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SHORT RESEARCH ARTICLE

Impact of iron levels on cognitive functioning among dental students of Udaipur, Rajasthan (India) [version 1; peer review: 1 approved, 1 approved with reservations, 1 not approved]

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V1 First published: 21 Nov 2012, 1:54
<https://doi.org/10.12688/f1000research.1-54.v1>
 Latest published: 21 Nov 2012, 1:54
<https://doi.org/10.12688/f1000research.1-54.v1>

Abstract

Health and intelligence are two closely related aspects of human well being. Nutrition, including iron levels, affects cognitive function and thereby may influence the occupational performance of an individual. Inadequate nutrition during adulthood may lead to decreased work efficiency, poor exercise tolerance and increased susceptibility to infections. The profession of dentistry requires keen recognizing abilities and decision making skills as well as ample physical stamina, which may be impaired in a state of malnourishment. Keeping this in view, this study was designed to assess the possible impact of iron levels on cognitive function among dental students. In this study 206 dental students (150 females and 56 males) participated and their cognitive functioning was determined by answering a questionnaire. The questionnaire evaluated the confidence level, work pattern and the tendency to be distracted by the physical environment of the study participants. Iron status was determined by estimating the hemoglobin level of the individuals. Each of the three cognitive traits was correlated with hemoglobin levels. The results revealed that that majority of dental students had good levels of confidence, work patterns with a low level of restriction and low levels of distraction by the physical environment. No significant correlations were found between any of the cognitive parameters and hemoglobin levels ($p > 0.05$) in female participants. In male participants significant correlations were found in two out of three cognitive functioning tests, confidence levels and work pattern ($p < 0.05$). The results of this study suggest that these three cognitive functions may not be influenced by hemoglobin levels in females and may be slightly or, due to the small male sample size which may have confounded the results, not influenced by hemoglobin in males.

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Any reports and responses or comments on the article can be found at the end of the article.

Keywords

nutrition, brain function

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Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

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How to cite this article: Sareen M, Sareen R, Khajuria S and Roy S. **Impact of iron levels on cognitive functioning among dental students of Udaipur, Rajasthan (India) [version 1; peer review: 1 approved, 1 approved with reservations, 1 not approved]** F1000Research 2012, 1:54 <https://doi.org/10.12688/f1000research.1-54.v1>

First published: 21 Nov 2012, 1:54 <https://doi.org/10.12688/f1000research.1-54.v1>

Impact of iron levels on cognitive functioning among dental students of Udaipur, Rajasthan (India) [v1; ref status: awaiting peer review, <http://f1000r.es/T4aiJR>]

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v1 First published: 16 November 2012, 1:54 (doi: 10.3410/f1000research.1-54.v1)

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How to cite this article: Sareen M, Sareen R, Khajuria S *et al.* (2012) Impact of iron levels on cognitive functioning among dental students of Udaipur, Rajasthan (India) [v1; ref status: awaiting peer review, <http://f1000r.es/T4aiJR>] *F1000Research* 1-54 (doi: 10.3410/f1000research.1-54.v1)

ABSTRACT Health and intelligence are two closely related aspects of human well being. Nutrition, including iron levels, affects cognitive function and thereby may influence the occupational performance of an individual. Inadequate nutrition during adulthood may lead to decreased work efficiency, poor exercise tolerance and increased susceptibility to infections. The profession of dentistry requires keen recognizing abilities and decision making skills as well as ample physical stamina, which may be impaired in a state of malnourishment. Keeping this in view, this study was designed to assess the possible impact of iron levels on cognitive function among dental students. In this study 206 dental students (150 females and 56 males) participated and their cognitive functioning was determined by answering questionnaires. The questionnaire evaluated the confidence level, work pattern and the tendency to be distracted by the physical environment of the study participants. Iron status was determined by estimating the haemoglobin level of the individuals. Each of the three cognitive traits was correlated with haemoglobin levels. The results revealed that that majority of dental students had good levels of confidence, work patterns with a low level of restriction and low levels of distraction by the physical environment. No significant correlations were found between any of the cognitive parameters and haemoglobin levels (p value >0.05) in female participants. In male participants significant correlations were found in two out of three cognitive functioning tests, confidence levels and work pattern ($p<0.05$). The results of this study suggest that these three cognitive functions may not be influenced by haemoglobin levels in females and may be slightly or, due to the small male sample size which may have confounded the results, not influenced by haemoglobin in males.

