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RESEARCH ARTICLE

Impact of Millet-Based Interventions on Weight, Body Mass Index and Haemoglobin of School-Going Adolescent Girls

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Abstract

Objective: To identify the nutritional impact of millet-based foods such as millet health mix and energy bars, finger millet cutlets, and biscuits pre- and post-intervention on weight, Body Mass Index (BMI), and haemoglobin. **Methods:** A cross-sectional interventional study was conducted with seventy-three (n=73) adolescent girls from a Zilla Parishad High School (ZPHS) of Gangapur village, Mahabubnagar, Telangana. Statistical analysis was conducted using SPSS and a p-value that is <0.05 was considered statistically significant. **Findings:** More than 90% of the adolescents were anemic and had blood haemoglobin levels between 7.0 to 9.9 g/dl. Post-intervention, the mean weight improved from 26.77±1.4 kg to 26.92±2.1 kg, mean BMI increased from 16.4±2.5kg/m2 to 17.3±2.2 kg/m2, and haemoglobin from 8.40±0.9 g/dl to 8.45±0.6 g/dl. The paired t-test analysis revealed statistically significant changes in the weight (p=0.001) and the BMI (p=0.001) pre-intervention and post-intervention at 95% CI. **Novelty:** As an adjunct to the Mid-Day Meal (MDM), four varieties of millet-based ready-to-eat foods were used to tackle the issue of anemia among school-going adolescent girls.

Keywords: Adolescent Girls; Anemia; Body Mass Index; Haemoglobin; MilletBased Foods; Weight

1 Introduction

Adolescent girls constitute a vulnerable group, particularly since they face a series of concerns related to morbidity and are often exposed to nutritional deficiencies. The major concerns include delayed menstruation, pain during menstruation, and increased iron losses through blood leading to iron deficiency anemia, which is a condition characterized by nutritional deficiencies of iron [(1)]. The review of literature helped identify that Telangana is a state with a high burden of anemia among adolescent girls [(2)] with about 59% of anemic adolescent girls. Hence, their nutritional needs are very critical to reduce the burden of anemia and improve overall health [(3)].

Millets are called "smart foods" since they are a superior source of micronutrients such as iron, calcium, and phosphorus amongst other nutrients. They have a higher iron content than cereals such as rice and wheat. They can be blended with other raw materials to produce nutrient-rich snack products [4] which are low-cost, nutritionally superior, iron-rich, ready-to-eat (RTE). However, millets contain anti-nutritional factors such as phytic acid that inhibit the absorption of the minerals by the body. A study recommended that cooking millets will help reduce the phytic acid content to some level [4]. Further, this study also highlighted that diversifying millet-based processed foods with legumes and vegetables will improve bioavailability [4]. A study demonstrated that a ladoo developed from finger millets is effective in increasing blood haemoglobin levels among adolescent girls [5] since finger millets are good sources of iron [6]. Furthermore, an interventional study had introduced millet-based foods into the school lunch program for adolescent girls in peri-urban Karnataka. It was observed that iron deficiency anemia can be combated by providing millet-based foods in the school lunch program like the Mid-Day Meal Program (MDM) [4]. Henceforth, a millet-based nutritional interventional strategy has the potential to combat the burden of anemia in a high-risk group such as adolescent girls [7]. Previous studies conducted in Telangana demonstrated the positive impact of ragi ladoo, which is made from single millet - ragi, on haemoglobin levels of adolescent girls. There is little evidence on the impact of diverse millet-based foods prepared from a combination of millets such as bajra, ragi, jowar amongst others on the blood heamoglobin levels of adolescent girls.

Thus, this present study aimed to assess the impact of diverse nutrient-dense millet-based foods on the weight, Body Mass Index (BMI), and haemoglobin of school-going adolescent girls based on the hypothesis that millet-based foods contribute to the improvements in weight, BMI, and haemoglobin among adolescent girls.

