FOOD SCIENCE RESEARCH JOURNAL;
Volume 2 Issue 1
(April, 2011) Page : 31-36

RESEARCH ARTICLE

Received : January, 2011; Accepted : February, 2011

Effect of anaemia on physical performance of the coalmine workers and the impact of iron supplementation

M. DAS AND B. BAROOVA

ABSTRACT

The effect of iron supplementation on the physical performance of the coalmine workers was studied. 300 samples were screened from 600 samples and were pair matched for haemoglobin and weight and three groups were formed namely Placebo, Group I and Group II consisting of 100 samples in each group. Group I and Group II received 60 mg and 120 mg of elemental iron and the Placebo received sugar coated tablets at a stretch for 180 days. Data on haemoglobin, Harvard step test, pre and post exercise pulse rate were collected at 0 days (baseline), 90 days (mid intervention), 180 days (final intervention) and 270 days (post intervention). Results revealed that both the dose levels significantly improved the endurance capacity and decreased the post exercise pulse rate but the performance was higher with 120 mg dose level. Performance of step test was significantly correlated with haemoglobin indicating the anaemia affected the workers ability to perform the test of physical endurance.

Das, M. and Baroova, B. (2011). Effect of anaemia on physical performance of the coalmine workers and the impact of iron supplementation, *Food Sci. Res. J.,* **2** (1) : 31-36.

Key words : Anaemia, Physical performance, Pulse rate, Haemoglobin

INTRODUCTION

Iron deficiency anaemia affects the physical capacity by reducing the availability of oxygen to the tissues which in turn affects cardiac output and the heart. It also reduces the efficiency of oxygen exchange in muscle and myoglobin. High prevalence of anaemia in developing countries assumes great importance because it may limit physical work capacity (PWC). Some studies have shown that anaemia and underweight workers are less productive than their better nourished co-workers (Wolgemuth *et al*., 1982). Other studies by Gardner *et al*. (1977) indicated that subjects with lower haemoglobin concentration had lower work capacity and that elevation of haemoglobin concentration by iron treatment resulted in an increase in work capacity. Literature documented that there is hardly any studies to measure the productivity of coalmine workers and changes in productivity after iron supplementation. Hence, the present study was undertaken with the following objectives to find out effect of anaemia on the physical performance of coalmine workers, impact of iron supplementation on physical performance and to assess the relative stress of exercise imposed before and after iron supplementation on the physical efficiency of coalmine workers.

MATERIALS AND METHODS

Subject and study design:

Three hundred samples were screened from six hundred samples and the samples were pair matched for haemoglobin level and weight. Pairs were randomly assigned as Placebo- receiving a sugar coated tablet, Group 1 – receiving 60 mg of elemental iron and Group II – receiving 120 mg of elemental iron. Each group consisted of one hundred samples and received oral supplementation at a stretch for 180 days. Data on physical performance, haemoglobin and pre-exercise and post-exercise pulse rate were collected at baseline (0 days), mid intervention (90 days), final intervention (180 days) and post final intervention (270 days), following the withdrawal of supplements.

Experimental procedure:

Haemoglobin was estimated by the

cyanmethemoglobin method (Oser, 1971). Physical endurance was measured by a simple test of physical capacity *i.e.* Harvard step test before and after the intervention study. The procedure, evaluation and interpretation followed the original method by Brouha *et al*. (1943) except for the bench height. Three benches of different height (16, 17 and 18 inches) were taken and the workers were asked to perform the steps (up and down) for five minutes in different heights and frequently asked about their discomfort. It was found that 17 inch bench was suitable for the coal workers.

Pulse rate was measured using an electronic digital blood pressure monitor (MS702 manufactured by WARS, Taiwan).

Statistical analysis :

Means and standard errors were calculated for all the parameters. Paired 't' test was applied to compare the impact of a specific treatment on the sample individual. F test was used to test the equality of different treatments on the respondents. Correlation was done to quantify the degree of relationship between different variables. Linear regression was used to predict the influencing power of the independent variables on dependent variables.

