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Evaluation of Impact of Low Hb, MCV, MCHC and MCH on Cognitive Ability of Undergraduated Medical Students

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ABSTRACT

Introduction: Low concentrations of hemoglobin or anemia can contribute chronic brain hypoxia and reduced aerobic capacity, thus increasing the risk of dementia or cognitive decline. From the clinical point of view, brain ischemia is a known risk factor of cognitive dysfunction and dementia. We investigated correlation and impact of low Hb, MCV, MCHC and MCH on cognitive abilities from 386 participants on 59 top 10 undergraduate medical students.

Objective: This study aimed to determine and evaluate the correlation and impact of low Hb, MCV, MCHC and MCH on cognitive abilities of 59 top 10 undergraduated medical students in Ahmad Shah Abdali Higher Education Institute of Khost province of Afghanistan.

Method and Materials: It is prospective descriptive cross sectional study, on 59 top 10 undergraduated medical students in Ahmad Shah Abdali Higher Education Institute of Khost province from 2023/ Oct / 12 to 2023/ Nov / 02. The including parameters were Hb, MCV, MCHC and MCH of all 386 participants under study that recorded in computer special format. Hb, MCV, MCHC and MCH are done by special regents and micro lab. Recorded findings processing, comparison and evaluation results have been identified by IBM SPSS-23 version.

Results: The study was conducted during (20) days on 386 undergraduated medical students in Ahmad shah Abdali Higher Education Institute of Khost province. Initially we described all male participants according to age. At the current study all male participants were with (mean age: 23.14 ± 3.68; range: 20-45 years). All participants of this study were from all (1st, 2nd, 3rd, 4th, 5th and 6th) classes. Statistic description of all participants, according to Hb, MCV, MCHC and MCH shows that normal range of Hb level for male (14-16.6g/dl) was more prevalent 301(77.97). Low level of Hb for male (Low < 13.5g/dl) was 19(4.92) and high level of Hb for male (High > 16.6g/dl) was 66(17.09).The normal range of MCV (80-95%) was 327(84.71), low range (Low <80) was 54(13.98) and high range (High>95%) was 5(1.29).The normal range of MCHC (32-36%) was 370(95.85), low range (Low < 32) was 15(3.88) and high range (High>36%) was 1(0.25).The normal range of MCH (23-31%) was 322(83.41), low range (Low < 23) was 19(4.92) and high range (High>31%) was 5(11.65). In the second part of this study we described all above parameters in the group of all 59 top 10 participants students for comparative outcomes. Statistic description of 59 top 10 participants, according to Age, Hb, MCV, MCHC and MCH shows that at the current study top 10 participants were with (mean age 23.40± 2.78; range: 18-32 years). Normal range of Hb level for male (14-16.6g/dl) was 43(72.88). Low level of Hb for male (Low < 13.5g/dl) was 2(3.38) and high level of Hb for male (High > 16.6g/dl) was 14(23.72). The normal range of MCV (80-95%) was 51(86.44), low range (Low <80) was 8(13.55) and high range (High>95%) was 0(0). The normal range of MCHC (32-36%) was 57(96.61), low range (Low < 32) was 2(3.38) and high range (High>36%) was 0(0).The normal range of MCH (23-31%) was 50(84.74), low range (Low < 23) was 2(3.38) and high range (High>31%) was 7(11.86).Pearson correlation between Hb and MCV is at the 0.01 level significant, (P<0.00).

Conclusion: Overall, findings of our study indicated that, low Hb, MCV, MCHC and MCH have significant correlation with cognitive ability of undergraduated students. However, this issue needs to further investigations to confirm these findings.

Keywords- Cognitive ability, Hb, MCV, MCHC, MCH, Khost.

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I. INTRODUCTION

No information is available regarding the prevalence of cognitive impairment in anemic adult population of India. Considering this fact, there is need to study the impact of anemia on cognitive functions in neurologically intact adult anemic patients in rural population from a tertiary care hospital [1].