2 Methodology

2.1 Selection of area & samples

A cross-sectional interventional study was conducted between November 2018 to February 2019 in a Zilla Parishad High School (ZPHS) of Gangapur Village in Jadcherla Mandal of Mahabubnagar district, Telangana in India. Jadcherla Mandal was selected through a purposive sampling technique based on its proximity to the district headquarters.

In the selected Mandal, the line listing of schools with the corresponding number of adolescent girls was developed with the help of government officials. The sample size was calculated using Cochrane Sample Size Calculator for categorical data with a formula of

n0=(t)2*(p)(q)/(d)2=384

$((1.96)^2 * (0.5) *(0.5))/ (0.07)^2 = 196$

Where n0 is the sample size, t is the value of the selected range at the alpha level, e.g. 1.96 for (0.25 in each tail) at 95% confidence level, p is an estimated proportion of the attribute in the population. q is 1-p. (p)(q) are the estimates of variance. d is an acceptable margin of error for proportion being estimated, so the confidence interval, in decimals [8].

Gangapur village with a ZPHS school was identified with the highest number of adolescent girls enrolled and hence was selected for the study. All the adolescent girls (n=119) from grade six to grade ten registered in the school and were enrolled for the study. At the end of the intervention, only seventy-three (n=73) adolescent girls were considered since there was a loss to follow-up (Figure 1). Further, all the adolescent boys were excluded from the study.

2.2 Millet-based formulations

All the formulations were developed by an urban food-producing company named Healthyfarm Foods LLP (Limited liability partnership), from Hyderabad. The company was solely responsible for the formulation, preparation of the foods, sensory evaluation, and hygiene maintenance. Millet-based foods were supplied to these girls on all working days.

The millet-based complementary food products supplied include (Table 1):

1. Mixed Millet Milk Malt: The product consisted of flour made of various millets. Jaggery, a sugar product developed from sugarcane [5] was added since it contributes to sweetness and is a source of iron and thus will contribute to the increase in the overall iron content of the developed millet-based foods. Milk powder was also added to enhance nutrient density. Fifteen grams of the malt was served with 100 ml water one time a day for all working days

2. Ragi cutlets: The product was prepared from Ragi (finger millets). Ragi is rich in proteins, iron, calcium, phosphorus, and fiber [9]. A premix powder was prepared and distributed. Two Ragi cutlets weighing 30 g each were served one time a day for once a week.

3. Mixed Millet Energy Bars: The product consisted of flour made of wheat, ragi, jowar, bajra, and corn. The powder was processed into a bar. Two bars of 25 g each were served one time a day for once a week.