Introduction

Nutrition is a fundamental pillar of human life¹. The influence of nutrition on cognitive functioning may in turn influence the occupational performance of an individual^{1,2}. Several studies in this regard have been done among growing children³⁻¹¹. For instance in a study conducted by Gabr M. Sayed *et al* to assess the magnitude of malnutrition among pre-school and primary school children and its impact on health, intellectual development and

scholastic achievement the results yielded a positive correlation between nutritional status and intellectual development as well as scholastic achievement⁴.

One partially accepted theory is that malnutrition is associated with low iron levels and that anaemia, via cerebral hypoxia and other possible mechanisms, has a major negative influence on cognitive function¹. But nutritional deficiencies and their

adverse outcomes are not age limited. Inadequate nutrition during adulthood may lead to decreased work efficiency, poor exercise tolerance and increased susceptibility to infection².

Studies related to the impact of hemoglobin levels on mental functioning in adult populations are few and the outcomes are inconclusive^{12,13}. Keeping this in view, the present study was designed to assess the possible impact of iron nutritional status on cognitive functioning among dental students between the ages of 18–25 years as the profession of dentistry requires keen recognizing abilities, decision making skills as well as ample physical stamina, which may be impaired by low iron/hemoglobin levels thereby influencing one's ability to be a successful dentist.

Materials and methodology

A total of 206 students, 150 (73%) females and 56 (27%) males studying dentistry at Udaipur, Rajasthan, India, volunteered for the study. The brain functioning of the individuals was determined by answering a questionnaire.

The questionnaire was adapted from the Inventory of Barriers to Creative Thought and Innovative Action¹⁴. This test identified and measured the degree of inhibitors affecting a person's ability to create and innovate. The questionnaire consisted of thirty-six items, set up in a sixpoint Likert-scale format. This test identifies and measures barriers in six different categories. Out of these six traits the scores identifying barriers related to 'need for conformity', 'ability to abstract' and 'ability to use systematic analysis' were not considered. Only scores of three traits were included which consisted of barriers related to self confidence, task achievement and ease of distraction by the physical environment. Each trait was graded according to the scores obtained and a grading system was introduced to classify each trait into different categories (Tables 1, 2 and 3).

Questionnaire: Adapted inventory of barriers to creative thought and innovated action

1 Questionnaire

<http://dx.doi.org/10.6084/m9.figshare.97572>

Table 1 Questionnaire scoring and grading system used to determine confidence level.

Score	Grade	Inference
31–36	1	Total Lack Of Confidence
25–30	2	Less Confident
19–24	3	Somewhat Confident
13–18	4	Confident
Less than 13	5	Highly confident

Table 2 Questionnaire scoring and grading system used to determine work pattern.

Score	Grade	Inference
31–36	1	Highly Restricted
25–30	2	Restricted
19–24	3	Somewhat Restricted
13–18	4	Less Restricted
6–12 (Less than 13)	5	Non Restricted

Table 3 Questionnaire scoring and grading system to determine physical distraction.

Score	Grade	Inference
31–36	1	Highly Distracted
25–30	2	Distracted
19–24	3	Somewhat Distracted
13–18	4	Less Distracted
Less than 13	5	Not At All Distracted

The second stage in the study involved estimation of haemoglobin levels of the individuals. The haemoglobin level was determined by Sahli's method. In this method the fingertip was first sterilized using rectified spirit. A quick prick was made to get a moderately large drop of blood. The blood was aspirated in the haemoglobin pipette up to the 20 cubic millimeter mark. The blood was immediately transferred into the hydrochloric acid taken in the diluting tube. The acid and blood was mixed and kept undisturbed for 10 minutes, to ensure that the haemoglobin was converted to acid haematin. After 10 minutes, the contents were diluted by adding distilled water drop by drop and mixing the contents after each drop with the stirrer, till the colour matches with the colour of the standard. Then the reading was taken both in grams and percentages by noting the lower meniscus.