Owing to the fact that larger red blood cells may have more difficulty passing through small capillaries, compromising to deliver adequate amounts of oxygen to cerebral tissues, there is biological plausibility that higher MCV level than the normal level might be associated with worse cognitive performance. Consequently, we aimed to explore the association between high MCV level and cognitive function based on data from China Health and Retirement Longitudinal Study (CHARLS). We hypothesized that higher MCV levels than 100 fl might be associated with worse cognitive performance [2].

To shed light into the relationship between MCV and cognition, they analyzed data from the Baltimore Longitudinal Study of Aging (BLSA). Their analysis addressed two primary aims: 1) to test the hypothesis that MCV is significantly correlated with various domains of cognitive performance independent of demographics, health covariates and other potential confounders (i.e. hemoglobin, folate, vitamin B12, erythrocyte sedimentation rate, ferritin, folate, iron, and white blood cells); 2) to test the hypothesis that age-related changes in cognitive performance are accounted for by changes in MCV independent of demographics and potential confounders. If their hypothesis is correct, and there is indeed a long-term longitudinal coupling between MCV and cognition, it may be worth to explore the mechanism of this association as a possible target of preventive and or therapeutic [3].

Anemia, a condition defined by abnormally low hemoglobin (Hb) levels, is a potential risk factor for cognitive impairment and dementia that is not only common but also increases in prevalence with older age. One in 10 adults aged 50 and older meets criteria for anemia. This proportion doubles for those aged 85 and older. Anemia is of particular concern for elderly African Americans, who have lower Hb on average and a prevalence of anemia two to three times as great as that of their white counterparts, a disparity that socioeconomic status, health behaviors, nutrition, or other chronic diseases do not account for. In a sample of predominantly black, urban-dwelling older adults, the association was investigated between Hb levels and cognitive performance and brain volumetric measures. It was hypothesized that lower Hb would be associated with poorer cognitive function and smaller brain volume, independent of comorbidities related to anemia. [4].

The prevalence of dementia is around 5% worldwide in people above 65 years, which increases with aging. Alzheimer's disease is the most common cause of dementia in the elderly. On the other hand, anemia is considered one of the most prevalent comorbidities in the elderly with a prevalence of 11% in those above the age of 65. It is crucial that we find the association between anemia and dementia, as this linkage can prove beneficial. Many currently conducted studies support the idea that anemia is a significant risk factor for dementia. However, some studies still consider anemia and dementia as just an aging process, nothing more. However, there is not enough data for the relationship between anemia and dementia. Previous studies are also limited in the adjustment of possible confounders, such as stroke, risk factors for the cardiovascular system, erythropoietin, mean corpuscular volume (MCV), and red cell distribution width (RDW) that may be correlated with the mechanism which links anemia to dementia [5].

Micronutrient deficiencies, especially those related to iodine and iron, are linked to different cognitive impairments, as well as to potential long-term behavioral changes. Among the cognitive impairments caused by iron deficiency, those referring to attention span, intelligence, and sensory perception functions are mainly cited, as well as those associated with emotions and behavior, often directly related to the presence of iron deficiency anemia. In addition, iron deficiency without anemia may cause cognitive disturbances [6].

The studies exploring the mediating role of cognitive reserve on cognitive aging, especially reflecting the cultural context of India, are far and few. In the present cross-sectional survey, conducted among elderly residing in urban areas of West Bengal (India), we proposed that cognitive reserve, taken as a cross-product of educational level and occupational complexity, would mediate the association between physical, psychological, and social determinants on cognitive function [7].

The authors emphasized that conducting more research was necessary to reach a robust conclusion because the number of prospective cohort studies were not sufficient. Since there are only four prospective cohort studies that have been published on this topic, we conducted an updated systematic review and meta-analysis that addressed the potential association between anemia and dementia risk [8].

Several micronutrient deficiencies affect functional, particularly cognition and physical performance of children. Identifying and preventing sub-clinical deficiencies may be important so that adverse effects on functional performance by these deficiencies, particularly of iron and the B vitamins, are prevented. There is also the potential for childhood micronutrient deficiencies to have long-term effects that affect health and productivity in adulthood. This is especially relevant in a developing country such as India, which faces the dual burden of malnutrition and where the prevalence of these deficiencies is high. This review highlights the extent of micronutrient deficiencies in Indian children and focuses on the effect of deficiencies of the B vitamins and iron on cognitive and physical performance in children [9.10 and 11].