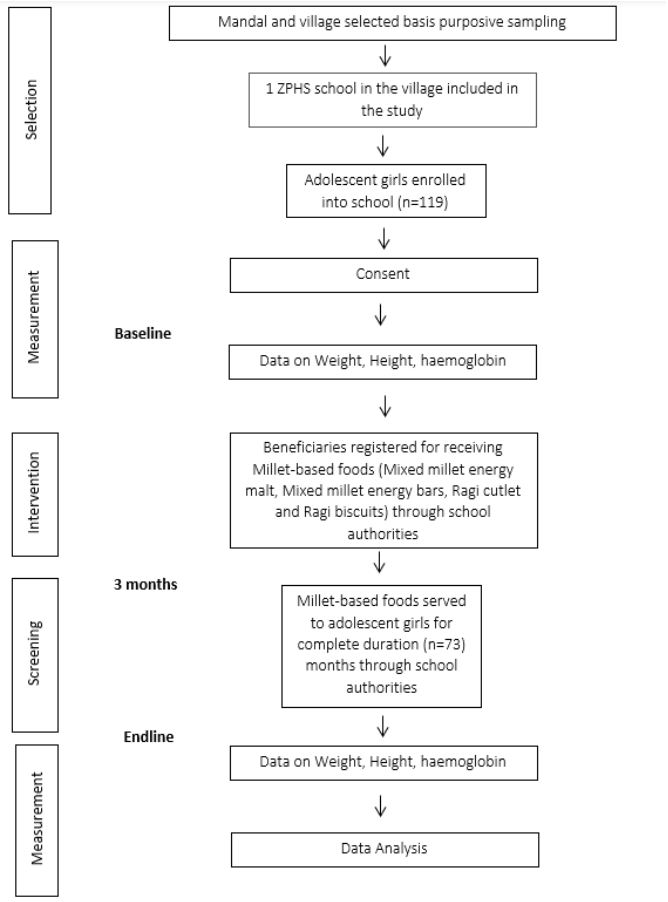

Fig 1. Steps involved in the distribution of millet-based foods to beneficiaries

4. Ragi biscuits: The product was prepared from Ragi (finger millets). Two Ragi biscuits weighing 20 g each were served one time a day for four days a week.

2.3 Ethics

An institutional review committee from Government Medical College Mahbubnagar reviewed and approved this study. Further, the school authorities and participants were informed about the study, and oral consent was obtained.

2.4 Experimental Protocol

Data on weight, BMI, and haemoglobin was collected during baseline and endline. The monthly weight gain was measured by using a weighing scale and the height was measured using a stadiometer during the baseline to calculate the BMI. Data on haemoglobin was collected by official lab technicians using Sahli's haemoglobinometer. The beneficiaries had been categorized into various categories of anemia based on World Health Organisation (WHO 2007) standards and BMI categories.

The formulation, production, sensory evaluation of the millet-based foods was outsourced to the food production unit. These foods were first introduced to a sample of ten (n=10) adolescent girls to understand their acceptance. It was observed that these foods had strong acceptability by beneficiaries. The cost of the intervention was between Rs 4 to Rs 8 per beneficiary per day. The financial support for the intervention was provided by the government authorities.

2.5 Data Analyses

The collected data was entered in Microsoft Excel, cleaned, and exported to SPSS. Data was analyzed using SPSS version 27. Descriptive statistics were conducted to determine the frequency, percentage, mean, and SD. A paired t-test was conducted to

Table 1. Recipe description and steps involved in the preparation

S.no	Millet based food Energy (kcal)/100g	Description and protocol
1	Mixed millet energy malt Serving Size:15g tablespoon Energy:386 kcal Iron:3.9 g	**Ingredients**: Multigrain - 50% (Oats, bajra, ragi, jowar, barley, soyabean, green gram, Bengal gram), milk powder - 30%, jaggery - 15%, cardamom- 5%) **Method**: Procurement of raw materials, machine-based cleaning, and segregation, roasting, pulverization into flour, blending into a dough, preparation of balls using ball preparation machinery, mixing, preparations of bars with jaggery using molds and cutters, cooling, packaging
2	Mixed millet energy bars Serving Size:20g Energy:452 kcal Iron: 5.52 g	**Ingredients**: Multigrain - 75% (Oats, bajra, ragi, jowar, barley, soyabean, green gram, bengal gram), Flax seeds- 5%, Jaggery - 15%, cardamom- 5%) **Method**: Procurement of raw materials, machine-based cleaning, and segregation, roasting, pulverization into flour, blending into a dough, preparation of balls using ball preparation machinery, mixing, preparations of bars with jaggery using molds and cutters, cooling, packaging
3	Ragi cutlets Serving Size:20g Energy:381 kcal Iron: 2.38 g	**Ingredients**: Potato flakes (60%), Ragi (35%), Vegetable oil, spices, and condiments (5%) **Method**: Procurement of raw materials, machine-based cleaning, and segregation, roasting, pulverization into flour, blending into a dough, mixing, cooling, packaging.
4	Ragi biscuits Serving Size:20g Energy:402 kcal Iron:4.35 g	**Ingredients**: Wheat flour (50%), Ragi (35%), jaggery (12 %), Baking powder (3%) **Method**: Procurement of raw materials, machine-based cleaning, and segregation, roasting, pulverization into flour, blending into a dough, mixing, baking in an oven, cooling, packaging

see the difference of means for weight, haemoglobin, and BMI on pre-and post-intervention parameters at 95% CI.