RESULTS AND DISCUSSION

Table 1 reveals a relatively better anthropometric status which could be attributed to their higher monthly per capita income than the other working population. Thereby they do have a better purchasing power of food, which directly contributed to better anthropometry. However, the mean haemoglobin value was 9.41±1.02 g/dl much below the accepted value of 13 g/dl (WHO, 1968) and 12 g/dl according to Indian cut off point (NIN, 1986). It appears that the coalmine workers suffered from moderate to severe type of anaemia. This may be due to various environmental factors and poor personal awareness towards health and hygiene.

Table 1 : Mean anthropometric measurements of male coalmine workers

Number of samples	Mean height (cm) ± SE	Mean weight (kg) ± SE
300	162.39 ± 0.364	54.99 ± 0.782

Impact of iron supplementation on physical performance:

Results of Table 2 reveals that before supplementation the number of steps performed by the subjects was 60 steps and 55 steps in Group I and Group II for a period of 5 minutes, respectively. However, after supplementation, there was a significant increment in the number of steps performed in both Group I and Group II receiving 60 mg and 120 mg of elemental iron. Impact of supplementation between different treatments showed that the number of steps performed was significantly ($P<0.01$) highest between Placebo and Group II, followed by Placebo and Group I then between Group I and Group II.

Within the same group, the subjects also registered significant ($P<0.01$) improvements in steps performed. In Group I the number of steps performed increased by 20 steps from baseline to mid intervention and 32 steps from baseline of final intervention. Similarly, in Group II number of steps performed was significant ($P<0.01$) at all stages but was highest between baseline to final intervention. In Group II, the number of steps increased by 28 steps from baseline to mid and 43 steps from baseline to final intervention. It was also found that as the haemoglobin level increased after supplementation from a baseline value of 9.42g/dl to 11.75g/dl and 12.24g/dl at mid and final intervention in Group I and to 11.9g/dl and 12.58g/dl at mid and final intervention in Group II, respectively, the ability to perform the test of physical endurance also kept markedly improving. The Placebo group also registered improvement in step performance. However, after withdrawal of supplementation, there was a significant decline in the steps performed from final to post final intervention. Hence, it can be concluded that iron supplementation at both the dose levels resulted in significantly improving endurance on work capacity of the workers in relation to their untreated counterparts. These results opined similar views with that of studies by Viteri and Torun (1974), Basta *et al*. (1979) who revealed that treatment with 100 mg of elemental iron for 60 days resulted in better step performance, work output among adult rubber plantation workers. Dodd *et al*. (1992) also reported that the performance of step test by anaemic subjects markedly improved after iron supplementation.

Correlation analysis (Table 3) revealed that there was a positive significant correlation between haemoglobin and step performance ($P<0.01$, $r = 0.380$) and number of days worked ($P< 0.01$, $r = 0.380$) indicating that anaemia affected the workers ability to perform the test of physical endurance. Viteri and Torun (1974) also stated that even mild anaemia was associated with a significant impairment in work capacity. Simple linear regression (Table 4) also showed that haemoglobin had positive impact on step performance and accounted 14.4% of the variability on work performance and morbidity accounted to 4.9% of the variability.

Table 2 : Impact of iron supplementation on the step performance capacity of the male coalmine workers