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II. OBJECTIVE

This study aimed to determine and evaluate the correlation and impact of low Hb, MCV, MCHC and MCH factors on cognitive abilities of top 10 undergraduated medical students in Ahmad shah Abdali Higher Education Institute of Khost province of Afghanistan.

III. METHOD AND MATERIALS

It is prospective descriptive cross sectional research, on 59 top 10 undergraduated medical students in Ahmad shah Abdali Higher Education Institute of Khost province from 2023/ Oct / 12 to 2023/ Nov / 02. The low Hb, MCV, MCHC, and MCH parameters of all 386 participants under study recorded in computer special format. Hb, MCV, MCHC and MCH are done by special regents and micro lop. Recorded findings processing, comparison and evaluation results have been identified by IBM SPSS-23 version.

IV. RESULTS

The study was conducted from 386 participants on 59 top10 undergraduated meal medical students (mean age: 23.14 ± 3.68; range: 20-45 years).The correlation and impact of low Hb, MCV, MCHC and MCH on cognitive abilities of top 10 undergraduated medical students are described in the following tables.

Table 1: Descriptive statistics of all 386 participants' students, according to under study parameters.

Parameters	Minimum	Maximum	Mean	Std. Deviation
Age	20	45	23.14	3.68
Hb	11.70	19.60	15.62	1.13
MCV	26.6	98.8	83.52	8.25
MCHC	13.8	35.1	35	16.3
MCH	37	84.1	29.14	4.88
n=386(100%)				

Table 2: Descriptive statistics of all 386 participants' students, according to Hb, MCV, MCHC and MCH range.

Hb (for male)	Normal range (14-18 g/dl) Mean (14-16.6 g/dl)	Low[1] ≤13.5g/dl	High[2] >16.6
	301(77.97)	19(4.92)	66(17.09)
n- 386(100)			
MCV	Normal range (80-95)%	Low< 80%	High> 95%
	327(84.71)	54(13.98)	5(1.29)
n- 386(100)			
MCHC	Normal range (32-36)%	Low<32%	High> 36%
	370(95.85)	15(3.88)	1(0.25)
n- 386(100)			
MCH	Normal range (23-31)%	Low< 23%	High> 31%
	322(83.41)	19(4.92)	45(11.65)
n= 386(100)			

[1]. Low = Less than or Equal; [2]. High = More than

Table 3: Descriptive statistics of all 59 top 10 participants' students, according to under study parameters.

Parameters	Minimum	Maximum	Mean	Std. Deviation
Age	18	32	23.40	2.78
Hb	12.7	17.9	15.79	1.10
MCV	60.1	92.1	84.93	5.73
MCHC	13.8	35.2	34.02	2.75
MCH	19.4	32.3	29.18	2.30
n=59(100%)				

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Table 4: Descriptive statistics of all 59 top 10 participants 'students, according to Hb, MCV, MCHC and MCH range.

Hb (for male)	Normal range (14-18 g/dl) Mean (14-16.6 g/dl)	Low ≤13.5g/dl	High > 16.6
	43(72.88)	2(3.38)	14(23.72)
n- 59(100)			
MCV	Normal range (80-95)%	Low< 80%	High> 95%
	51(86.44)	8(13.55)	0(0)
n- 59(100)			
MCHC	Normal range (32-36)%	Low<32%	High> 36%
	57(96.61)	2(3.38)	0(0)
n- 59(100)			
MCH	Normal range (23-31)%	Low< 23%	High> 31%
	50(84.74)	2(3.38)	7(11.86)
n- 59(100)			

Table 5: Comparative descriptive statistics of all 386 and 59 top 10 participants 'students, according to Hb, MCV, MCHC and MCH range.

