The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Issue 5 | May 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Anemia and BMI in Adolescent Girls: A School Based Study in Dindigul District

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ARTICLE DETAILS

Research Paper

Accepted: 19-05-2025

Published: 10-06-2025

Keywords:

Body Mass Index, Anemia, Adolescent Girls, Dindigul.

ABSTRACT

Adolescent girls are vulnerable to iron deficiency worldwide, and have a undesirable impact on health and education. The study aims to assess the BMI and prevalence of anemia among adolescent girls between the ages of 13 and 18years in Dindigul District of Tamil Nadu, India. Using multi-stage sample technique, 2,238 adolescent girls were selected and 1,813 were identified as they are suffering from moderate anemia based on World Health Organization (WHO) classification. A sample of 328 girls was selected for detailed analysis, including anthropometric measurements and reviews of hemoglobin due to pandemic restrictions. This result showed a significant prevalence of moderate anemia, with 2% of participants showing hemoglobin levels below 8 g/dL. Socioeconomic profile shows that majority belonged to the lower middle class. The null hypothesis H01 is accepted, and it is determined that the mean body mass index of the adolescent girls before and after the test shows no discernible mean difference between the experimental and control groups. H02 is rejected, and there is a notable mean difference between the experimental and control groups in the adolescent girls hemoglobin levels before and after the nutrition education intervention.

DOI : https://doi.org/10.5281/zenodo.15639096

Introduction

It is alarming to know that adolescent girls around the world are vulnerable to iron deficiency. UNICEF/WHO report (2009) recommends countries to assess the prevalence of anemia and its risk factors (Icyishatse et al., 2019). More than 1.2 billion adolescents are in the world (Fentie et al., 2020). It is understood that adolescent age group constitute 20 per cent of the population and among them 80 per cent live in developing countries and India has the largest adolescent population followed by China (Deshmukh & Chaniana, 2020). In India 21.4 per cent of the population are adolescents and among them 10 per cent are adolescent girls (Reshmi & Takalkar, 2020).

In India, 55.3% of women between the ages of 15 and 49 suffer from anemia, according to the National Family Health Survey-5 (NFHS-5; 2021). Similarly, anemia affects 52.6% of women in Tamil Nadu and 42.6% of women in Dindigul District who are between the ages of 15 and 49. Adolescent anemia has significant effects on a variety of outcomes, and the severity of anemia is closely linked to almost all of the functional repercussions of iron shortage.

Reduced attention, memory, and academic achievement in adolescents decreased school attendance; retention of physical growth; the appearance of menarches; reduced immunity and infection-related morbidity; diminished physical ability and effectiveness at work; elevated fetal morbidity and mortality; raised prenatal risk for mothers and newborns; occurrence of low birth weight; and increased infant mortality are all consequences of iron deficiency (Munira, 2021).

The World Health Organization (WHO) defines anemia as a condition in which the body's physiological needs are not fulfilled by the amount of red blood cells (and hence their oxygen carrying capability) (Fletcher et al., 2022). When the level of hemoglobin, or Hb, is below 12 g/dL or the red blood cell (RBC) count is less than 4.2 million/μL, anemia has been identified (Sari et al., 2022). Adolescent girls who are 10 to 11 years old and have a hemoglobin level of ≥11.5 g/dL (no anemia), 11.0 g/dL to 11.4 g/dL (mild), 8.0 g/dL to 10.9 g/dL (moderate), and < 8.0 g/dL (severe), as well as those who are 12 years of age and older and have a hemoglobin level of ≥12.0 g/dL (no anemia), 11.0 g/dL to 11.9 g/dL (mild), 8.0 g/dL to 10.9 g/dL (moderate), and < 8.0 g/dL (severe).

Addressing anemia among adolescent girls requires a multi faceted approach that includes dietary improvements, education, and healthcare interventions. Diagnosis and treatment depends on the specific

type and cause of anemia. It also involves dietary changes, iron supplements, vitamin supplements, blood transfusions, or addressing the underlying condition responsible for the anemia.

Common strategies to combat anemia among vulnerable populations are recommendations to consume a balanced diet, fortified cereals and vitamin C rich foods and impart nutrition and menstrual hygiene education, deworming treatment for hookworm infestation and Iron tablet supplementation.

