

**Original article:**

## **Impact of anemia, iron deficiency on physical and cardio respiratory fitness among young working women in India**

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### **Abstract:**

**Aims:** Anemia, iron deficiency is highly prevalent in working women in India and more so in low socio economic working population. A negative influence of anemia and iron deficiency exists on physical fitness index(PFI) in women.

**Objectives:** This study is set to understand the impact of anemia, iron deficiency(ID) on physical and cardio respiratory fitness on young women and also to evaluate the modified QCT in field study.

**Methods:** 600 apparently healthy non pregnant non lactating women, aged 18-55 years, working in small scale industries, Davangere, Karnataka were recruited by simple random sampling. 3 groups of 200 were evaluated (mild-moderate anemic, ID & control).PFI was determined by modified Queens College step test (QCT) and VO<sub>2</sub>max was calculated.

**Results:** A statistical significant value of PFI and VO<sub>2</sub>max score was observed in the anemic, ID groups (p<0.05).

**Conclusion:** Indian women frequently complain of early fatigue in the lower limb. Though difficult to complete the QCT, it still is a good indicator of PFI. Anemia & ID impair the delivery of oxygen to tissues and lead to a reduced VO<sub>2</sub>max and thus have impact on the physical activity.

**Key words:** anemia, iron deficiency, physical fitness, women

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### **Introduction**

Young working women who are physically active seem to have a higher risk of anemia and iron deficiency (1). This could be due to increased iron loss associated with work load in addition to the iron loss in menses and low dietary intake of iron (2, 3).Iron deficiency (ID) and anemia reduces physical work capacity in such women. Decrease in hemoglobin as seen in anemia reduces the availability of oxygen to the tissues, which further affects the cardiac output. Iron (Fe) an important micronutrient, has an important role in oxygen transport and its use

(4). ID is found to impair aerobic physical performance. A decrease in maximal consumption of oxygen (VO<sub>2</sub>max) an indicator of aerobic work capacity occurs in anemic individual leads to reduction in oxygen-transport capacity of the blood by the body during heavy work(5,6) .

Although much attention has been paid to iron deficiency, anemia and its effects, little is known about the functional consequences in terms of PFI of each and its correlation in India. It has been observed that a negative influence of anemia and ID exists on Physical Fitness Index (PFI) in women (1). PFI and

Maximum oxygen uptake (VO<sub>2</sub> max) are considered as an essential and important parameter to evaluate the cardio-respiratory fitness (7, 8).

QCST is commonly used among the Indian women population because of its simplicity to carry out in households and also in fields. Recent investigation of acute cardio respiratory responses to the current popular style of bench step exercise has validated its use in improving aerobic physical fitness particularly in women (9, 10). Its efficacy of step test aerobics as a module for understanding the fitness levels has been established among girls.

There is dearth of evidence on the physical activity of women in India more so in women and the influence of anemia and ID. Regional, cultural, socio-economic and demographic differences could lead to differences in physical. However with evidences pointing towards the increase in overweight and non communicable diseases, promotion of good nutrition and health care should be a public health priority. Also Indian women often report premature exhaustion in the lower limb while performing the Harvard step test (HST), thus this study aimed to evaluate the suitability & relevance of modified HST in field study, to study the influence of anemia and ID on the physical fitness and cardio respiratory fitness in working women.

### Methods

This study was conducted on 600 non pregnant non lactating (NPNL), 18-55 yrs aged women, working in a garment, cotton, soap, small scale factory, Davangere, India. This was a non randomized controlled study. Physical performance evaluation studies were performed on 3 groups; 3 groups (n=200 each) were ID, anemic & control women. (ID: Serum Ferritin < 15 µg/L, anemia (mild-mod): Hb > 8 to < 12 g/dl). The procedure was explained as follows to all

the participants. They were called in a group of 5 and the test was demonstrated (11). The test of choice to assess aerobic capacity is the maximum oxygen consumption (VO<sub>2</sub>max) test (12). Protocols for the VO<sub>2</sub> max test have been standardized and widely used as an indicator of physical (aerobic) fitness. The test is designed to assess oxygen uptake at a point at which the subject has achieved a level of maximum exertion.

