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IMPROVEMENT IN PHYSICAL FITNESS INDEX, VO_2 MAX SCORE AND HEMOGLOBIN LEVEL WITH DIET AND NUTRITION INTERVENTION

Preeti Chaudhary*, Radhna Gupta and Ranjana Verma

Department of Food Science, Nutrition and Technology CSK Himachal Pradesh Agricultural University, Palampur - 176 062, Himachal Pradesh (India)
*e mail: *preetichoudhary0070@gmail.com*

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ABSTRACT

The physical fitness index measures the physical fitness for muscular work and the ability to recover from the work. The study was undertaken to assess the physical fitness index and aerobic capacity by using Harvard step test and evaluate hemoglobin level of moderately anemic (8-10.9 mg dL^{-1}) adolescent girls (10-18 yr). Intervention was given 90 moderately anemic adolescent girls divided into three groups for a period of 4 months. Each group constituted 30 girls. Group-I was given iron-rich diet as well as nutrition counseling and group-II received only nutrition counseling. Group-III formed the control group i.e. no intervention of any type was provided to them. The scores of physical fitness index showed the positive impact of intervention on experimental groups. Nutrition intervention improved their physical fitness index and Vo2 max scores level to good and excellent fitness. Nutrition and dietary intervention improved their Hb level. The study concluded that physical fitness index, VO_2 max scores and level of hemoglobin improved with diet as well as nutrition counseling nutritional intervention.

Keywords: Adolescent girls, aerobic capacity, hemoglobin, intervention, physical fitness index

INTRODUCTION

Iron deficiency, the most common cause of anemia, is one of the leading risk factors for disability and death worldwide, affecting an estimated 2 billion people (WHO, 2011). It is a state in which the iron content in a body decreases which manifests as decreased serum iron, decreased transferrin saturation, low hemoglobin and low hematocrit (Bhat *et al*., 2015). Iron deficiency results in decreased iron containing enzymes of mitochondrial respiratory chain in skeletal muscles with a concomitant decline in muscle respiratory capacity to utilize oxygen. According to the World Health Organization report, the hemoglobin level should be 12 g dL^{-1} in adolescent girls (WHO, 2011). A hemoglobin level of less than 12 g dL^{-1} is considered as anemia. in iron deficiency anemia physical work capacity is reduced as decrease in hemoglobin lessens the availability of oxygen to the tissues, which, in turn, affects the cardiac output. Further, iron deficiency changes iron content and its distribution in brain, thereby affects neurotransmitter function which may affect cognition. Anemia may produce scholastic under-achievement and behavioral disturbances in school children Resmi *et al.* (2017).

Physical fitness implies not only the absence of disabling deformity or disease and the capacity to perform a sedentary task efficiently but also a sense of physical well-being and the capacity to deal with emergencies demanding unaccustomed physical effort. Physical fitness, commonly consisting of cardiorespiratory endurance, muscle strength endurance, flexibility and body composition, is an important health marker and is a critical part of the overall physical and mental health and growth in

school aged children (Ortega *et al.*, 2008). Physical fitness has been shown to be positively associated with cognition, weight status, psychological well-being, academic achievement scores and the performance of real-world tasks ((Coe *et al.,* 2006). Contrarily, low physical activity or fitness can lead to the development of cardiovascular disease risks and an increased prevalence of cardiovascular disease risk factors in childhood, which can, in turn, track into adulthood (Donnelly *et al.*, 2016). The present study was undertaken to evaluate the effect of iron deficient diet and assess nutrition intervention on physical fitness performance and aerobic capacity of adolescent girls.

MATERIALS AND METHODS

Locale and selection of subjects

The study was conducted in selected Government Senior Secondary Schools of three blocks of Kangra district *viz.*, Baijnath, Panchrukhi and Bhawarna. Prior permission and approval to conduct the present study in selected schools was taken from the Principals of concerned schools as well as from the parents of selected volunteers (respondents). The study was conducted with the consent and as per the suggestions of Senior Medical Officer of the study area. Blood samples for hemoglobin estimation were taken with help of trained medical assistants.

A total of 300 subjects (10-18 yr) were assessed for hemoglobin assessment and on the basis of hemoglobin level ninety moderately anemic subjects (Hb 8.0-10.9 g dL^{-1}) were purposively selected on the basis of their hemoglobin profile, physical fitness performance and aerobic capacity to study the impact of nutrition intervention (for a period of 4 months). These subjects were divided into three groups of 30 individuals each. Group 1 received iron-rich garden cress products along with nutrition education for 4 months. Group 2 was imparted nutrition education for 4 months. Group 3 served as control to whom no nutrition intervention in any form was provided.

