ORIGINAL ARTICLE OPEN ACCESS

Association of Iron Deficiency with Electronic Gaming Addiction and Low Health Influencing School Performance

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ABSTRACT

Background: Anemia does not only have a deleterious effect on the physical growth of children but also impairs mental development and slows down memory, cognitive functioning, and academic performance. The study aimed to assess the association between video gaming, iron deficiency anemia and school performance in children 5-16 years of age.

Methods: A cross-sectional study was conducted on 306 children 5-16 years of age between grades 1 and 10 in various schools in Sikandarabad for one academic year. The iron deficiency, screen time along with past health records were noted. School assessments were analyzed for academic achievements, and class concentration and Intelligent Quotient (IQ) tests were done multiple times. Hemoglobin was checked to establish an association with learning difficulties. Multivariate logistic regression was done to see the association of electronic gaming with academic performance. *p*-value <0.001 was considered significant.

Results: Mean age of children was 11.73+1.8 years. Mean hemoglobin was 12.3+1.2g/dl. Children with iron deficiency had a poor concentration in class ($p<0.001$) and achieved below-average assessment results ($p<0.001$). Also, anemic children participated less in extra-curricular activities ($p=0.004$). Children who played excessive video games, 63.2%, had ($p<0.001$) lower IQ in comparison to the ones exposed to less screen time. Moreover, kids who scored less than average grades in school had also shown to have low IQ ($p<0.001$) with statistically significant results.

Conclusion: Excessive video gaming was associated ($p<0.001$) with anemia and low IQ in this study. Anemic children participated less in extracurricular activities and were shown to have poor scholastic performance.

Keywords: Iron Deficiency Anemia, Academic Performance, IQ (Intelligent Quotient).

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Doi: https://doi.org/10.36283/PJMD12-2/004

How to cite: Rehman F, Jehangir F, Tahir T, Adnan T, Akbar II. Association of Iron Deficiency with Electronic Gaming Addiction and Low Health Influencing School Performance. Pak J Med Dent. 2022;12(2): 16-22. doi: 10.36283/PJMD12-2/004

INTRODUCTION

We live in a world where health is wealth and yet people are unaware of the impact that a well-balanced diet containing all the essential nutrients can have on everyday life. One such micronutrient is iron which is important for a variety of physiological processes within the body. Iron helps in hemoglobin formation, respiration and energy metabolism, synthesis of collagen, dopamine metabolism, neuronal myelination, and the structural and functional development of the hippocampus[1-3]. Iron deficiency can have adverse consequences on the body. It can cause anemia, chronic fatigue syndrome, restless leg syndrome, fatigue on physical exertion, and cognitive impairment within individuals of all age groups[4]. According to statistics, around two billion individuals worldwide are iron deficient[4].

A consequence of anemia that is highly concerning is its negative impact on behavior and cognition within children. Multiple studies have been conducted to prove the existence of low mental and motor developmental test scores in children diagnosed with iron deficiency anemia[5]. According to the studies conducted in Islamabad in February 2015, Nowshera Pakistan in December 2016 and Peshawar in 2021, IDA not only causes decreased physical and mental activity but is also associated with low school performances, low IQ and lower intellectual performance scores in school children[6-8].

Anemia, a common hematological disorder in children, usually presents, as fatigue, lethargy, and a strain on bodily organs. Children belonging to low socioeconomic backgrounds are at a high risk of iron deficiency anemia and its consequences on the brain and cognition, presenting in the form of learning problems and inattentiveness. The findings of numerous studies support this hypothesis; contrary to studies done in South Africa that have provided limited evidence. A study was done in KwaZulu-Natal; South Africa recruited 184 children from the ages of 6 to 8. They assessed the participants through clinical examination, laboratory testing such as hemoglobin levels and iron studies, and through evaluation of their school performance, (by interviewing parents, teachers, and the respective children) to analyze the impact of anemia and iron deficiency on growth, cognition, and psychomotor development[9].

