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ORIGINAL ARTICLE

School-Based Nutrition Education Improves Knowledge and Consumption of Omega-3-Rich Foods Among Rural Adolescent Girls

Inderpreet Kaur Sall[1], Poonam Bakhetia[2]

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ABSTRACT

Background: Omega-3 fatty acids are essential nutrients required for cognitive development, immunity, and overall health. However, inadequate intake and poor awareness regarding omega-3-rich foods are commonly observed among adolescent in rural India.

Objective: The study aimed to assess the efficacy of a nutrition education intervention on knowledge and dietary practices related to omega-3 fatty acids among adolescent girls studying in rural schools of Ludhiana district, Punjab.

Methods: An intervention-based study was conducted among 100 adolescent girls aged 16–17 years, equally selected from one Government School (GS) and one Private School (PS). Baseline information on socio-demographic profile, anthropometric measurements, dietary intake, consumption frequency score (CFS), and knowledge, attitude, and practices (KAP) related to omega-3 fatty acids was collected using structured questionnaires and dietary pattern and food intake was collected using 24-hour dietary recall method for three non-consecutive days. A nutrition education programme was carried out for 120 days, which included lectures, demonstrations, distribution of pamphlets, quizzes, and counselling sessions. After completion of the intervention, the participants were reassessed using the same methods. The collected data were analysed using mean, standard deviation, paired t-test, independent t-test, and Pearson correlation analysis.

Results: Baseline findings revealed poor dietary diversity, inadequate intake of omega-3-rich foods, and low awareness regarding omega-3 fatty acids among participants. Intake of nuts and oilseeds was negligible, while omega-3 intake was considerably lower than recommended levels. Following the intervention, significant improvement was observed in KAP scores ($p<0.05$). Increased consumption frequency of omega-3-rich foods such as flaxseed and nuts along with improved dietary diversity was also reported.

AUTHOR'S AFFILIATION:

[1] Research Scholar, Department of Food and Nutrition, College of Community Science, Punjab Agricultural University, Ludhiana, Punjab, India.

[2] Assistant Professor, Department of Food and Nutrition, College of Community Science, Punjab Agricultural University, Ludhiana, Punjab, India.

CORRESPONDING AUTHOR:

Inderpreet Kaur Sall, Research Scholar, Department of Food and Nutrition, College of Community Science, Punjab Agricultural University, Ludhiana, Punjab, India.

E-mail: inderpreetsall17@gmail.com

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Conclusion: The nutrition education intervention effectively improved knowledge and dietary practices related to omega-3 fatty acids among adolescent girls. School-based nutrition education programs may help promote healthier dietary behaviors among rural adolescents.

KEYWORDS

• Omega-3 Fatty Acids • Adolescent Girls • Nutrition Education • Dietary Practices • Rural Schools

INTRODUCTION

Adolescence is an important phase of life marked by rapid physical growth, emotional development, and psychological changes. The term *adolescence* is derived from the Latin word *adolescere*, meaning "to mature." According to the World Health Organization (WHO), adolescents are individuals aged 10–19 years. Globally, adolescents constitute nearly 16 per cent of the total population, while India has the largest adolescent population in the world, accounting for approximately 17 per cent of the country's population.[1] Thus, the nutritional health of adolescents is of great importance as it directly influences the future health and productivity of the population.

Adolescence is considered a nutritionally sensitive period due to the increased demand for energy and nutrients required to support rapid growth and development. Adequate nutrition during this stage is essential for proper physical growth, cognitive development, and overall well-being. However, dietary habits developed during adolescence are often influenced by lifestyle changes, peer influence, media exposure, and changing food environments.

Over the last few decades, dietary patterns among Indian adolescents have undergone considerable changes. Traditional diets rich in whole grains, pulses, vegetables, and fruits are gradually being replaced by processed foods, fast foods, and energy-dense convenience products.[2] These dietary transitions have led to excessive intake of omega-6 fatty acids along with inadequate consumption of omega-3 fatty acids, resulting in an imbalanced omega-6 to omega-3 ratio, which is much higher than the level recommended by the World Health Organization.[3] Such imbalance has been associated with increased risk of obesity, cardiovascular diseases, metabolic disorders, and chronic inflammation.[4] Recognizing this issue, global initiatives such as the WHO "REPLACE" programme have emphasized the need to reduce unhealthy fats and promote healthier dietary fat sources.

Among dietary fats, omega-3 fatty acids are considered essential because of their multiple health benefits. The major forms include alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). These fatty acids play an important role in maintaining cardiovascular health, regulating inflammation, supporting immune function, and promoting brain and visual development.[6,7] During adolescence, adequate omega-3 intake becomes even more important because this stage involves significant brain maturation and cognitive development. Research has also highlighted their role in improving metabolic health and their potential involvement in managing inflammatory conditions and chronic diseases.[8,9]

Despite their importance, omega-3 intake among adolescents remains low worldwide.[10] Foods rich in omega-3 fatty acids such as fatty fish, flaxseeds, chia seeds, and walnuts are not regularly consumed by many adolescents. In India, fish is an important dietary source of EPA and DHA; however, its consumption is often limited due to vegetarian dietary practices, cultural preferences, accessibility issues, and concerns regarding contamination.[11,3] Consequently, attention has shifted towards plant-based sources such as flaxseed, microalgae, and omega-3-enriched oilseeds.[12-14] However, the conversion of plant-derived ALA into the biologically active EPA and DHA forms is limited, highlighting the importance of improving dietary quality and awareness among adolescents.[15]