Development of educational package

The information obtained from knowledge score of subjects during pre-intervention was utilized for preparing the educational package. Combined package of audio-visual aids including posters/ leaflets/flip cards/power point presentations (in Hindi) was prepared for conveying them the message and information regarding nutrition education to the selected respondents covering various aspects of food and nutrition science such as food and nutrients, balanced diet, nutrients preservation, right ways to cook food, anemia, iron-rich foods, junk food and sanitation, hygiene, etc.

Educational intervention

Subjects were imparted nutrition education through lectures-cum-discussion using audio-visual aids *viz*., posters/leaflets/flip cards/power point presentations. The lectures were delivered to the groups 1 and 2 for a period of 4 mon. at weekly interval on selected topics. The pamphlets or leaflets were distributed to the subjects.

Preparation of recipes

Primarily, four value-added iron-rich products *viz*., *ladoo, mathri, shakkarpare* and biscuits were prepared for standardization and to select one sweet and one savory recipe for intervention purpose on the basis of their high acceptability and high iron content.

i) ***Ladoo:*** Wheat flour was roasted till light brown, then all the measured ingredients were added to it and simultaneously prepared jaggery syrup of one thread consistency. The syrup was added to prepared mixer and small rounded *ladoos* were made.

ii) ***Mathri:*** In refined wheat flour all the measured ingredients were added, then rubbed with melted ghee (shorting), kneaded stiff dough and small flattened rounded *mathri* were prepared. These were deep fried till light brown in colour.

iii) ***Shakkarpare:*** The measured ingredients were added to refined wheat flour, then kneaded stiff dough and the dough was rested for 20 min by covering with damp cloth. The dough was then rolled and cut into diamond shaped s*hakkarpare* and deep fried in medium flame till golden brown.

iv) **Biscuits:** All the measured ingredients were mixed, then stiffened thrice, creamed in ghee and folded the flour into it. Dough was prepared and rested for 20 min by covering with damp cloth. These were then rolled, cut in squares with the help of a cutter and baked at 175ºC for 15 min.

The ingredients used in above recipes were as under:

Recipe (ingredients)	Control	Variant - 1	Variant – II
Ladoo (common items: jaggery, 40 g & fats 10 g)	Amaranth flour, 25 g & wheat flour, 25 g	Amaranth flour, 25 g; wheat flour, 20 g & garden cress powder (UP), 10 g	Amaranth flour, 10 g; wheat flour, 10 g; garden cress powder (P), 10 g; sesame seeds, 15 g; grated coconut, 5 g & raisin, 5 g
Mathri (common items: fat 20 g & salt 1.5 g)	Refined flour, 50 g & amaranth flour, 30 g	Refined flour, 40 g; amaranth flour, 30 g & garden cress powder (UP), 10 g	Refined flour, 30 g; amaranth flour, 20 g; garden cress powder (P), 10 g; sesame, 16 g, dry fenugreek leaves, 2 g & black pepper, 2 g
Shakkarpare (common items: sugar 30 g)	Refined flour, 60 g & amaranth flour, 10 g	Refined flour, 40 g; amaranth flour, 10 g & garden cress powder (UP), 10 g	Refined flour, 30 g; amaranth flour, 20 g; garden cress powder (P), 10 g & sesame seeds, 10 g
Biscuit (common items: fats, 30 g; salt, 1 g; sugar, 4 g; omum, 2 g; cumin 2 g & baking powder 0.3 g)	Refined flour, 50 g & amaranth flour, 10 g	Refined flour, 45 g; amaranth flour, 5 g & garden cress powder (UP), 10 g	Refined flour, 40 g; amaranth flour, 10 g & garden cress powder (P), 10 g

P = Processed garden cress (soaked + dried + roasted); UP = Unprocessed whole garden cress seed powder