A decrease in cognition and attention span seen in school-going children and adolescents caused by anemia can have a disastrous impact on human capital accumulation. Children hailing from low-income households have a higher chance of being anemic due to micronutrient deficiencies[10].

The prevalence of anemia worldwide is estimated to be around 30% and around 51% of these individuals are young children[6,11]. Private organizations along with the help of the government should work on initiating programs that aid in the supplementation of iron and folic acid to adolescent girls for the prevention of hematological and non-hematological ramifications of iron deficiency[12]. According to a study conducted in Tertiary Care Hospital Lahore in 2017, the prevalence of anemia in children under 12 years was 54.8 % in females and 45.2% in males[11]. In this study, we assessed how electronic gaming and iron deficiency affected the cognitive abilities, intellectual capacity, and physical activity of school-age children and adolescents.

METHODS

A cross-sectional study was conducted in various schools in the neighborhood of Sikandarabad. The study included 306 students ranging in age from five to sixteen years old. The duration of the study was from 1st March 2021 to 28th February 2022 i.e., one academic year. Parents and students were explained in detail about the study in the school assembly priorly. After written and informed consent from the parents, the children were thoroughly examined by a consultant family physician.

Inclusion Criteria were all children between 5 to 16 years of age from grade 1 to grade 10 who volunteered to participate in the study and students whose parents had given written consent to let their child/children participate. Exclusion criteria included children having established learning difficulties such as Autism, ADHD, Dyslexia, congenital abnormalities, Down Syndrome, other learning disabilities and malignancy.

Screen time was assessed in detail for each student including hours spent on video games and watching TV. Learning capabilities and IQ of children were judged using age-appropriate Borden Wisconsin tests. Students' active participation and concentration in class, interest in physical activities and easy fatigability were evaluated in detail. Their interest in video games, interest in physical and class activities, lack of concentration from teachers/students, and parents' occupations were also evaluated. For assessment of scholastic performance, the grade obtained in the final term examination of the previous grade was noted from the report card as per the school record. The assessed academic subjects were English, Urdu and Mathematics. The skills assessed were global cognitive, specific cognitive, social communication, memory, attention, visuospatial, reading and numeracy along with motor skills. A phlebotomist drew the blood sample and checked the hemoglobin level to assess anemia.

Data entry was done by using SPSS version 20. Mean and standard deviation were analyzed for numerical

variables like age and hemoglobin; frequencies and percentages were computed for categorical variables. One sample group t-test was computed for hemoglobin levels and paired sample t-test was computed to correlate levels of hemoglobin and the classes attended in school. Regression analysis was done to see the association of iron deficiency anemia with risk factors. Chi-square was also computed to see an association between video gaming with anemia and academic performance. *p*-value <0.05 was considered significant.

RESULTS

The mean age of the children was 11.73±1.8 years. Mean hemoglobin was 12.3±1.2g/dl. On one sample group t-test, the mean hemoglobin of students, i.e., 12.33g/dl was like the normal lab value of hemoglobin (*p*-value <0.001). On paired sample t-test, there was a weak association between anemia status and the child's class in school. The mean of class came out to be 5.44±1.936 and the mean hemoglobin was 12.33 ±1.16 (*p*-value 0.091). On logistic regression, children with iron deficiency had poor concentration in class (*p*-value <0.001) and achieved below-average assessment results (*p*-value <0.001). Also, anemic children participated less in extra-curricular activities (*p*-value 0.004) in our study (Table 1).

Table 1: Multivariate regression showing the association of anemia with risk factors.