Anemia Prevalence in Adolescent Girls

International Status

The prevalence of anemia in the world reaches 50 to 80 per cent of the total population. About 27 per cent of adolescent girls had anemia in developing countries (Ekasanti et al., 2020). South East Asia region, the prevalence estimates of adolescent anaemia ranged from 27 per cent to 55 per cent. In Indonesia, the incidence of anemia reaches 23.7 per cent with the prevalence of incidence in female adolescents aged 15 to 24 years old at 32 per cent (Zaqiyah & Puspitasari, 2022). Recent studies shows that the prevalence of Iron Deficiency (ID) among adolescents has varied between 8.06 per cent in Kuwait, 10.9 per cent in Nepal, 13.3 per cent in Spain, 21.3 per cent in India and 23 per cent in Indonesia, which confirms the current worldwide extent of this public health problem (Ciampo & Ciampo, 2020).

According to the 2017 Ghana Micronutrient Survey, the national prevalence of anemia among teenage females aged 15 to 19 who are not pregnant was 26.4%, making it a moderately significant public health issue (Gosdin et al., 2020b). In accordance with several community-based studies performed throughout India, the prevalence of anemia varied from 30% to as high as 68.8%. This burden was similar to, sometimes greater than, the prevalence found in other countries that are developing (Poyyamozhi et al., 2018). While a few studies looked at hemoglobin levels and the incidence of anemia in children and adolescents in China, they were unrepresentative because of their small sample sizes or geographic compositions with particular populations (Jinghuan et al., 2019).

National Scenario

Because of inadequate consumption of iron (less than 20 mg/day) and folic acid (less than 70 µg/day), poor bioavailability of iron (only 3-4%), a diet high in phytates and dietary fiber, and continuous blood loss from infections, anemia was quite prevalent in India include hookworm infections and malaria (Moreshwar & Naik, 2020). The majority of South Asian teenage girls suffered from anemia; in

Bangladesh, India, and Nepal, anemia was found in 70, 51.8, and 67.7 percent of adolescents, respectively (Gonete et al., 2018).

Even though anemia has long been acknowledged as a public health issue, there hasn't been significant progress reported, and the prevalence of anemia global stays too high (Sathya et al., 2017).

While a lack of iron is the most widespread type of nutritional anemia in India, folate and vitamin B12 deficiencies also play an essential part, according to Sarna (2020, as referenced in Dandona, 2020). Furthermore, adolescents are prone to suffer from folate or vitamin B12 failing anemia (703 [25·6%] of 2740). the findings of the research, anemia is a prevalent disorder that has an immense impact on the health and wellbeing of the individuals who have it.

Anemia is a severe global public health issue that mostly impacts adolescent girls. It can lead to discomfort and decreased work efficiency and is connected to poor cognitive and motor development outcomes in teenage girls. Some common causes for anemia include chronic disease, infections (such intestinal parasites and malaria), and scarcity in specific nutrients (iron, folate, and vitamin B12).They also have limited access to healthcare services, and hence may not be screened for anemia. Adolescent girls also experience heavy bleeding during menstrual cycles, which can lead to a loss of iron and exacerbate anemia. Cultural factors such as early marriage and pregnancy can throw anemia in adolescent girls.

Adolescent Girls health is at grave risk if they become married young, requiring them to have their offspring early. Adolescent moms are slightly more prone to succumb to anemia-related symptoms during workforce, premature births, delayed fetal growth, and even mortality rates.

Adolescent girls have a key role to play in response to their health and well-being. Adolescent girls are mostly found in schools. Schools are not only places of academic learning but also important settings for fostering the holistic development, health, and well being of adolescent girls. By integrating comprehensive health education, promoting healthy behaviors, and creating a supportive atmosphere, schools can help adolescent girls build a foundation for a healthier and more fulfilling life.

Addressing anemia in rural adolescent girls requires a multi faceted approach, which includes improving access to nutritious food and healthcare and also enhancing their attitudes positively towards their health. Despite several National level programmes being implemented, the state of nutrition among adolescent girls continues to be of concern, especially in rural areas. The present study focuses on Anemia and BMI in Adolescent Girls in Dindigul District, Tamil Nadu.