Based on per cent adequacy of iron as well as sensory acceptability, the sweet and savory preparations of *ladoo* and *mathri* of variant - II were selected for nutritional intervention for 4 mon. period for group-1. Weekly package of four *ladoo* and three *mathris,* 20 g each that met 100% RDA of iron for adolescent Indian girls were provided to the selected group of moderately anemic adolescent girls. The variant - II of *shakkarpare* and biscuits met only 74% RDA of iron so these two recipes were not selected for intervention. The intervention was personally supervised for regular intake of these dietary preparations. Control recipe was taken for comparison purpose. Since variant - I of all recipes had low acceptability owing to pungent and peppery taste of garden cress so this variant was not also considered. The sensory evaluation (done with 9-point Hedonic scale) of prepared products showed no bitter after-taste in variant - II in all the recipes in which processed garden cress (soaked + dried + roasted) was used; whereas variant - I in all recipes had bitter after-taste in which unprocessed garden cress (whole garden cress powder) was used. Among all recipes, *ladoo* and *mathri* were 'liked very much' while *shakkarpare* and biscuit were 'liked moderately' by the selected panel of judges.

Dietary intervention

On calculation basis (Gopalan *et al.,* 2010), iron content per 100 g in *ladoo* and *mathri* was highest in variant - II in all the developed recipes. The consumption of 20 g each of *ladoo* and *mathri* met 100% RDA of iron for adolescent Indian girls. Therefore, based on per cent adequacy of iron as well as sensory acceptability, the sweet and savory preparations of *ladoo* and *mathri* were selected for nutritional intervention period of 4 mon. for group - 1. Weekly package of four *ladoo* and three *mathri* were provided to the selected moderately anemic adolescent girls and were personally supervised for regular intake of these dietary preparations.

Effectiveness of interventions for hemoglobin level

Hemoglobin level of all the selected subjects was measured before and after nutrition intervention using Sahli's hemoglobinometer. As per WHO (2011) classification, anemia was categorized as normal ($\geq$12 g dL^{-1}), mild degree (11-11.9 g dL^{-1}), moderate (8-10.9 g dL^{-1}) and severe (<8 g d L^{-1}).

Physical fitness index

Physical fitness/efficiency of adolescent girls was measured as per Varghese *et al.* (1995) before and after nutritional intervention using step-stool ergometer. The step-stool ergometer (wooden) used was 45 cm long, 30 cm broad and 24 cm high. The duration of stepping was minimum (3 min.) and maximum (5 min.) with stepping rate of 30 steps min^{-1}

Methodology for step-stool test

Selected adolescent girls were allowed enough resting time and then their heart rates were measured with heart rate monitor (Polar RS 400). After 5 min. rest, the subjects were asked to perform the stepping activity on step stool ergometer for maximum of 5 min. with a uniform stepping rate of 30 steps min^{-1}. During stepping activity, the heart rate was recorded for every minute with heart rate monitor. After 5 min. of stepping activity, the subjects were asked to stop, sit comfortably and then their recovery heart rate recorded after every 1 min. for a period of 5 min.. Physical fitness index (PFI) was calculated by using the following formula:

$$\text{Physical fitness index} = \frac{\text{Duration of stepping (sec.)}}{\text{Sum of } 1^{st}, 2^{nd} \text{ and } 3^{rd} \text{ min recovery heart rate}} \times 100$$

Aerobic capacity was calculated by using formula as below.

$(VO_2$ mL kg^{-1} x min.) = 0.377 × Step-stool test score (PFI) - 12.767

Interpretation of health status of girls as per PFI scores was <77 poor, 77-83 fair, 84-91 good and >91 excellent (Edward *et al*., 1973). Interpretation of health status of girls, as per aerobic capacity values given by Anonymous (2000), was upto 15 poor, 16-25 low average, 26-30 high average, 31-40 good, 41-45 very good and > 45 excellent.

Data analysis

All the information gathered was coded on master sheets and then tabulated into master tables. Paired-'t' test was used to compare pre- and post-experimental results (McDonald, 2014).

RESULTS AND DISCUSSION

Physical fitness index

Physical fitness is linked to an individual's capacity to do physical activity with a reasonable degree of efficiency without fatigue and with rapid recovery from the effect of exercise. Several studies have established that anemia reduces physical work capacity. The decrease in hemoglobin reduces the availability of oxygen to tissues which, in turn, affects the productivity, cardiac output and concentration level, mild and moderate anemia impose physical endurance and fitness. A good physical work capacity is a desirable attribute that depends on adequate intake of calories and iron. Physical fitness index (PFI) and aerobic work capacity (AWC) are considered important parameters to evaluate the cardiac respiratory fitness. The physical fitness activity was performed by the adolescent girls before and after nutritional intervention to calculate PFI and AWC in groups I and 2 as well as control group (Table 1).

