ORIGINAL ARTICLE

A Comparative Study of Audiovisual Reaction Time in Anemic and Nonanemic Adolescent Girls

Swati Sharma[1], Aparna Garg[2], Ramesh Chand Gupta[3]

Abstract

Introduction: Anemia is a major public health challenge worldwide and remains a very severe and common health problem in many developing countries including India. The decrease in hemoglobin levels in adolescent age may lead to decreased attentiveness and low neuronal metabolic activity. Reaction time is found to be altered in anemia and has a negative effect on cognitive performance in adolescent girls.

Aims and objectives: To study the relation between anemia in adolescent girls and the audiovisual reaction time. To assess the severity of anemia with the audiovisual reaction time.

Observation and results: A highly statistically significant difference (p value < 0.001*) was observed between control and anemic groups in both the audiovisual reaction time, and a highly statistically significant difference (p value < 0.001*) was observed in the audiovisual reaction time as the severity of anemia progressed.

Conclusion: There is a significant increase in both auditory reaction time (ART) and visual reaction time (VRT) in anemic adolescent girls when compared to the control group. A linear relationship was also established between the severity of anemia and an increase in the ART and VRT values in the adolescent girls.

Keywords: Adolescent girls, Anemia, Audio reaction time, Visual reaction time.

Journal of Mahatma Gandhi University of Medical Sciences & Technology (2019): 10.5005/jp-journals-10057-0102

Introduction

Anemia is a major public health challenge worldwide and remains a very severe and common health problem in many developing countries, including India.[1] According to World Health Organization (WHO), anemia is defined as a hemoglobin level of less than 13 g/dL in men and less than 12 g/dL in women.[2] Based on the WHOcriteria, more than two billion people are estimated to be anemic.

Adolescence has been defined by the WHO as a period of life spanning between the ages of 10 and 19 years. This is the formative period of life when the maximum amount of physical, psychological, and behavioral changes take place. The period of adolescence is a period of intense growth.[3] Adolescent girls are at greater risk of developing nutritional anemia, especially iron deficiency anemia (IDA), because of their more physiologic requirements, combined with increased menstrual losses and poor dietary intake.[4]

Nutritional anemia is a disorder characterized by the inadequate production of hemoglobin or erythrocytes caused by deficiency of iron (most common) folic acid, vitamin B_{12} as well as proteins, trace elements (zinc, cobalt, copper), vitamins C and A, riboflavin, and hormones (androgens and thyroxine).[5]

Human body gives desired and purposeful voluntary response to stimulus, within a desired time period.[6] Thus, reaction time is defined as a time interval between the application of a stimulus and initiation of appropriate voluntary response under the condition that the subject has been instructed to respond as early as possible.[7,8] It has physiological significance and is a simple and noninvasive test for evaluating the peripheral as well as central nervous status of the individual.[9] Visual, auditory, pain, temperature, and touch are various modalities of sensory stimuli that are used to assess the reaction time.[10] Reaction time is found to be altered by major factors which include:[10]

Types of reaction time experiments, types of stimulus (auditory, visual, pain, touch, temp.), age, gender, cerebral dominance, central v/s peripheral vision (pattern of stimulation), distraction, exercise, practice, fatigue, also affected by mood, memory, psychological states, stress, first time performance, and behavioral and mental attitude of the individual.[11] Anemia has a negative effect on cognitive performance in adolescents. It may cause generalized as well as systemic health consequences, the important one being irreversible brain dysfunction.[12]

Most of the scientific studies on the effect of anemia deal with infants, young children, and pregnant women; there are, however, very few studies dealing with the anemia on autonomic neurocognitive function and reaction time (which is an indirect index of processing capability of central nervous system and an inexpensive means of determining sensorimotor function) in adolescents. Thus, the decrease in hemoglobin levels in adolescent age may lead to decreased attentiveness and low neuronal metabolic activity.

Since there is a dearth of available literature regarding studies in relation to anemia and the audiovisual reaction time in adolescent girls, this study was taken up to establish any correlation between

[1–3]Department of Physiology, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India

Corresponding Author: Aparna Garg, Department of Physiology, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India, Phone: +91 8504092472, e-mail: draparnagarg19@gmail.com

How to cite this article: Sharma S, Garg A, Gupta RC. A Comparative Study of Audiovisual Reaction Time in Anemic and Nonanemic Adolescent Girls. J Mahatma Gandhi Univ Med Sci Tech 2019;4(2): 40–43.

