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A positive effect of iron supplementation on the IQS of iron deficient children

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Summary—To examine possible effects of iron supplementation on the intelligence of young adolescents, iron supplements and placebos were given daily for 16 weeks to two matched groups of 208 and 205 12–15-year-olds. Iron status before the trial began was assessed by the measurement of serum ferritin and haemoglobin levels. In the sample considered as a whole, the iron supplementation had a small but non-significant effect on IQ, but those who were iron deficient, with serum ferritin levels of 12 ng/ml and below, showed a statistically significant IQ gain of 5.8 IQ points, as compared with a matched control group given placebos. © 1998 Published by Elsevier Science Ltd

INTRODUCTION

During the last decade there have been several reports of improvements in children's intelligence following the taking of nutritional supplements (Benton and Roberts, 1988; Benton and Cook, 1991; Schoenthaler *et al.*, 1991). The research literature on this issue has recently been reviewed by Eysenck and Schoenthaler (1997). Crombie *et al.* (1990) report a negative result but as their methodology differed from that of the studies reporting positive results, their findings are not strongly damaging to the positive studies. It is considered, therefore, that the positive studies are sufficiently promising to warrant further investigation.

We believe that the design of the existing studies could be improved in two regards. Firstly, the supplements used have generally contained approximately 25 vitamins and minerals. Probably only a few of these are responsible for the intelligence rises, but there is no way of telling which these are. The only way of determining this is to test each of the constituents in turn. We considered that one of those most likely to have a positive effect is iron. Iron deficiency produces anaemia which is generally debilitating and likely to impair mental functioning and cause a reduction in intelligence. Research literature on the adverse effects of iron deficiency on psychological functioning has been reviewed by Fordy and Benton (1994), who report a study in which they found no association between low ferritin levels and digit span and reaction times. This can be regarded as a discouraging result. Nevertheless, we considered it worthwhile to carry out a study of the possible effect of iron supplementation on intelligence measured by a non-verbal reasoning test (the Standard Progressive Matrices).

A second respect in which the existing studies could be usefully improved is by examining the possible effects of nutritional supplements on those who are nutritionally deficient. It seems probable that only these will show any improvement in intelligence following nutritional supplementation, whereas those whose nutrition is adequate will show no improvement. In order to investigate this possibility, some method has to be found for identifying those with sub-optimal nutrition and investigating the effects of nutritional supplementation on these as a separate sub-group. We deal with this problem in the study to be reported.

METHOD

The initial target sample consisted of all 12–16-year-olds attending seven comprehensive schools in a city in north east England. The sample number comprised approximately 600 young people. Of these, complete information was obtained for 413. The mean age of the sample was 13.1 years and there were approximately equal numbers of boys and girls. The sample was first tested for intelligence by Raven's Standard Progressive Matrices, a well known test of non-verbal reasoning. They were also assessed for iron status. Blood samples were taken in the morning after overnight fasting and these were assessed for levels of haemoglobin and serum ferritin (a measure of iron stores) by radioactive immunoassay.

The sample was then divided into two groups matched for age, IQ and sex. One group was given iron supplement tablets containing 17 mg elemental iron with 70 mg ascorbic acid and a starch excipient (iron can only be absorbed when it is taken in conjunction with ascorbic acid). The tablets were taken daily for 16 weeks, under the supervision of teachers and parents. The second (control) group was given placebo tablets of identical appearance. The tablets were identified by codes known only to the manufacturer and not broken until the end of the trial.

Following the end of the trail, the sample was retested with the Progressive Matrices. Raw scores on the Matrices were transformed to age-standardised percentiles from the test manual (Raven, Court and Raven, 1983) and percentiles were transformed to IQs.

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RESULTS

Descriptive statistics for the sample in respect of iron status measured by haemoglobin and ferritin levels are shown in Table 1. The salient points of the results are that 2.9% of the sample had haemoglobin levels below normal (12 g/dl) and 16.9% had serum ferritin levels below normal (12 ng/ml). A further 34.9% had moderate levels of serum ferritin (12.1–20 ng/ml). There was a statistically significant association between haemoglobin level and initial IQs ($r = 0.17$, $P = 0.01$) but not between ferritin level and IQ.

We now consider the question of whether the subjects taking iron supplements showed any rise in IQ as compared with those taking placebos. This question is analysed in two stages, first for the sample as a whole, and secondly for the sample subdivided into those with low, moderate and high iron status. The results for the sample considered as a whole are shown in Table 2. This shows that the sub-samples taking the placebo and the iron supplement were very closely matched for initial levels of haemoglobin and ferritin and IQ. The two groups show a slight difference in the apparent response of the IQs to the treatments. The placebo group shows a non-significant decline of IQ of 0.45 IQ points, while the supplement group shows a non-significant increase of IQ of 1.11 IQ points. The difference between the two groups is not statistically significant ($t = 1.51$).

