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RESEARCH ARTICLE

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Effect of iron supplementation on the productivity of adult coalmine workers of Assam

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ABSTRACT

The effect of iron supplementation (Group I and Group II receiving 60 mg and 120 mg of ferrous sulphate per day, respectively) for a period of 6 months was examined on coal mine workers of Assam. Workers productivity, haemoglobin estimation, parasitology and morbidity data were collected from 300 samples at baseline (0 days), mid intervention (90 days), final (180 days) and post final (270 days) intervention. Prevalence of anaemia was universal with a mean haemoglobin level of 9.42g/dl. 77.3% of the subjects were morbid and after supplementation there was decrease in the incidence of morbidity. Supplementations have significant impact on productivity variables and haemoglobin level. The number of days worked improved from the base line value of 18 days to 24 days in Group I and 20 to 25 days in Group II, respectively. There was also significant improvement in coalcutting performance and money earning capacity of the workers. Significant correlation was found between number of working days, haemoglobin, money earned and negative correlation with morbidity.

Key words : Anaemia, Productivity, Morbidity, Parasitic infection, Supplementation

INTRODUCTION

A reduction in work output and economic productivity is an inevitable consequence of severe nutritional deprivation in humans. For working population in developing countries, this has a greater and important economic implications because the productivity of the workers is a key to the nation's development and secondly the workers survival depends on their daily job performance. Some previous studies have found that the productivity of the workers was reduced in both iron deficiency and iron deficiency anaemia (Li, 1994). But it is not clear so far in which way this harmful effect occurs and what physiological mechanism it is. Productivity of the labour force in developing countries is generally low. This has been mainly attributed to their poor physique resulting from chronic malnutrition. Widespread malnutrition thus cripples the nation's productivity (Devdas, 1988). The present study was planned to assess whether anaemia among workers affected their productivity and their resistance to infection and to find out whether iron supplementation could diminish iron deficiency anaemia and raise work out put among the workers.

MATERIALS AND METHODS

Characteristics of the population :

A total of 300 samples in the age group of 25-45 years old were selected randomly from a list of 600 samples. Out of the 300 samples 30 coal cutter were among the study population during randomization and therefore 10 coal cutters were included in each group purposively to study the impact of supplementation on the coal cutting performance and more importantly they belonged to the piece rated category of workers and were paid according to the quantum of work turned out by them everyday. Then the samples were pair matched for weight and haemoglobin and three groups were formed namely, Placebo (receiving sugar coated tablets), Group I (receiving 60mg of ferrous sulphate) and Group II (receiving 120mg ferrous sulphate) at a stretch for a period

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of 180 days. Data on various parameters like haemoglobin, weight, morbidity, productivity were collected at 0 days (baseline), 90 days (mid intervention), 180 days (final intervention) and 270 days (post final intervention).

Biochemical assessment :

Haemoglobin was estimated using the cyanmethemoglobin method (Oser, 1971). Stool analysis was done by microscopic examination of stained and unstained smear and by concentration method following the procedures outlined by Chatterjee (1981).

Morbidity profile :

Records of morbidity status of the subjects was maintained and the information on sickness during one month preceding the date of interview was elicited using a pre-tested proforma and cross checked with the hospital records.

Productivity measurements :

The productivity of the subjects was assessed in terms of number of days worked and in terms of money earned over a period of one month. For the coal cutters productivity was measured as per his coal cutting performance.

Statistical analysis :

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

RESULTS AND DISCUSSION

Prevalence of anaemia was universal (100%) using both the WHO norms of haemoglobin (13g/dl) and by using modest cut off point given by NIN (1986) for man depicting a disturbing picture among the working population of a vast labour oriented industry. The mean haemoglobin level of the subjects was 9.41+1.02g/dl. After iron supplementation, increment in haemoglobin level was observed in the supplemented groups. From Fig. 1 it was found that in Group I receiving 60mg of elemental iron, the mean increment was 2.33g/dl at mid intervention and 2.82g/dl at final intervention. However, highest increment was observed in Group II receiving 120mg of elemental iron. The increment was 2.48g/dl at mid intervention and 3.16g/dl at final intervention. Effectiveness of a continuous supplementation to achieve change in haemoglobin level was also reported by Cantodec *et al*. (1979) and Demaeyer (1989). A significant association was observed between the severity of the parasitic infection and haemoglobin level (Table 1). *Ascaris lumbricoides* was reported in 37% with a mean haemoglobin level of 9.26+0.064g/dl, *Ancylostoma duodenale* in 25% with a mean haemoglobin level of 8.30+0.102g/dl and *Trichuris trichiunia* in 7% of the subjects with a mean haemoglobin level of 9.27+0.15g/dl. The high rate of parasitic infection was due to poor personal hygiene, polluted environment and lack of proper sanitation.

