

Original Article

A Study of Correlation Between Hemoglobin Level and Cognitive Function in Children from Rural Area Staying in Residential School

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Abstract

Objectives: Poor performance in the academic activities is common in children of low socioeconomic background. The following study was conducted to see the effect of nutrition by measuring their hemoglobin on cognitive function.

Methods: 60 children between 9 to 12 years of age residing in the residential school were included in study. Their hemoglobin measured by Sahli's method. The cognitive functions were assessed by

A. Reaction time - Visual reaction time -simple and choice (choice-simple), Whole body reaction time - simple and choice (C1).

B. MMSE Score

Results: The study showed a highly significant negative correlation between hemoglobin and various reaction times (SWBRT $r = -0.617$, $p = 0.000^{**}$), (CWBRT $r = -0.530$, $p = 0.000^{**}$).

Conclusion: Our study showed positive correlation between hemoglobin % and cognitive function in children. This study confirms the hypothesis that nutrition has a positive effect on cognitive function.

Key words: Reaction time, MMSE Score, cognitive function, hemoglobin

Introduction

Hemoglobin (Hb) is a protein in red blood cells that moves oxygen and carbon dioxide between the lungs and body tissues. It is responsible for the metabolism of all the cells of the body. Decreased Hb leads to

reduced oxygen carrying capacity of blood leading to anemia. India is among the countries with highest prevalence of anemia in the world. The prevalence of anemia is very commonly seen in school children (1). Approximately 600 million preschool and schoolage children are anemic worldwide. It is estimated that half of these cases are due to a lack of iron. In India, the prevalence of anemia is high because of

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* Low dietary intake, poor iron (less than 20 mg/day) and folic acid intake (less than 70 µg/day);

- * Poor bio-availability of iron (3-4 percent only) in phytate fiber-rich Indian diet; and
- * Chronic blood loss due to infection such as malaria and hookworm infestations.

Cognitive function can be defined as the person's capacity to acquire and use information to adapt to environmental demands and the process involves many skills including attention, creativity, memory, perception, problem solving, thinking, and the use of language (2). Cognitive function can be studied by various test types like application of standard mini mental status examination (MMSE) test and comparative performance in the previous annual examination in languages and mathematics can be an indicator of their mental ability (3). We can study cognitive function by using simple and choice visual reaction time (SVRT and CVRT) and whole body reaction time (SWBRT and WBRT) using the instrument with chronoscope. The difference between the simple and choice time indicates cognitive ability (4).

Iron deficiency is also responsible for its effect on cognitive function and psychomotor behavior even before anemia is observed even though the exact mechanisms is not yet clear (5). Various studies shown that there is a positive correlation between Hb% and cognitive function.

As the iron deficiency anemia is very common in India the following study was conducted to test relationship between the hemoglobin level and cognitive function in the school going children.

Material and Methods

The above study conducted in the Department of Physiology, SDMCMS&H Dharwad. The following study was designed to see the correlation between hemoglobin and cognitive functions which were measured using reaction time and MMSE score. Approval from the Institutional Ethical Committee and informed consent from the parents or guardian for participation of the children for the study were taken before the conduction of study. 60 school going

children, irrespective of sex, between 9 to 12 yrs of age were selected randomly from rural area residing in the residential school of Dharwad.

Exclusion criteria

Children who were physically handicapped, mentally retarded, have H/O Neurological disorders, Low birth weight, Color blindness were excluded from the study.

Study procedure

1. Visual reaction time

VRT in milliseconds (ms) was measured by using reaction time apparatus (ANAND AGENCIES, 1433/A, SHUKAWAR PETH, PUNE-411002)

The visual stimulus is used to determine simple reaction time and choice reaction time. The simple reaction involved the stimulus in the form of red light which glowed after a brief adjustable fore period (1.5 ms). On perceiving the stimulus (i.e., the red light) the subject was instructed to press a button with right finger. The timer starts recording just after the fore period and stops when the button is pressed. The reaction time is displayed on a led screen measured in ms.

Similarly, the choice reaction involved two stimuli-one red and another green light. Either of the two light glow randomly as controlled by operator. On perceiving the green light, the subject was asked to press the right button and if the red light was seen to glow, he is asked to press button on left.

2. Whole body reaction time

a. Simple whole body reaction time:

Here the operator manually presses on a button on the control box, which makes the LED arrow which points to the right to glow on the stimulus board. As soon as the subject perceives the red arrow pointing to the right, he/she is instructed to step on the

right stepping board with the right leg. The controller provides the operator with two different values on 2 separate LED displays - the first one called chronoscope reading 1 (C1) which we are measuring measures the time taken between the stimulus presentation (i.e. red light) and the lifting of the foot from the starting board. This reading gives the time taken for the nerve impulse transmission - the sensory recognition, the cognition and the motor impulse transmission to the lower limbs and thus the initiation of the motor response.

b. Choice whole body reaction:

Here, the operator can control the direction of stimulus. Randomly, any arrow on the screen can glow. Thus the subject is again asked to specifically concentrate on the stimulus board.

If the arrow points upwards, the subject is asked step on stepping board placed in front, if it is downward, to step on the one placed behind, if it points on the left they are asked to step on left, and similarly on right.

3. MMSE Score ⁶

The mini-mental state examination is a test done to assess the cognitive function. It contains 11 questions which assess orientation, registration, attention and calculation, recall and language. The total score is 30. Examiner ask set of questions (given in questionnaire) to the children and based on their performance score was given.