Source of support: Nil

Conflict of interest: None

them so as to implement measures that may lead to betterment of the adolescent healthcare among girls.

Objective

- To find out the association between audio reaction time (ART) and visual reaction time (VRT) and anemia.
- To find out correlation of VRT with severity of anemia.
- To find out correlation of ART with severity of anemia.

Materials and Methods

The present case–control study was conducted in the Department of Physiology at Mahatma Gandhi Medical College and Hospital, Jaipur, after obtaining the institutional ethical committee clearance. The study was done on 180 adolescent girls visiting the Department of Medicine, Obstetrics and Gynecology and Pediatrics of Mahatma Gandhi Medical College and Hospital, Jaipur. The participants who fulfilled the underlying inclusion and exclusion criteria were enrolled for the study.

Inclusion Criteria

- Adolescent girls aged between 10 years and 19 years[13] and belonging to similar socioeconomic status.
- Willingness to participate and cooperative
- Not having any vision and hearing problem.

Exclusion Criteria

- Acute/chronic disease infection
- Physical/mental illness
- Hearing or visual disorder
- History of blood transfusion and vitamin supplements.

Methods

All the 180 participants were selected based on the abovementioned inclusion criteria. The study was explained to them in their vernacular language, and informed consent was also obtained from their parents or their local guardian. A detailed history pertaining to their social, personal, and demographic profile was obtained.

All the patients were evaluated for their anthropometric measures like height (in cm) and weight (in kg), and the BMI was then calculated. The participants were also evaluated for the estimation of the hemoglobin levels, and the peripheral blood film was prepared following the standard protocol and reviewed. Estimation of hemoglobin levels was carried out with Sahli's Hemoglobinometer method using the standard procedure protocol[14] in the Department of Physiology. The resulting hemoglobin values were matched and standardized with values obtained after performing the cyanmethemoglobin method done in the haematology laboratory, Department of Pathology, MGMC & H, Jaipur.

- Based on these reports of hemoglobin levels, the sample size of 180 adolescent girls was divided into:-
- Group I–(control group): In this group, the girls hemoglobin level was >12 g/dL ($n = 90$)
- Group II–(study group) This group included 90 adolescent girls who were having hemoglobin less than the normal value (<12 g/dL).

According to hemoglobin levels of the study group, this group was again divided in to three sub types

- Mild anemic—10–12 g% ($n = 30$)
- Moderate anemic—7–9.8 g% ($n = 30$)
- Severe anemic—<7 g% ($n = 30$)

The peripheral blood smear done in the study group of adolescent girls revealed the morphological appearances of microcytic hypochromic morphology suggestive of iron deficiency anemia, the most common nutritional anemia found in the girls.[9]

The reaction time was measured with the help of the "research reaction time apparatus" supplied by Medisystem Yamunanagar. It is a portable device with inbuilt 4-digit chronoscope with least count of 1/1,000 seconds, i.e., 1 millisecond. The apparatus has two modes of stimulus:

- Auditory
- Visual

Procedure

Green light was used for visual stimulus and high-pitch (7 dB) sound for auditory stimulus. Participants were asked to respond to stimuli by pressing the response key with the index figure of their dominant hand. The display indicates the reaction time (RT) in seconds. The technique was explained to each and every participant and was followed by demonstrating the procedure to eliminate any kind of fear and apprehension. VRT and ART were recorded in all the participants. Three practical trials were given to make them familiar with the software. The interval between the stimuli randomly varied from 2 to 5 seconds,[15] and the mean of these three reading was taken as the value for RT. The recordings were conducted in the morning between 9 am and 11 am, about 2 hours after light breakfast, at a comfortable room temperature 25 to 30°C in noise-free room.

Results

All the results were expressed in mean + standard deviation (SD) for both the groups. Mean and SD of all the parameters were calculated according to the accepted statistical method. The observed data are presented in tabulated form after applying one-way analysis of variance (ANOVA) and unpair *t* test along with mean, SD, and level of significance as *p* value.