Morbidity profile :

77.3% of the coalmine workers suffered from

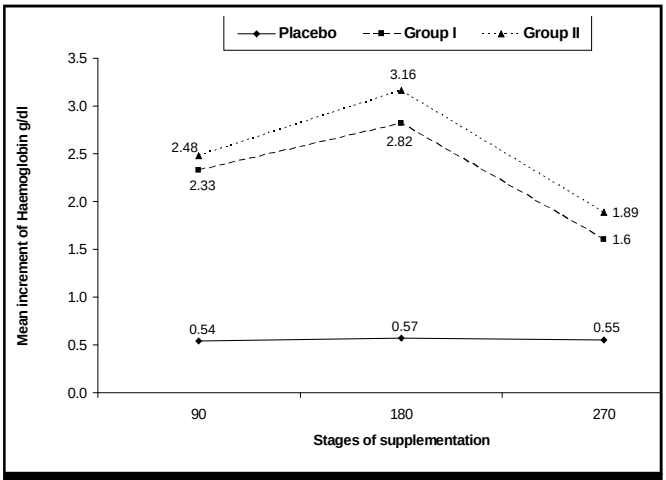

Fig. 1 : Impact of iron supplementation on the mean increment of haemoglobin level at various stage of evaluation

Table 1: Impact of parasitic infection on the haemoglobin level of the male coalmine workers

Parasitic infection	Percentage infected	Mean Hb. g/dl ± SE
Absent	31 (93)	10.44 ± 0.046
Present	69 (207)	8.96 ± 0.107
Ascaris lumbricoides (round worm)	37 (112)	9.26 ± 0.064
Ancylostoma duodenale (hook worm)	25 (76)	8.30 ± 0.102
Trichuris trichiuria (whip worm)	7 (19)	9.27 ± 0.157

Figures in parenthesis indicate the number of workers

Table 2 : Percentage prevalence of episodes of morbidity among male coalmine workers

Episodes	Morbidity present		Morbidity absent	
	Percentage	Mean Hb(g/dl)	Percentage	Mean Hb(g/dl)
Respiratory tract infection	4 (12)	9.46±0.230	96 (220)	9.40±0.061
Gastrointestinal tract infection	13.33 (40)	8.92±0.167	86.60 (192)	9.50±0.062
General morbidity	53 (159)	9.05±0.073	47 (73)	9.82±0.083
Metabolic disorder	0.33 (1)	9.14	99.67 (231)	9.42±0.059
Febrile conditions	6.67 (20)	9.71±0.166	93.33 (212)	9.39±0.062
Total morbidity	77.33 (232)	9.25±0.159	22.67 (68)	10.39±0.06

Figures in parenthesis indicate the number of workers

Table 3 : Impact of supplementation on the morbidity episodes of male coalmine workers

Groups/ Treatment	Episodes	Stages of evaluation								F value
		Baseline		Mid		Final		Post final		
		No of Morbids	Mean Hb (g/dl) ±SE	No of Morbids	Mean Hb (g/dl) ±SE	No of Morbids	Mean Hb (g/dl) ±SE	No of Morbids	Mean Hb (g/dl) ±SE	
Placebo	Absent	14 (14%)	10.46±0.108	40 (40%)	10.65±0.092	49 (49%)	10.54±0.100	47 (47%)	10.50±0.104	Within treatment
	Present	86 (86%)	9.64 ± 0.210	60 (60%)	9.47±0.240	51 (51%)	9.50±0.208	53 (53%)	9.67± 0.374	28.91**
Group I	Absent	28 (28%)	10.47±0.424	55 (55%)	12.03±0.069	81 (81%)	12.33±0.047	54 (54%)	12.22±0.041	Between
	Present	72 (72%)	9.12 ± 0.282	45 (45%)	11.63±0.239	19 (19%)	12.06±0.252	46 (46%)	10.75±0.156	the
Group II	Absent	26 (26%)	10.32±0.118	79 (79%)	12.03±0.064	88 (88%)	12.62±0.044	57 (57%)	11.56±0.042	treatment
	Present	74 (74%)	9.09± 0.266	21 (21%)	11.37±0.306	12 (12%)	12.23±0.265	43 (43%)	11.00±0.103	17.48**

Figures in parenthesis indicates percentage morbids
** indicates significance of value at P<0.01

systemic or local infection during the four weeks preceding examination. 13.33% had gastrointestinal tract infection like diarrhea, dysentery, gastritis. 53% suffered from general morbidity like back pain, weakness, lack of appetite. 6.67% had either malaria, typhoid, fever and 4% had respiratory tract infection. There was a significant relationship between morbidity pattern and haemoglobin level. The haemoglobin level was worst affected in case of gastrointestinal tract infection followed by general morbidity (Table 2).