4. Hemoglobin level was assessed using Sahli’s acid hematin method.

Statistical analysis

It is a cross sectional study done to assess the correlation between hemoglobin and cognitive function of 60 residential school children. Statistical analysis was done by using SPSS software version 20. A Pearson’s correlation was used to see the

relationship between hemoglobin and cognitive function. p value <0.05 was considered as statistically significant.

Results

The present study consists of 60 residential school children. (n=60) which includes both the genders.

(Boys (n=48), girls (n=12). the results obtained were expressed as mean±SD. the age of the subject ranged from 9 to 12 years, with the mean age being 10.4±1.07.

Table I: shows the mean±SD of the parameters studied in the children which includes Hb, Visual reaction time, Whole body simple reaction time, Whole body choice reaction time, Mini mental state examination score.

Relationship among Hb, cognitive functions assessed by using visual reaction time, C1 of simple and choice whole body reaction time and MMSE score was done by using Pearson’s co-relation test.

A Pearson’s correlation shows that there is a negative correlation exists between Hb and simple and choice whole body reaction time which is statistically

TABLE I : Mean±SD of the parameters studied in the subjects (n=60).

<i>Study parameter</i>	<i>Mean±SD</i>
Hb (gm %)	11.83±1.45
Visual reaction time(ms)	40.20±18.46
Whole body simple reaction time (chronoscope 1) in ms	317.36±81.99
Whole body choice reaction time (chronoscope 1) in ms	381.80±81.92
Mini mental state examination score (/30)	22.56±3.15

TABLE II : Shows the correlation of Hb in gm% with above various parameters studied in the children.

	<i>SWBRT C1 (ms)</i>	<i>CWBRT C1 (ms)</i>	<i>VRT (CVRT-SVRT) (ms)</i>	<i>MMSE (/30)</i>
Hb (gm%)	r= -0.617 p=0.000**	r= -0.530 p=0.000**	r= -0.081 p=0.268	r= -0.027 p=0.420

significant ($p=0.000$). There is also negative correlation seen between Hb and visual reaction time as well as MMSE score which is not statistically significant.

Discussion

The term cognition refers to faculty for the human processing of information, applying knowledge and changing preferences. Our study done to see the relationship between hemoglobin and cognitive function by using reaction time (VRT, C1 of simple and choice WBRT) and MMSE score in children. A negative correlation was observed between hemoglobin and reaction time. Especially between hemoglobin, simple and choice WBRT, a highly significant negative correlation was observed. There is also negative correlation seen between Hb and MMSE score which is not statistically significant. MMSE score which is commonly used to evaluate the cognitive functions in adults was used to evaluate cognitive functions in children. May be the less sample size and age of the children were the limiting factors in our study for not getting a statistically significant values.

So our study proves the hypothesis of positive correlation between hemoglobin and cognitive functions. The findings of our study are similar to the study done by Hamid and Ilam Jalil (2, 3) who also showed a positive correlation between hemoglobin and cognitive function. Work done by Peirano PD in 2009 showed lasting effects of early iron deficiency on Sleep and neurofunctions throughout child development: (7) the above study shows that the Infants with IDA test lower in mental and motor development assessments and show affective differences. After iron therapy, follow-up studies point to long-lasting differences in several domains.

Youdim MB in 2008 showed effect of Brain iron deficiency on cognitive impairment and neurodegeneration with involvement of striatum and hippocampus in rats (8).

Effects of hemoglobin and serum ferritin on cognitive function in school children by Sungthong and his colleagues found a dose-response relationship

between hemoglobin and cognitive function in children with iron deficiency, whereas no similar evidence was found in iron sufficient children (9).

Iron is essential for normal neurological function because of its role in oxidative metabolism and because it is a cofactor in the synthesis of neurotransmitters and myelin. Nevertheless, despite this increased attention and awareness, our knowledge of iron metabolism in the brain at the cellular and molecular levels is still limited (10).

There has been little work on the effects of iron deficiency on brain metabolism and function despite the fact that iron deficiency is one among the most common nutritional disorder in the world iron is present in the brain in relatively large amounts and is particularly concentrated in the basal ganglia .It has been suggested that iron is a cofactor for tyrosine hydroxylase and tryptophan hydroxylase enzymes involved in the formation of Catecholamine and 5-hydroxytryptamine (5-HT) and dopamine. The activity of the Monoamine degradative enzyme monoamine oxidase) has also been shown to be lowered in the tissues of both humans and rats with iron deficiency anemia. The neurotransmitters s-HT, DA and noradrenalin are intimately involved in the regulation of mood and neuronal activity which is required for cognitive function of the brain.

Anemia affects cognition by its direct neurochemical effect and by its indirect effect on behavior, where children become less attentive and less responsive. Direct neurochemical effect by which anemia affects cognition via affecting the normal oxidative metabolism in the brain. The indirect mechanism by which iron deficiency anemia affects cognition is by causing a decrease in the iron concentration in the brain, which causes a reduction in the neurotransmitter levels like epinephrine, dopamine and 5-HT which are required for cognitive function in case of anemia there will be impaired neurotransmitter functions, leading to hypomyelination and delayed neuromaturation thus lowering the cognition (11).

Limitations of the study

Sahli's acid hematin method which is a manual

method was used instead of automated method, due to cost effective reasons. Serum Ferritin levels were not assessed in our study.

Scope of the study

Along with the hemoglobin levels serum ferritin can

be measured for exact correlation between iron level in the blood and cognitive functions. The above study also way for further research where researcher can follow up the children who are iron deficient, putting them on therapy and to check for the improvement of cognitive functions.

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