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International Journal of Current Research
Vol. 9, Issue, 06, pp.53072-53076, June, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

A STUDY ON THE EFFECT OF HAEMOGLOBIN CONCENTRATION ON AUDIO-VISUAL REACTION

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ARTICLE INFO

Article History:
Received 17th March, 2017
Received in revised form
06th April, 2017
Accepted 09th May, 2017
Published online 30th June, 2017

Key words:
Reaction time,
Haemoglobin concentration,
Anemia, ART, VRT.

ABSTRACT

The present study was conducted to compare Auditory Reaction Time (ART) and Visual Reaction Time (VRT) in normal and anemic female subjects and also to correlate the same with the haemoglobin (Hb) concentration. Female students of age group 18-20 years were recruited. After haemoglobin estimation subjects with Hb<12g% were assigned as group I (n=30) and subjects with Hb≥12g% were assigned as group II (n=30). ART and VRT were assessed by making use of an in-house built device PC 1000. Data was analysed employing unpaired student's "t" test using SPSS version 16 and significance value was fixed at p <0.05. The results showed highly significant prolonged ART and VRT in anemic individuals (p =0.001) and a negative correlation between ART and Hb; also VRT and Hb. Thus it can be concluded that with decreased haemoglobin concentration the ART and VRT are prolonged and that early correction of anemia can prevent ill effects.

Citation: Dr. Rashmi, S. and Dr. Prashanth Kumar, M. 2017. "A Study on the effect of Haemoglobin concentration on audio-visual reaction", *International Journal of Current Research*, 9, (06), 53072-53076.

INTRODUCTION

The World Health Organization defines anemia as the level of haemoglobin less than 13g% in males and less than 12g% in females (Johnston, 1975). Anemia is a condition characterized by the deficiency of haemoglobin or decreased level of red blood cells associated with decreased oxygen carrying capacity of the blood (Guyton, 2006). In many low and middle income countries including India, anemia is one of the commonest and severe public health issues leading to morbidity in children and reproductive age women (Beard, 2001). The World Health Organization statistics states that about 1.6 - 2 billion people are anaemic worldwide (Benoist, 2014). According to the National Family Health Survey (NFHS)-(III), more than 50% of the women in India have anemia amongst which 39 % are mildly anemic, 15 % moderately anemic and 2% severely anemic (National Family Health Survey, 2014). Adolescent girls, who constitute a considerable segment of Indian population form a vulnerable group and are at a greater risk. Adolescence is the shaping period of life when maximum amount of physical, psychological and behavioural changes take place.

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Thus this is a vulnerable phase for the development of nutritional anemia (Chaudhary, 2008). They are particularly prone to iron deficiency anemia because of increased demand of iron for synthesis of haemoglobin. This is to make up the loss of iron during menstruation (Beard, 2000). In addition there is also a mismatch between their high metabolic demands and poor dietary intake (Agarwal, 2003). Abu Rayhan al-Biruni, a Persian scientist was the first person to explain the concept of reaction time (RT) and the first scientist to measure reaction time (RT) in the laboratory was Donders in the year 1868 (Chandra, 2010). Reaction time is the time interval between the presentation of a stimulus and the appearance of appropriate swift voluntary response by the subject (Teichner, 1954). It involves stimulus processing, decision making, attention and response programming (Asmita, 2010). Normal auditory reaction time is 100-200 msec and normal visual reaction time is 200-400 msec (Jain, 2012). Our study group beingcollege-age individuals mean RT is about 160 milliseconds to detect an auditory stimulus, and approximately 190 milliseconds to detect visual stimulus (Kosinski, 2008 and Taoka, 1989). Reaction time evaluates the processing speed of central nervous system (CNS) and assesses the coordination between the sensory and motor systems. Its measurement includes 1) the latency in sensory neural code traversing peripheral and central pathways, 2) perceptive and cognitive processing, and 3) a motor signal traversing both central and peripheral neuronal structures. The motor signal also includes the latency in the end effectors activation (muscle activation) (Botwinik, 1966). Reaction time has physiological significance and is a simple and non - invasive test for peripheral as well as central neural structures. It is a measure of function of sensorimotor association (Shenvi, 1994). The audio-visual reaction time is found to be prolonged with decreasing haemoglobin levels and the reason has been attributed to the decreased neuronal conduction caused due to reduced levels of iron in anemia (Mishra, 2012). Iron has been implicated in the myelination and the development of various neurotransmitter systems in the brain (Beard, 2003). Iron deficiency is one of the commonest causes for developing anemia amongst other causes (WHO, 2007). Reaction timeplays a significant role in everyday activities like driving, operating machines, various forms of sports etc. The purpose of this study is to find if there is any relation between haemoglobin levels and audio-visual reaction time. Since such studies are very few in India, this study will help to fill the lacuna in this regard.