Results

The mean haemoglobin level of female participants was 10.4gm/dL and that of male participants was found to be 11.6gm/dL. Considering the normal range of haemoglobin is 12–14g/dL for females and 14–16g/dL for males, only 8% females (n=13) had haemoglobin within the normal range and none of the male participants (n=0) had haemoglobin level over 14g/dL.

The outcome of the cognitive functioning tests revealed that no study participant scored grade 1 in any of the categories, and the greatest proportion of participants scored grade 4 in all three categories indicating good level of confidence, less restricted work patterns and lower amounts of physical distraction respectively. 47% females and 57% males belonged to grade 4 in confidence level, 61% females and 53% males belonged to grade 4 in work pattern and 50% females and 57% males belonged to grade 4 in physical distraction [Table 4, 5 and 6].

Table 4 Number of individuals and mean hemoglobin levels in each confidence level grade.

Grade	Female			Male		
	Average of Hbg/dL	n	n%	Average of Hbg/dL	n	n%
2	10.60	12	8%	11.65	4	7%
3	10.48	52	35%	11.39	17	30%
4	10.40	71	47%	11.83	32	57%
5	10.11	15	10%	12.07	3	6%
Total	10.42	150		11.70	56	

Table 5 Number of individuals and mean hemoglobin levels in each work pattern grade.

Grade	Female			Male		
	Average Hbg/dL	n	n%	Average Hbg/dL	n	n%
2				10.60	1	2%
3	10.21	32	22%	11.31	14	25%
4	10.46	92	61%	11.89	30	53%
5	10.53	26	17%	11.77	11	20%
Total	10.42	150		11.70	56	

Table 6 Number of individuals and mean hemoglobin levels for each physical distraction grade.

Grade	Female			Male		
	Average of Hbg/dL	n	n%	Average of Hbg/dL	n	n%
2				11.90	2	4%
3	10.33	38	25%	10.76	17	30%
4	10.36	75	50%	10.77	32	57%
5	10.63	37	25%	10.71	5	9%
Total	10.42	150		11.70	56	

Table 7 Correlation coefficients between haemoglobin levels and each of the three mental functioning categories in males and females.

Coefficient of correlation (r)	Confidence level	Work pattern	Physical distraction
Female (r)	-0.11	0.10	0.10
	NS	NS	NS
Male (r)	0.20	0.25	-0.09
P Value	<0.05 (S)	<0.05 (S)	NS

NS-Not significant, S-Significant

A significant positive correlation between was revealed between haemoglobin levels and both confidence levels and work pattern restrictiveness in males ($r=0.20$ and 0.25 respectively). However, no significant correlation was found between haemoglobin levels and distraction in males and haemoglobin levels did not significantly correlate with any of these three parameters in females ($r=-0.11$, 0.10 and 0.10 for confidence levels, work pattern restrictiveness and ease of distraction by the physical environment respectively) [Table 7].

Test scores for each cognitive trait and haemoglobin levels of study participants

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.97571>

Grades for each cognitive trait and haemoglobin levels of study participants

1 Data File

<http://dx.doi.org/10.6084/m9.figshare.97570>

Discussion

The present study revealed that the correlations of all the cognitive function tests with haemoglobin levels in male participants were found to be positive. This could be explained by the fact that the number of male participants compared with the number of female participants was far less. Out of the 206 study participants 150 (73%) were females and 56 (27%) were males. This could be a reason for getting such correlations in male participants as the smaller number of male participants might have affected the statistical analysis.

Further the results of the study reflected a few limitations of the present study.

First as the evaluation of the cognitive function was determined by using questionnaire, the chances of getting exact results were diminished. The chances of giving fake answers by the study participants, particularly by the male participants who had a chauvinistic approach in answering questions evaluating confidence level and work efficiency could have attributed to such results.

Secondly the assessment of nutritional status was done by evaluating only the haemoglobin level of study participants, which had its own limitations. For the assessment of haemoglobin level Sahli's method was used. This method is not highly sensitive^{15,16} and resulted in errors in determining the exact values of haemoglobin levels of individuals in the present study.