Stages of evaluation	Treatment mean ± SE			F value	C.D. (P=0.05)	S.E.±
	Placebo	Group I	Group II			
Baseline	52± 0.799	60± 1.49	55± 0.907	For factor treatment		
Mid	62± 0.763	80± 1.05	83± 1.06	387**	1.32	0.677
Final	63± 0.768	92± 0.871	98± 0.977	For factor treatment 459**	1.53	0.781
Post final	63	69	73			
Between treatment	Mean difference of two factors	t value		Between time	Mean difference of two factors	t value
Placebo Vs Group I				Placebo		
				P_B V$_S$ P_M	10	32.24**
P_B V$_S$ GI_B	8	5.99**		P_B V$_S$ P_F	11	31.41**
P_M V$_S$ GI_M	17	18.08**		P_B V$_S$ P_{PF}	11	27.12**
P_F V$_S$ GI_F	29	30.77**		P_M V$_S$ P_F	1	6.76**
P_{PF} V$_S$ GI_{PF}	6	6.96**		P_M V$_S$ P_{PF}	1	3.57**
				P_F V$_S$ P_{PF}	0	1.42^{NS}
Group I Vs Group II				Group I		
				GI_B V$_S$ GI_M	20	13.18**
GI_B V$_S$ GII_B	5	3.20*		GI_B V$_S$ GI_F	32	20.89**
GI_M V$_S$ GII_M	3	19.04**		GI_B V$_S$ GI_{PF}	9	5.98**
GI_F V$_S$ GII_F	6	4.52**		GI_M V$_S$ GI_F	12	16.32**
GI_{PF} V$_S$ GII_{PF}	4	10.46**		GI_M V$_S$ GI_{PF}	11	13.07**
				GI_F V$_S$ GI_{PF}	23	26.30**
Placebo Vs Group II				Group II		
				GII_B V$_S$ GII_M	28	36.56**
P_B V$_S$ GII_B	3	4.00**		GII_B V$_S$ GII_F	43	50.09**
P_M V$_S$ GII_M	21	23.02**		GII_B V$_S$ GII_{PF}	18	26.48**
P_F V$_S$ GII_F	35	31.38**		GII_M V$_S$ GII_F	15	18.67**
P_{PF} V$_S$ GII_{PF}	10	3.34**		GII_M V$_S$ GII_{PF}	10	21.41**
				GII_F V$_S$ GII_{PF}	25	37.53**

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS=None-significant

Table 3 : Correlation between work performance (Harvard step test) and haemoglobin, weight, morbidity and number of working days

Variables	Correlation with work performance in terms of Harvard step tests (r value)
Haemoglobin	0.380*
Weight	0.073^{NS}
Morbidity	- 0.222**
Number of working days	0.380**

** indicates significant of value at P=0.01 NS =Non-significant

Table 4 : Linear regression of different variables on the work performance (in terms of step performance) by the male coalmine workers

Independent variables	Intercept	Regression co-efficient	Co-efficient of determination %
Haemoglobin	16.10**	4.28**	14.4
	(5.72)	(0.6)	
Weight	50.72^{NS}	0.10^{NS}	0.5
	(4.58)	(0.08)	
Morbidity	60.5**	-1.80**	4.9
	(1.21)	(0.45)	
Number of	38.4**	0.99**	14.4
working days	(2.61)	(0.13)	

Figures within parenthesis indicate SE
* and ** indicate significant of values at P=0.05 and 0.01, respectively NS= Non-significant

Impact of iron supplementation on the pre and post exercise pulse rate of the workers :

Measurement of pulse rate is a sensitive monitor of haemoglobin status. Several investigators have reported

Table 5 : Impact of iron supplementation on the exercise pulse rate of the male coalmine workers

Stages of evaluation	Treatment mean ± SE			F value	C.D. (P=0.05)	S.E. ±
	Placebo	Group I	Group II			
Baseline	80.76± 0.926	78.98± 0.929	75.48± 0.589	For factor treatment		
Mid	80.37± 0.88	78.58± 0.906	75.29± 0.583	40.77**	1.12	0.572
Final	80.30± 0.878	77.98± 0.85	75.06± 0.575	For factor treatment		
				0.353^{NS}	1.29	0.66
Post final	80.59± 0.959	77.45± 0.859	75.58± 0.598			
Between treatment	Mean difference of two factors	t value		Between time	Mean difference of two factors	t value
Placebo Vs Group I				Placebo		
				P_B V$_S$ P_M	0.39	1.99^{NS}
P_B V$_S$ GI_B	1.78	2.06**		P_B V$_S$ P_F	0.46	1.40^{NS}
P_M V$_S$ GI_M	1.79	2.24**		P_B V$_S$ P_{PF}	0.17	0.65^{NS}
P_F V$_S$ GI_F	2.32	2.86**		P_M V$_S$ P_F	0.07	1.38^{NS}
P_{PF} V$_S$ GI_{PF}	3.14	3.50**		P_M V$_S$ P_{PF}	0.22	0.94^{NS}
				P_F V$_S$ P_{PF}	0.29	1.25^{NS}
Group I Vs Group II				Group I		
				GI_B V$_S$ GI_M	0.40	1.46^{NS}
GI_B V$_S$ GII_B	3.50	6.38*		GI_B V$_S$ GI_F	1.00	1.64^{NS}
GI_M V$_S$ GII_M	3.29	6.70**		GI_B V$_S$ GI_{PF}	1.53	2.93*
GI_F V$_S$ GII_F	2.92	3.79**		GI_M V$_S$ GI_F	0.60	2.61*
GI_{PF} V$_S$ GII_{PF}	1.87	5.87**		GI_M V$_S$ GI_{PF}	1.13	2.30*
				GI_F V$_S$ GI_{PF}	0.53	1.31^{NS}
Placebo Vs Group II				Group II		
				GII_B V$_S$ GII_M	0.19	0.85^{NS}
P_B V$_S$ GII_B	5.28	4.08**		GII_B V$_S$ GII_F	0.42	1.90^{NS}
P_M V$_S$ GII_M	5.08	4.08**		GII_B V$_S$ GII_{PF}	0.10	0.46^{NS}
P_F V$_S$ GII_F	5.24	6.90**		GII_M V$_S$ GII_F	0.23	1.83^{NS}
P_{PF} V$_S$ GII_{PF}	5.01	2.37*		GII_M V$_S$ GII_{PF}	0.29	1.77^{NS}
				GII_F V$_S$ GII_{PF}	0.52	1.52^{NS}