MATERIALS AND METHODS

Subjects: Sixty healthy female students in the age group of 18-20 years of Rajarajeswari Medical College and Hospital, Bangalore, meeting the requisite inclusion and exclusion parameters were enrolled in the study. Haemoglobin estimation was done by Haemocue Hb 301+ analyser. After haemoglobin estimation subjects with Hb<12g% were assigned as group I (N=30) forming study group and subjects with Hb≥12g% were assigned as group II (N=30) forming the control group. Exclusion criteria were female students who have neural disease, muscle disease, uncorrected hearing impairment, visual impairment, alcohol abuse, psychiatric disorders, sleep disorders, and girls receiving iron supplementation or blood transfusion in the past 1 month, interfering medication, thyroid disorders.

Methodology

The study was done in the department of Physiology, Rajarejeswari Medical College between January 2015 and June 2015 after obtaining ethical approval from the Institutional Ethical committee. Individual consents were obtained from all the participants. A detailed history was taken to rule out other comorbid conditions if any. Anthropometric variables included measurements of weight, height and BMI. Height was measured without shoes using stadiometer (Prestige Ltd, India) and weight was recorded with light clothes using a standard weighing machine (Krups Ltd India) to the nearest 0.1Kg. Body mass index was calculated by Quetelet's index that is BMI = weight (Kg)/ height (m^2). Haemoglobin estimation was done by Haemocue Hb 301+ analyser using standard procedure protocol (Morris, 2007). After haemoglobin estimation subjects with Hb<12g% were assigned as group I (N=30) forming study group and subjects with Hb≥12g% were assigned as group II (N=30) forming the control group.

The study was conducted between 10am and 12 noon in a quiet secluded room with good ambience. The subject was made to feel relaxed and comfortable and was instructed to use her dominant hand for response. In both, the subjects and controls auditory and visual reaction time was assessed by making use of an in-house built add on device called PC 1000. PC 1000 is a thousand Hz square wave oscillator with least count of 1/1000 second which has a soft key for start and stop function (Niruba, 2011). This instrument has two components (A&B) connected to each other. The A component has a START button and is used by the investigator. The B component has a STOP button and given to the subject to record their response. This B component also has a RED LED light for recording visual reaction time which glows every time when the stimulus is given. Red light has a long time representation in retina and hence red light was used. The component B is also connected to a headphone which gives the stimulus of a high frequency (1000Hz) beep sound for recording auditory reaction time. These two components are connected to a Personal computer which has audacity software installed in it. Audacity software records the reaction time in 0.001sec accuracy in wave format. Visual reaction time: After giving proper instructions to the individual, the examiner presses the start button in component A. This component is not seen by the subject as they are separated by a cardboard placed between component A and B, when the stimulus is given. Red LED light in component B glows when the stimulus is given and the subject is asked to give response as quickly as possible by pressing the stop button when they see this.

Auditory reaction time

Examiner presses the start button (A) which will be out of the view of the subject, and the subject is instructed to press the stop button (B) as soon as she hears the high frequency beep sound (1000 hertz's tone) through the headphone connected to it. The subject was asked to respond by pressing the response switch by index finger of the dominant hand. For each subject the lowest reading was taken as the value for the reaction time task. The recording was taken five times consecutively and the least value among the five was taken as the final value. This recorded data was stored in separate files and analysed using audacity software version 1.3 Beta (Devanand, 2014).

