Original Article

DOI: 10.7860/JCDR/2026/83999.22741

Nursing Section

Effectiveness of a Multi-intervention Program on Haemoglobin Levels among Adolescent Girls with Anaemia: A Prospective Interventional Study

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ABSTRACT

Introduction: Anaemia continues to be a major health concern among adolescent girls, affecting their growth, cognitive abilities, academic performance, and future maternal and child health. Although iron and folic acid supplementation programmes have been implemented, long-term improvement in haemoglobin levels remains a challenge. Holistic approaches that combine dietary interventions to enhance iron intake, yoga, lifestyle modifications, and health education have proven to be more beneficial in improving overall health and haemoglobin status. Schools provide an ideal platform to effectively deliver such integrated interventions to adolescents.

Aim: To evaluate the effectiveness of a structured multi-intervention program-including iron-rich nutritional supplementation, structured health education, and supervised yoga-on haemoglobin levels among adolescent girls with anaemia.

Materials and Methods: The present prospective interventional study was conducted among 64 adolescent girls (aged 14-18 years) with mild to moderate anaemia (Hb 7-12 g/dL) at a government high school in Raigarh, Chhattisgarh, India, from August 2022-January 2023. The 12-week intervention included daily consumption of iron-rich nutritious balls, interactive educational sessions on nutrition, dietary diversification, and menstrual hygiene, and supervised yoga sessions lasting 60-70 minutes, conducted six days per week. Haemoglobin levels were measured at baseline and at 6, 11, and 15 weeks. Paired t-tests and Pearson correlation analyses were used to assess changes over time and the consistency of haemoglobin improvement, with $p<0.05$ considered statistically significant.

Results: At baseline, 51 participants (79.7%) had mild anaemia and 13 (20.3%) had moderate anaemia; no cases of severe anaemia were observed. Mean haemoglobin levels increased steadily from 10.54±0.94 g/dL at baseline to 11.52±0.95 g/dL at 15 weeks. Normal haemoglobin status improved from 0% at baseline to 3.1% at 6 weeks, 12.5% at 11 weeks, and 37.5% at 15 weeks, while moderate anaemia declined to 6.3% by the final assessment. Paired t-tests showed a non-significant change at 6 weeks ($t=1.725$, $p=0.089$) but significant improvements at 11 weeks ($t=-4.316$, $p<0.001$) and 15 weeks ($t=-11.623$, $p<0.001$). Strong positive correlations between baseline and follow-up haemoglobin values ($r=0.718$-0.781, $p<0.001$) indicated consistent and stable improvement throughout the intervention period.

Conclusion: The current study demonstrated that a combined approach of nutritional supplementation, supervised yoga, and health education produced sustained improvements in haemoglobin levels among adolescent girls with anaemia, shifting many from moderate to mild or normal status within 15 weeks. This holistic, school-based model is practical, effective, and scalable for anaemia management.

Keywords: Adolescent health, Dietary supplements, Health education, Iron-deficiency, Nutritional status, Yoga therapy

INTRODUCTION

Anaemia remains one of the most widespread nutritional deficiencies globally, contributing significantly to maternal and child morbidity, impaired physical and cognitive development, and reduced productivity [1]. The World Health Organisation (WHO) estimates that 571 million women and adolescent girls worldwide are anaemic, highlighting the magnitude of this public health challenge [2]. Adolescents, particularly girls aged 10-19 years, are especially vulnerable due to rapid growth during puberty, increased iron requirements, and menstrual blood loss [3].

In India, anaemia among adolescent girls continues to be alarmingly high. According to the National Family Health Survey (NFHS-5), 59.1% of adolescent girls aged 15-19 years are anaemic, reflecting a persistent burden despite multiple national programmes [4]. A recent systematic review and meta-analysis by Daniel RA et al., reported a pooled anaemia prevalence of 66% among Indian adolescent girls, confirming the need for evidence-based interventions [5].

Low dietary iron intake and poor absorption remain major contributors to anaemia among adolescents. A landmark multicentric Indian survey conducted across 16 districts reported that more than half of adolescent girls consume insufficient iron, predisposing them to deficiency [6]. Similarly, a study addressing the gap between anaemia prevalence and its determinants among adolescents in Uttar Pradesh and Bihar highlighted significant dietary and behavioural contributors [7]. Behavioural factors such as skipping meals, poor dietary diversity, and limited awareness further aggravate the condition. A cross-sectional study conducted in Delhi found that unhealthy eating practices and lack of nutrition knowledge were significantly associated with iron-deficiency anaemia among school girls [8].