n=59				n=386		
Hb (for male)	Normal range (14-18 g/dl) Mean (14-16.6 g/dl)	Low ≤13.5g/dl	High > 16.6	Normal range (14-18 g/dl) Mean (14-16.6 g/dl)	Low ≤13.5g/dl	High > 16.6
	43(11.14)	2(0.94)	14(3.62)	301(77.97)	19(4.92)	66(17.09)
n=59(15.28)				n=386(100)		
MCV	Normal range (80-95)%	Low< 80%	High> 95%	Normal range (80-95)%	Low< 80%	High> 95%
	51(13.21)	8(2.07)	0(0)	327(84.71)	54(13.98)	5(1.29)
n=59(15.28)				n=386		
MCHC	Normal range (32-36)%	Low<32%	High> 36%	Normal range (32-36)%	Low<32%	High> 36%
	57(14.77)	2(0.51)	0(0)	370(95.85)	15(3.88)	1(0.25)
n=59(15.28)				n=386		
MCH	Normal range (23-31)%	Low< 23%	High> 31%	Normal range (23-31)%	Low< 23%	High > 31%
	50(12.95)	2(0.52)	7(1.81)	322(83.41)	19(4.92)	45(11.65)
n=59(15.28)				n=386		

V. DISCUSSION

This study is conducted during (20) days on 386 undergraduated medical students in Ahmad shah Abdali Higher Education Institute of Khost province. Initially we described all male participants according to age. At the current study all male participants were with (mean age: 23.14 ± 3.68; range: 20-45 years). All participants of this study were from all (1st, 2nd, 3rd, 4th, 5th and 6th) classes. Statistic description of all participants, according to Hb, MCV, MCHC and MCH shows that normal range of Hb level for male (14-16.6g/dl) was more prevalent 301(77.97). Low level of Hb for male (Low < 13.5g/dl) was 19(4.92) and high level of Hb for male (High > 16.6g/dl) was 66(17.09).The normal range of MCV (80-95%) was 327(84.71), low range (Low <80) was 54(13.98) and high range (High>95%) was 5(1.29).The normal range of MCHC (32-36%) was 370(95.85), low range (Low < 32) was 15(3.88) and high range (High>36%) was 1(0.25).The normal range of MCH (23-31%) was 322(83.41), low range (Low < 23) was 19(4.92) and high range (High>31%) was 5(11.65). In the second part of this study we described all above parameters in the group of all 59 top 10 participants students for comparative outcomes. Statistic description of 59 top 10 participants, according to Age, Hb, MCV, MCHC and MCH shows that at the current study top 10 participants were with (mean age 23.40± 2.78; range: 18-32 years). Normal range of Hb level for male (14-16.6g/dl) was 43(72.88). Low level of Hb for male (Low < 13.5g/dl) was 2(3.38) and high level of Hb for male (High > 16.6g/dl) was 14(23.72). The normal range of MCV (80-95%) was 51(86.44), low range (Low <80) was 8(13.55) and high range (High>95%) was 0(0). The normal range of MCHC

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(32-36%) was 57(96.61), low range (Low < 32) was 2(3.38) and high range (High>36%) was 0(0).The normal range of MCH (23-31%) was 50(84.74), low range (Low < 23) was 2(3.38) and high range (High>31%) was 7(11.86).Pearson correlation between Hb and MCV is at the 0.01 level significant, (P<0.00).

The comparison of findings; the mean age of 386 participants under study (mean age: 23.14 ± 3.68; range: 20-45 years) and the mean age of top ten students (mean age 23.40± 2.78; range: 18-32 years) were approved.

The comparison of findings; the low hemoglobin of 386 participants under study (low Hb ≤ 13.5g/dl; 19(4.92%) and the low hemoglobin of top ten students (low Hb ≤ 13,5g/dl; 2 (0.94); were approved. It is noticeable that the before mentioned percentage is included low cognitive group (6-10 roll numbers).

The comparison of findings the low MCV <80%; 54 (13.98) of 386 participants under study and the low MCV <80%; 8 (2.07) of top ten students were approved. It is noticeable that the before mentioned percentage is included low cognitive group (6-10 roll numbers).

The comparison of findings the low MCHC <32%; 15 (3.88) of 386 participants under study and the low MCHC <32%; 2 (0.51) of top ten students were approved. It is noticeable that the before mentioned percentage is included a single participant in low cognitive group (6-10 roll numbers) and a single participant is included in high cognitive group (1-5 roll numbers).