Simultaneously, the increasing prevalence of obesity and other non-communicable diseases among Indian adolescents has emerged as a major public health concern. Studies have linked these conditions with unhealthy dietary practices and sedentary lifestyles.[16] Evidence suggests that improving omega-3 intake may contribute to better lipid metabolism,

enhanced antioxidant status, and improved metabolic outcomes.[17]

Nutrition education has been recognized as one of the most effective approaches for promoting healthy dietary practices among adolescents. Schools provide an ideal setting for implementing nutrition interventions because they offer direct access to students during the stage when food habits are developing. Educational programmes involving lectures, demonstrations, counselling sessions, and interactive activities have been shown to improve nutritional knowledge, attitudes, and food-related behaviours.[18,19] Moreover, adolescents often transfer acquired knowledge to their families, thereby influencing dietary practices at the household and community levels.[20]

Although awareness regarding adolescent nutrition has increased, studies specifically focusing on omega-3 fatty acid knowledge and dietary practices among rural adolescent girls in Punjab remain limited. Rural adolescent girls are particularly vulnerable due to limited dietary diversity, inadequate nutrition awareness, and changing food consumption patterns. Furthermore, evidence regarding the effectiveness of school-based nutrition education programmes targeting omega-3 fatty acid awareness and intake is still scarce. Therefore, the present study was undertaken to assess the knowledge, attitude, practices, and consumption of omega-3-rich foods among rural adolescent girls and to evaluate the effectiveness of a school-based nutrition education intervention in improving their awareness and dietary practices related to omega-3 fatty acids.

MATERIALS AND METHODS

Study Design

The present study was designed as an **intervention-based study** to assess the effectiveness of a nutrition education programme on improving knowledge and dietary practices related to omega-3 fatty acids among adolescent girls.

Study Area

The study was conducted in rural areas of Ludhiana district, Punjab. Two schools, comprising one Government School (GS) and one Private School (PS), located in selected villages (Bhaini Darera and Andloo) of Ludhiana district, were purposively selected to ensure representation from different educational settings.

Selection of Participants

A total of 100 adolescent girls aged 16–17 years were included in the study, with 50 participants selected from each school. Girls who were apparently healthy, attending school regularly during the study period, and willing to participate were included in the investigation.

Ethical Considerations

Prior permission was obtained from the authorities of both selected schools before initiating the study. The objectives and purpose of the study were clearly explained to all participants and informed consent was obtained. Confidentiality of the collected information was strictly maintained throughout the study. Ethical principles related to human participation were followed during the entire investigation.

Development of Research Tools

A structured interview schedule was developed and pre-tested on a sub-sample before final administration to ensure clarity and suitability. The questionnaire consisted of the following sections:

Socio-Demographic Profile

Information related to age, educational status, family type, parental education, occupation, and socio-economic status of the participants was collected.

Anthropometric Measurements

Anthropometric measurements including height, weight, waist circumference, and hip circumference were recorded following standard procedures. Body Mass Index (BMI) was calculated using the following formula:

$$BMI = \text{Weight (kg)} / \text{Height (m)}^2$$

Nutritional status was interpreted using standard cut-off values. BMI was classified according to WHO[21], where 18.5–22.99 kg/m² was considered normal. Waist circumference cut-off values recommended by WHO[22] was 80 cm for women. Waist-to-Hip Ratio (WHR) cut-off values recommended by ICMR[23] was 0.80 for women, while Waist-to-Height Ratio

(WHtR) values ranging from 0.40–0.49 were considered normal according to Ashwell and Hsieh.[24]

In addition, Waist-Hip Ratio (WHR) and Waist-Height Ratio (WHtR) were calculated to assess body fat distribution and nutritional status.

Dietary Assessment

Dietary intake of participants was assessed using 24-hour dietary recall method for three non-consecutive days. Information regarding food consumption patterns and intake of omega-3-rich foods was collected. Nutrient intake was calculated using DietCal software and compared with the Recommended Dietary Allowances (RDA) and Suggested Dietary Intakes (SDI) recommended by the Indian Council of Medical Research.[25]

Dietary Diversity and Consumption Frequency

Dietary Diversity Score (DDS) and Consumption Frequency Score (CFS) were used to assess the diversity and regularity of food intake among participants across different food groups.

Knowledge, Attitude, and Practice (KAP) Assessment

A Knowledge, Attitude, and Practice (KAP) questionnaire was developed to evaluate participant's awareness, perceptions, and practices related to omega-3 fatty acids. The questionnaire included information regarding knowledge of omega-3 fatty acids, dietary sources, health benefits, and consumption practices associated with omega-3-rich foods.

Nutrition Education Intervention

A nutrition education module focusing on omega-3 fatty acids was developed and implemented for a period of 120 days. The intervention programme included lectures, demonstrations, posters, pamphlets, quizzes, and counselling sessions to improve awareness regarding the importance, dietary sources, and health benefits of omega-3 fatty acids.

Educational sessions were conducted at regular intervals to encourage healthy eating practices and promote consumption of omega-3-rich foods such as flaxseeds, chia seeds, walnuts, and green leafy vegetables.