Emerging evidence suggests that lifestyle-based approaches, including yoga, may complement nutritional strategies. Yoga improves autonomic balance, circulation, digestion, and overall metabolic efficiency. A study conducted in Tamil Nadu reported significant improvements in haemoglobin levels and fatigue following yogic practice among college-going students [9]. Yoga balances physical and mental functions, enhances respiratory capacity, improves circulation, and increases metabolic activity. These physiological effects facilitate improved oxygen delivery, thereby positively influencing haemoglobin levels [10].

Despite national initiatives such as the Weekly Iron and Folic Acid Supplementation (WIFS) scheme and the Anaemia Mukt Bharat programme, long-term haemoglobin improvement remains limited due to poor compliance and unhealthy dietary habits [11]. Comprehensive interventions integrating nutrition, yoga, and health education have shown promise but remain under-evaluated among Indian adolescents.

Given the persistent prevalence of anaemia and the multifactorial nature of its determinants, there is an urgent need for holistic, school-based, multi-component interventions that collectively address dietary insufficiency, behavioural practices, and lifestyle factors. Therefore, the current study aimed to evaluate the effectiveness of a structured multi-intervention programme comprising nutritional supplementation, supervised yoga, and health education on improving haemoglobin levels among adolescent girls with anaemia.

MATERIALS AND METHODS

The present prospective interventional study was conducted among adolescent girls at a government high school in Raigarh district, Chhattisgarh, India, over a six-month period (August 2022-January 2023). Ethical approval was obtained from the Institutional Ethics Committee of Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu (IEC Approval No: 005/08/2022/IEC/SMCH). Participants and their parents were informed about the study objectives and procedures, and written informed consent was obtained. Participation was voluntary, and confidentiality was maintained throughout the study.

Inclusion criteria:

- Adolescent girls aged 14-18 years
- Baseline haemoglobin levels >7.0 g/dL and <12.0 g/dL (mild to moderate anaemia as per WHO classification) [12]
- Willingness to participate with parental consent

Exclusion criteria:

- Haemoglobin <7.0 g/dL requiring immediate medical referral
- Presence of chronic medical conditions such as tuberculosis, gastrointestinal disorders, or haematological diseases
- Current use of iron or folic acid supplementation
- Neurological or orthopaedic conditions preventing participation in yoga

Sample size calculation: The sample size was calculated to detect a minimum expected difference of 1.0 g/dL in haemoglobin concentration. Using a Standard Deviation (SD) of 3.12 from previous nutritional intervention studies [13], with a 5% significance level and 80% power, the required sample size was calculated as follows:

$n=(Z\alpha/2 + Z\beta)^2 \times SD^2)/(\text{mean difference})^2$

$Z\alpha/2=1.96$, $Z\beta=0.84$

Thus, $n \approx 63.1$, rounded to 64 participants.

Study Procedure

Baseline haemoglobin levels were measured using a calibrated digital haemoglobinometer following standard laboratory protocols. Sociodemographic data included age, education, family type, residence, dietary habits, parental occupation and education, and monthly income. Anthropometric measurements {height, weight, Body Mass Index (BMI)} were obtained according to WHO standards [14]. Menstrual characteristics were assessed using validated epidemiological tools [15,16]. Awareness regarding anaemia and its prevention was also documented. The Multi-Intervention Programme included the following steps:

1. **Nutritional supplementation:** Nutritious balls (ladoos) were prepared using iron-rich ingredients such as garden cress seeds, sesame seeds, jaggery, and rice flakes, following traditional dietary formulations used in previous supplementation models [17]. Each participant consumed 50 g per day, six days per week for 12 weeks.
2. **Structured teaching programme:** Educational sessions included lectures supported by audiovisual aids and discussions focusing on iron-rich foods, menstrual hygiene, and anaemia prevention.
3. **Yoga practices:** Supervised yoga sessions were conducted six days per week for 60-70 minutes, incorporating asanas, pranayama, and relaxation techniques aimed at improving circulation, digestion, and overall physical well-being.

Haemoglobin levels were reassessed at baseline and at 6, 11, and 15 weeks using aseptic blood collection techniques. All instruments were calibrated regularly, and quality control measures were implemented to ensure data reliability.