The comparison of findings the low MCH <23%; 19 (4.92) of 386 participants under study and the low MCH <23%; 2 (0.52) of top ten students were approved. It is noticeable that the before mentioned percentage is included in the low cognitive or (6-10) graded students group. The assignment of the noticed factor illustrated that the high MCH>31%; 45(11.65) of 386 members under the study and the high MCH>31%; 7(1.81) of top ten students were approved. The before mentioned proves the iron deficiency anemia along with the signal of folic acid and vitamin B12 deficiencies.

Another study showed that there was a significant correlation between the anemia and the cognitive skills in the neurologically intact patients [1, 2, 3].

In another study more than half of the 196 participants (85% female, 93% black) were obese (BMI >30.0 km/m2), and 67% reported being hypertensive. Mean Hb level was 12.99 g/dL (range 9.8–16.9 g/dL). In multivariable regression models that included age, sex, education, hypertension, BMI, HbA1c, eGFR, and depressive symptoms, lower Hb was associated with slower processing speed and working memory but not executive functioning, verbal learning, or memory. For MRI measures, lower Hb was associated with smaller ICV and gray matter volume; the direction of effect was similar for white matter volume. Although cross-sectional, these results may indicate that the effect of low hemoglobin is evident in brain and behavior [4].

In another study, they found that there are a lot of theories, such as low brain hemoglobin associated with low oxygen levels, which leads to neuron damage. One article mentioned that it is dependent on the level of hemoglobin as an effect with mild to moderate anemia, but apparent with severe forms of it. Researchers are expected to further explore and identify the exact relationship between anemia and dementia [5].

At present, the prevalence of iron deficiency and iron deficiency anemia is 2%-6% among European children. Given the importance of iron deficiency relative to proper cognitive development and the alterations that can persist through adulthood as a result of this deficiency. The relevance of iron deficiency and iron deficiency anemia, the distinction between the cognitive consequences of iron deficiency and those affecting specifically cognitive development, and the debate about the utility of iron supplements are the most relevant and controversial topics [6].

In another study on 370 elderlies interviewed (mean age = 68.9 years), cognitive function was abnormal in 13.5%. The cognitive function had a significant inverse relationship with depression symptoms, loneliness, hypertension, anemia, and basic activities of daily living. There was a significant difference in the cognitive reserve of the elderly with normal and abnormal cognitive function (mean 33.7 and 26.8, respectively). In the presence of covariates like sleep quality, depression, hypertension, and hemoglobin levels, the effect of age on cognitive function had a significant mediation influence of cognitive reserve - total effect = -0.2349; 95% CI = (-0.2972 to -0.1725) and direct effect = -0.2583; 95% CI = (-0.3172 to -0.1994) [7].

In Updated Systematic Review and Meta-Analysis a total of 20 studies, involving 6558 OCI patients were included. Anemia was significantly associated with an increased risk of OCI (adjusted RR (aRR) 1.39 (95% CI, 1.25–1.55; p < 0.001)). In subgroup analysis, anemia was also associated with an increased risk of all-cause dementia (adjusted RR (aRR), 1.39 (95% CI, 1.23–1.56; p < 0.001)), Alzheimer's disease [aRR, 1.59 (95% CI, 1.18–2.13; p = 0.002)], and mild cognitive impairment (aRR, 1.36 (95% CI, 1.04–1.78; p = 0.02)) [8].

This review highlights the extent of micronutrient deficiencies in Indian children and focuses on the effect of deficiencies of the B vitamins and iron on cognitive and physical performance in children. Most studies on multiple micronutrient supplementation or fortification in Indian school children show modest effects on cognitive and physical performance, and it is relevant to point out that these studies have largely been conducted on urban children with mild deficiency at most; children with moderate or severe deficiency have not been studied. However, diets of rural children indicate large deficits in micronutrient intake, particularly of folic acid, riboflavin and iron, and their consequences have not been studied [9, 10, 11].

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Our study shows that, low Hb, MCV, MCHC and MCH have significant correlation with cognitive ability of undergraduated students. However, this issue needs to further investigations to confirm these findings.

VI. CONCLUSION

Overall, findings of our study indicated that, low Hb, MCV, MCHC and MCH have significant correlation with cognitive ability of undergraduated students. However, this issue needs to further investigations to confirm these findings.