Post-Intervention Assessment

After completion of the 120-day intervention programme, the same assessment tools used during baseline evaluation were administered again. The post-intervention assessment was carried out to determine changes in knowledge, attitudes, dietary practices, and consumption of omega-3-rich foods among the participants following nutrition education.

Statistical Analysis

The collected data were systematically tabulated and analysed using appropriate statistical methods. Descriptive statistics including mean, standard deviation, and percentages were calculated. Inferential statistics such as paired t-test, independent t-test, and Pearson correlation analysis were applied for interpretation of data. Statistical significance was considered at $p < 0.05$.

RESULTS

Socio-Demographic Profile of the Participants

The study included a total of 100 adolescent girls aged 16–17 years, equally selected from one Government School (GS) and one Private School (PS), with 50 participants from each school. Most of the participants (95%) belonged to rural areas, while only 5 per cent had an urban background.

Regarding religion, the majority of girls were Sikh (57%), followed by Christians (24%), Hindus (17%), and Muslims (2%). With respect to caste distribution, nearly half of the participants (46%) belonged to the Scheduled Caste category.

Family structure analysis showed that most participants belonged to nuclear families (70%), whereas 30 per cent were from joint families. Based on family size, more than half of the households (52%) consisted of medium-sized families having 5–8 members.

The economic profile indicated that a large proportion of participants belonged to lower-income households. About 45 per cent of families reported an annual income below ₹ 2.5 lakh, whereas only 9 per cent had an annual income above ₹10 lakh.

According to socio-economic classification, the highest proportion of participants belonged to the upper lower class (45%), followed by lower class (34%), upper middle class (16%), and upper class (5%).

Anthropometric Profile

The anthropometric parameters of the selected participants are presented in Table 1. No significant differences were observed between girls from the Private School (PS) and Government School (GS) for any of the anthropometric measurements ($p > 0.05$).

The mean height and weight of PS girls were 157.09 ± 7.28 cm and 45.74 ± 5.46 kg, respectively, while GS girls recorded values of 156.22 ± 7.02 cm and 45.20 ± 7.56 kg. The mean BMI was 17.96 ± 2.17 kg/m² among PS girls and 18.52 ± 3.06 kg/m² among GS girls, indicating values close to the normal BMI range recommended by WHO[21] (18.5–22.99 kg/m²).

Similarly, waist circumference values in both groups were below the recommended cut-off value for women (80 cm) given by WHO.[22] The mean waist-to-hip ratio and waist-to-height ratio were also within the recommended limits suggested by ICMR[23] and Ashwell and Hsieh[24] respectively.

Table 1: Anthropometric parameters of the selected subjects

Anthropometric parameters	Girls (N=100)		P-value
	PS (n=50)	GS (n=50)	
Height (cm)	157.09±7.28	156.22±7.02	0.86^{NS}
Weight (kg)	45.74±5.462	45.20±7.56	0.75^{NS}
BMI (kg/m2)	17.964±2.17	18.52±3.06	0.32^{NS}
Waist circumference (cm)	65.91±6.68	67.64±7.23	0.21^{NS}
Waist to hip ratio	0.77±0.06	0.79 ±0.86	0.25^{NS}
Waist height ratio	0.41±0.03	0.43±0.52	0.47^{NS}

Values are Mean±S.D.
^{NS}Values are Non-significant
BMI: 18.5-22.99 kg/m^2 [21;] Waist circumference: men 94 cm and women 80 cm [22;] Waist to hip ratio (WHR): men 0.90 and women 0.80 [23;] WHtR: 0.40-049[24]

Dietary Patterns

Table 2 shows that vegetarian diet was the most common dietary pattern among participants from both schools. Consumption of three meals per day was reported by 50% of PS girls and 74% of GS girls.

Regarding water intake, more than half of the participants (56%) consumed 4–6 glasses of water per day, whereas 27% reported consuming less than four glasses daily.

Frequent snacking habits were common among the participants, with 84% of PS girls and 94% of GS girls reporting regular snacking and munching practices. Nutritional supplement use was comparatively higher among GS girls (90%) than PS girls.

Table 2: Dietary habits and food preferences of selected subjects

Dietary Pattern	Girls		
	PS (n=50)	GS (n=50)	Total (N=100)
Food habits			
Vegetarian	30 (60)	24 (48)	55
Non-vegetarian	11 (22)	17 (34)	28
Ova vegetarian	09 (18)	09 (18)	17
No. of meals/day			
Two	17 (34)	08 (16)	25
Three	25 (50)	37 (74)	62
Four	08 (16)	05 (10)	13
Intake of water/day			
Less than 4 glasses	11 (22)	16 (32)	27
4-6 glasses	30 (60)	26 (52)	56
More than 6 glasses	09 (18)	08 (16)	17
Snacking and munching Preference			
Yes	42 (84)	47 (94)	89
No	08 (16)	03 (6)	11
Nutrition supplements			
Yes	20 (40)	45 (90)	65
No	09 (18)	26 (52)	35

Values in parentheses represent percentage

Baseline Knowledge, Attitudes, and Practices Related to Omega-3 Fatty Acids

Baseline assessment revealed poor knowledge and awareness regarding omega-3 fatty acids among the participants. About 59% of girls had no knowledge of omega-3 fatty acids, while only 12% had basic awareness. Knowledge regarding dietary sources was also limited, with 74% unaware of food sources of omega-3 fatty acids and 84% unfamiliar with their different types. More than 80% of participants lacked knowledge about the health benefits and disease preventive role of omega-3 fatty acids.