STATISTICAL ANALYSIS

Data were entered and analysed using Statistical Package for the Social Sciences (SPSS) version 25. Continuous variables were summarised using mean±SD, while categorical variables were expressed as frequencies and percentages. The paired sample t-test was used to evaluate changes in haemoglobin levels across different time points. A p-value <0.05 was considered statistically significant. This analysis enabled assessment of trends in haemoglobin improvement and evaluation of the intervention's effectiveness over time.

RESULTS

[Table/Fig-1] presents the socio-demographic and baseline characteristics of the adolescent girls enrolled in the study. The participants were distributed across four age groups: 14-15 years 18 (28.1%), 15-16 years 26 (40.6%), 16-17 years 17 (26.6%), and 17-18 years 3 (4.7%). The majority were Hindu 55 (85.9%) and were studying in the 10th or 11th standard 62 (96.9%). More than half lived in urban areas 37 (57.8%), belonged to joint families 44 (68.8%), and followed a mixed diet 47 (73.4%).

Parental education showed that most fathers 20 (31.3%) and mothers 27 (42.2%) had completed middle school, while occupations were

Variables	Category	Frequency (f) n=64	Percentage (%)
Age (years)	14-15	18	28.1
	>15-16	26	40.6
	>16-17	17	26.6
	>17-18	3	4.7
Religion	Hindu	55	85.9
	Muslim	9	14.1
	Christian	0	0.0
Education	10th	24	37.5
	11th	38	59.4
	12th	2	3.1
Area of residence	Rural	27	42.2
	Urban	37	57.8
Type of family	Nuclear	20	31.3
	Joint	44	68.8
Type of diet	Vegetarian	17	26.6
	Mixed	47	73.4
Father's education	Undergraduate	1	1.6
	Technical course	2	3.1
	Higher secondary	11	17.2
	High school	18	28.1
	Middle school	20	31.3
	No formal education	12	18.8

Mother's education	Higher secondary	3	4.7
	High school	14	21.9
	Middle school	27	42.2
	Elementary	1	1.6
	No formal education	19	29.7
Father's occupation	Government job	5	7.8
	Private job	11	17.2
	Daily wages	20	31.3
	Unemployed	3	4.7
	Business	7	10.9
	Others	18	28.1
Mother's occupation	Government job	3	4.7
	Private job	6	9.4
	Daily wages	8	12.5
	Unemployed	4	6.3
	Business	6	9.4
	Others	37	57.8
Family monthly income (Rs)	<10,000	33	51.6
	10,001-15,000	14	21.9
	15,001-20,000	7	10.9
	20,001-25,000	6	9.4
	>25,001	4	6.3
BMI	Underweight	38	59.3
	Normal	24	37.5
	Overweight	1	1.6
	Obese	1	1.6
Duration of menstrual cycle	<28 days	11	17.2
	28 days	43	67.2
	>28 days	10	15.6
Duration of menstrual days	2-3 days	13	20.3
	4-5 days	33	51.6
	>5 days	18	28.1
History of menstrual bleeding	Normal & regular	46	71.9
	Menorrhagia	14	21.9
	Polymenorrhea	4	6.3
Flow of menstrual days	Heavy	21	32.8
	Moderate	36	56.3
	Scanty	7	10.9
Previous knowledge of anaemia	Yes	35	54.7
Sources of information	Electronic media (internet, television, radio, smartphones)	20	31.2
	Print materials (newspapers, books)	5	7.8
	Others (teachers, peer groups, healthcare professionals)	10	15.7
	No	29	45.3

[Table/Fig-1]: Sociodemographic variables of participants.

mainly daily wage work for fathers 20 (31.3%) and other informal roles for mothers 37 (57.8%). Low-income families (<10,000) formed the majority 33 (51.6%) of the sample. Nutritional status assessment revealed that 38 (59.3%) were underweight, and only 24 (37.5) had a normal BMI, underscoring a high prevalence of undernutrition in this group.

Menstrual characteristics indicated mostly regular cycles 43 (67.2%), bleeding for 4-5 days 33 (51.6%), normal/regular patterns 46 (71.9%), and moderate flow reported by 36 (56.3%). Prior knowledge of anaemia was present in 35 (54.7%) participants, with sources including electronic media 20 (31.2%), print materials 5 (7.8%), and teachers or healthcare workers 10 (15.7%). Overall, the findings reflect a nutritionally at-risk group with diverse educational, occupational, and menstrual backgrounds that may influence anaemia status and responsiveness to intervention.