Impact of iron supplementation was observed and there was a decreasing trend in the incidence of morbidity in all the groups. From Table 3 it was observed that in Group I (receiving 60 mg of elemental iron), the decrease in the incidence of morbidity from baseline to mid intervention was 27% and to final intervention was 53%. Similarly in Group II (receiving 120 mg of elemental iron), the decline in the incidence of morbidity from baseline to mid intervention was 53% and final intervention was 62%. The impact between treatment and within the treatment was highly significant (P<0.01). However, after withdrawal of supplementation increase in morbidity was observed.

Productivity results :

Number of days worked : Iron supplementation showed a marked improvement in the number of days worked compared to the Placebo irrespective of the dose level. Table 4 reveals that highest significant (P<0.01) impact was observed between Placebo and Group II; secondly between Placebo and Group I followed by Group I and Group II. Between different stages of intervention within the individual group, showed highest significant improvement (P<0.01) between baseline to final intervention in Group I and Group II. In Group I number of days worked improved from a baseline value of 18 days to 24 days at final intervention and from 20 days to 25 days in Group II, respectively. The results are similar to those of Rahamatullah (1983) among tea plantation workers of South India where the number of days worked improved from 21 days to 24 days at the end of the supplementation period.

Correlation analysis showed (Table 5) a high significant (r = 0.698; P<0.01) correlation between haemoglobin and number of days worked. A significant positive linear relationship (r = 0.845; P<0.01) was found between working days and money earning capacity and a significant negative correlation (r = -0.272; P<0.01) with morbidity confirming that it has a direct affect on the

Table 4 : Impact of iron supplementation on the number of days worked by 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	17±4.63	18±0.457	20±0.365	For factor		
Mid	20±0.368	22±0.322	23±0.259	treatment	0.45	0.23
Final	22±0.342	24±0.265	25±0.17	96.13** For	0.52	0.266
Post Final	21±0.352	23±0.231	24±0.156	factor time		
				149.33**		
Between treatment	Mean difference of two factors	t value	Between	Time	Mean difference of two factors	t value
Placebo Vs Group I			Placebo			
			PB Vs PM		3	10.77**
PB Vs GIB	1	4.50**	PB Vs PF		5	11.40**
PM Vs GIM	2	5.48**	PB Vs PPF		4	9.93**
PF Vs GIF	3	6.55**	PM Vs PF		2	6.57**
PPF Vs GIPF	2	7.11**	PM Vs PPF		1	2.98*
			PF Vs PPF		1	2.99*
Group I Vs Group II			Group I			
			GIB Vs GIM		4	15.48**
GIB Vs GIIB	2	7.92**	GIB Vs GIF		6	16.79**
GIM Vs GIIM	1	10.00**	GIB Vs GIPF		5	15.24**
GIF Vs GIIF	1	6.63**	GIM Vs GIF		2	10.58**
GIPF Vs GIIPF	1	9.63**	GIM Vs GIPF		1	8.68**
			GIF Vs GIPF		1	2.99*
Placebo Vs Group II			Group II			
			GIIB Vs GIIM		3	14.80**
PB Vs GIIB	3	4.43**	GIIB Vs GIIF		5	18.95**
PM Vs GIIM	3	6.15**	GIIB Vs GIIPF		4	14.34**
PF Vs GIIF	3	10.98**	GIIM Vs GIIF		2	12.91**
PPF Vs GIIPF	3	4.10**	GIIM Vs GIIPF		1	5.80**
			GIIF Vs GIIPF		1	8.93**

* Significant at P < 0.05
** Significant at P < 0.01

absenteeism of the workers.

Simple linear regression analysis (Table 6) revealed that 71.3% of the total variability on the number of days worked was explained by the money earning capacity, haemoglobin accounted 48.7% of the variability and morbidity could explain 7.4% of the variation.

Money earning capacity :

Comparison of productivity increments in terms of money earned is presented in Table 7. Differences in amount of money earned were observed in all the groups. Highest significant increment was observed between Placebo and Group II, secondly between Group I and Group II followed by Placebo and Group I. Between different stages of intervention within the same group revealed that highest increment (P<0.01) was observed between baseline to final intervention in both Group I and Group II. A similar trend was also observed in the Placebo group but the gross amount was less compared to Group I and Group II.