Attitudes towards omega-3-rich foods reflected uncertainty, as many participants were unaware of their importance and perceived their inclusion in daily diets as difficult or expensive.

Dietary practices were also inadequate. None of the participants reported regular consumption of omega-3-rich foods, while 88% had never used omega-3 supplements. Intake of foods such as flaxseeds, walnuts, and other omega-3-rich foods was found to be very low.

Changes in Knowledge, Attitudes, and Practices Related to Omega-3 Fatty Acids After Nutrition Education Intervention

The nutrition education intervention resulted in noticeable improvements in participant's knowledge, attitudes, and practices related to omega-3 fatty acids, as presented in Tables 3, 4, and 5.

Knowledge regarding omega-3 fatty acids improved considerably after the intervention. About 67% of participants reported good knowledge of omega-3 fatty acids, while 69% were able to correctly identify omega-3-rich food sources. Awareness regarding flaxseed as a plant-based source of omega-3 fatty acids also increased, with **39**% of girls identifying it correctly.

Positive changes were also observed in attitudes towards omega-3 fatty acids. Nearly 71% of participants recognized their health importance, while 68% expressed willingness to include omega-3-rich foods in their daily diet. Additionally, 87% reported that they would recommend these foods to their family members and friends.

Dietary practices also improved following the intervention. Around 46% of participants reported moderate consumption of omega-3-rich foods. Consumption of balanced meals improved, and 40% of girls had started incorporating foods such as flaxseeds and walnuts into their diets.

Table 3: Impact of Nutrition Education on Knowledge scores about Omega-3 Fatty Acids among Subjects

Statement	Did not know at all		Do not know well		General knowledge		Know well		Know very well	
	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I
Do you know what are omega 3 fatty acids	59	-	29	9	12	24	-	67	-	-
More number of people getting influenced about using omega 3 fatty acids	59	-	23	13	18	35	-	12	-	40
Are you aware about sources of omega 3 fatty acids	61	-	39	-	-	40	-	15	-	45
Are omega 3 fatty acids considered essential nutrients	73	-	26	9	1	6	-	68	-	17
Do you understand what are primary health benefits of consuming omega 3 fatty acids	83	-	17	-	-	52	-	30	-	18
Do you know about types of omegas 3 fatty acids	96	-	4	9	-	8	-	65	-	18
Do you know which type of omega 3 is most commonly found in plant based foods	94	-	6	9	-	25	-	42	-	24
Are flaxseeds a good source of omega 3 fatty acids	93	-	7	5	-	36	-	20	-	39
Are omega 3 fatty acids most effective in preventing diseases	76	-	17	-	7	15	-	67	-	18
Do you know consumption of omega 3 fats can help in lowering blood sugar level	82	-	17	-	1	9	-	39	-	52
Can omega 3 fatty acids be synthesized by the human body	73	8	27	8	-	9	-	60	-	15
Are omega 3 fatty acids important for children's growth and development	50	9	33	-	17	-	-	31	-	60

Pre-I: pre-intervention; Post-I: post-intervention

Table 4: Impact of Nutrition Education on Attitude scores towards consumption and benefits of omega-3 fatty acids by selected subjects

Statement	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I
Do you think omega-3 fatty acids are important for overall health	49	-	19	-	32	14	-	15	-	71
Do you believe that your current diet provides enough omega-3 fatty acids	33	24	12	-	41	15	13	46	-	15
Are you willing to include more omega-3-rich foods in your diet	30	9	12	6	22	17	20	68	16	-
Do you like to recommend omega-3-rich foods to family or friends	50	-	12	-	38	-	-	14	-	87
omega-3 supplementation is only option	36	-	8	9	56	9	-	36	-	46
Do you agree that omega-3 fatty acids should be part of a balanced diet	45	-	15	9	35	59	5	23	-	43
Incorporating omega-3 into a regular diet is affordable	58	-	19	9	23	59	-	23	-	39
Including plant-based omega-3 sources like flaxseeds in your diet is better option	37	9	14	31	29	-	21	36	-	24
Including animal-based omega-3 sources like fish in your diet is more beneficial	41	15	24	15	35	30	-	17	-	13
Meal should be properly planned throughout the day	51	-	4	-	45	23	-	38	-	39

Pre-I: pre-intervention; Post-I: post-intervention

Table 5: Impact of Nutrition Education on Practices scores in relation to omega-3 fatty acids consumption by selected subjects