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS=None-significant

that even at mild rest and at various level of exercise the pulse rate at given oxygen consumption is greater in anaemic subjects. It was observed from Table 5 that between treatments highest significant increase ($P < 0.01$) in the decrease of pre exercise pulse rate was observed between Placebo and Group II, secondly between Placebo and Group I followed by Group I and Group II. The pre exercise pulse rate of Group I was higher than Group II and after supplementation it decreased from 79 beats/ minute at baseline to 78 beats/ minute at final intervention.

The post exercise pulse rate of the iron supplemented groups were significantly lower than the Placebo (Table 6). Impact between different treatments revealed that the highest significant ($P<0.01$) increase in the decrease of pulse rate was observed between Placebo and Group II, secondly between Placebo and Group I followed by Group I and Group II. Within different stages of intervention the decrease in the post exercise was not so marked in the Placebo group. In Group I, it dropped from 103 beats/ minutes at baseline to 92 beats/ minutes at final intervention and from 98 beats/ minute to 89 beats/ minute in Group II, respectively. Both the dose levels were found to be equally effective in the post exercise state and thus pulse rate could be used as a parameter to assess physical work capacity of an individual or a group. Gardner *et al.* (1975), Edgerton *et al.* (1979) and Dodd *et al.* (1992) observed similar results and reported that haematinic supplementation not only improved the haemoglobin level but also the oxygen carrying capacity of blood and inhibited excessive conversion of pyruvate to lactate and also brings about reduction in the pre and post exercise pulse rate.

Table 6 : Impact of iron supplementation on the post exercise pulse rate of the male coalmine workers

Stages of evaluation	Treatment mean ± SE			F value	C.D. (P=0.05)	S.E.±
	Placebo	Group I	Group II			
Baseline	104.90± 0.853	103.10± 1.03	98.80± 1.09	For factor treatment		
Mid	103.27± 0.796	97.95± 0.815	94.05± 0.523	116.22**	1.21	0.619
Final	102.93± 0.793	92.03± 1.15	89.04± 0.502	For factor treatment 38.03^{NS}	1.40	0.715
Post final	103.46± 0.797	97.65± 1.23	95.30± 0.502			
Between treatment	Mean difference of two factors	t value	Between time		Mean difference of two factors	t value
Placebo Vs Group I			Placebo			
			P_B V$_S$ P_M		1.63	11.66**
P_B V$_S$ GI_B	1.80	2.00*	P_B V$_S$ P_F		1.97	13.43**
P_M V$_S$ GI_M	5.32	6.92**	P_B V$_S$ P_{PF}		1.44	9.08**
P_F V$_S$ GI_F	10.90	10.32**	P_M V$_S$ P_F		0.34	1.86^{NS}
P_{PF} V$_S$ GI_{PF}	5.81	5.10**	P_M V$_S$ P_{PF}		1.90	2.12*
			P_F V$_S$ P_{PF}		0.53	1.96^{NS}
Group I Vs Group II			Group I			
			GI_B V$_S$ GI_M		5.15	9.56**
GI_B V$_S$ GII_B	4.22	4.88**	GI_B V$_S$ GI_F		11.07	11.59**
GI_M V$_S$ GII_M	3.90	12.93**	GI_B V$_S$ GI_{PF}		5.45	5.38**
GI_F V$_S$ GII_F	2.99	2.76*	GI_M V$_S$ GI_F		5.92	7.13**
GI_{PF} V$_S$ GII_{PF}	2.35	11.55**	GI_M V$_S$ GI_{PF}		0.30	0.31^{NS}
			GI_F V$_S$ GI_{PF}		5.62	5.62**
Placebo Vs Group II			Group II			
			GII_B V$_S$ GII_M		4.83	5.75**
P_B V$_S$ GII_B	6.02	3.29	GII_B V$_S$ GII_F		9.84	11.65**
P_M V$_S$ GII_M	9.22	5.12**	GII_B V$_S$ GII_{PF}		3.58	4.27**
P_F V$_S$ GII_F	13.89	18.43**	GII_M V$_S$ GII_F		5.01	19.50**
P_{PF} V$_S$ GII_{PF}	8.16	2.01*	GII_M V$_S$ GII_{PF}		1.25	5.85**
			GII_F V$_S$ GII_{PF}		6.26	32.41**