Correlation studies (Table 8) revealed that money earning capacity was significantly correlated (r = 0.845; P<0.01) with the number of days worked. Morbidity also had a significant negative correlation (r = 0.288; P<0.01) with income explaining the fact that increase in morbidity would result in decreased productivity translating that a high level of haemoglobin would reflect better work performance among the workers at a lesser energy cost.

Linear regression (Table 9) revealed that 71.3% of variability on the money earning capacity was explained by the number of days worked, haemoglobin accounted 55% of the variation and morbidity another 8.3% of the variability. Similar correlation was found between haemoglobin concentration and productivity among Indonesian rubber tapers (Basta *et al.,* 1979) and tea plantation workers.

Table 5 : Correlation between number of working days and haemoglobin, weight, morbidity and money earning capacity

Variables	Correlation with number of days worked (r value)
Haemoglobin	0.698**
Weight	0.100NS
Morbidity	-0.272**
Money earning capacity	0.845**

** Significant at P < 0.01
NS Not significant

Table 6 : Simple linear regression of different variables on the number of days worked by the male coalmine workers

Independent variables	Intercept	Regression co-efficient	Co-efficient of determination (%)
Haemoglobin	10.24**	3.01**	48.7
	(1.69)	(0.17)	
Weight	15.12**	0.05NS	1.0
	(1.75)	(0.03)	
Morbidity	20.03**	-0.84**	7.4
	(0.46)	(0.17)	
Money earning capacity	8.26**	0.002**	71.3
	(0.38)	(0.001)	

Figures within parenthesis indicate SE
* Significant at P < 0.05
** Significant at P < 0.01
NS Not significant

Coal cutting performance :

Highest improvement in coal cutting performance was observed (Table 10) in Group II followed by Group I. Supplementation impact between different treatments showed that impact was highly significant (P < 0.05)

Table 7 : Impact of iron supplementation in terms of money earning capacity by the male coalmine workers

Stages of evaluation	Treatment Mean ± SE			F value	C.D (5%)	S Ed.
	Placebo	Group I	Group II			
Baseline	2968.00 ±12.19	3293.40 ±131.12	3749.80 ±115.17	For factor treatment		
Mid	3526.00 ±106.00	3913.00 ±111.9	4433.10 ±100	77.47** For	148.41	75.64
Final	3748.00 ±105.24	4291.00 ±102.5	4828.00 ±87.55	factor time		
Post Final	3769.00 ±83.49	4153.00 ±101.27	4659.00 ±83.49	46.64**	171.3	87.34
Between treatment	Mean difference of two factors	t value	Between	Time	Mean difference of two factors	t value
Placebo Vs Group I			Placebo			
			PB Vs PM		558.00	8.50**
PB Vs GIB	325.40	3.71**	PB Vs PF		780.60	9.50**
PM Vs GIM	387.40	4.60**	PB Vs PPF		801.00	8.51**
PF Vs GIF	543.00	6.04**	PM Vs PF		222.60	5.91**
PPF Vs GIPF	384.00	5.56**	PM Vs PPF		243.00	2.81*
			PF Vs PPF		20.40	1.77NS
Group I Vs Group II			Group I			
			GIB Vs GIM		620.00	11.51**
GIB Vs GIIB	456.40	7.86**	GIB Vs GIF		998.00	16.70**
GIM Vs GIIM	519.70	9.37**	GIB Vs GIPF		860.00	12.76**
GIF Vs GIIF	536.00	7.51**	GIM Vs GIF		378.00	10.60**
GIPF Vs GIIPF	506.00	9.61**	GIM Vs GIPF		240.00	5.27**
			GIF Vs GIPF		138.00	4.10**
Placebo Vs Group II			Group II			
			GIIB Vs GIIM		683.30	12.54**
PB Vs GIIB	781.80	5.98**	GIIB Vs GIIF		1078.20	16.75**
PM Vs GIIM	907.10	6.67**	GIIB Vs GIIPF		909.20	13.14**
PF Vs GIIF	1079.40	10.74**	GIIM Vs GIIF		394.90	11.82**
PPF Vs GIIPF	890.00	6.36**	GIIM Vs GIIPF		226.00	5.04**
			GIIF Vs GIIPF		169.00	4.86**

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS Not significant

Table 8 : Correlation between money earning capcity and haemoglobin, weight, morbidity and number of working days