REFERENCES

[1] Agrawal S, Kumar S, Ingole V, Acharya S, Wanjari A, Bawankule S, Raisinghani N. Does anemia affects cognitive functions in neurologically intact adult patients: Two year cross sectional study at rural tertiary care hospital. Journal of Family Medicine and Primary Care. 2019 Sep; 8(9):3005. Rihab Alsadi. Personality Traits and Their Relationship with Blood Groups among of Palestinian University Students. International Journal of Psychology and Behavioral Sciences 2020, 10(2): 34-42 DOI: 10.5923/j.ijpbs.20201002.02. At: http://creativecommons.org/licenses/by/4.0/.

[2] Badea M, Gaman L, Delia C, Ilea A, Leaşu F, Henríquez-Hernández LA, Luzardo OP, Rădoi M, Rogozea L. Trends of lipophilic, antioxidant and hematological parameters associated with conventional and electronic smoking habits in middle-age Romanians. Journal of clinical medicine. 2019 May 12;8(5):665.

[3] Chen Y, Ma CX, Luo L, Yin J, Gao Z, Yu Z, Wan Z. The cross-sectional association between mean corpuscular volume level and cognitive function in Chinese over 45 years old: Evidence from the China Health and Retirement Longitudinal Study. Plos one. 2020 Dec 3; 15(12):e0243227.

[4] Gamaldo AA, Ferrucci L, Rifkind J, Longo DL, Zonderman AB. Relationship between mean corpuscular volume and cognitive performance in older adults. Journal of the American Geriatrics Society. 2013 Jan; 61(1):84-9.

[5] Gattas BS, Ibetoh CN, Stratulat E, Liu F, Wuni GY, Bahuva R, Shafiq MA, Gordon DK. The impact of low hemoglobin levels on cognitive brain functions. Cureus. 2020 Nov 8;12(11). *Khaled A. Alswat, MBBS, CCD, Abdullah D. Al-shehri, MBBS, Tariq A. Aljuaid, MBBS, et.All.* The association between body mass index and academic performance. Saudi Med J 2017; Vol. 38 (2) At: www.smj.org.sa.

[6] Jáuregui-Lobera I. Iron deficiency and cognitive functions. Neuropsychiatric disease and treatment. 2014 Nov 10:2087-95. Amy Pullan – University of Sheffield. Your Blood Type May Help Protect You From Cognitive Decline. Published online June 03 2015 doi: 10.1016/j.brainresbull.2015.05.005.

[7] Kaur A, Sonal A, Ghosh T, Ahamed F. Cognitive reserve and other determinants of cognitive function in older adults: Insights from a community-based cross-sectional study. Journal of Family Medicine and Primary Care. 2023 Sep 1; 12(9):1957-64. Avinash Kumar, Kumar Sarvottam, Satyam Vishwakarma. Blood group- and gender-wise comparison of big five models of personality among medical students. National Journal of Physiology, Pharmacy and Pharmacology, August 27, 2020.At: www.njppp.com.

[8] Kung WM, Yuan SP, Lin MS, Wu CC, Islam MM, Atique S, Touray M, Huang CY, Wang YC. Anemia and the risk of cognitive impairment: an updated systematic review and meta-analysis. Brain Sciences. 2021 Jun 11;11(6):777. Margo Pierce. The Strange Link Between Blood Type and Cognitive Health. Published by: August 7, 2015 by braindecoder.com https://www.braindecoder.com/how-blood-type-affects-brain-health-1285605041.html.

[9] Pollitt E. Iron deficiency and cognitive function. Annual review of nutrition. 1993 Jul; 13(1):521-37.

[10] Swaminathan S, Edward BS, Kurpad AV. Micronutrient deficiency and cognitive and physical performance in Indian children. European journal of clinical nutrition. 2013 May; 67(5):467-74.

[11] Zhang Z, Gao S, Dong M, Luo J, Xu C, Wen W, Huang Y, Wu Y, Zhou J, Yuan Z. Relationship between red blood cell indices (MCV, MCH, and MCHC) and major adverse cardiovascular events in anemic and nonanemic patients with acute coronary syndrome. Disease Markers. 2022 Nov 3; 2022.