ORIGINAL ARTICLE

Effect of food-based iron supplementation on the physical work performance of adolescent girls in Banasthali campus: A case study

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Background: Iron deficiency is the most common nutritional disorder, which affects about 20% of the world population. Iron is an essential element for blood production. About 70% of body's iron is found in the red blood cells of our blood called haemoglobin (Hb) and in muscle cells called myoglobin. Hb level and Physical Work Capacity (PWC) are directly proportional to each other. Decrease in Hb level leads to the decrease in physical work performance. Hence, the strategies are needed to study the effect of iron supplementation on Hb levels and physical work performance. **Aim:** The study was carried out to assess the impact of daily food-based iron supplementation along with Vitamin C on physical work capacity (PWC) and haemoglobin (Hb) level of adolescent girls. **Materials and Methods:** A randomised control trial was carried out on 85 subjects of three different hostels of Banasthali University, where pre and post supplementation data was collected using Modified Harvard's Step Test. **Statistical analysis:** The results were statistically analysed with student's *t* test. **Results:** Out of three study groups the supplemented one, i.e., Anaemic Experimental group had shown a significant improvement in the steps taken while compared to group Anaemic Control with higher Hb gain (0.9 g/dl). No significant difference was observed regarding recovery time (RT). **Conclusion**: The food-based iron supplementation had shown satisfactory results in increasing haemoglobin (Hb) levels and physical work capacity.

Key words: Antinutrients, haemoglobin, oxalates, physical work capacity, phytates, tannins

INTRODUCTION

The prevalence of anaemia ranges from 33% to 89% among pregnant women and is more than 60% among adolescent girls.[1] The prevalence of anaemia is disproportionately high in developing countries, due to poverty, inadequate diet, certain disease, pregnancy, lactation and poor access to health.[2,3]

Haemoglobin (Hb) level and physical work capacity (PWC) are directly proportional to each other. In case of decreased concentration of Hb, the transportation of O_2 to the tissues becomes a hindrance, resulting in decrease in PWC.[4]

According to a study, iron pills have shown injury of mucosa, injury of hypo pharynx.[5] Besides this; the iron tablets-based supplementation programmes have also not shown the impressive results. This is because of many reasons such as unawareness of the people, disliking for iron tablets, some side effects of these tablets, and improper availability. So, to overcome these problems the interest is shifting towards the real nutrition, i.e., the food-based supplementation. Food-based approach aims to combat anaemia at community as well as house hold level by increasing the availability and consumption of iron rich diets using variety of foods available.

Lotus stem (*Nelumbiam nelumbo*) also known as *Kamal kakdi*, is a rich source of iron and the data on supplementation of lotus stem on iron nutriture of the adolescent girls have shown positive results.[6,7] But there is no data available on its effect on PWC while the medicinal iron or iron folic acid (IFA) supplementation have shown the positive results on physical work performance, especially among the girls. So, the present study was planned to evaluate the impact of supplementation of Lotus stem (as an iron source) along with Vitamin C on the PWC among the adolescent girls.

MATERIALS AND METHODS

The study was carried out in adolescent girls of Banasthali University (residing in different hostel) to evaluate the effectiveness of food-based iron supplementation on the Hb level and PWC.[8]

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Selection of Subjects

Selection of subjects was mainly done according to the age of girls (13 to 17 years) and their Hb level. Back ground information was acquired through a performa filled by the subjects themselves. Potential study subjects were thoroughly interrogated for history in local dialect and questioned for detailed information pertaining to their information about their date of birth, age, class, period of staying in the Banasthali and dietary habits.

Supplementation

The selected subjects were divided into the three different groups: Anaemic experimental (AE), anaemic control (AC) and non anaemic (NA). The subjects of AE group were supplemented for 60 days (supervised) whereas subjects of AC and NA were excluded from supplementation. Every subject of AE group was intervened with 45 g of standardised selected recipe, i.e., *Namkeen sev* along with the 100 mg of Vitamin C tablet, i.e., 'Celin' (dissolved in 100 ml of drinking water). Every subject was consuming 9.2 mg of iron per day. At the time of supplementation, it was taken care that all the subjects had taken their last meal at least 1-2 hrs before the supplementation. They were also asked to consume the iron-rich recipe and Vitamin C together and were forbidden from having tea or any dairy product along with the supplementation as these foods can inhibit the iron absorption.

Haematological Assessment

Hb levels were estimated by the cyanmethemoglobin method.[9] Hb level of the subject was assessed before and after the supplementation.