We now consider whether there was any rise in the IQs of those who were initially low in iron. For this purpose, both the iron supplement and the placebo groups were divided into three subgroups consisting of those with low, moderate and high ferritin levels. The criteria adopted for these three groups were that those with ferritin levels of 12 ng/ml and below were allocated to the low groups, those with ferritin levels between 12–20 ng/ml were allocated to the moderate groups and those with ferritin levels above 20 ng/ml were allocated to the high groups. The results analysed in this way are shown in Table 3. Looking first at the groups with low ferritin levels, we see that the placebo group lost 2.71 IQ points, while the iron supplementation group gained 3.07 IQ points. The difference between the two groups is 5.78 IQ points and is statistically

Table 1. Distributions of serum ferritin (ng/ml) and haemoglobin (g/dl) levels

Ferritin	Frequency	%	Haemoglobin	Frequency	%
0–5	4	1.0	0–12	12	2.9
5.1–12	66	15.9	12.1–13	112	27.0
12.1–20	145	34.9	13.1–14	190	45.8
20.1–30	107	25.8	14.1–15	80	19.3
30.1–40	60	14.5	15.1–16	21	5.6
40.1+	33	7.9			

Table 2. Pre-trial and post-trial means for iron supplementation and placebo groups

Variables	Iron Supplement	Placebo
Number	208	205
Age	13.11 (1.06)	13.10 (1.06)
Ferritin	22.52 (13.08)	22.52 (12.17)
Haemoglobin	13.46 (0.90)	13.52 (0.88)
Initial IQ	96.91 (11.74)	96.61 (10.74)
Final IQ	98.02 (12.68)	96.16 (11.18)
IQ rise	1.11	−0.45

Table 3. Data for supplementation and control groups divided into low, moderate and high iron status groups

Variables	Low iron	Moderate iron	High iron
Supplementation			
Number	42	67	99
Ferritin	9.04 (2.17)	15.66 (2.26)	32.75 (11.59)
Haemoglobin	13.13 (0.88)	13.37 (0.78)	13.65 (0.94)
Initial IQ	94.64 (11.26)	97.39 (12.08)	97.55 (11.71)
Final IQ	97.71 (11.97)	95.24 (12.51)	100.03 (12.84)
IQ rise	3.07 (11.64)	−2.15 (9.16)	2.48 (11.22)
Placebo			
Number	28	77	100
Ferritin	8.88 (2.14)	15.82 (2.23)	31.45 (11.56)
Haemoglobin	13.07 (1.22)	13.58 (0.73)	13.59 (0.85)
Initial IQ	96.67 (9.87)	95.22 (9.98)	97.66 (11.49)
Final IQ	93.96 (9.09)	95.86 (11.02)	97.01 (11.01)
IQ rise	−2.71 (7.25)	0.64 (10.72)	−0.65 (10.26)

significant ($t = 2.34$, $P = 0.02$). Looking next at the moderate ferritin level groups, we see that the placebo group showed a negligible rise of 0.64 IQ points while the supplementation group showed a fall of 2.15 IQ points. The difference between these two groups is not statistically significant ($t = 1.66$). Finally, looking at the high ferritin level groups, we see that the placebo group showed a fall of 0.65 IQ points while the supplementation group showed a rise of 2.48 IQ points. This difference is statistically significant ($t = 2.06$, $P = 0.05$). The results for the moderate and high ferritin level groups are paradoxical in so far as the supplementation group with moderate ferritin level showed no IQ rise, while the group with high ferritin level showed an IQ rise. These should probably be regarded as chance fluctuations. One way of treating this anomaly is to combine the two groups. When this is done, the combined supplementation group shows a gain of 0.70 IQ points as compared with the placebo group. This is negligible and not statistically significant ($t = 0.62$).

DISCUSSION

The results contain six points of interest:

(1) 16.9% of this sample of 12–16-year-olds had ferritin levels of 12 ng/ml and below and would consequently be considered deficient in iron stores.
(2) This group showed a statistically significant gain of 5.78 IQ points following 16 weeks of iron supplementation, as compared with a matched control group taking placebos.
(3) The remaining 72.1% of the sample showed no benefit from taking iron supplements, gaining only a negligible 0.7 IQ points as compared with the placebo group.
(4) It appears therefore that the IQ rises hitherto reported as a result of taking omnibus nutritional supplements are partly due to the improvement of iron stores.
(5) Only a minority of young adolescents who are deficient in iron stores show any improvement in intelligence as a result of taking iron supplements.
(6) The critical level of ferritin below which intelligence is impaired and which responds to iron supplementation appears to be around 12 ng/ml. This is suggested by the results shown in Table 3 that the 12.1–20 ng/ml group showed no intelligence gain following iron supplementation.

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