Subjects was instructed to perform cycles of the four steps synchronizing with the beeps till the tester is comfortable that they have been able to synchronize their steps with the beeps (coinciding with 22 cycles/min). The four steps - right foot up for first beep, left up for the second, right down for the third and left down for the fourth. The step height was 16.25 inches (41.3 cm). The metronome was started and begins a 4-beat cadence on the signal, at the instruction of the research assistant. They had to continue the test for 3 minutes with 22 cycles per minute and were asked to stop at the end of the 3-minute exercise. Subjects who could not complete the 3 minutes, the duration they could perform the test was recorded and accordingly PFI was calculated. After this the subject was asked to sit comfortably for 5 minutes, at the end of which resting pulse rate will be recorded twice at a minute interval from a 15 sec. Pulse rate recorded at the radial pulse. Care was taken that the subject understands that if they feel giddy, have chest pain or wheezing, they could stop at any time and sit down. All 600 women performed the **Queens College step test** as below and VO<sub>2</sub>max was calculated

**Physical fitness index** = (Duration of exercise in sec) \* 100  
(2 \* Sum of 1-1.5, 2-2.5 & 3-3.5 minutes recovery pulse)

**VO<sub>2</sub> max (ml.kg-1.min-1)** = 65.81 - 0.1847 x heart rate (bpm)

Statistical analysis:

Data are presented as mean ± standard deviation. Paired t-test were used to determine the significance of differences between VO<sub>2</sub>Max groups. ANOVA was used to determine the significance of differences between groups and p value <0.05 was considered statistically significant.

### Results

The mean ± SD age of all these women was 27 ± 3.4years. The socio demographic characteristics of the women (Table 1) show that these women hale from low socio economic strata with a monthly income of 2000INR. Majority of the women were married and had finished high school education, belonged to Hindu religion.

100% of women could perform this procedure but the striking fact was that 95% of the individuals could not complete the 5 min duration of the test. However the calculation accounted for this.

The mean VO<sub>2</sub> max in ID women was 40.24 ml/kg/min and there were statistical significant differences between the anemic and control groups (Table 2).Also significant correlations were not found between measured VO<sub>2</sub>Max and the height. There was a significant change in the PFI across the groups. The mean PFI (%) for anemic, ID was significantly higher than that of control group (p<0.05) (Figure 1).

### Discussion

In this study we found strong associations of VO<sub>2</sub> max with the iron and hemoglobin status of young NPNL women. Limited data exists on estimation of VO<sub>2</sub> max by using prediction equations to calculate the VO<sub>2</sub>max from recovery heart rate using QCST which is presumed to be the simplest (13, 14).The values of directly measured VO<sub>2</sub>max showed no

significant correlation with the estimated VO<sub>2</sub>max with QCST (15). Decrease in VO<sub>2</sub> max that occurs in patients with anemia is likely due to low hemoglobin concentration and the consequent reduction in oxygen-transport capacity of the blood(16,17).VO<sub>2</sub> max is not affected by marginal ID as long as the hemoglobin concentration is in the normal range (18).We also found that, in subjects with normal hemoglobin concentrations, ID still had adverse effects on physical performance This effect seemed to be positively related to body iron storage but not to oxygen transport capacity.

Studies carried out in humans have confirmed a strong association with haemoglobin and work output (19). A study done in tea estate workers in Srilanka (20) and road construction workers in Kenya (21) have shown a similar relationship between Fe status and work output. Among female tea estate workers (age: 22 –65 years), work time on a treadmill (10% grade at 1.59 km /hr) ranged from 10.4 ± 0.8 (mean ± SEM) minutes for those subjects in the lowest Hb group to 18 minutes for those subjects in the highest Hb group (22). Productivity gains of about 4 % was seen with improvement in Hb and arm muscle area in road construction workers from Kenya who were supplemented with energy (1000 kcal/day) for 4 months (21).The scientific basis for impairment in aerobic capacity arose from a series of experiments (23-25) that showed that the severity of anaemia in rats was directly proportional to the degree of impairment in aerobic capacity. It is also assessed aerobic capacity in rats at various levels of haemoglobin depletion and showed a non linear relationship. They also found that as haemoglobin concentrations fell from 140 g/l to 80 g/l, VO<sub>2</sub> max declined linearly by 16%. Further, VO<sub>2</sub> max declined at much more rapid rate when haemoglobin

fell below 70 g/l. Following 3 days of Fe repletion, both haemoglobin and VO<sub>2</sub> max returned to control values, while it took 5 days for oxidative enzymes to return to control values. On repletion, both hemoglobin and VO<sub>2</sub> showed a similar recovery curve suggesting that haemoglobin is the primary determinant of aerobic capacity in the rat model (27). Similar studies conducted on humans have shown that changes in haemoglobin resulted in significant changes in VO<sub>2</sub> max, ranging from a 30% decline on induction of anaemia to a 24% improvement after 12 week of Fe supplementation (28-32). Other studies that assessed aerobic capacity in humans have showed that aerobic capacity was affected only when anaemia was present (33).

Impairment of oxidative capacity in turn impairs physical endurance and energetic efficiency. (34). However we have not measured the endurance which is a limitation of this study. The impairment in aerobic capacity, endurance capacity and energetic efficiency directly reduce economic productivity. It has been estimated that due to physical productivity losses linked to Fe deficiency alone, a country, on an average, loses 0.6 per cent of its gross domestic product (GDP) (35). Annually, this would amount to a loss of about \$4.2 billion in India and other developing countries. These losses can be easily offset by improving the Fe status of the population and this has been demonstrated in field studies done in India, Indonesia, Srilanka, Philippines, China and other countries.