Objectives

- To assess the Socioeconomic profile of Adolescent Girls in the selected block.
- To determine the Mean Body Mass Index (BMI) of Adolescent Girls.
- To estimate the Mean prevalence of Anemia among Adolescent Girls.

Methodology

Based on a review of the 2011 Census of India, the study focused on adolescent girls aged 13 to 18 years residing in rural areas. Schools were identified as effective locations to reach this demographic, as they bring adolescent girls together in a centralized setting. Palani and Thoppampatti Block was selected from Dindigul District. Prior Permission was obtained from the District Education Officer. A multistage sampling technique was used to select the adolescent girls for the study.

Screening of Anemia among Adolescent Girls

A total of 2,238 adolescent girls aged 13 to 18 years were selected for the present study. Health cards of girls registered at the Urban Primary Health Center were reviewed to obtain secondary data, as direct blood examinations were not permitted due to the pandemic. Hemoglobin levels recorded in the health cards were noted, along with other relevant health information. Based on the World Health Organization's classification of anemia, the records were categorized into normal, mild, moderate, and severe anemia. The majority of the girls were found to have moderate anemia. Applying the study's inclusion and exclusion criteria, 1,813 girls with moderate anemia were selected for participation. Although severe cases were identified, those individuals were referred to physicians at the Primary Health Center for further medical attention.

As the population size is known and finite, the sample size was adjusted through finite population correction as 328. The sample size was taken from the population of 1813 adolescent girls who were the representatives of the selected schools and was approximated to 328 for the convenience of analysis.

Table 1

School wise Distribution of the Study Sample

S.No.	Name of the School	Sample size	Total
1	Government Girls Higher Secondary School, Palani	$\frac{920}{1813 \times 328}$	166

2	Government High School, Old Ayakudi	$\frac{210}{1813x328}$	38
3	Government High School, Kanakanpatti	$\frac{331}{1813x328}$	60
4	Government Higher Secondary School, Thoppampatti	$\frac{352}{1813x328}$	64
	Total		**328**

From among the 1813, 328 adolescent girls were selected by systematic random sampling. 164 adolescent girls chosen from the four schools constituted the experimental group and another 164 adolescent girls from the same schools served as the control group.

Assessment of Nutritional Status of the Adolescent Girls

Height and weight were the anthropometric measurements collected from the adolescent girls, following the guidelines established by the Indian Council of Medical Research (ICMR). These measurements were used to calculate Body Mass Index (BMI), expressed as the ratio of weight in kilograms to height in meters squared (kg/m²). The revised growth chart recommended by the Centers for Disease Control and Prevention (CDC, 2000) was used to determine percentile rankings for girls aged 2 to 20 years. Based on these percentiles, weight status was categorized as follows: healthy weight (5th to <85th percentile), overweight (85th to <95th percentile), and obese (≥95th percentile). Hemoglobin levels were obtained from health cards maintained at the Primary Health Center (PHC), as direct blood testing was not permitted due to COVID-19 restrictions. The biochemical data recorded in the health cards, including hemoglobin and other relevant parameters, were collected for the study. All biochemical values were considered valid as they had been tested within two months prior to the study period. Structured close ended questionnaire was used to get the basic information and nutrition intervention was given to the target for four months in the regional language. Statistical measures was used to find the results followed by pre and post test.