Assessment of Physical Work Capacity

To evaluate the impact of supplementation on physical work capacity, Harvard Step Test (MHST) was carried out. PWC was assessed before and after the dietary intervention.

Development of Lotus Stem Powder

Fresh lotus stems were collected from local commercial market of Jaipur, Rajasthan. The stems were peeled out and trimmed into small pieces. In order to reduce the oxalate content, these lotus stems pieces were boiled in water for 10-15 minutes and allowed to dry under shade. The dried stem was converted in to the fine powder form using mixer grinder.

Recipe Standardisation

Namkeen sev and *Mathri* was standardised on the basis of their iron content. Two different types of iron rich recipes were prepared by the incorporation of lotus stem powder (LSP) in the proportion of 30% and 40%. Further, these recipes were evaluated for their acceptability regarding its taste and colour. The recipes with 30% incorporation of lotus stem powder were found to be acceptable and were used to carry out further studies.

Sensory Evaluation

Quality of recipe *Mathari* and *sev* was evaluated using 9 point Hedonic Scale Method.

RESULTS AND DISCUSSION

The study was carried out to evaluate the effects of food-based iron supplementation on Hb level and PWC of adolescent girls in Banasthali campus.

Background Information

Background information obtained from the subjects gives an outline about their personal data such as age, eating habits etc., The whole information is compiled as follows:

Age

The one criteria of sample selection was age. Therefore, the subjects, with the age of 13-17 years were selected for the study among the many. Out of 36 subjects, who had participated in the study, 10 girls were 13-15 years old while others were 13-17 years old.

Class

The girls were selected from the three hostels of Banasthali University where the students of class 9^{th}-12^{th} reside. Among the selected 36 girls, six subjects were from class 9^{th}, five subjects were from class 10^{th} and the rest were from class 11^{th} and 12^{th}.

Duration of study in Banasthali

Almost all the girls were new comers, which mean that they had not completed even 1 year in Banasthali. The students of class 9^{th} and 11^{th} were from this category while some of them had spent 1-2 years. Only three girls, one of class 9^{th} and two of class 11^{th} had been living in Banasthali since more their 4 years.

Dietary habits

As all the girls were residing in the same hostel conditions, they all were following the same habits. Almost every girl was found lacto vegetarian while only seven girls were ovo-lacto vegetarian.

Consumption manner

Not only 36 selected girls, but all the 85 girls were asked about their food consumption manner and also about their likings and disliking for the hostel food. When the performa was filled by the 36 selected girls, 11 girls out of them did not like the hostel food and seven girls used to take their most of meal out of hostel as they liked to eat snacks. It was also observed that out of these 18 girls, 13 were suffering from anaemia.

Haematological assessment

In the present study, assessment of Hb level was screened at the time of sampling for the screening of anaemia among the adolescent girls. Out of 84 selected girls only 25 were found anaemic, while 59 girls were non anaemic [Figure 1].

The range of Hb among the selected subjects was 9.5-13.5 g/dl and the Hb level <12 g/dl was considered as anaemic. The significant difference between the anaemic and non anaemic [Tables 1 and 2] was observed.

Assessment of physical work capacity

PWC refers to the person's own capacity of carrying maximum work for a certain period with the normal pulse rate. In order to assess the PWC, steps taken by the subjects and their pulse rare recovery time (RT) were recorded.

As a result, it was found that the girls who were anaemic had lower scores of steps taken and higher the recovery time in comparison to non anaemic girls [Tables 3 and 4].

Table 1: Recipe *Namkeen sev*

Ingredients	Standard	Variant
Bengal gram	60 g	40 g
Potato	30 g	20 g
Cooking oil	10 ml	10 ml
Lotus stem powder	ND	30 g

Table 2: Recipe *Mathri*

Ingredients	Standard	Variant
Refined flour	60 g	40 g
Semolina	25 g	15 g
Cooking oil	15 ml	15 ml
Lotus stem powder	ND	30 g

Table 3: Background information of subjects

Information	*n* (%)
Age (yrs)	
13-15	10 (27.7)
15-17	26 (72.2)
Class	
9^{th}– 10^{th}	11 (30.5)
11^{th}-12^{th}	25 (69.4)
Staying in Banasthali since	
<1 yr	19 (52.7)
1-2 yrs	5 (13.8)
2-4 yrs	9 (25)
>4 yrs	3 (8.3)
Eating habits	
Lacto vegetarian	29 (80.5)
Ovo-lacto vegetarian	7 (19.4)
Non vegetarian	ND
Consumption manner	
Take food in the hostel	11 (30.5)
Take out of the hostel	25 (69.4)

The same variations were also found in the data of recovery time (RT). The subjects of the group non anaemic (NA) were having less recovery time than the subjects of group anaemic experiment (AE) and anaemic control (AC) [Table 5]. Table 6 shows that the mean of recovery time was significantly better for non anaemic when compared with the anaemic girls.

