of education was greater among those subjects who had marginal or low serum retinol concentrations at baseline, indicated by a significant (P<0.001) improvement in serum retinol concentration (Table 4). The mean serum retinol concentration increased from 16.3µg/dl (SD=2.17µg/dl) to 28.3µg/dl (SD=13.1µg/dl) in subjects who had an initial serum retinol concentration between 10µg/dl and 20µg/dl. The increase in mean serum retinol concentration of subjects with a baseline serum concentration of <10µg/dl was from 7.67µg/dl (SD=1.95µg/dl) to 22.2 µg/dl (SD= 12.9µg/dl. Serum retinol concentrations did not change with education in subjects who were not initially deficient (Table 4).

Discussion

The effectiveness of nutrition education was studied in relation to serum retinol concentrations, in 229 adolescent school girls. In our study, nutrition education was effective in improving knowledge, food consumption patterns and serum retinol concentrations in adolescent school girls. These girls did not receive any nutrition education messages outside our intervention, from school, during the period of study. Knowledge on nutrition among adolescent girls increased significantly following education (P<0.001). This was associated with increased frequency of consumption of locally available foods rich in carotenoids such as pumpkin, dark green leaves, mango and carrot. The smaller increase in consumption of egg and papaw did not reach statistical significance possibly due to the increased cost of these foods. A quantitative analysis of the food frequency questionnaire was not possible as data for micronutrient composition of local plants is not yet available. A reduction in prevalence of low serum retinol concentration (<20µg/dl) was achieved. Further, serum retinol concentrations were significantly (P<0.001) higher following nutrition education, in subjects who had low serum retinol concentrations at baseline.

In a previous study we demonstrated an inverse relationship between serum retinol concentration and *Trichuris trichura* load[15], therefore, helminthic infection was considered a possible confounder. All subjects selected for this study were those who tested negative for helminthiasis. Social marketing has been demonstrated to be effective in achieving behavioral change leading to the consumption of carotene rich foods and significantly reducing vitamin A deficiency in Thailand.[6] In Vietnam, a national vitamin A deficiency prevention program included nutrition education to increase awareness of vitamin A deficiency and feeding practices related to vitamin A deficiency. The results indicated an increase in consumption of vitamin A rich foods over a ten year period.[16] Nutrition education was also successfully carried out among mothers in Tamil Nadu, India and Bangladesh.[17,18]

Girls in this study were from low socioeconomic groups and their living conditions were poor.[15] Despite the considerable social and economic constraints that they face leading to less purchasing power our study reveals that it is still possible to use education as an effective tool. When they were exposed to information that was relevant to them and delivered in a practicable manner these girls were able to utilize it.

Our study aimed at dietary diversification by promoting local foods rich in retinol, carotenoids and other micro-nutrients and by promoting locally acceptable recipes and preparation methods. The importance of the adequacy of the total diet was emphasized. Local dietary practices which enhance the absorption of micronutrients were identified and promoted. The aims of the education package were to highlight dietary practices that enhance micronutrient content and bioavailability and to indicate practices that are less desirable. Acceptance of the food based intervention is central to its effectiveness. Therefore ideas and practices that were unfamiliar to the local community were not introduced. In identifying the pacific pandanus fruit, as an important source of provitamin A carotenoids, Englberger *et al*, highlight that foods selected for promotion should be acceptable to the local community.[19] Our findings support this view, demonstrating that promotion of acceptable dietary practices can be effective.

In conclusion, we were able to demonstrate that nutrition education can be used effectively to reduce the prevalence of vitamin A deficiency and to improve serum retinol concentration in subjects with low concentrations by changing food consumption patterns. The effectiveness of an intervention is best measured by its ability to make a change in those subjects who need an improvement. Thus, in this population, education brought about a biologically significant change. Future research should address issues of long term sustainability. From the view point of a national intervention scheme the school going population affords easy access. However, feasibility in terms of cost effectiveness needs to be assessed prior to implementation.

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Original Article

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营养学教育提高青少年学校中女生的血清维生素 A 浓度

在亚临床维生素 A 缺乏的发展中国家中，饮食多样性可以看作是一种可负担的起的饮食干扰方式。营养学教育对于包括提高饮食多样性在内的营养干扰来说是至关重要的。而在斯里兰卡的国家计划中，极少量的数据又限制了营养学教育的有效利用。我们以 229 个年龄在 15－19 岁的青少年学校的女生为受试对象，评价了营养学教育对她们营养学知识的掌握情况、饮食模式以及血清中维生素 A 浓度的影响。试验首先记录了学生在基础期的营养学知识掌握情况、饮食模式和血清中维生素 A 的浓度，随后进行营养干扰。干扰措施包括以演讲讨论为形式的营养学教育、组间讨论以及四种不同的强化方式。经过 10 星期干扰后，重新对营养学知识、饮食模式和血清中维生素 A 的浓度进行检测。结果显示：营养学教育使得学生所掌握的营养学知识显著增多（$P<0.001$），对本地富含维生素 A 食物的消费量也显著增加。同时低血清维生素 A 浓度（<20μg/dL）的受试者比例由试验前的 17％下降至 4.8％。对于那些在基础期血清维生素 A 浓度低于 20μg/L 的受试者来说，营养学教育对维生素 A 浓度的提高作用是高度显著的（$P<0.001$）。营养学教育可以有效的促进这些女生对相关知识的掌握以及饮食模式的改善。营养学教育对血清维生素 A 浓度的提高作用，对于那些具有较低初始浓度的受试者来说是生物学显著的。而对于那些具有正常初始浓度的受试者来说，这个促进作用并不显著。

关键词： 血清维生素 A、营养学教育、青少年、斯里兰卡。