3 Results and Discussion

The study observed that millet-based foods had a positive impact on the anthropometric parameters of adolescent girls. Table 2 depicts the pre- and post-intervention impact of millet-based foods on the anthropometric parameters of adolescent girls.

Table 2. Pre and Post Intervention impact of millet-based foods on anthropometric parameters of adolescent girls

S.No	Category	Range	Pre-intervention	Post-intervention
			% (n)	% (n)
1	Weight (kgs)	20-30	30% (22)	23% (17)
		31-40	45% (33)	44% (32)
		41-50	23% (17)	30% (22)
		51-60	1% (1)	3% (2)
		161-170	3% (2)	3% (2)
2	Body Mass Index (kg/m2)	Underweight (<18.5)	78% (57)	71% (52)
		Normal (18.5-24.9)	22% (16)	29% (21)

The results indicate anthropometric changes for weight and BMI among adolescent girls after the introduction of millet-based foods (Table 2). An improvement in mean weight from 26.77±1.4 kg to 26.92±2.1 kgs was observed with an increase in the number of adolescent girls weighing between 41 to 50 kg. It was observed that pre-intervention, 23% of the adolescent girls weighed between 41-50 kgs, however, post-intervention 30% of them weighed between 41-50 kgs. Additionally, there was a similar improvement in the BMI of adolescent girls. The mean BMI increased from 16.4±2.5 pre-intervention kg/m2 to 17.3±2.2 kg/m2 post-intervention. There was also an increase in the number of adolescent girls with a BMI of 18.5-24.9 from 22% to 29% post-intervention. This study demonstrated a positive impact of millet-based formulations on the weight and BMI

of adolescent girls. The study observed an average increase in weight by 1.8 kgs among adolescent girls, an observation which is similar to the findings of another study that had demonstrated that millet-based foods improved the weight significantly among adolescent girls [10].

Table 3. Pre and Post Intervention impact millet-based foods on haemoglobin of adolescent girls

S.No	Category	Range	Pre-intervention	Post-intervention
			% (n)	% (n)
1	Haemoglobin (g/dl)	< 7.0	4% (3)	3% (2)
		7.0-9.9	93% (68)	97% (71)
		10-10.9	3% (2)	0% (0)

In this study, all of the participants were anemic with mean haemoglobin levels of 8.40±0.9g/dl. About 93% of the anemic adolescent school-going girls had blood haemoglobin levels between 7.0 to 9.9 g/dl. Further, 4% of the adolescent girls has blood haemoglobin levels less than 7 g/dl and 3% had levels between 10.0 to 10.9 g/dl. These findings depict a higher prevalence of anemia among adolescent girls similar to the findings of other studies conducted in India and Telangana [3,11,12]. A positive impact of millet-based foods without statistically significant improvement on haemoglobin level (Table 3) was observed. Post-intervention, there was a mean improvement in haemoglobin from 8.40±0.9 g/dl to 8.45±0.6 g/dl. Furthermore, pre-intervention, 93% of adolescent girls had haemoglobin levels between 7.0 to 9.9 g/dl however, post-intervention, 97% had haemoglobin levels between 7.0 to 9.9 g/dl. Henceforth, these findings indicate a positive impact of millet-based foods on blood haemoglobin levels. These findings are similar to the findings of other studies that identified that supplementation with iron-rich millet-based foods had a positive impact on haemoglobin levels and reduced the prevalence of anemia [13,14].