Statement	Never		Rarely		Occasionally		Frequently		Very frequently	
	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I	Pre-I	Post-I
How often do you consume omega-3-rich foods such as fatty fish, nuts, seeds, or fortified products	100	15	-	46	-	24	-	15	-	-
Do you take omega-3 supplements regularly	88	65	8	16	4	19	-	-	-	-
Do you consume balanced diet	92	20	8	9	-	20	-	36	-	48
Do you skip your meals	88	16	12	15	-	60	-	9	-	-
Do you consume your breakfast daily	96	36	4	16	-	18	-	25	-	25
Are fibre rich food part of your balanced diet	88	36	12	25	-	24	-	15	-	-
Do you prepare foods to retain their omega-3 content (e.g., steaming, avoiding overcooking)	96	16	4	16	-	38	-	30	-	-
Do you add extra fat in your meals	92	34	8	6	-	30	-	15	-	15
Do you balance omega-3-rich foods with other dietary fats	100	33	-	37	-	15	-	15	-	-
Have you recently made any dietary changes to increase your omega-3 intake	100	50	-	15	-	35	-	-	-	-
Do you take fruits like mango, banana, grapes	47	9	36	17	23	30	-	44	-	-
Do you drink plenty of water	83	8	8	25	9	16	-	15	-	56
How often do you consume animal-based omega-3 sources (e.g., fish)	80	58	20	15	-	9	-	9	-	9
Do you check labels on food packaging for omega-3 content	87	16	4	31	-	30	-	23	-	-
How often do you consume plant-based omega-3 sources (e.g., flaxseeds, walnuts)	100	60	-	12	-	9	-	19	-	-
Do you consider the omega-3 content when choosing oils for cooking	87	30	13	45	-	12	-	13	-	-

Pre-I: pre intervention; Post-I: post intervention

Changes in Food Intake Before and After the Intervention

Figure 1 shows the changes in food intake adequacy before and after the nutrition education intervention. Improvement in dietary intake was observed among participants following the intervention.

Adequacy of cereals and millets increased significantly from 43 to 45% among PS girls and from 42 to 47% among GS girls. Similarly, fruit intake adequacy improved significantly, increasing from 20 to 30% in PS girls and from 22 to 28% in GS girls.

A significant increase in roots and tubers intake was observed among PS girls, where adequacy improved from 86 to 96%. Intake adequacy of milk and milk products also increased significantly among PS girls from 83 to 92%.

Adequacy of edible oils and fats showed slight but significant improvements, increasing from 54 to 57% in PS girls and from 46 to 48% in GS girls. Intake of pulses and legumes remained nearly adequate throughout the study period.

However, intake of green leafy vegetables, other vegetables, and nuts/oilseeds remained below the SDI levels and showed non-significant changes after the intervention.

Overall, the nutrition education programme positively influenced dietary intake, with notable improvements observed particularly for cereals and millets, fruits, and milk products.

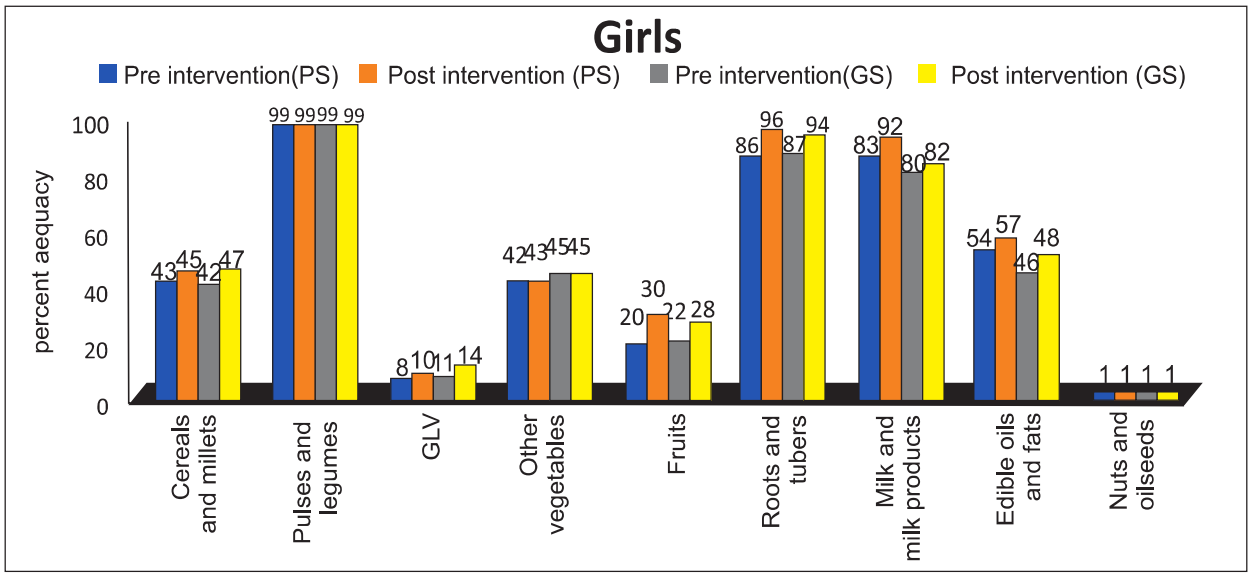

Figure 1: Pre and post-intervention percent adequacy of food intake among selected girls