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS=None-significant

Conclusion:

The results of the study on work performance clearly indicates the need for iron supplementation to improve physical work capacity. It can also be concluded that prophylactic iron supplementation is successful in raising the haemoglobin level and also bringing about significant reduction in the pre and post exercise pulse rate and thereby creating a sense of well being and reducing the incidence of absenteesim among the workers as well as increasing their income.

REFERENCES

Basta, S.S., Soekirman, M.S., Karyadi, D. and Scrimshaw, N.S. (1979). Iron deficiency anaemia and productivity of adult males of Indonesia. *American J. Clin. Nutr.,* **32**: 916-925.

Brouha, L., Graybiel, A. and Heath, C.W. (1943). The step test. A simple method of measuring physical fitness for hard muscular work in adult men. *Rev. Canad. Biol.,* **2**: 86.

Dodd, N.S., Sheela, T.S. and Sharma, U.K. (1992). Effect of different levels of iron supplementation on the iron status and physical work capacity of anaemic Indian women. *Indian J. Med. Sci.,* **46**(2): 33-39.

Edgerton, V.R., Gardner, G.W., Ohira, Y., Gunawardena, K.A. and Senewirtne, B. (1979). Iron deficiency anaemia and its effect on workers productivity and activity patterns. *Brit. Med. J.*, **2**: 1546-1549.

Gardner, G.W., Edgerton, V.R., Barnard, R.J. and Bernauer, E.M. (1975). Cardiorespiratory, haematological and physical performance responses of anaemic subjects to iron treatment. *American J. Clin. Nutr.,* **28**: 982.

Gardner, G.W., Edgerton, V.R., Senewirtne, B., Barnard, R.T. and Ohira, Y. (1977). Physical work capacity and metabolic stress in subjects with iron deficiency anaemia. *American J. Clin. Nutr.,* **30**: 910-917.

National Institute of Nutrition (1986). Anaemia and endurance capacity (physical performance). Annual Report. I.C.M.R. **7**(5): 164-165.

Oser, B.L. (1971). *Hawk's physiological chemistry*. 14th Ed. Tata McGraw Hill Pub. Co. Ltd., New Delhi.

Viteri, F.E. and Torun, B. (1974). Anaemia and physical work capacity. *Clin. Hematol.* **3**: 609-626.

Wolegmuth, J.C., Latham, M.C., Hall, A., Chesher, A. and Crompton, D.W.T. (1982). Workers productivity and the nutritional status of Kenyan road construction worker labourers. *American J. Clin. Nutr.,* **36**: 68-78.

World Health Organization (1968). Nutritional anaemia. *Tech. Rep. Ser.* WHO, Geneva.

World Health Organization (1972). *Nutritional anaemias.* Technical Report Series. Geneva : 503.

Address for correspondence :
M. DAS
Department of Food and Nutrition
Assam Agricultural University,
JORHAT (ASSAM) INDIA

Authors' affiliations :
B. BAROOVA
Department of Food and Nutrition
Assam Agricultural University,
JORHAT (ASSAM) INDIA