Table 1 presents the mean of ART along with SD. A highly statistically significant difference (*p* value < 0.001*) was observed between control and anemic groups.

Table 2 presents the mean of VRT along with SD. A highly statistically significant difference (*p* value < 0.001*) was observed between control and anemic groups.

Table 3 presents the comparison of mean value of ART in anemic groups with increasing severity using one-way ANOVA. A highly

Table 1: Comparison of mean + SD of auditory reaction time between control and anemic group by unpaired *t*-test

		ART		
Group	*n*	*Mean*	*SD*	*p value*
Control	90	0.151	0.017	0.000*
Anemic	90	0.468	0.146	

n, no. of subjects in each group; ART, audio reaction time

Table 2: Comparison of mean + SD of visual reaction time between control and anemic groups

		VRT		
Group	*n*	*Mean*	*SD*	*p value*
Control	90	0.172	0.018	0.000*
Anemic	90	0.488	0.146	

n, no. of subjects in each group; VRT, visual reaction time

Table 3: Comparison of mean + SD of audio reaction time in patients of mild, moderate and severe anemia

	ART		
Groups (n)	*Mean*	*SD*	*p value*
Mild (30)	0.296	0.049	0.000*
Moderate (30)	0.470	0.044	
Severe (30)	0.639	0.026	

n, no. of subjects in each group; ART, auditory reaction time

Table 4: Comparison of mean + SD of visual reaction time in patients with mild, moderate severe anemia

	VRT		
Groups (n)	*Mean*	*SD*	*p value*
Mild (30)	0.314	0.049	0.000*
Moderate (30)	0.492	0.044	
Severe (30)	0.658	0.026	

n, no. of subjects in each group; VRT, visual reaction time

statistically significant difference (p value < 0.001*) was observed in the audio reaction time as the severity of anemia progressed.

Table 4 presents the comparison of mean value of VRT along with SD in anemic group using one-way ANOVA. A highly statistically significant difference (p value < 0.001*) was observed in the visual reaction time as the severity of anemia progressed.

Discussion

The present study was conducted to evaluate the effect of anemia on ART and VRT in adolescent girls. In the present, Table 1 shows that when the comparison between anemic group and the control group for the ART was done, it was found to be highly statistically significant in the anemic group compared to the control group.

The findings of the study are in accordance with the study done by Sun et al.,[16] where they mentioned that hearing loss was affected initially for the high frequency, but low frequencies also were affected as iron-deficient diet was continued.

In another study of clinical survey done by Xiao et al.,[17] it was proposed that involvement of red cells in iron deficiency may produce various effects in arteries of the inner ear, resulting in disturbance of blood circulation in cochlea which can alter the ART in anemic patients.

Yassin[18] et al. in their study reported the association between anemia and hearing loss. They reported sensorineural hearing loss in patients with iron deficiency anemia due to ankylostomiasis, which recovered totally or partially following iron therapy. Kapoor et al.[2] showed altered dopaminergic function because of anemia, which could disrupt the normal progression of auditory pathway. Serotonin also seems to play a role in neurotransmission for ART.

In our study, Table 2 shows that the visual reaction time is longer in anemic groups, and the difference is found to be statistically highly significant when compared to the control group.

This finding is supported by the work done by Webb and Oski,[15] where they found that anemic children had a longer latency period than nonanemic children on visualization of an image.

Kahlon et al. in their study done in 2011[19] showed the effect of iron deficiency anemia on VRT and found significantly increased VRT in iron-deficient adolescent girls aged 17 to 19 years.

In contrast to the abovementioned finding of increased ART and VRT in anemic group, Shivani et al.[20] reported that spinal motor neuron excitability is not reduced in iron deficiency anaemia as depicted by bilateral median and common peroneal nerve F wave studies, where F wave mean latency chronodispersion, persistence, and mean amplitude were within the normal range between anemic and control groups.

Table 3 shows that with the increasing severity of anemia, the ART values also increased. This result is in accordance to a study done by Murray-Kolb et al.[21] who reported the relation between iron status and cognitive abilities. They found that iron-sufficient individuals performed better on cognitive tasks and completed them faster than those with iron deficiency anemia.