Statistical Analysis

The data collected was analysed and expressed as Mean±SD. Student's t test was applied for the statistical analysis using SPSS software version 16.0 and significance value was set at $p<0.05$. Correlation between haemoglobin and reaction time was done using Pearson's correlation.

RESULTS

There was no statistically significant difference in the anthropometric parameters between group I and group II. Hence they were comparable for the study (Table 1).

Table 1. Age and anthropometric parameters between Group I and Group II

Parameters	Group I (n = 30) Mean±SD	Group II (n = 30) Mean±SD
Age (years)	18.17±0.46	18.23±0.43#
Height (m)	1.58±0.03	1.59±0.03 #
Weight (kg)	58.1±3.2	57.5±4.0 #
BMI (kg/m^2)	23.68±0.9	23.19±1.4#

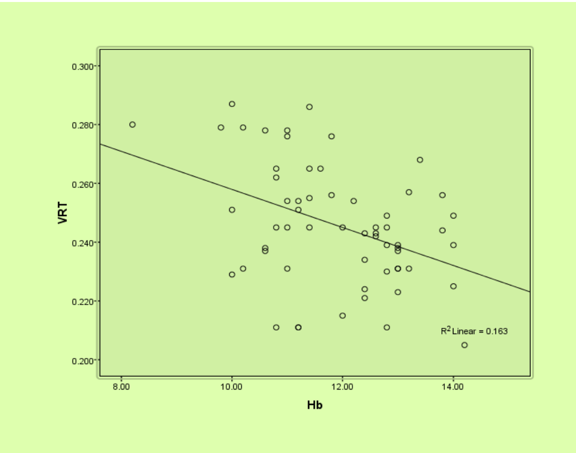
- Statistically not significant (p >0.05),
* - statistically significant (p<0.05),
** - highly significant

The mean haemoglobin level was 10.80 ±0.72 g% in group I (Hb<12) and was 12.97 ± 0.60 g% in group II (Hb≥12).Observation shows delayed auditory and visual reaction time in Group II. We found a negative correlation between the levels of haemoglobin and the both auditory and visual reaction time.

Table 2. Comparing the Hb levels(g%) with VRT (msec) and ART (msec)

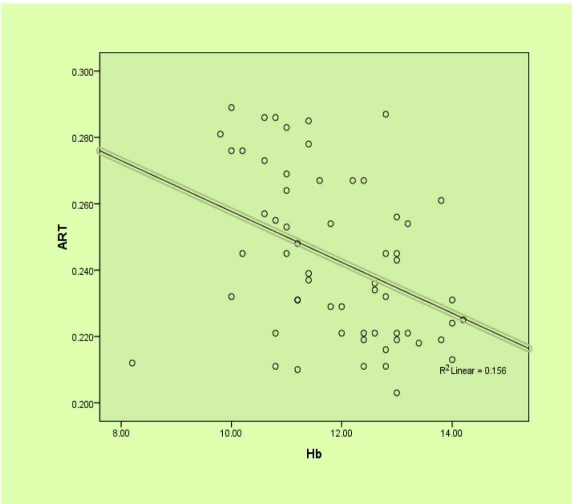
Parameters	GROUP I (Hb < 12g%) (n = 30)	GROUP II (Hb ≥ 12g%) (n = 30)	Statistical significance (p Value)
Hb (g%)	10.8 ± 0.7	12.9 ± 0.6 **	0.001
Visual Reaction Time ± SD (msec)	0.254 ± 0.22	0.237 ± 0.14 **	0.001
Auditory Reaction Time ± SD (msec)	0.250 ± 0.13	0. 236 ± 0.18 **	0.001

- Statistically not significant (p >0.05), * - statistically significant (p<0.05), ** - highly significant



Graph 1. Showing negative correlation between Hb and VRT

As seen in the above graph as the Haemoglobin (Hb) levels decrease there is a rise in the Visual Reaction Time(VRT) indicating that lower Hb levels cause prolonged VRT.



Graph 2. Showing negative correlation between Hb and ART

The above graph shows a negative correlation between Haemoglobin levels and Auditory Reaction Time (ART), as the levels of Hb decreases the ART gets prolonged.