Variables	OD	CI Lower	Upper	*p*-Value	AOR	CI Lower	Upper	*p*-Value
Gender (*male*)	1.48	0.777	2.84	0.231	1.941	0.821	4.586	0.131
Playing video games excessively	2.06	1.1	3.8	**0.023***	0.329	0.139	0.778	0.11
No participation in extracurricular activities	0.179	0.062	0.513	**0.001***	0.165	0.049	0.562	**0.004***
Below-average school grades	7.9	3.552	17.57	**0.000***	0.183	0.074	0.454	**0.000***
Low IQ	4.16	0.000	-	0.997	-	-	-	-
Lack of concentration in class	15.01	7.3	30.8	**0.000***	0.080	0.031	0.203	**0.000***
Absenteeism and low interest in the class	4.382	2.237	8.585	**0.000***	0.501	0.215	1.165	0.109
Low socioeconomic status	0.798	0.394	1.167	0.532	-	-	-	-
Acute infections in the past	0.000	0.000		0.999	-	-	-	-

**p-value ≤ 0.05 was considered significant.*

Table 2 shows the association of various risk factors with school performance. Figure 1 demonstrates the traits of children who use video games excessively.

Of those children who watched excessive video games, 63.2%, had (*p*-value 0.001) low IQ and those kids who scored less than average grades in school also had low IQ (*p*-value <0.001), both of which are statistically significant. Of low school performers 60.7% had fatigue on minimal exertion (*p*-value 0.01) and 60.2% did not consume an iron-rich diet (*p*-value 0.005), both of which are statistically significant.

Table 2: Association of various risk factors with school performance.

Variables	School Grades More than Average n (%)	School Grades Less than Average n (%)	Chi-Square	*p*-Value
Excessive video games	58(48.3)	62(51.7)	2.78	0.023
A diet low in Iron	33(39.8)	50(60.2)	7.36	0.004
Recurrent infections	0(0)	2(100)	2.38	0.209
Severe anemia	13(45.8)	17(54.2)	11.2	0.000
Excessive fatigue	22(39.3)	34(60.7)	6.18	0.006
Low IQ	0(0)	38(100)	51.44	0.001
Participation in extracurricular activities	117(54.4)	98(45.6)	0.008	0.099
Low socio-economic status	60(55)	49(45)	0.097	0.447

**p-value ≤ 0.05 was considered significant.*

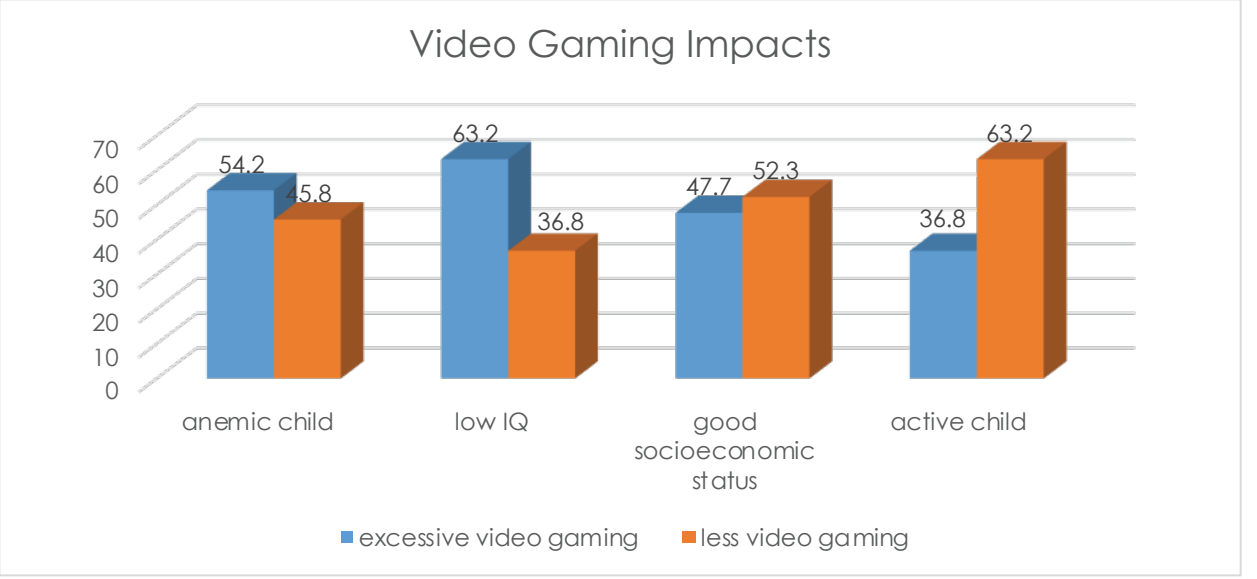

Figure 1: Video gaming association with IQ, anemia, physical activity and socio-economic status.