Conclusion

The results of the study revealed that iron levels appears to have less of an impact on cognitive functioning in adult female participants than it does in adult male participants, though the smaller male sample size may have contributed to a false

positive result in males. These results may be due, in part, to limitations with the study. As such we recommend further studies in this regard.

Author contributions

Mohit Sareen wrote the article and carried out research. Ra-teesh Sareen contributed to the design of study. Sarang Khajuria contributed in conception of study and revised the article

for intellectual content. Sayak Roy contributed to the data analysis.

Competing interests

No competing interests were disclosed.

Grant information

The authors declared that no grants were involved in supporting this work.

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Current Peer Review Status:

Version 1

Reviewer Report 02 May 2014

<https://doi.org/10.5256/f1000research.224.r4633>

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Huguette Turgeon

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In my opinion, the title is misleading because iron levels are not measured in this study, only hemoglobin levels. The summary does reflect the content of the article. However, the introduction needs to be revised. Firstly, it is mentioned that malnutrition is associated with low iron levels and that anaemia, via cerebral hypoxia and other possible mechanisms, has a major negative influence on cognitive function. Malnutrition is not always associated with low iron levels as it depends on what nutrients are missing in the diet. Also, anemia (low hemoglobin levels) is not always caused by a low iron status. Considering that only hemoglobin levels are measured, I suggest approaching the introduction from this angle. Materials and methodology have been correctly explained and correspond with the topic being studied. However, the precision of the Sahli's method of measuring hemoglobin compared to the hemiglobincyanide or cyanmethemoglobin method should be mentioned, as well as the statistical software and correlation coefficients used. Concerning the discussion and conclusion, I don't think that the smaller number of male participants explains why positive results were observed in male participants only. Factors related to women's physiology such as the moment of the menstrual cycle is an important factor affecting cognitive functioning and this should be brought up here. In my opinion, we can't explain the absence of significant relationships in female participants saying that male participants reached statistical significances because there were a smaller number of them. The discussion and conclusion need to be revised.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 02 December 2013

<https://doi.org/10.5256/f1000research.224.r2242>

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- The title is appropriate for the content of the article and the abstract gives a suitable summary of the investigation.
- The design, methods and analysis of the results from the study have been correctly explained and correspond with the topic being studied.
- The conclusions are in accordance with the results obtained from the study.
- The authors have provided enough information to be able to replicate the experiment.
- The format/structure of the article are adequate.

Competing Interests: No competing interests were disclosed.

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 17 September 2013

<https://doi.org/10.5256/f1000research.224.r1842>

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Gerald Keusch

Boston University, Boston, USA

The title is misleading because iron levels are not measured in this study. The summary does reflect the content of the article. However, there are serious concerns about the validity of even the limited findings related to cognition and iron status in Indian dental students. First of all, dental students as a population reflect a group of academic attainers, who have distinguished themselves sufficiently to be admitted to dental school. This is a skewed and privileged cohort to begin with, who are likely to have come from economically stable families and are less likely to have suffered from significant malnutrition earlier in life. Second, early nutritional insults affecting

cognitive development can be overcome with nutritional and educational interventions, and this cohort is likely to have benefitted from these inputs. Third, the hemoglobin levels as reported (means without standard deviations) are mostly in the low normal range, with the lowest reported hemoglobin (8 Gm/DL) in 5 females who would be labelled moderately anemic. The lowest hemoglobin a male was 9.7 Gm/DL, and would not likely be symptomatic except with considerable physical stress. Fifth, the authors themselves do not have confidence in the accuracy of the methodology to assess hemoglobin. Sixth, iron levels are not in fact measured, just hemoglobin. While iron deficiency in menstruating females can explain the lower hemoglobin levels compared to males, there are many other causes of mild-moderate anemia which have not been assessed. Finally, the testing of cognitive function was by questionnaire rather than more rigorous assessment tools. It is for these reasons that I judge the work to be irrelevant to any evaluation of the relationship between iron levels and cognitive function in Indian dental students.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

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