Variables	Correlation with number of working days (r value)
Haemoglobin	0.742**
Weight	0.126*
Morbidity	-0.288**
Money earning capacity	0.845**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 9 : Simple linear regression of different variables on the money earning capacity by the male coalmine workers

Independent variables	Intercept	Regression co-efficient	Co-efficient of determination (%)
Haemoglobin	5270**	913**	55
	(453.4)	(47.8)	
Weight	2260**	19.68*	1.6
	(498.0)	(9.01)	
Morbidity	3910**	-255**	8.3
	(130.8)	(49.2)	
Money earning capacity	1035**	241.0**	71.3
	(165.2)	(8.85)	

* and ** indicate significance of values at P=0.05 and 0.01, respectively

between Placebo and Group II, followed by Placebo and Group I. But between Group I and Group II, no significant difference was observed. However, between different stages of intervention within the group revealed that in Group I highest significant ($P < 0.01$) improvement in coal cutting performance was observed between baseline to final intervention followed by baseline to mid intervention. Similar trend was also observed in Group II. The coal cutting performance increased from a baseline value of 191 cft to 607 cft in final intervention in Group I and from 243 cft to 614 cft in Group II, respectively. At the same

Table 10 : Impact of iron supplementation of the coal cutting perfromance of the coal cutters

Stages of evaluation	Treatment Mean ± SE			F value	C.D (P=0.05)	S.E.±
	Placebo	Group I	Group II			
Baseline	120 cft ±16.6	191 cft ±34.37	243 cft ±60.52	For factor		
Mid	228 cft ±21.7	475 cft ±84.10	455 cft ±89.07	treatment 11.54**	97.76	49.32
Final	294 cft ±27.2	607 cft ±112.93	614 cft ±128.1	For factor time		
Post final	176 cft ±22.7	357 cft ±64.02	337 cft ±56.94	11.51**	112.88	56.95
Between treatment	Mean difference of two factors	t value	Between	Time	Mean difference of two factors	t value
Placebo Vs Group I			Placebo			
			PB Vs PM		108	2.69**
PB Vs GIB	71	2.81*	PB Vs PF		173	6.66**
PM Vs GIM	247	3.08*	PB Vs PPF		56	1.76NS
PF Vs GIF	313	2.87*	PM Vs PF		66	1.70NS
PPF Vs GIPF	181	3.11*	PM Vs PPF		52	1.40NS
			PF Vs PPF		118	9.50**
Group I Vs Group II			Group I			
			GIB Vs GIM		284	4.44*
GIB Vs GIIB	52	0.82NS	GIB Vs GIF		416	4.60**
GIM Vs GIIM	20	0.27NS	GIB Vs GIPF		166	4.49**
GIF Vs GIIF	7	0.06NS	GIM Vs GIF		132	3.13**
GIPF Vs GIIPF	20	0.28NS	GIM Vs GIPF		118	2.66**
			GIF Vs GIPF		250	3.49*
Placebo Vs Group II			Group II			
			GIIB Vs GIIM		212	5.01**
PB Vs GIIB	123	2.94*	GIIB Vs GIIF		371	4.90**
PM Vs GIIM	227	2.44*	GIIB Vs GIIPF		94	2.51*
PF Vs GIIF	320	2.32*	GIIM Vs GIIF		159	2.72*
PPF Vs GIIPF	161	2.70*	GIIM Vs GIIPF		118	2.80*
			GIIF Vs GIIPF		277	3.39*

* and ** indicate significance of values at P=0.05 and 0.01, respectively NS Not significant

time there was gradual and significant ($P < 0.01$) improvement in the amount of money earned from their coal cutting performance. However after withdrawal of supplementation there was decrease in the coal cutting performance as well as the amount of money earned.

Conclusion:

The study of rubber plantation workers by Basta *et al.* (1979) and tea plantation workers by Edgerton *et al.* (1979) could correlate the results of the work performed with the degree of anaemia. The data reported here supports the concept that work productivity may be improved in subjects suffering from iron deficiency anaemia treated with oral iron supplementation. The overall mean increase in the number of days worked, amount of money earned and the amount of coal cut could be attributed to iron treatment. The increase was quite impressive considering the fact that the mean haemoglobin concentration of the subjects was 9.48g/dl. The subjects with lower haemoglobin concentration seem to have experienced the greatest increase in productivity. The data presented in Fig. 1 support our conclusion that increase in the haemoglobin concentration improves work output. Although it cannot be ruled out that work productivity was not affected by some non-haemoglobin factors.

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