Lactate is the end product of anaerobic glycolysis which is inversely proportion to Hb levels. At the time of exercise the O_2 becomes decreased in the anaemic, it directly affects the performance of the person resulting a feeling of fatigue. The present study also supports this theory as the results indicate that steps taken and recovery times were lower in anaemic in comparison to non anaemic.

Impact of supplementation on haemoglobin level

At the end of supplementation, the reassessment of Hb level was done to assess the effectiveness of supplementation. The mean difference was observed between the pre and

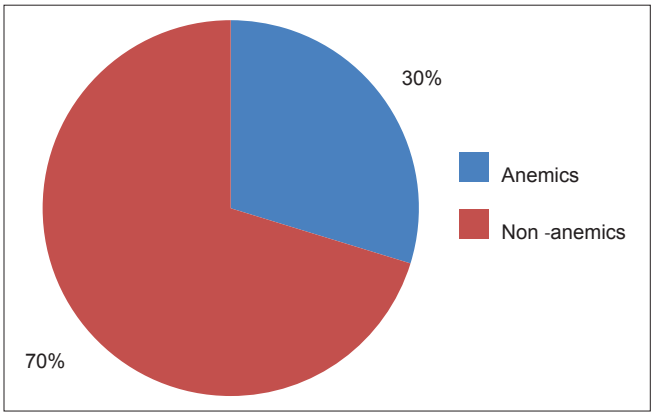

Figure 1: Prevalence of anaemia in the study group of adolescent girls

Table 4: Haemoglobin level of subject of the three study groups at pre and post intervention stages

Study groups	*n*	Haemoglobin (mean±SD)	
		Pre intervention	Post intervention
Anaemic experiment	12	10.87±0.49	11.70±0.74
Anaemic control	12	10.91±0.76	10.92±0.56
Non anaemic	12	13.69±0.58	13.15±0.85
Whole group	12	11.82±1.46	12.06±1.32

Table 5: Student's *t* values for haemoglobin level between study groups at pre and post intervention stages

Comparative study groups	t_{cal}	
	Pre intervention stage	Post intervention stage
Anaemic control vs. anaemic experiment	0.13^{NS}	3.48**
Anaemic control vs. non anaemic	7.43**	9.06**
Anaemic experiment vs. non anaemic	8.04**	5.56**

*Significant at 5% confidence level, **Significant at 1% confidence level, ^{NS}Non significant, t_{tab} 1.71 at 5%, t_{tab} 2.50 at 1%

post stages. The mean Hb level of the AE group was found increased and it was about 0.9 g/dl which was significant [Table 7].

In this study, a significant difference between Hb levels of the supplemented group i.e., AE group was found; although there was no difference among those groups who were unsupplemented, i.e., group NA and AC. The above stated studies are strongly supporting the effectiveness of iron supplementation, but these all were based on medicinal iron. While another study conducted by Kowsalya and Shimpray (2008),[7] had strongly supported the food-based supplementation, in this study 35 gm of fresh Lotus Stem as an iron source was supplemented equals to 14.5 mg of iron and the positive results were obtained regarding iron nutritive and haematological profile.[10]

Impact of supplementation on physical work capacity

After the collection of post intervention data regarding Hb levels, the data on PWC was also gathered. Steps taken by the girls and recovery time (RT) were measured using the same procedure which was used in the pre intervention data collection.

Table 6: Number of steps taken by subjects of the three study group pre and post intervention stages

Study groups	Steps (mean±SD)	
	Pre intervention	Post intervention
Anaemic experimental	238.33±17.34	249±20.08
Anaemic control	237.16±26.01	227±38.91
Non-anaemic	285.66±28.75	280.75±39.44
Whole group	253.72±33.3	251.97±40.8

Table 7: Student's *t* values for steps taken by subjects between the study groups at pre and post intervention stages

Comparative study groups	t_{cal}	
	Pre intervention stage	Post intervention stage
Anaemic control vs. anaemic experiment	0.12^{NS}	1.73*
Anaemic control vs. aon anaemic	4.33**	3.76**
Anaemic experiment vs. non anaemic	4.88**	2.48*