DISCUSSION

Micronutrients have always played a crucial role in the various processes and enzymatic reactions that take place within the Central Nervous System[13]. One such nutrient is Iron, which is incredibly important for the production of neurotransmitters, myelination of neurons and the metabolism of neuronal and glial cells[14]. An iron deficiency is also associated with changes in the metabolism of dopamine and serotonergic neurotransmission within the brain along with alterations in dopamine receptors[13]. According to Georgieff, different studies have proven the negative effect of iron deficiency on these neurotransmitter systems, especially due to its effect on enzymes such as tyrosine hydroxylase that require iron as a co-factor[14]. The cognitive abnormalities associated with iron deficiency are a cause of concern in both developed and underdeveloped countries as they can have a detrimental impact on a child's behavior, psychosocial development, and intellectual performance in academic environments[15].

The results of our study clearly show a correlation between iron deficiency and inadequate academic performance in school-going children (*p*-value <0.001). This is highlighted in a variety of other studies done around the world. A case study from Nowshera Pakistan proved that iron-deficient children, despite being anemic or non-anemic had below-average scores in Math, English and Urdu. They also demonstrated a lack of concentration in classes and had a weak memory[8]. A study done in the United States by Halterman et al. evaluated data from a large, nationally representative sample of school-aged children and teenagers with and without iron deficiency. Their study highlighted similar results, where children with iron deficiency were more than twice as likely to score below average on math tests as compared to children and adolescents who did not have iron deficiency. They also demonstrated a relationship between poorer math scores among children who were iron deficient without signs of anemia[5]. This was seen in our study too where students who were deficient in iron did not particularly have to be anemic to develop cognitive impairment, indicating that iron deficiency even without anemia can cause cognitive disturbances[5,13].

A study done in Islamabad on the effect of iron deficiency anemia on the intellectual performance of primary school children highlighted similar findings, where the intellectual performance scores of children with iron deficiency anemia were lower as compared to the scores of students who were given iron supplements and were not anemic[6]. Furthermore, Lukowski et al. study on the negative impact of iron deficiency in infancy on neurocognitive functions in young adults showed, that chronic severe iron deficiency in childhood gave rise to poor mathematical and writing skills which were consistent with chronic changes in the hippocampus and the frontal cortex. The participants of this study did not perform well on frontostriatal-mediated functions and exhibited impairment on a hippocampus-based recognition memory task, suggesting a correlation between long-term iron deficiency and hippocampal abnormalities[1,14].

According to the results of our study, children who were deficient in iron and had fatigue on minimal

exertion were shown to have low school performance; 60.2% of these students did not consume an iron-rich diet. Iron is one of the main nutrients required for hemoglobin production. People belonging to a low socioeconomic class, such as the participants of our study tend to be deficient in iron due to financial constraints which prevent them from affording and having iron-rich food like red meat and green leafy vegetables as a part of their diet[16]. Chronic blood loss due to hookworm infestation is also a leading cause of iron deficiency in children in such localities[17]. Lack of iron in the body causes the red blood cells to become microcytic and hypochromic because of a decrease in hemoglobin synthesis[16]. The decreased blood supply to the brain and other tissues for metabolism leads to poor concentration in class. Children also become easily exhausted, hence leading to a decrease in attentiveness during academic lessons, which then manifests as a lack of school performance. This was also seen in a study done by Sen and Kanani on the impact of anemia on physical work capacity and cognition in adolescent girls in India[18]. He concluded that iron deficiency anemia in young pubescent girls, despite being mild or moderate, showed a decrease in their cognitive abilities along with harming their ability to carry out physical activities[18]. Similar findings were seen in Soleimani's research, where a positive correlation was seen between hematological agents, such as hemoglobin, hematocrit, MCV, MCH, serum Iron and Ferritin, and the academic performance of third-grade, high school female students[19].