At the pretest, none of the participants had normal haemoglobin levels; the majority were in the mild anaemia category 51 (79.7%), while 13 (20.3%) had moderate anaemia. By post-test 1, normal haemoglobin appeared in 2 (3.1%) participants, mild anaemia slightly decreased to 47 (73.4%), and moderate anaemia was observed in 15 (23.4%). At post-test 2, the number of girls with normal haemoglobin increased to 8 (12.5%), mild anaemia remained predominant at 49 (76.6%), and moderate anaemia declined to 7 (10.9%). By post-test 3, substantial improvement was evident, with 24 (37.5%) achieving normal haemoglobin, mild anaemia reducing to 36 (56.3%), and moderate anaemia further declining to 4 (6.3%). Overall, the findings indicate a consistent shift of participants from moderate and mild anaemia toward normal haemoglobin levels over time [Table/Fig-2].

The Mean haemoglobin levels increased steadily from 10.54±0.94 g/dL at baseline to 11.52±0.95 g/dL at 15 weeks. [Table/Fig-3] shows a progressive increase in haemoglobin levels across the three follow-up intervals. The comparison between baseline and the first follow-up (Pair 1) indicated a small, non-significant change in mean haemoglobin ($p=0.089$), suggesting minimal early improvement. In Pair 2, haemoglobin levels increased significantly from baseline to 11 weeks ($p<0.001$), indicating a meaningful mid-phase effect of the intervention. Pair 3 demonstrated the most substantial and statistically significant rise, with haemoglobin reaching 11.520±0.946 at 15 weeks ($p<0.001$), confirming strong and sustained improvement by the end of the intervention period. Overall, the paired t-test results reflect a clear, time-dependent enhancement in haemoglobin levels following the multi-intervention program.

The paired samples correlation analysis for the experimental group revealed strong and statistically significant positive relationships between baseline and subsequent haemoglobin measurements. The correlation between Hb and Hb1 was 0.781 ($p<0.001$), indicating a strong association, while Hb and Hb2 showed a moderately strong correlation of 0.718 ($p<0.001$), and Hb and Hb3 demonstrated a strong correlation of 0.745 ($p<0.001$) [Table/Fig-4]. These findings suggest that participants with higher baseline haemoglobin levels maintained proportionately higher values across follow-up measurements, reflecting a consistent and stable trend in haemoglobin improvement over time, likely indicating the effectiveness of the intervention in the experimental group.

	Pretest		Post-test 1		Post-test 2		Post-test 3	
Haemoglobin level	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Normal	00	00	02	3.1%	08	12.5%	24	37.5%
Mild anaemia	51	79.7%	47	73.4%	49	76.6%	36	56.3%
Moderate anaemia	13	20.3%	15	23.4%	07	10.9%	04	6.3%
Total	64	100%	64	100%	64	100%	64	100%

[Table/Fig-2]: The table summarises haemoglobin levels at multiple assessment points: pre-test, post-test 1, post-test 2, and post-test 3.

Pair	Comparison	Hb Mean (±SD)	Follow-up mean (±SD)	Mean difference	Std. error mean	t-value	df	p-value
Pair 1	Hb-Hb1	10.542±0.938	10.409±0.924	0.1328	0.0770	1.725	63	0.089
Pair 2	Hb-Hb2	10.542±0.938	10.923±0.944	-0.3813	0.0883	-4.317	63	<0.001
Pair 3	Hb-Hb3	10.542±0.938	11.520±0.946	-0.9781	0.0842	-11.624	63	<0.001

[Table/Fig-3]: Paired samples statistics and test results showing progressive changes in haemoglobin levels among adolescent girls across three post test intervals.
Pair 1: Baseline and follow-up 1; Pair 2: Baseline to 11 weeks (follow-up 2); Pair 3: Baseline and 15 weeks (follow-up 3)

Pair	Comparison	N	Correlation	Sig.
Pair 1	Hb & Hb1	64	0.781	<0.001
Pair 2	Hb & Hb2	64	0.718	<0.001
Pair 3	Hb & Hb3	64	0.745	<0.001

[Table/Fig-4]: Correlation analysis between the baseline and subsequent haemoglobin measurements for the experimental group (n= 64).