*significant at 5% confidence level, **Significant at 1% confidence level, ^{NS}Non significant, t_{tab} 1.71 at 5%, t_{tab} 2.50 at 1%

Table 8: Recovery time of subject of the three study groups at pre and post intervention stages

Study groups	Recovery time* (mean±SD)	
	Pre intervention	Post intervention
Anaemic experimental	24.70±6.97	21.66±6.71
Anaemic control	25.41±4.29	26.95±7.12
Non-anaemic	20.45±4.96	21.08±8.75
Whole group	23.00±5.93	23.5±7.98

*in minutes

There was increment in step taken by the subjects of AE group and other difference was significant while no significant change was observed in the AC group as this group was not supplemented. There was also no significant change found in NA group between pre and post intervention stages [Table 8]. But on comparing AE and NA group at post intervention there was still NA group was significantly better than AE group as the Hb level was significantly higher [Tables 9-11]. A study conducted by Sen and Kanani (2009),[11] had shown the increment in steps taken and improvement in recovery time after the supplementation of IFA tablets. But, in the present study, no significant change was observed in recovery time in any group [Table 8]. Although there was positive difference in the mean values of AE group between pre and post stages but the difference was not significant. The one reason behind it may be short duration of supplementation (only for 60 days).

Nutritional analysis

The selected recipe and the LSP were analysed nutritionally and anti nutritionally. Estimation of iron by Wong's method,

Table 9: Student's *t* values for recovery time between the study groups at pre and post intervention stages

Comparative study groups	t_{cal}	
	Pre intervention stage	Post intervention stage
Anaemic control vs. anaemic experiment	0.29^{NS}	1.87*
Anaemic control vs. non anaemic	2.62**	1.81*
Anaemic experiment vs. non anaemic	1.72*	0.18^{NS}

*Significant at 5% confidence level, **Significant at 1% confidence level, ^{NS}Non Significant, t_{tab} 1.71 at 5%, t_{tab} 2.50 at 1%

Table 10: Student's *t* value for haemoglobin level of various study groups for comparing pre and post intervention stages

Study groups	Hb level
Anaemic experimental	3.58**
Anaemic control	0.97^{NS}
Non anaemic	0.35^{NS}
Whole group	1.75*

*Significant at 5% confidence level, **Significant at 1% confidence level, ^{NS}Non significant, t_{tab} 1.71 at 5%, t_{tab} 2.50 at 1%, Hb – Haemoglobin

Table 11: Student's *t* value for steps taken and recovery time of various study groups for comparing pre and post intervention stages

Study groups	Steps taken	Recovery time
Anaemic experimental	2.04*	0.39^{NS}
Anaemic control	1.10^{NS}	0.07^{NS}
Non anaemic	0.25^{NS}	0.74^{NS}
Whole group	0.29^{NS}	0.26^{NS}

Significant at 5% confidence level, **Significant at 1% confidence level, ^{NS}Non significant, t_{tab} 1.71 at 5% confidence level, t_{tab} 2.50 at 1% confidence

protein by Micro-Kjeldahl method, Vitamin C using the titration procedure, fat by using Soxhlet was done.

As the result of this estimation, iron was found in good amount in LSP and selected recipe but Vitamin C was found low even negligible in the selected recipe (*Namkeen sev*) [Table 12].

Bioavailability of iron

The anti nutritional factor inhibits the absorption of iron such as phytates, oxalates, tannins etc., Lotus stems are rich in nutrients and contains high amount of oxalic acid i.e., 420 mg in 100 g lotus stem was found.[12]

The amount of oxalic was also estimated using the trimetric method. It has been already proved that oxalic acid content can be reduced by boiling. Therefore, in this study after processing (boiling) there was a marked reduction in the oxalic acid content of the LSP [Table 13].

Sensory evaluation

Sensory evaluation is the type of food evaluation which is done by using the senses. LSP enriched recipes (*Mathari* and *Namkeen sev*) were sensory evaluated and they were found the moderately acceptable.

The result of rating test which was carried out by the 20 panellists had shown that out of two recipes (*Mathari* and *Namkeen sev*) *Namkeen sev* had got more scores than the *Mathari* [Tables 14 and 15].