Results and Discussion

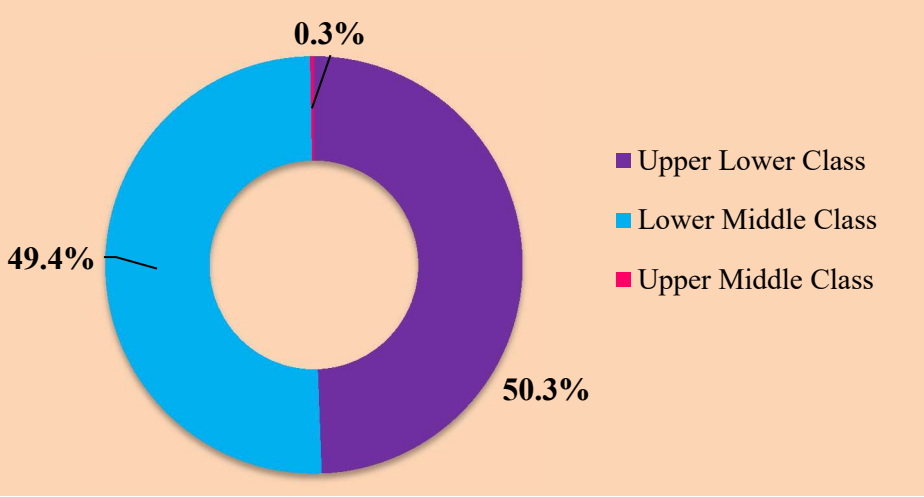
Table 2

Prevalence of Moderate Anemia among Adolescent Girls in Selected Blocks

Haemoglobin level	Palani Block			Thoppampatti Block	Total
	Palani Girls Hr.Sec. School	Kanakanpatti, Government High School	Old Aayakudi, Government High School	Thoppampatti, Government Higher Secondary School	
8gm/dl	76	26	16	27	145
9gm/dl	60	23	14	21	118
10gm/dl	30	11	8	16	65
Total	166	60	38	64	328

A total of 328 adolescent girls from four schools across Palani and Thoppampatti blocks were assessed based on their hemoglobin levels, categorized into 8 g/dl, 9 g/dl, and 10 g/dl indicative of moderate anemia. Palani Girls Hr. Sec. School recorded the highest number of moderately anemic girls (n = 166), making up over 50% of the total sample. The other three schools had significantly smaller groups, with Kanakanpatti Government High School (n = 60), Old Aayakudi Government High School (n = 38), and Thoppampatti Government Higher Secondary School (n = 64). The majority of girls in each school had hemoglobin levels at or below 9 g/dl. Palani Girls Hr. Sec. School had the highest count of girls with the lowest hemoglobin level (8 g/dl) at 76 students. Across all schools, 145 girls (44.2%) had hemoglobin at 8 g/dl, indicating a considerable proportion with more severe moderate anemia. About 118 girls (36%) had a hemoglobin level of 9 g/dl, and 65 girls (19.8%) were at 10 g/dl at the upper threshold of moderate anemia.

Figure 1: *Socio-Economic Status of the Adolescent Girls*



The Socio-Economic scores computed for the respondents revealed that 49.4 per cent of them belonged to Upper Lower Class, 50.3 per cent of them belonged to Lower Middle Class and very few 0.3 per cent of them belonged to Upper Middle Class. None of the adolescent girls belonged to Lower Class or Upper Class. The variables like parent's education level, occupation and income was calculated and scoring was given using Kuppuswamy's Socio Economic Scale.

Table 3

BMI for age Percentiles of the Adolescent Girls

Age of the adolescent girls (N=328)	**BMI range cut off**			
	<5th percentile Underweight (<18.5)	**5th to 85th percentile** Normal (18.5to 24.9)	**85th to 95th percentile** Overweight (25 to 29.9)	**Total**
	No.(%)	**No.(%)**	**No.(%)**	**No.(%)**
13+	15(22.4)	66(28.2)	13(48.1)	94(28.7)
14+	28(41.8)	59(25.2)	5(18.5)	92(28.0)
15+	18(26.9)	59(25.2)	3(11.1)	80(24.4)
16+	4(6.0)	26(11.1)	0	30(9.1)
17+	2(3.0)	24(10.3)	6(22.2)	32(9.8)
Total	67(20.4)	234(71.3)	27(8.2)	328(100.0)

Note: Figures in the parentheses represents row-wise and column-wise percentage

The Body Mass Index (BMI) of the selected adolescent girls is presented in Table 3. From the results it was found that two third (71.3 %) of the adolescent girls had normal BMI for age between the 5th to 85th percentile, less than one fourth (20.4%) of the adolescent girls were underweight with BMI for age falling below 5th percentile and a few (8.2%) were overweight and had BMI for age above 85th to 95th percentile. It is also evident that the percentage of underweight was high among girls in 13+,to 15+. Giri and Giri (2022) also found that majority i.e. 66.1 per cent was found normal, less than one fourth i.e. 18 per cent and 11.2 per cent was found overweight and underweight.