Physical fitness data of selected adolescent girls elucidated that mean PFI score obtained during pre-test by control, group-1 and group-2 was 41.27±1.34, 42.57±1.96 and 43.88±1.71 and the corresponding mean values in post-test were 41.93±1.44, 99.21±1.35 and 95.51±1.07, respectively. Gain in capacity score after 4 mon. intervention was 0.66 in control whereas in group-1 and 2 it was 56.64 and 51.63, respectively. The quantum of improvement was 2.33 and 2.17 times more in group-1 and group-2 as compared to control group indicating that the dietary and nutrition interventions enhanced the nutrition status; and also improved physical work and capacity. AWC calculated using PFI data showed that the mean values for group-1, group-2 and control before the initiation of intervention programme were 10.82±0.74, 11.32±0.64 and 8.10±0.50 VO_2 mL kg^{-1} 15 min^{-1} of

Table 1: Impact of nutritional intervention on physical fitness index (PFI) of selected adolescent girls

Parameters	Pre-test	Post-test	t-value	Gain in capacity	Quantum of improvement
Group-1 (n = 30)					
PFI score	42.57±1.96	99.21±1.35	15.5 ^{S}	56.64	2.33
Aerobic capacity*	10.82±0.74	24.64±0.51	15.6 ^{S}	13.82	2.28
Group-2 (n = 30)					
PFI score	43.88±1.71	95.51±1.07	16.04^{S}	51.63	2.17
Aerobic capacity*	11.32±0.64	23.74±0.35	17.49^{S}	12.42	2.10
Control (n = 30)					
PFI score	41.27±1.34	41.93±1.44	0.49^{NS}	0.66	1.01
Aerobic capacity*	8.10±0.50	8.15±0.50	1.14^{NS}	0.05	1.00

*VO_2 mL kg dL^{-1} 15 min.; S = Significant at 5% (t value at 28 degree of freedom 2.04); NS = Non-significant

exercise time. After intervention, an increase in hemoglobin level of moderate anemic adolescent girls was observed thereby shifting a little to a safer zone of mild anemia which enhanced their aerobic capacity with the scores of 24.64±0.05, 23.74±0.35 and 8.15±0.50 for VO_2 mL^{-1} kg^{-1} 15 min^{-1} for group-1, group-2 and control. A decrease in maximal consumption of oxygen (VO_2 max), an indicator of AWC, occurs in anemic individuals which leads to the reduction in oxygen transport capacity of blood by body. Control group did not record any appreciable increase in their aerobic capacity.

Aerobic capacity

Physical fitness rating calculated in hierarchy of poor to excellent PFI explained the positive impact of diet and nutritional intervention. During pre-intervention 96.7 and 30.0% subjects in group-1 and 2 were rated with poor fitness while 3.3 and 20.0% improved their fitness level to good and excellent fitness after nutritional intervention (Table 2). Control group showed same poor fitness before and after intervention. There was a drastic positive shift in aerobic capacity of group 1 and 2 after nutritional intervention improved from poor to low average grade in pre-test to good and excellent category later. Only 6.7% had excellent capacity after intervention in group-1. No such change occurred in adolescent girls of control group.

The study revealed that the physiological endurance or aerobic capacity, as assessed by measuring VO_2 max, improved with nutritional intervention. A significant increase in VO_2 max was found after 4 mon. exercise. This finding is in agreement with Kharbanda *et al.* (2015) who found a

Table 2: Impact of nutritional intervention on physical fitness rating of selected adolescent girls

Parameters	Group-1 (n = 30)		Group-2 (n = 30)		Control (n = 30)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Physical fitness rating						
Excellent (>91)	0	27 (90.0)	0	20 (66.7)	0	0
Good (84-91)	0	3 (10.0)	0	7 (23.3)	0	0
Fair (77-83)	1 (3.3)	0	6 (20.0)	3 (10.0)	21 (70.0)	20 (66.7)
Poor (<77)	29 (96.7)	0	24 (30.0)	0	9 (30.0)	10 (33.3)
Aerobic capacity (VO_2 mL^{-1} kg^{-1} 15 min^{-1})						
Poor (≥5)	1 (3.3)	0	26 (86.7)	0	27 (90.0)	26 (86.7)
Low average (16-25)	29 (96.7)	0	4 (13.3)	0	3 (10.0)	4 (13.3)
High average (26-30)	0	0	0	2 (6.7)	0	0
Good (31-40)	0	9 (30.0)	0	22 (73.3)	0	0
Very good (41-45)	0	19 (63.3)	0	6 (20.0)	0	0
Excellent (≥45)	0	2 (6.7)	0	-	0	0

#Figure in parentheses represents percentage;

linear increase in VO_2 max with training revealing a prolonged training can increase VO_2 max in normal sedentary individuals by more than 40%. The observation suggests that sedentary medical students engaged in regular endurance training could improve their AWC. A significant positive correlation was found between body mass index and post-exercise VO_2 max.