Table 4 shows that with the increasing in the severity of anemia, the VRT values were also increased. A study done by Katasaras et al.[22] showed similar results, where they reported that central conduction time was found to be prolonged in the anemia group compared to non-anemic group. The investigator speculated that the prolonged central conduction time was due to changes in myelination that have been reported in iron-deficient patients. Thus, in anemic children, central conduction time was found to be prolonged and longer latencies in visual-evoked potentials.[22] Yehuda[23] et al. in their study found that people who received iron for iron deficiency anemia reported improved memory, attention, mood, and energy before any improvement in hemoglobin indices. Sachdev et al. in 2006[24] found that in supplementation led to improvements in cognition and motor development in anemic and iron-deficient individuals. Lucca et al.[25] investigated the association of mild-grade anemia with cognitive functions, and they found that mild-grade anemia is independently associated with worse selective attention performance. Decreased hemoglobin levels may lead to decreased attentiveness and low neuronal metabolic activity, while observational evidences suggest a strong link between anemia and cognitive deficit. Anemia produced generalized weakness and fatigue.[23] These symptoms along with the other symptoms of anemia, such as poor concentration, poor attention, and irritability, and tiredness, could be the reason of prolongation of VRT and ART. There is positive association between hemoglobin levels, somatic iron levels, and performance in tests of cognitive functions. Thus, one can account for most and perhaps all of the difference between VRT and ART.[26]

Iron is also involved in synthesis of neurotransmitters such as dopamine, serotonin, GABA, etc. A decreased in cerebral iron content resulting from anemia may decrease the activity of these neurotransmitters.[19,27] Dopamine neurotransmitter has specific roles in circuits involved in transmitting visual and auditory information.[5] Hence altered dopaminergic function because of anemia could disrupt the normal progression of fine-grained mechanisms of synchronization, including intermodal integration.

Serotonin also seems to play a role in neurotransmission in auditory pathway, and it has been seen that substances, which deplete serotonin affect various components of BAEP.[6]

Thus, we conclude that the factors mentioned earlier may be responsible for increase in ART and VRT in the adolescent girls. More physiologic requirements, combined with increased menstrual losses malnutrition and poor dietary intake, are needed.[3] Decreased hemoglobin levels may lead to decreased attentiveness and low neuronal metabolic activity.

Conclusion

It can thus be concluded that there is a significant increase in both ART and VRT in anemic adolescent girls when compared to its control group. A linear relationship is also established between the severity of anemia and increase in ART and VRT values. The low neuronal metabolic activity, decreased nerve conduction velocity, and alteration in neurotransmission system due to low hemoglobin values alters the cognition and is responsible for prolongation in ART and VRT in anemic individuals. This may act synergistically to induce and alter the functions. The clinical implication for this study is early detection, prevention, and treatment of anemia in the adolescent girls. This will go a long way in reducing morbidity due to complications of anemia.