DISCUSSION

Anemia is defined as a decrease in blood haemoglobin concentration and has shown to be a major public health issue that affects low and middle income countries. Although the most unswerving indicator of anemia at the population level is blood haemoglobin concentration, measurements of this alone do not determine the cause of anemia. Anemia may result from a variable number of causes like nutritional deficiencies (folate, vitamin A and vitamin B12), parasitic infections, acute and chronic inflammation, inherited or acquired disorders that have an effect on haemoglobin synthesis, red blood cell production or red blood cell survival, but the most significant contributor globally is iron deficiency (WHO, 2007 and Stevens *et al*., 2013). Studies done on adolescent girls have shown that decreased concentration of haemoglobin results in a number of symptoms such as weakness, general fatigue and also has adverse effects on immune system (Agarwal, 2003). Anemia resulting from iron deficiency has adverse effects on cognitive and motor development, associated with fatigue and low productivity (Stoltzfus, 2004; Balarajan, 2011; Tolentino, 2007). The finding of this study indicates that the decreased haemoglobin levels have a significant impact on the audio-visual reaction time; this is in accordance with the results of Mishra *et al* study (Mishra, 2012). The delay in response is profound in anaemic individuals compared to their normal counterparts. Longitudinal studies have shown that iron deficiency in infancy is related to poorer cognition in early childhood and if uncorrected continues to adulthood as well (Grantham, 2001). A detailed review written by Sachdev HPS and Gera T on iron supplementation in infants and children aged less than 5 years states that supplementation of iron in these children led to improvements in their cognition and motor development (Sachdev, 2006). Adolescence, being the determining growing phase in life is more prone to major nutritional deficiency. Many factors contribute to anemia in adolescent girls like low iron intake, poor iron absorption, high metabolic demands for iron during menstruation and growth spurts. And due to this the pubescent girls are at a higher risk of developing anemia (Mishra, 2012).

Infants having iron deficiency anemia show lower cognitive, motor, social, emotional and neurophysiologic development when compared to infants with normal haemoglobin concentration. Human and monkey infants with neonatal iron deficiency have shown poorer outcome with respect to physical and mental growth in their early developmental years. With respect to CNS iron deficiency is associated with 1) hypomyelination of neurons, 2) effects on the dopaminergic system and 3) deficiency of enzymes involved in the development of parts of the brain important for cognitive function and memory (Lozoff, 2006). In context to reaction time specifically, the central conduction time was found to be prolonged in infants with anemia when compared with non anaemic children. The Katasaras E *et al* study states that the prolonged central conduction time might be due to changes in myelination that have been reported in iron deficient infants. Thus in anaemic children central conduction time was prolonged and also longer latencies in visual evoked potentials were recorded (Katasaras, 2004). Two commonly reasoned mechanisms for delayed reaction time in anaemic individuals are the effects on the dopaminergic system and effects on myelination (Grantham, 2001). Current medical reviews indicate that signalling through the dopamine pathways originating in the ventral tegmental area is strongly positively correlated with improvements in (i.e., reduced) reaction time. Dopaminergic drugs like amphetamine have been shown to expedite responses during interval timing, while dopamine antagonists (specifically, for D2-type receptors) produce the opposite effect (Parker, 2013). Iron levels play a prominent role in neuronal functioning and it is also noted that the dopaminergic system is sensitive to serum iron concentration (Beard, 2001). Mechanism behind the attention to environmental information is dependent on rate of dopamine clearance from the interstitial space and that this proposes that iron status may affect behaviour and response through dopamine metabolism (Breitmeyer, 1994).

Conclusion and Summary

From the above discussion it is evident that, iron deficiency causing changes in the Central Nervous System (CNS) which results in a prolonged audiovisual reaction time. The important implication of the study is that the deficiency of iron could be correctable cause of delayed reaction time. And it can be concluded saying, it is advisable to detect and correct anemia at the early stages is a must and awareness in this regard is mandatory. Limitations of the study include the limited sample size and assessment of serum iron levels. Further studies however, with a bigger sample size and assessment of serum iron levels will help to prove the above point. A follow up of the anemic individuals and recording audiovisual reaction time after correcting anemia will prove to be more efficient.

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