The mean PFI scores of control group (no nutrition education and diet intervention) were lower as compared to other groups. A positive correlation was observed between physical fitness Index and VO_2 max, suggesting that improvement in VO_2 max improves cardiorespiratory fitness. Sen and Kanani (2006) reported that non-anemic girls took higher number of steps to climb and shorter time to revert to basal pulse rate (recovery time) as compared to anemic girls. Physical work capacity refers to a person's own capacity of carrying maximum work for a certain period with normal pulse rate. Physical work capacity was reduced in iron deficiency anemia because the decrease in hemoglobin reduced the availability of oxygen to tissues. These observations are in line with Ekta *et al.* (2013) who studied the impact of lotus stem + vitamin C on adolescent girls with iron deficiency anemia and found a significant improvement in their physical work capacity in comparison to anemic control group. Gupta and Koch (2010) found 3-fold increase in mean hemoglobin level and improvement in work capacity in anemic girls supplemented with iron and folic acid capsule. Food-based iron supplementation increased hemoglobin level and physical work capacity. Resmi *et al.* (2017) reported the effectiveness of amla and pumpkin leaf-extracted juice with jaggery syrup for 2 mon. in improving the physical work capacity and intelligence of adolescent girls aged 14-17 yr. The results showed significant improvement in hemoglobin, vitamin C and iron which significantly affected physical work capacity and intelligence.

Hemoglobin level

Hemoglobin level is the most commonly used indicator to detect anemia at field level. The classification of different grades of anemia given by WHO (2011) was used to screen the subjects for anemia. The hemoglobin level of 90 moderately anemic adolescent girls was recorded before and after nutritional intervention. The mean initial hemoglobin level in group-1 was 9.31±0.12 g dL^{-1} which increased significantly ($p \leq 0.05$) to 11.44±0.12 g dL^{-1}. In group-2 the initial hemoglobin was 9.51±0.11 g dL^{-1} which increased significantly to 10.97±0.16 g dL^{-1} at final level, whereas the mean initial level of hemoglobin increased insignificantly from 9.35±0.11 to 9.84±0.20 g dL^{-1} in control group after 4 mon. of nutritional intervention (Table 3). The impact of nutritional intervention on the prevalence of anemia was also calculated. All the adolescent girls were moderately anemic (8-10.9 g dL^{-1} Hb) during pre-intervention as well as after receiving the intervention for 4 mon., while in group-1 only 13.3% were non-anemic and 76.7% fell in mild anemic category. Only 10% did not show any improvement. Group-2 respondents were imparted nutrition counseling only and 86.7% remained in the same category (moderately anemic) while 13.3% shifted to mild anemic category. There was no change/shift observed in control group obviously because they did not receive any intervention. The studies suggest that anemia prevalent in India appears mainly due to the lower dietary intake and poor absorption of iron from cereal-based vegetarian diets which lead to nutritional anemia. Further, dietary interventions have remarkable effect on hemoglobin as compared to nutrition education intervention. During dietary intervention, subjects of group-1 were provided with iron-rich food preparations i.e. 20 g per day of each *ladoo* and *mathri* which provided them 100% RDA.

Angel and Devi (2015) assessed the therapeutic impact of garden cress seed *ladoo* among the selected anemic adolescent girls of 12-15 years age. The *ladoo* that contained 10 mg iron was given

Table 3: Impact of nutritional intervention on mean hemoglobin level of selected adolescent girls (n = 90)

Parameters	Reference value	Pre-test	Post-test	t-value
Group-1		9.31±0.12	11.44±0.12	11.94*
Group-2	≥12	9.51±0.11	10.97±0.16	7.48*
Control		9.35±0.11	9.84±0.20	1.38NS

*Significant at 5% (t value at 28 degree of freedom 2.04); NS = Non-significant

for 6 mon. along with 5 g amla powder; and after 6 mon. of supplementation, they found improvement in clinical signs of experimental group and the haemoglobin level gradually increased from 8.67±0.59 to 12.43±0.70 g dL^{-1} with no specific change in control group. Grover and Choudhary (2017) evaluated the effectiveness of different nutrition intervention for improvement in hemoglobin level as the average haemoglobin levels were 8.55 and 9.21 g dL^{-1} in adolescent girls of experimental group and control, respectively. The corresponding values increased to 10.66 and 9.85 g dL^{-1} after nutritional intervention. They also found a highly significant ($p<0.01$) improvement in both the groups but the levels still were lower than the standards of World Health Organization (2001).