Table 4

Haemoglobin Level of the Adolescent Girls

Haemoglobin level in gm/dl	**8gm/dl**	**9gm/dl**	**10gm/dl**	**Total**
Age of the adolescent girls (in years) (N=328)	**No.(%)**	**No.(%)**	**No.(%)**	**No.(%)**
13-14	46(31.7)	30(25.4)	18(27.7)	94(28.7)
14-15	41(28.3)	38(32.2)	13(20.0)	92(28.0)
15-16	32(22.1)	27(22.9)	21(32.3)	80(24.4)
16 -17	12(8.3)	12(10.2)	6(9.2)	30(9.1)
17-18	14(9.7)	11(9.3)	7(10.8)	32(9.8)
Total	145(44.2)	118(36.0)	65(19.8)	328(100.0)

Note: Figures in the parentheses represents row-wise and column-wise percentage

The Table 4 shows the haemoglobin level of the selected adolescent girls. Majority (44.2%) of the adolescent girls had 8gm/dl of haemoglobin. 36 per cent of the adolescent girls had 9gm/dl and nearly 20 per cent had 10 gm/dl of Haemoglobin. Similar to BMI for age, the haemoglobin values were also less among 13+, 14+ and 15+ adolescent girls. As per WHO, (2009) individuals with haemoglobin level between 8 and 10gm/dl are classified under moderate anemia. After screening adolescent girls with moderate anemia were selected for the present study.

$H0_1$: There is no significant mean difference between the control group and experimental group in the pre and post-test in the Mean Body Mass Index of the adolescent girls.

Table 5

Mean BMI of the Control and Experimental Group of the Adolescent girls Before and After Test

Age of the respondents	Group	Test performed	Mean ± SD	't' value
13+ (n=47)	Control	Pre-test	20.86±3.599	0.858*
		Post-test	20.95±3.443	
	Experimental	Pre-test	21.78±3.426	1.858*
		Post-test	21.92±3.421	
14+ (n= 46)	Control	Pre-test	20.29±5.003	0.629*
		Post-test	20.33±4.943	
	Experimental	Pre-test	20.71±3.837	0.444*
		Post-test	20.75±3.692	
15+ (n= 40)	Control	Pre-test	22.21±3.700	0.259*
		Post-test	22.20±3.631	
	Experimental	Pre-test	20.38±4.448	1.682*
		Post-test	20.44±4.450	
16+ (n= 15)	Control	Pre-test	21.64±3.669	1.000*
		Post-test	21.58±3.584	
	Experimental	Pre-test	21.59±2.747	1.000*
		Post-test	21.52±2.785	
17+ (n=16)	Control	Pre-test	24.30±3.494	0.340*
		Post-test	24.26±3.334	
	Experimental	Pre-test	24.71±4.103	1.456*
		Post-test	24.60±4.054	

Note: p-value: **Significant at 0.05 % level (p<0.05); *Not Significant

It is clear from Table 5 that there was not significant difference in the 13+,14+,15+,16+and 17+adolescent girls in control and experimental groups between their pre and post test BMI for age. It is evident that education intervention has no influence on adolescent's girls BMI for age. This mean difference in the control and experimental group is statistically not significant at 5% level (p>.05).

As a result, the null hypothesis H01 is accepted, and it follows that the adolescent girls Mean Body Mass Index scores before and after the test show no discernible mean change between the experimental and control groups.