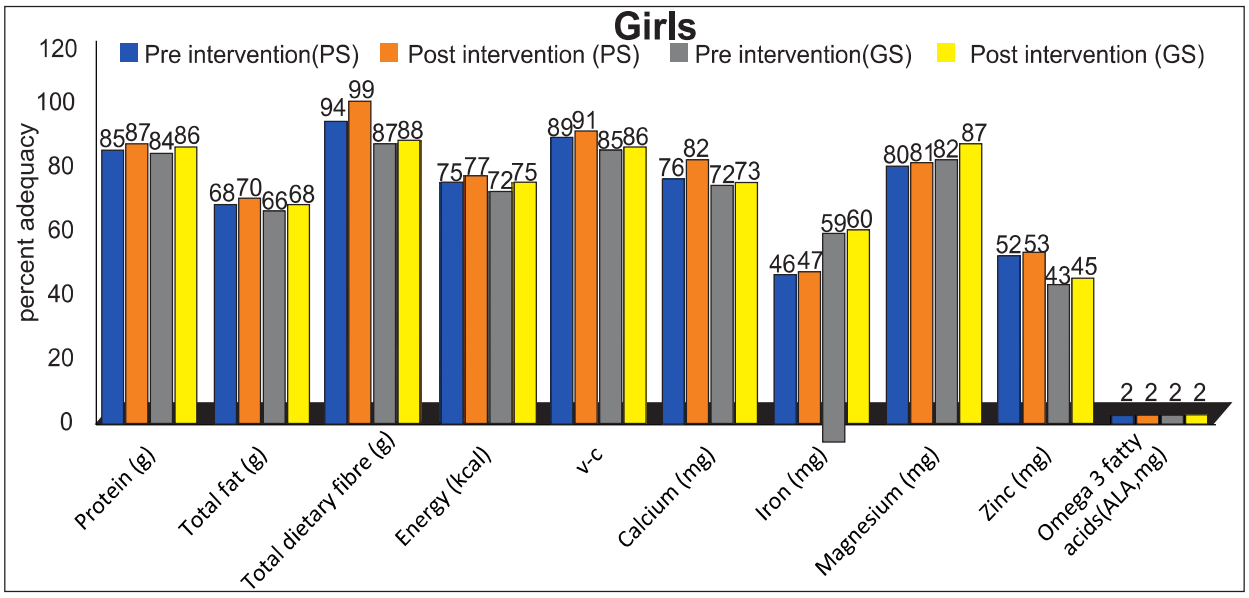

Figure 2: Pre and post-intervention nutrient adequacy ratio among selected girls

Figure 2: shows the changes in nutrient intake adequacy before and after the intervention. Overall, nutrient intake improved following the nutrition education programme.

Energy adequacy increased significantly among PS girls from 75 to 77%, while protein adequacy improved in GS girls from 84 to 86%. Fat adequacy also increased significantly from 68 to 70% in PS girls and from 66 to 68% in GS girls.

Fiber adequacy improved significantly among PS girls from 94 to 99%. Calcium adequacy increased in both groups, from 76 to 82% in PS girls and from 72 to 73% in GS girls. Iron adequacy showed slight improvements in both groups.

However, vitamin C, magnesium, and zinc showed only minor non-significant changes, and omega-3 fatty acid adequacy remained below the recommended levels in both groups.

Change in Consumption Frequency of Omega-3-Rich Foods after education intervention

Table 6 shows improvements in the consumption frequency of omega-3-rich foods after the intervention. *Bathua* leaf consumption increased significantly in both PS (p = 0.001) and GS girls (p = 0.002). Mustard leaves and spinach intake also improved significantly among GS girls.

Among fats and oils, desi ghee consumption increased, while *dalda* intake decreased significantly among PS girls (p = 0.02), indicating a positive dietary change.

Among nuts and seeds, walnut intake increased significantly in PS girls, peanut consumption improved in GS girls, and almond intake increased in both groups.

Flaxseed intake showed the most notable improvement. No consumption was reported at baseline; however, intake increased significantly after the intervention in both PS (p < 0.001) and GS girls (p = 0.04).

Table 6: Pre and Post-education intervention consumption frequency score of omega 3 fatty acids rich foods by selected subjects

Consumption Frequency Score	PS (n=50)		p-value	GS (n=50)		p-value
	Pre-Intervention	Post-Intervention		Pre-Intervention	Post-Intervention	
Green leafy vegetables						
Bathua leaves	2.58±2.57	3.24±2.51	0.001*	1.75±1.08	2.19 ±0.44	0.002*
Mustard leaves	3.46±3.05	3.97±3.46	0.39^{NS}	3.19±0.94	3.85 ±1.49	0.003*
Fenugreek leaves	3.15±2.97	3.28±3.07	0.32^{NS}	2.14±.082	1.65 ±0.94	0.001*
Spinach	3.55±3.53	4.15±4.46	0.37^{NS}	2.41±1.49	3.13±0.85	0.0008*
Oils						
Desi ghee	39.60±26.58	41.60±28.03	0.03*	37.04±28.34	38.18±27.97	0.32^{NS}
Mustard oil	61.54±21.04	63.82±18.48	0.17^{NS}	62.68±19.09	64.96±17.77	0.07^{NS}
Dalda	33.05±23.81	27.35±23.88	0.02*	45.58±28.05	42.16±27.60	0.07^{NS}
Canola	0	0.56±4.02	0.32^{NS}	0	0	0
Nuts and seeds						
Walnuts	5.07±3.57	6.06±3.70	0.009*	3.89±3.59	3.99±2.76	0.76^{NS}
Peanuts	7.20±4.53	7.44±4.46	0.32^{NS}	6.60±3.60	7.39±4.06	0.02*
Almonds	7.98±3.24	9.17±1.11	0.03*	2.41±1.90	2.81±1.99	0.03*
Flaxseed	0	1.38±2.23	<0.001*	0	0.19±0.67	0.04*

Values are Mean±S.D.