Thus, ID especially when it results in anemia, reduces VO<sub>2</sub>max and by extension, reduces endurance. Individuals with low endurance cannot sustain moderate-to-heavy physical labor to the extent seen in those with better endurance. There is even evidence that low levels of physical activity such as those seen in cotton factories are performed at higher energy costs if women experienced IDA. Laboratory tests show that even in non anemic women, iron deficiency accounts for a 5% greater energy cost to perform the same work compared with a non iron-deficient individual. This greater metabolic cost of work should render the iron-deficient individual more fatigued at the end of a work day compared with a non iron-deficient individual who performed the same amount of physical work. Even if the iron deficiency does not result in a reduced amount of work performed, the higher cost of performing that work leaves the iron-deficient person less able to engage fully in non workplace responsibilities, such as child care, household maintenance, and participation in social and leisure activities.

#### **Conclusion**

Mild- moderate anemia might be an independent risk factor for functional impairment. ID being highly prevalent in Indian women exhibit a poor physical fitness level and thus are prone to exhaustion, leading to reduced work capacity both at work and at domestic levels. There is an urgent need to address anemia, ID in working women to improve the effectiveness and overall health

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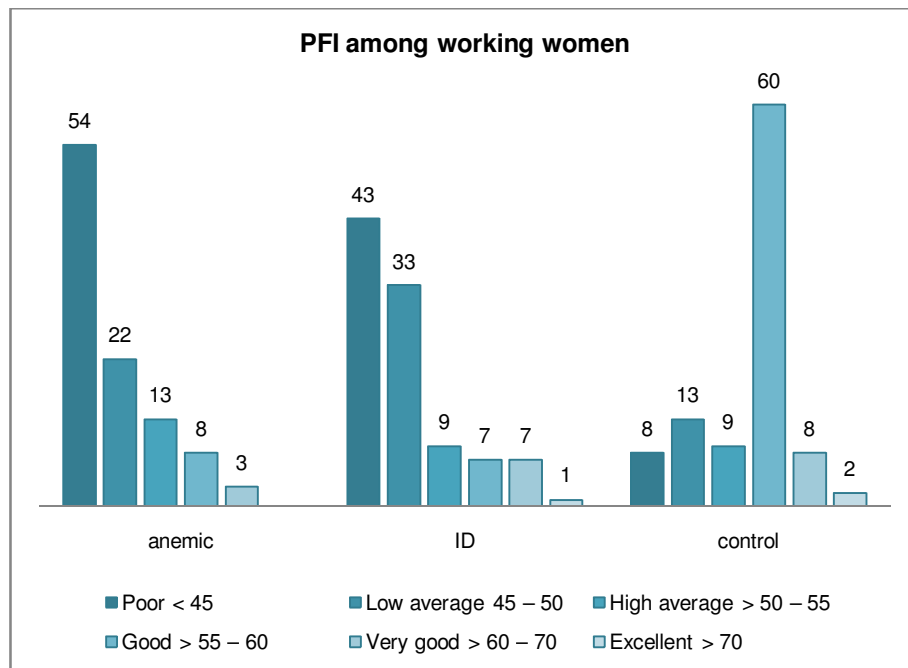
Table 1: Baseline demographic characteristic of the study subjects

Demographic variables	Control group (n=200)	ID group (n=200)	Anemic arm (n=200)	p-value
	%	%	%	
<b>Marital Status</b>				
Married	71.7	60.6	51.2	0.01
Unmarried	28.3	39.4	48.8	
<b>Education</b>				
Uneducated	14.2	13.6	10.8	0.6
Primary	10.6	15.9	14.1	
Secondary	16.1	15.8	14.2	
High school	40.7	36.9	42.6	
PUC/Diploma	20.6	17.5	17.3	
Graduate	1.9	1.2	1.0	
<b>Occupation</b>				
Unskilled	1.6	0.9	4.3	0.13
Skilled	87.2	93.0	84.0	
Professional	11.2	6.1	9.2	
<b>Type of House</b>				
Kuccha	14.6	11.4	14.2	0.76
Pucca	34.6	30.6	31.8	
Semi-pucca	50.9	58.0	54.0	
<b>Religion</b>				
Hindu	91.2	87.4	85.6	0.24
Muslim	3.6	6.4	6.8	
Christian	1.6	0.9	5.0	
Others	3.5	5.3	2.6	

Table 2: Mean and Standard deviation of Vo2 max Queen Step test

Mean and Standard deviation of Vo2 max Queen Step test		
Women	Mean	Standard deviation
Anemic	38.65	6.2
Iron deficient	40.24	2.97
Control	45.53	5.32

Figure 1 : PFI across the study groups based on classification of fitness according to Harvard index.



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