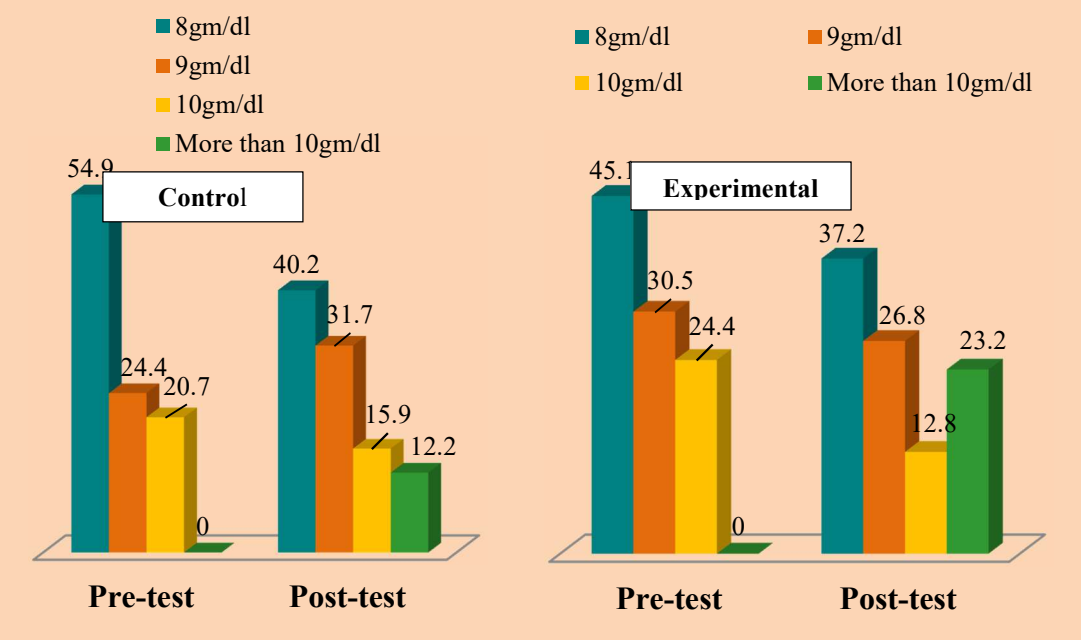
Table 6

Adolescent Girls' Blood Haemoglobin Levels in the Control and Experimental Groups

Haemoglobin level in gm/dl	Control Group (n=164)		Experimental Group (n=164)	
	Pre-test No. (%)	Post-test No. (%)	Pre-test No. (%)	Post-test No. (%)
8gm/dl	90(54.9)	66(40.2)	74(45.1)	61(37.2)
9gm/dl	40(24.4)	52(31.7)	50(30.5)	44(26.8)
10gm/dl	34(20.7)	26(15.9)	40(24.4)	21(12.8)
>10gm/dl	0	20(12.2)	0	38(23.2)

Figure 2

Haemoglobin Level of the Control and Experimental Group of the Adolescent Girls



Hemoglobin in selected young girls was recorded before and after the nutrition education intervention in. Results show that 5.1% of young girls initially in 5.9% and 5.1% had 8 g/dL hemoglobin in the control or experimental group. Almost half of the youthful girls had 9gm/dL hemoglobin mirrors in both the and the experimental group. Over a third of young girls had both gm/dL hemoglobin in both control and experimental groups. When mediating nutritional

education, post-test results showed that the decline in the number of young girls with 8 g/dL

hemoglobin decreased from 5.1% to 37.2%. Similarly, the number of young girls with hemoglobin levels of 9 and 10 g/dL decreased from 30.5% to 26.8%, and from 2 % to 12.8%. It was also clear that 23.2% of young girls switched from moderate anemia to slight anemia. The results after testing for the control group showed a slight increase in hemoglobin levels. Almost 12.2% of the female had nothing >10 g/dL hemoglobin in the pretest. Rabie et al. (2019) reported that hemoglobin status in the test group was improved over the controlled group. Therefore, the analysis shows that hemoglobin levels of gradually increased young girls in the experimental and control groups. There are intervening variables that affect hemoglobin levels in both groups.

Table 7

Mean Blood Haemoglobin Level of Adolescent Girls in Control and Experimental Group

Groups	Haemoglobin			't' value
	Pre-Test	Post Test	Std. Error Mean	
Control	8.82±0.78	8.82±0.78	.06372	0.20**
Experimental	8.68±0.73	9.02±0.93	.07276	0.53**

Note: p-value: **Significant at 0.05 % level (p<0.05); *Not Significant

Table 7 shows that the mean blood hemoglobin count of the adolescent girls in the experimental group increased from 8.82±0.78 to 9.51±1.07, indicating a significant increase. As a result, nutrition education promotes choices for a healthy life, anemia consciousness, and food consumption behavior. Also, there are minor variations in the blood hemoglobin values of the teenage girls in the control group.

$H0_2$: Adolescent girls' hemoglobin levels in the blood before and after the test showed no noticeable mean change between the experimental and control groups.