As a whole, the means score of *Mathari* was lower than *Namkeen sev* for various attributes, which was significant for taste, crispness and flavour but for colour and appearance there was no significant difference observed [Table 16 and Figure 2]. *Mathari* and *Namkeen sev* both were moderately acceptable at 9 point Hedonic Test which was carried out by the selected subjects. The mean scores for *Mathri* were seven while it was higher for *Namkeen sev*, i.e., 7.5. At 9 point Hedonic Scale, it was observed that no one disliked the *Namkeen sev*

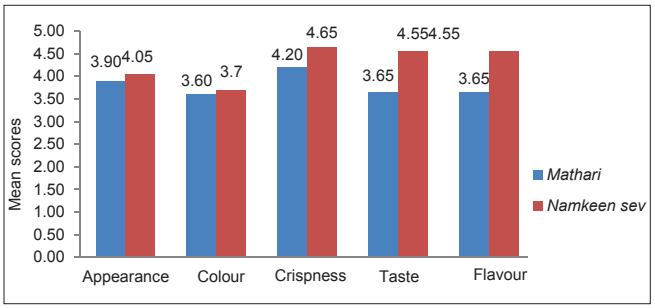

Figure 2: Mean rating test scores for various attributes of *Mathri* and *Namkeen sev*

Table 12: Nutritional composition of lotus stem powder and selected iron recipe

Nutrients	Lotus stem powder	*Namkeen sev*
Moisture (g/100g)	12.1	16.3
Fat (g/100g)	1.3	6.0
Fibre (g/100g)	21.4	24.1
Protein (g/100g)	6.2	7.1
Iron (mg/100g)	51.3	18.4
Vitamin C (mg/100g)	4.3	ND

Table 13: Oxalic acid content in processed and unprocessed lotus stem powder

Types of LSP	Oxalic acid (mg/100g)
Unprocessed	380
Processed (Boiling)	175

LSP – Lotus stem powder

Table 14: Frequency of rating test scores for different attributes of *Namkeen sev*

Attributes	Very good *n* (%)	Good *n* (%)	Average *n* (%)	Fair *n* (%)	Poor *n* (%)
Appearance	5 (25)	8 (40)	7 (35)	ND	ND
Colour	2 (10)	8 (40)	10 (50)	ND	ND
Crispness	7 (35)	10 (50)	3 (15)	ND	ND
Taste	3 (15)	9 (45)	5 (25)	3 (15)	ND
Flavour	4 (20)	7 (35)	7 (35)	2 (10)	ND

*No. of judges=20

Table 15: Frequency of rating test scores for different attributes of *Mathri*

Attributes	Very good *n* (%)	Good *n* (%)	Average *n* (%)	Fair *n* (%)	Poor *n* (%)
Appearance	6 (30)	9 (45)	5 (25)	ND	ND
Colour	1 (5)	14 (70)	4 (20)	1 (5)	ND
Crispness	13 (65)	7 (35)	ND	ND	ND
Taste	14 (70)	5 (25)	1 (5)	ND	ND
Flavour	12 (60)	7 (35)	1 (5)	ND	ND

*No. of judges=20

Table 16: Student's *t* value of various attributes for comparing *Mathri* and *Namkeen sev*

Attributes	T_{cal}
Appearance	1.23^{NS}
Colour	0.37^{NS}
Crispness	2.11*
Taste	2.83*
Flavour	2.03*

*Significant, ^{NS}Non significant t_{tab} 1.86 at 5%

Table 17: Frequency* of 9 point Hedonic test scores of *Mathari* and *Namkeen sev*

Scores *n* (%)	*Mathri*	*Namkeen sev*
9	2 (5)	5 (15)
8	10 (27)	15 (75)
7	14 (38)	10 (27)
6	3 (8)	6 (16)
5	7 (19)	ND
Total	36 (100)	36 (100)

*No. of total subjects=36

while one subject scored four for *Mathari* as she disliked it [Table 17].

The present was conducted in Banasthali and the school going adolescent girls (aged between 13 years and 17 years). The study revealed that the prevalence of anaemia in the study group was 30%. The PWC of anaemic girls was found to be lower than the non anaemic. Out of the two iron-rich LSP incorporated recipes, *Namkeen sev* were supplemented as they were more acceptable. The LSP and selected recipe were found nutritionally rich. As well as the 9 point Hedonic Test scores mean was almost same for both recipe. It was seven for *Mathri* and 7.5 for *Namkeen Sev*. Impact of supplementation was positive for Hb levels and steps taken by the subjects but not significant difference was found in the recovery time. The mean rating test scores were significantly better for *Namkeen Sev*.

CONCLUSION

The food-based iron supplementation had shown satisfactory results in increasing Hb levels and PWC.

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