^{NS}Values are Non-significant

*Values are significant at 5 percent

Change in Anthropometric parameters Before and After the Intervention

Slight improvements in anthropometric measurements were observed after the intervention. Body weight increased significantly among GS girls by 0.9 kg. BMI also showed significant improvement in both groups, increasing from 17.96 ± 2.17 to 18.85 ± 3.43 kg/m² among PS girls (p = 0.03) and from 18.52 ± 3.06 to 19.22 ± 2.70 kg/m² among GS girls (p = 0.005). However, waist circumference, waist-hip ratio, and waist-height ratio showed only minor non-significant changes in both groups.

Correlations Between KAP Scores, Nutritional Status, and Omega-3 Intake

Correlation analysis highlighted the positive influence of improved omega-3-related knowledge, attitudes, and practices on the overall dietary quality of participants. Higher post-intervention KAP scores were positively associated with important nutrients such as iron (r = 0.687), zinc (r = 0.598), protein (r = 0.356), calcium (r = 0.308), magnesium (r = 0.288), and total fat intake (r = 0.472). Positive associations with pulses and legumes, roots and tubers, nuts and oilseeds, and body weight further suggest that better awareness was linked with healthier food choices and improved nutritional status.

Before the intervention, omega-3 intake showed only limited associations with cereals, pulses, and iron intake. However, after nutrition education, omega-3 intake became positively associated with dietary fiber and cereal intake, along with a slight negative association with edible fats and oils, indicating a gradual shift towards healthier eating behaviours.

These findings strengthen the importance of the present study by demonstrating that nutrition education not only improved knowledge regarding omega-3 fatty acids but also influenced broader dietary behaviours and nutritional outcomes. The results indicate that improving awareness among rural adolescent girls can serve as an effective strategy for promoting healthier food habits and enhancing overall diet quality.

DISCUSSION

The present study was undertaken to evaluate the effectiveness of a structured nutrition education intervention in improving knowledge, attitudes, and dietary practices related to omega-3 fatty acids among adolescent girls, and the findings demonstrated encouraging improvements while highlighting the need for continued efforts.

Socio-Demographic Context and Its Dietary Implications

The participants mainly belonged to rural and lower socio-economic backgrounds, which may have influenced their dietary habits and limited intake of omega-3-rich foods. Story *et al*[26] also reported that socio-economic status and family environment significantly affect adolescent food choices. Predominantly vegetarian dietary practices and frequent snacking habits observed in the present study further support the dietary transition reported among adolescents by Misra *et al*.[2] Similar findings on lower omega-3 intake among vegetarian populations have been reported by Iqra Nazir *et al*[11] and Karageorgou *et al*.[13] The improvement observed after intervention highlights the potential of nutrition education in promoting healthier dietary practices among rural adolescent girls.

Anthropometric Status and Nutritional Vulnerability

The BMI values recorded at baseline indicated a tendency towards nutritional vulnerability among the participants. Similar findings were reported by Santra *et al*[27], who documented undernutrition among 44.8% of Indian adolescent girls, highlighting the existing dual burden of malnutrition. The significant improvement in BMI observed after the intervention suggests that improved nutritional awareness positively influenced dietary practices, supporting the importance of adolescence as a critical period for targeted nutrition interventions as emphasized by WHO.

Dietary Patterns and Nutritional Concerns

The baseline dietary pattern showed greater dependence on cereals with lower intake of fruits, vegetables, nuts, oilseeds, and dairy products, indicating poor dietary diversity among participants. Similar dietary shifts among Indian adolescents have been reported by Misra *et al*[2], where traditional nutrient-rich diets are increasingly being replaced by energy-dense foods. The high prevalence of snacking and irregular breakfast habits observed in the present study further reflects unhealthy dietary behaviours, emphasizing the need for nutrition education interventions to promote healthier food choices among adolescents.

Baseline Knowledge, Attitudes and Practices Related to Omega-3 Fatty Acids

The present study revealed poor baseline knowledge regarding omega-3 fatty acids, with most participants being unaware of their sources and health benefits. Similar findings were reported by Małgorzewicz *et al*[28], where only 27% of adolescents could correctly identify omega-3 food sources, indicating that inadequate awareness among adolescents is a widespread concern. In the Indian context, predominantly vegetarian

dietary practices may further contribute to low omega-3 intake due to limited availability of EPA and DHA-rich foods. Previous studies have also highlighted the lower bioavailability of plant-based omega-3 sources in vegetarian diets. These findings emphasize the need for practical and nutrition-focused interventions to improve awareness and promote affordable omega-3-rich food choices among adolescents.

Post-Intervention Improvements in Knowledge, Attitudes and Practices

The nutrition education intervention resulted in marked improvements in knowledge, attitudes, and practices related to omega-3 fatty acids. Post-intervention, 67% of participants reported good knowledge regarding omega-3 fatty acids, while awareness of flaxseed as a plant-based source increased to 39%. Similar improvements following nutrition education interventions among adolescents have also been reported by Sharrif *et al*.[18] Likewise, Jha *et al*[29] observed that structured health promotion programmes significantly improved healthy dietary behaviours among adolescents.

Positive changes in attitude were observed after the intervention, with 71% of participants recognizing the health importance of omega-3 fatty acids, while 87% showed willingness to recommend omega-3-rich foods to their family members and friends.