Table 4. t-test for pre-interventional and post-interventional c omparison of the impact of millet-based foods on weight, haemoglobin, and BMI of adolescent girls

Category	Pre-intervention (Mean±SD)	Post-Intervention (Mean±SD)	p-value
Weight (kg)	26.77±1.4	26.92±2.1	0.001*
Haemoglobin (g/dl)	8.40±0.9	8.45±0.6	0.516
Body Mass Index (BMI) (kg/m2)	16.40±2.5	17.30±2.2	0.001*

* p value significant at <0.01 level (p<00.1)

A paired t-test was conducted to assess differences in baseline and the end line for weight, haemoglobin, and BMI (Table 4). The result indicates that the changes were positive and statistically significant for weight gain (<0.001) and BMI (<0.001). The results showed a statistically significant impact on the BMI of the adolescent girls with a mean increase of 0.88±0.9 kg/m2. These results are in contrast to the findings of another study which indicated that millet-based foods have no statistically significant impact on the BMI of adolescent girls [7]. Furthermore, another study had evidenced a statistically significant impact of millet-based foods such as ragi on the haemoglobin levels of anemic adolescent girls [7]. However, similar statistically significant results were not obtained through this study.

A study highlighted that the prevalence of anemia among adolescent girls is alarming, and it is unsurprising that it is ignored in policies and programs and thus the numbers have not improved in the past ten years [15]. Similarly, studies also evidenced that the incorporation of iron-rich elements such as millets is a low-cost strategy to reduce iron deficiency anemia [14] and help enhance nutrient density [4]. Thus, it is recommended that millet-based foods are introduced into school-lunch programs to combat the burden of anemia [4].

The results helped prove the hypothesis and the objective of the study that millet foods have a significant impact on weight and BMI and they contributed to the improvement of blood haemoglobin levels of adolescent girls. The significant improvement in weight and BMI is attributed to the energy-dense formulation of the millet-based foods and the results helped identify the need to develop iron-rich formulations to observe similar statistically significant results for haemoglobin improvement. The study had certain limitations in terms of finances and hence was implemented only for three months and challenges in enrolling adolescent girls into the study. Furthermore, the impact of other parameters such as menstruation and dietary practices amongst others on blood haemoglobin levels was not considered due to constraints in time.

4 Conclusion

This cross-sectional interventional study with millet-based foods such as mixed millet malt, ragi biscuits, ragi cutlets, and mixed millet energy millet bars developed with ragi, jowar, bajra demonstrated a positive impact on the weight and BMI of adolescent girls. The introduction of diverse millet-based formulations contributes to the improvement in weight by 1.8 kgs and BMI by 0.9 Kg/m2. However, there is a need to develop an iron-rich formulation to observe a significant impact on blood haemoglobin levels beyond the observed improvement of 0.5 g/dl. Thus, the introduction of these millet-based foods into schemes such as the Mid-Day Meal will help ameliorate the problem of anemia among adolescent girls. Henceforth, there is a need for the Governments and NGOs working for adolescents to devise strategies and meals of millet-based foods in view to improve the nutritional status of school-going adolescent girls.