Conclusion: The subjects of experimental groups 1 (diet as well as nutrition counseling) and 2 (nutrition counseling only) showed significant improvement in physical fitness, aerobic capacity and hemoglobin as compared to the control group. Adolescent girls need proper nutrition, education and physical exercise to go a long way. The study revealed that physical fitness index, VO_2 max scores and level of hemoglobin improved with nutritional intervention.

REFERENCES

Angel, M. and Devi, K.V. 2015. Therapeutic impact of garden cress seed *ladoo* among the selected anemic adolescent girls in the age group of 12-15 years in Dindigul district, Tamil Nadu, India. *International Journal and Research*, **3**: 64-66.

Anonymous. 2000. Standard values of physical strength of the Japanese by the Standard Physical Strength Survey Team (SPSST). Tokyo Metropolitan University, Tokyo, Japan.

Bhat, A.N., Yograj, S. and Sahi, M. 2015. Presence of iron deficiency anemia in adolescent girls of Jammu district and its effect in their physical performance. *Indian Journal of Clinical Anatomy and Physiology,* **2**(4):164-168.

Coe, D.P., Pivarnik, J.M., Womack, C.J., Reeves, M.J. and Malina, R.M. 2006. Effect of physical education and activity levels on academic achievement in children. *Medicine and Science in Sports and Exercise*, **38**: 1515–1519.

Donnelly, J.E., Castelli, D., Hillman, C.H., Etnier, J.L., Lee, S., Tomporowski, P., Lambourne, K, and Szabo-Reed, A.N. 2016. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine and Science in Sports and Exercise*, **48**: 1223-1224.

Edward, L., Fox, C.E., Billings, R.L., Robert, B. and Mathews, D. 1973. Fitness standards for college students. *European Journal of Applied Physiology and Occupational Physiology*, **31**: 231-236.

Ekta, S., Pankaj, K.J. and Swapnil, S. 2013. Effect of food-based iron supplementation on the physical work performance of adolescent girls. *International Journal of Green Pharmacy* **23**(4): 95-98.

Gopalan, C., Rama Sastri, B.V. and Balasubramanian, S.C. 2010. Nutritive Value of Indian Foods. NIN (National Institute of Nutrition). Hyderabad, India.

Grover, K. and Choudhary, M. 2017. Effectiveness of long-term community based nutrition intervention for prevention and management of anaemia among adolescent girls. *Asian Journal* of *Dairy and Food Research*, **36**(3): 235-240

Kharbanda, M., Angesh B. and Aniruddha J. 2015. Effect of Exercise on Aerobic Power and Correlation of Aerobic Power with Body Mass Index and Physical Fitness Score in Medical Students. *Asian Journal of Biomedical and Pharmaceutical Sciences*, **5**(43): 21-26.

McDonald, J.H. 2014. Handbook of Biological Statistics (3rd ed.). Sparky House Publishing, Baltimore, Maryland, USA.

Ortega, F.B., Ruiz, J.R., Castillo, M.J. and Sjostrom, M. 2008. Physical fitness in childhood and adolescence: A powerful marker of health. *International Journal of Obesity*, **32**: 1-11.

Resmi, S., Fathima, L. and Vijayaraghavan, R. 2017. Effect of nutritional support therapy on level of hemoglobin, vitamin C, iron and its impact on physical work capacity and intelligence among adolescent girls with iron deficiency anemia: A pilot study. *International Journal* of *Research* in *Ayurveda and* Pharmacy **8**(3): 99-103

Sen A and Kannani S.J. 2006. Deleterious functional impact of anemia on young adolescent school girls. *Indian Pediatrics,* **43**: 219.

Varghese, M.A., Saha, P.N. and Atreya, N. 1995. A rapid appraisal of occupational work load from a modified scale of perceived exertion. *Ergonomics,* **37:** 485-491.

WHO. 2011. Iron deficiency anaemia: Assessment prevention and control. A guide for program managers. World Health Organization, Geneva, Switzerland.