Our study showed how anemic children did not participate in extra-curricular activities as much as non-anemic children (*p*-value 0.004). This is because anemia due to any reason, regardless of the child being iron deficient, leads to decreased delivery of oxygen to the tissues. This presents as fatigue, lethargy, and a lack of interest in extracurricular ventures along with a decreased ability to perform physical activities[8].

Along with genetics, a variety of other factors have an influence over the Intelligence Quotient in school-going children; nutrition, living conditions, and history of child abuse can influence the IQ of a child. A deficiency in iron, vitamin B12, zinc, folic acid and proteins is associated with a low IQ in children[20]. In our study, children who had low academic scores due to iron deficiency were found to have a low IQ. These results are in congruence with studies done in both Peshawar and Islamabad, where the IQ of children with iron deficiency anemia was lower in comparison to non-anemic children[7]. Studies carried out by Pollitt et al. on the effect of iron deficiency on educational development have reported similar results[17,21]. Falkingham et al. in their study reported an improvement in IQ over 13 -29 weeks after iron supplementation in females and children diagnosed with iron deficiency anemia, and an improvement in attention and concentration in adolescents and women with baseline iron levels when they were supplemented with iron throughout 8-17 weeks[22]. Sachdev et al. also reported an improvement in the mental developmental score in iron-deficient anemic children after they were supplemented with iron (p=0.001) [23]. Both studies highlight the importance of iron in IQ and cognitive development.

In our study children who played video games excessively were found to have a lower IQ as compared to children who did not. According to the studies related to the effect of video gaming on the IQ of children, a few, claim to show an enhancement in cognitive abilities in children who play video games, while there existence of other studies that have defied this argument[24]. A study carried out by Syväoja et al. showed how excessive video game playing leads to a decrease in visuospatial memory[25]. Similar findings were also shown by Johnson et al.[26], Landhuis et al.[27], Swing et al.[28] and Weis et al.[29] in their respective studies. The adverse effects of computer games on verbal memory, attention and cognition have also been reported by Drowak et al[30]. On the contrary, studies carried out by Boot et al.[31], Granic et al.[32] and Spence et al[33]. have reported that sedentary screen time, like video game playing is associated with an enhancement in cognition and memory. Bittman et al. also documented, that children who used computers had better language skills[34].

CONCLUSION

As seen in our study, iron deficiency has a significant impact on the cognitive and intellectual abilities of children and adolescents. Anemic individuals have a low IQ and exhibit low school performance due to iron's effect on the structures of the central nervous system. The participants of our study who had iron deficiency anemia also displayed fatigue on minimal exertion in response to decreased oxygen delivery. Most of the existing literature is based on school children and adolescents; hence our study has investigated the impact of game addiction on poor school performance in this age group. Due to the inconsistent results of our study, further analysis is required to obtain a convincing conclusion regarding the impact of online gaming addiction on iron deficiency and poor academic performance. This can be done using a systematic review and meta-analysis.

ACKNOWLEDGEMENTS

The authors are grateful to the management of schools in Sikandarabad for cooperating and effectively involving in giving feedback and sharing students' evaluations.

CONFLICT OF INTEREST
There was no conflict of interest among the authors.

ETHICS APPROVAL
The study was approved by the ethics review committee of the hospital.

PATIENT CONSENT
Verbal and written consent was taken from the parents of all children.

AUTHORS' CONTRIBUTION
FR was involved in conception bench work, data gathering and proofreading. FR, IA and FJ wrote the manuscript. FJ analyzed the study and proofread it. IA, TT and TA were involved in data gathering and proofreading.

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