Table 8

Adolescent females' mean blood hemoglobin counts in both control and experimental groups

Age of the Adolescent Girls	Group	Test performed	Mean ± SD	't' value
13+ (n=47)	Control	Pre-test	8.55±0.746	2.923**
		Post-test	8.93±0.894	
	Experimental	Pre-test	8.85±0.779	3.077**
		Post-test	9.25±1.169	

14+ (n= 46)	Control	Pre-test	8.63±0.644	2.662*
		Post-test	8.91±0.894	
	Experimental	Pre-test	8.76±0.765	6.104**
		Post-test	9.60±0.954	
15+ (n= 40)	Control	Pre-test	8.85±0.802	2.563*
		Post-test	9.20±1.017	
	Experimental	Pre-test	8.87±0.822	3.250**
		Post-test	9.32±1.022	
16+ (n= 15)	Control	Pre-test	8.86±0.743	0.367*
		Post-test	8.93±0.883	
	Experimental	Pre-test	8.73±0.798	4.432**
		Post-test	9.86±1.060	
17+ (n=16)	Control	Pre-test	8.68±0.793	2.764*
		Post-test	9.25±1.064	
	Experimental	Pre-test	8.87±0.806	7.251**
		Post-test	10.06±0.928	

Note: p-value: **Significant at 0.05 % level ($p<0.05$); *Not Significant

Table 8 shows the mean haemoglobin level of the selected adolescent girls in control and experimental group. Among 13+ age group the mean haemoglobin level in pre intervention period was 8.55±0.746 and it had a slight improvement on post intervention period and was statistically significant. The reason for improvement may be attributed to the iron supplement that was provided in the schools. The mean haemoglobin level of the 13+ adolescent girls in experimental group increased by gram in post intervention period and was statistically significant between the pre and post test values.

Among the 14+, 15+, 16+ and 17+ age groups adolescent girls in control group initially before intervention had a mean haemoglobin level of 8.63±0.644, 8.85±0.802, 8.86±0.743 and 8.68±0.793 respectively. In post intervention there was a slight increase of 0.18gm to 0.57 gm respectively and the difference was statistically significant. While the mean haemoglobin value of the experimental group in 14+, 15+, 16+ and 17+ age group before intervention ranged from 8.76 to 8.87 and post intervention the mean haemoglobin level increased by 0.5 to 1.19 gm/dl in each group. The maximum increase was noticed in 17+. Statistically the differences in pre and post test haemoglobin value of adolescent girls in

experimental group was significant. Similar results was reported by Abu Baker (2021), Khani (2021), and Sulistiyanti (2022) in their studies. Ghadam et al. (2022) results showed that the effect of nutrition education on markers of iron deficiency anemia that nutrition education caused a significant increase in haemoglobin level in both control group and experimental group. According to Khani Jeihooni (2021, as cited in Ghadam) that haemoglobin level increased after four months intervention compared with control group.

The post-test results show significant variance for the experimental group but not for the control group. Thus, it becomes apparent that the H02 is rejected and that, during the nutrition education intervention, there is a significant mean difference in the hemoglobin counts of the adolescent females in the control group and experimental group in each of the pre-test and post-test.

Conclusion

The study concludes 328 adolescent girls from four schools in the Palani and Thoppampatti blocks, focusing on hemoglobin levels and BMI-for-age as indicators of health and nutritional status. A significant proportion of the girls were found to be moderately anemic, with 44.2% having a hemoglobin level of 8 g/dl, and a further 36% and 19.8% with 9 g/dl and 10 g/dl respectively. Palani Girls Hr. Sec. School reported the highest number of anemic girls, especially those with more severe levels of moderate anemia. Two-thirds (71.3%) of the adolescent girls had a normal BMI-for-age, while 20.4% were underweight and 8.2% were overweight. Underweight status was more prevalent among younger adolescents aged 13+ to 15+. The intervention phase, which involved nutrition education, showed no statistically significant impact on BMI-for-age across control and experimental groups. However, a positive trend was observed in hemoglobin levels post-intervention. Notably, the number of girls with the lowest hemoglobin level (8 g/dl) decreased from 45.1% to 37.2% in the experimental group, suggesting that nutrition education may have a beneficial effect on anemia management, even if not strongly significant in BMI changes and it is concluded as anemia and undernutrition remain prevalent among adolescent girls in the study area, targeted interventions such as nutrition education show potential for improving hemoglobin levels, highlighting the need for continued health and nutrition programs in schools.

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