DISCUSSION

The current study demonstrated that a structured multi-intervention program consisting of nutritional supplementation, supervised yoga, and structured health education led to significant improvements in haemoglobin levels among adolescent girls with anaemia. Haemoglobin levels increased progressively across the follow-up period, and by week 15, over one-third of participants had achieved normal haemoglobin levels. These findings reinforce the need for integrated, school-based approaches to address the high burden of anaemia among Indian adolescents, a concern consistently highlighted in national surveys and epidemiological studies.

A population-based longitudinal study conducted across multiple states reported that dietary inadequacy, menstrual losses, and infections are major determinants of anaemia among Indian adolescents, emphasising the importance of multi-factorial strategies similar to the present intervention [18].

Nutritional supplementation remains one of the most effective approaches for improving haemoglobin status. Evidence from large-scale evaluations supports this finding. In a cluster-randomised school trial in Burkina Faso, weekly iron-folic acid supplementation produced a statistically significant increase in haemoglobin compared with standard nutrition education alone (β=0.32; 95% CI: 0.02-0.62) [19]. Similarly, a systematic review of integrated interventions targeting adolescent anaemia confirmed that dietary or supplemental iron interventions significantly improve haemoglobin levels, highlighting the biological plausibility of the nutritional gains observed in the current study [20].

Yoga, included as a lifestyle modification in this study, may also have contributed to haematological improvement. Research indicates that yoga enhances autonomic balance, improves circulation, and modulates physiological stress-all factors associated with improved nutrient uptake and haematopoiesis. A longitudinal study conducted among 35 healthy individuals aged 18-45 years in Rajasthan reported significant improvements in haemoglobin and overall metabolic parameters following a structured yoga program [21]. A broader systematic review of yoga interventions similarly highlighted positive effects on physical and mental health, including haematological indices, thereby reducing the signs and symptoms of anaemia [22].

Health education played a complementary role by improving awareness, dietary behaviour, menstrual health practices, and treatment adherence. A pre-experimental one-group pretest/post-test study conducted among senior secondary school adolescent girls in East Sikkim reported a significant increase in knowledge following structured educational sessions [23]. Additionally, a non-randomised controlled trial in Ghana showed that the intervention group achieved significantly higher mean knowledge scores than the control group ($p<0.05$), supporting the importance of educational strategies in sustaining nutritional interventions [24].

Likewise, a study evaluating multicomponent school health programs in Asia among 240 participants reported significant reductions in anaemia prevalence following combined nutrition education, supplementation, and physical activity initiatives. Approximately 40% of adolescent girls achieved normal haemoglobin levels in the experimental group, demonstrating that multi-sectoral approaches yield the most meaningful improvements in adolescent nutritional outcomes [13].

The outcomes of the current study support this integrated model, as the combination of nutritional supplementation, yoga-based activity, and structured education produced cumulative improvements in haemoglobin across repeated measurements. The significant changes observed between baseline and later follow-ups (weeks 11 and 15) suggest that sustained exposure to combined interventions yields better results than short-term, single-strategy approaches.

Limitation(s)

The current study was conducted in a single government school with a modest sample size (n=64), limiting the generalisability of the findings. The follow-up period was restricted to 15 weeks, preventing assessment of long-term sustainability or recurrence of anaemia. Factors such as meal skipping due to school schedules, fasting practices, or socio-cultural food restrictions were not assessed, although they influence iron intake and absorption. Physical activity outside the yoga sessions (sports, household work, walking distance to school) was also not assessed and may have influenced nutritional status and haemoglobin levels.

CONCLUSION(S)

The current study demonstrated that a structured program combining nutritional supplementation, yoga, and health education significantly improved haemoglobin levels among anaemic adolescent girls. By week 15, most participants progressed from moderate to mild or normal anaemia through consistent monitoring and tailored management. The integrated, school-based, and culturally adaptable approach proved more effective than single interventions, offering a cost-effective model for sustainable anaemia prevention and improved adolescent and maternal health outcomes.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 13, 2025
- Manual Googling: Dec 22, 2025
- iThenticate Software: Dec 24, 2025 (4%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Aug 29, 2025**
Date of Peer Review: **Sep 22, 2025**
Date of Acceptance: **Dec 26, 2025**
Date of Publishing: **Feb 01, 2026**