Similar observations were reported by Maluccio *et al*[20], who highlighted adolescents as important channels for transferring nutrition knowledge within families and communities. Kaur *et al*[30] further emphasized that school-based interventions involving adolescents can positively influence household dietary behaviours, extending the impact beyond the school environment.

Comparison Between Government and Private School Participants

GS girls showed slightly higher overall improvement in KAP scores (79.49) compared to PS girls (73.31). The greater improvement observed among GS girls may be attributed to their lower baseline awareness, providing greater scope for change following the intervention. The findings also suggest that nutrition education interventions may be particularly effective among adolescents from comparatively less-advantaged educational and socio-economic backgrounds.[31]

Improvements in Food and Nutrient Intake Following the Intervention

The nutrition education intervention resulted in improvements in food and nutrient intake, particularly in cereals, fruits, and dairy products. The reduction in dalda consumption along with increased intake of desi ghee, nuts, and flaxseed indicates a positive shift towards healthier fat choices, supporting the objectives of the WHO "REPLACE" campaign.[5]

A notable finding was the increase in flaxseed consumption from no intake at baseline to significant intake after intervention in both groups, highlighting the acceptance of an affordable and locally available plant-based omega-3 source.

These findings are important as emerging evidence suggests that inadequate omega-3 intake during adolescence may affect not only physical health but also cognitive development and mental well-being. Thus, improving awareness and promoting sustainable dietary changes during adolescence remain essential.

Omega-3 Intake and Remaining Nutritional Gaps

Although omega-3 intake improved after the intervention, intake levels remained below the recommended values in both groups. A significant increase was observed among GS girls; however, the intake was still inadequate. Similar concerns have been reported by Prasad *et al* (2021)[15], who noted that plant-based omega-3 sources alone may not sufficiently meet physiological requirements because of limited conversion of ALA to EPA and DHA. Likewise, Dempsey *et al* (2023)[32] reported inadequate omega-3 intake and poor omega-3 status in a large proportion of the global population.

The persistently low intake may be attributed to predominant vegetarian dietary practices, negligible fish consumption, and limited intake of nuts and oilseeds. These findings indicate that while nutrition education improved awareness and consumption patterns, sustained efforts are still required to achieve adequate omega-3 intake among rural adolescents.

Correlation Between Knowledge Improvement and Dietary Quality

Post-intervention correlation analysis supported the effectiveness of the nutrition

education programme. Improved KAP scores showed positive associations with higher intake of protein, total fat, calcium, iron, zinc, and magnesium, indicating that increased awareness was accompanied by better dietary practices. These findings suggest that nutrition education not only improved knowledge regarding omega-3 fatty acids but also positively influenced overall dietary quality among adolescents.

Overall Implications

The findings of the present study demonstrate that a structured nutrition education intervention can effectively improve knowledge, attitudes, and dietary practices related to omega-3 fatty acids among adolescent girls within a short duration. However, despite these improvements, omega-3 intake remained below recommended levels, indicating that awareness alone may not be sufficient, particularly in predominantly vegetarian populations with limited access to alternative omega-3 sources.

The study highlights the need to integrate nutrition education programmes into school settings along with supportive dietary and environmental strategies. Promoting affordable omega-3 sources such as flaxseeds, nuts, and fortified foods, together with inclusion in school meal planning, may help translate awareness into sustained dietary improvements and better nutritional outcomes.

Limitations of the Study

The present study was conducted among adolescent girls selected from one Government School and one Private School; therefore, the findings may not be generalized to all adolescent populations. The sample size was limited and mainly represented rural participants.

The intervention period was relatively short, and long-term follow-up could not be undertaken to assess the sustainability of dietary and behavioural changes. Dietary intake assessment was based on self-reported 24-hour dietary recalls, which may be subject to recall bias and possible under- or over-reporting.

Biochemical assessment of omega-3 status could not be carried out due to resource and laboratory limitations. In addition, socio-cultural food practices and economic constraints may have influenced dietary choices and accessibility to omega-3-rich foods among participants.

Despite these limitations, the study provides important evidence on the effectiveness of school-based nutrition education interventions in improving omega-3-related knowledge, attitudes, and dietary practices among adolescent girls.

CONCLUSION

The present study revealed poor baseline knowledge, attitudes, and dietary practices related to omega-3 fatty acids among adolescent girls, accompanied by inadequate intake of omega-3-rich foods and several essential nutrients. The dietary pattern was predominantly cereal-based with lower consumption of fruits, green leafy vegetables, nuts, and oilseeds, indicating poor dietary diversity.

The nutrition education intervention effectively improved knowledge, attitudes, and practices related to omega-3 fatty acids among both Government School and Private School girls. Positive changes were also observed in food intake, nutrient intake, consumption frequency of omega-3-rich foods, and BMI following the intervention. Increased awareness and consumption of affordable plant-based sources such as flaxseeds and walnuts further highlighted the effectiveness of the programme.

However, omega-3 intake remained below the recommended levels even after intervention, suggesting the need for continued nutrition education and greater promotion of accessible plant-based omega-3 sources.

Overall, the findings demonstrate that school-based nutrition education programmes can serve as an effective approach for improving dietary awareness and promoting healthier eating behaviours among adolescents. Early interventions during adolescence may contribute to improved nutritional status and help reduce the future burden of nutritional deficiencies and non-communicable diseases.

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