References

1. Stoltzfus RJ, Mullany L, Black RE. Iron deficiency anaemic. Ezzati M, Lopez AD, Rogers A, et al., ed. Comparative qualification of health risk; global and regional burden of disease attribution to selected major risk factor, vol. I, Geneva: World Health Organization; 2004. pp. 163–209.
2. Kapoor R, Singh L, Malhotra S, et al. Demasking of subclinical left ventricular dysfunction in anaemic adolescent. Indian Paediat 1999;36:991–998.
3. Castro R, Irwin C, Moriarty C. Diagnosis and management of iron deficiency anaemia. Califor J Health-Syst Pharm 2010. 5–14.
4. Ramzi M, Haghpanah S, Malekmakan L, et al. Anaemia and iron deficiency in adolescent school girls in Kavar urban area, southern Iran. Iran Red Crescent Med J 2011;13(2):128–133.
5. Lozoff B, Jimenez E, Wolf AW. Long term developmental outcome of infants with iron deficiency. The N Engl J Med 1991;325(10):687–697. DOI: 10.1056/NEJM199109053251004.
6. Jain A, Bansal R, Kumar A, et al. A comparative study of auditory and visual reaction time on the basis of gender and physical activity levels of medical I year students. Int J Appl Basic Med Res 2015;5(2):124–127. DOI: 10.4103/2229-516X.157168.
7. Teichner WH. Recent study of simple reaction time. Psychol Bull 1954;51(2:1):128. DOI: 10.1037/h0060900.
8. Parekh N, Gajbhiye Ipr, Wahane M, et al. The study of audiovisual reaction time in healthy controls and patients of diabetes mellitus on mordent Allopathic treatment and those performing aerobic exercises. J Indian Acad Clin Med 2004;5(3):239–243.
9. Hultsch DF, Macdonald SW, Dixon RA. Variability in reaction time performance in younger and older adults. J Geront: Psychol Sci 2002;57B(2):101–115. DOI: 10.1093/geronb/57.2.P101.
10. Maruthy N. Glycosylated haemoglobin verses reaction time in diabetic patients-across sectional study. Nat J Basic Med Sci 2011;1(4):198–201.
11. Woodworth H, Schlosberg RS. Experimental Physiology. New York: Henry Holtz; 1954.
12. Karia RM, Ghuntla TP, Mehta HB, et al. Effect of gender difference on visual reaction time: a study on medical students of Bhavnagar region. IOSR J Pharm 2012;2(3):452–454. DOI: 10.9790/3013-0230452454.
13. Thomas D, Chandra J, Sharma S, et al. Determinants of nutritional anaemic in adolescents. Indian Pediatr 2015;52(10):867–869. DOI: 10.1007/s13312-015-0734-7.
14. Wintrobe MN. Clinical Hematology. 7th ed., Philadelphia: LEA and Febiger; 1975. pp. 114–115.
15. Webb TE, Oski FA. The effect of iron deficiency anaemia on scholastic achievement, behavioural stability and perceptual sensitivity of adolescents. Pediatr Res 1973;7:294.
16. Sun AH, Xiao SZ, Zheng Z, et al. Iron deficiency and hearing loss. experimental study in growing rats. ORL Otorhinolaryn Relat Spec 1987;49(3):118–122. DOI: 10.1159/000275920.
17. Sun AH, Xiao SZ, Zheng Z, et al. Change in the cochlear iron enzymes and adenosin triphosphatase in experimental iron deficiency. Ann Otol Rhino Laryngiol 1990;99(12):988–992. DOI: 10.1177/000348949009901211.
18. Yassin A, Taha M. Hearing disorder in secondary anaemia. J Laryngol Otol 1965;79(10):917–920. DOI: 10.1017/s0022215100064574.
19. Kahlon N, Gandhi A, Mondal S, et al. Effect of iron deficiency anaemic on audiovisual reaction time in adolescent girls. Indian J Phys Pharm 2011;55(1):53–59.
20. Shivani A, Nasreen A, Rashmi B. Spinal motor neuron excitability in iron deficiency anaemia. Ind J Phys Pharm 2005;49(2):193–198.
21. Murray-Kolb LE, Beard JL. Iron treatment normalizes cognitive functioning in young women. Am J Clin Nutr 2007;85(3):778–787. DOI: 10.1093/ajcn/85.3.778.
22. Katasaras E, Adam E, Dewey KG. Effect of iron supplementation on cognition in Greek preschoolers. Europ J Clin Nutr 2004;58(11):1532–1542. DOI: 10.1038/sj.ejcn.1602005.
23. Yehuda S, Mostofsky DI. The effect of an essential fatty acid compound and a cholesystokinin-8 antagonist on iron deficiency induced anorexia and learning deficits. Nutr Neurosci 2004;7(2):85–90. DOI: 10.1080/10284150410001704552.
24. Sachdev HPS, Gera T. Effect of iron supplementation on physical growth in children. systemic review of randomized control trails. Pub Health Nutrit 2006;9(7):904–920. DOI: 10.1017/PHN2005918.
25. Lucca U, Tettamanti M. Association of mild anaemia with cognitive functional, mood and quality of life outcomes in the elderly: the Health and anaemia study Italy plus–one. 2008.
26. Mehta BC, Panjwani DD, Jhala DA. Electrophysiological abnormalities of heart in iron deficiency anaemia: effect of iron therapy. Acta Hemat 1983;70(3):180–193. DOI: 10.1159/000206721.
27. Foley D, Hey DA, Mitchell RJ. Specific cognitive effect of mild iron deficiency and association with blood polymorphism in young adults. Ann Hum Biol 1986;13(5):417–425. DOI: 10.1080/03014468600008601.