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References

1) Bhargava M, Bhargava A, Ghate SD, Rao RSP. Nutritional status of Indian adolescents (15-19 years) from National Family Health Surveys 3 and 4: Revised estimates using WHO 2007 Growth reference. *PLOS ONE*. 2020;15(6):e0234570–e0234570. Available from: http://dx.doi.org/10.1371/journal.pone.0234570.
2) Arunjyothi R, Jahan A. Effect of Nutritional intervention in ameliorating Anemia among adolescent girls of rural Telangana state. *The Pharma Innovation*. 2021;10(2):185–188. Available from: https://doi.org/10.22271/tpi.2021.v10.i2c.5651.
3) Reshmi PS, Takalkar AA. Prevalence of anemia in adolescent girls and its association with certain demographic variables: our experience from rural Telangana. *International Journal Of Community Medicine And Public Health*. 2020;7(3):1007–1007. Available from: http://dx.doi.org/10.18203/2394-6040.ijcmph20200539.
4) Anitha S, Kane-Potaka J, Tsusaka TW, Tripathi D, Upadhyay S, Kavishwar A, et al. Acceptance and Impact of Millet-Based Mid-Day Meal on the Nutritional Status of Adolescent School Going Children in a Peri Urban Region of Karnataka State in India. *Nutrients*. 2019;11(9):2077–2077. Available from: https://doi.org/10.3390/nu11092077.
5) Moharana A, Nursing MS, College SN, Siksha O. Effect Of Finger Millet [Ragi] Ladoo Consumption On The Level Of Haemoglobin. 2020;7:1018–1040. Available from: https://doi.org/10.1080/24694193.2018.1440031.
6) Patel I, Patel K, Pinto S, Ragi PS. A Powerhouse of Nutrients. *Research & Reviews: Journal of Dairy Science and Technology*. 2018;5(3):36–47. Available from: https://doi.org/10.37591/rrjodst.v5i3.461.
7) Karkada S, Upadhya S, Upadhya S, Bhat G. Beneficial Effects of ragi (Finger Millet) on Hematological Parameters, Body Mass Index, and Scholastic Performance among Anemic Adolescent High-School Girls (AHSG). *Comprehensive Child and Adolescent Nursing*. 2019;42(2):141–150. Available from: https://doi.org/10.1080/24694193.2018.1440031.
8) . . Available from: https://gist.github.com/marcoscaceres/7137166.
9) Durairaj M, Gurumurthy G, Nachimuthu V, Muniappan K, Balasubramanian S. Dehulled small millets: The promising nutricereals for improving the nutrition of children. *Maternal & Child Nutrition*. 2019;15(S3):1–5. Available from: https://doi.org/10.1111/mcn.12791.
10) Srivastava A, Kumar R, Sharma M. Nutritional anaemia in adolescent girls: an epidemiological study. *International Journal of Community Medicine and Public Health*. 2016;3(4):808–812. Available from: http://dx.doi.org/10.18203/2394-6040.ijcmph20160687.
11) Srivastava A, Kumar R, Sharma M. Nutritional anaemia in adolescent girls: an epidemiological study. *International Journal of Community Medicine and Public Health*. 2016;3(4):808–812. Available from: http://dx.doi.org/10.18203/2394-6040.ijcmph20160687.
12) Rajaratnam J, Abel R, Asokan JS, P J. Prevalence of anemia among adolescent girls of rural Tamilnadu. *Indian Pediatr*. 2000;37(5):532–538. Available from: http://dx.doi.org/10.21746/ijcls.2021.10.1.2.
13) Suri S, Dutta A, Shahi NC, Raghuvanshi RS, Singh AS, Chopra CS. Numerical optimization of process parameters of ready-to-eat (RTE) iron rich extruded snacks for anemic population. *LWT*. 2020;134:110164–110164. Available from: https://doi.org/10.1016/j.lwt.2020.110164.
14) Anitha S, Kane-Potaka J, Botha R, Givens DI, Sulaiman NLB, Upadhyay S, et al. Millets Can Have a Major Impact on Improving Iron Status, Hemoglobin Level, and in Reducing Iron Deficiency Anemia–A Systematic Review and Meta-Analysis. *Frontiers in Nutrition*. 2021;8:1–14. Available from: https://doi.org/10.3389/fnut.2021.725529.
15) Scott SP, Murray-Kolb LE, Wenger MJ, Udipi SA, Ghugre PS, Boy E, et al. Cognitive Performance in Indian School-Going Adolescents Is Positively Affected by Consumption of Iron-Biofortified Pearl Millet: A 6-Month Randomized Controlled Efficacy Trial. *The Journal of Nutrition*. 2018;148(9):1462–1471. Available from: https://doi.org/10.1093/jn/nxy113.