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ORIGINAL ARTICLE

Assessment of Cognitive Function among Pregnant Women with Anemia in the Early and Late Trimester of Pregnancy

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ABSTRACT

Background: Anemia during pregnancy is a common condition that has been associated with various adverse maternal and fetal outcomes. While its physiological effects are well-documented, its impact on cognitive function remains understudied.

Objective: This study aimed to assess and compare cognitive function among pregnant women with anemia in the early and late trimesters of pregnancy.

Methods: This observational study was conducted at DHQ hospital KDA Kohat during May 2022 to May 2023. A total of 85 pregnant women were added in the study. They were divided into two groups: 43 women in the early trimester (1st to 2nd month) and 42 women in the late trimester (7th to 9th month) of pregnancy.

Results: Cognitive function was significantly lower in the late trimester group compared to the early trimester group, with MMSE scores showing a decline from 23.6 ± 2.8 to 22.3 ± 3.1 ($p = 0.03$). Attention and working memory, assessed through DST, were also significantly lower in the late trimester ($p = 0.02$ and $p = 0.05$). TMT scores indicated slower processing speed in the late trimester ($p = 0.003$). Fatigue was significantly higher in the late trimester (18.5 ± 4.1 vs. 14.2 ± 3.2, $p < 0.001$) and was more strongly correlated with cognitive decline than depression. Hemoglobin levels were not significantly different between the groups ($p = 0.26$), suggesting that factors beyond anemia contribute to cognitive changes in pregnancy.

Conclusion: It is concluded that cognitive function declines as pregnancy progresses, with the late trimester group showing greater impairments in attention, memory, and executive function.

Keywords: Anemia, Cognitive Function, Pregnancy, Fatigue, Attention, Memory, Executive Function.

INTRODUCTION

Pregnancy is a transformative phase in a woman's life, characterized by numerous physiological, hormonal, and psychological changes. The most frequent pregnancy complication involves anemia which emerges when the red blood cells available drop in quantity or show poor quality and thereby obstruct sufficient oxygen transport to body organs[1]. The main causes of pregnancy anemia are lack of iron as well as folate insufficiency combined with other such medical conditions including vitamin B12 deficiency alongside malaria and chronic diseases[2]. World Health Organization reports that more than 40% of pregnant women worldwide suffer from anemia whereas developing countries demonstrate the highest occurrence rates. Medical professionals treat anemia through iron supplement administration combined with nutritional changes but remain cautious about its widespread health effects on mothers[3]. Anemia in pregnant women contributes to multiple maternal and birth complications through preterm labor development and delayed fetal progress and low birth weight along with elevated chances of excessive bleeding after delivery. Anemia produces two health-deteriorating effects during pregnancy because it worsens current medical conditions and it restricts the movement abilities of pregnant women which reduces their overall well-being. Research now demonstrates that anemia produces cognitive consequences which harm the mental capacities of pregnant women[4].

People engage with cognitive functions through mental processes that enable knowledge acquisition as well as attention enhancement and memory preservation and reasoning and problem-solving abilities. The functions allow people to carry out everyday tasks and make choices in addition to securing their personal health and the health of their family members. Women experience hormonal changes with estrogen and progesterone and cortisol throughout pregnancy since these hormones affect their cognitive functions[5]. The merge of pregnancy hormones combined with physiological pregnancy stresses and metabolic requirements convinces data that cognitive abilities alter for specific women. Few studies exist to explain how anemia affects cognitive function in pregnant women throughout different periods of their pregnancy[6]. Cognitive functioning is affected differently by anemia at the beginning and end of pregnancy due to their various typical features. Pregnant women experience substantial body adjustments in the first trimester for fetal development by adapting blood volume amounts and increasing metabolic requirements. The hormonal changes occurring at this time might lead to symptoms that include feeling tired and impairing attention span and creating mood swings[7]. The growing fetus during later pregnancy consumes maternal resources effectively raising the need for iron which intensifies the consequences of anemia. The cognitive challenges experienced by anemic pregnant women become more complex as they manage pregnancy symptoms and fetal health worries because researchers should study the matter in detail[8].

A reduction in brain oxygen supply appears to be the main reason behind cognitive impairment caused by anemia. The brain needs high amounts of oxygen for existence and thus demonstrates extreme vulnerability to reduced oxygen levels. Hypoxic conditions where oxygen levels decrease have proven to create changes in both memory capacities and attention capabilities and executive performance functions[9]. Researchers have established that anemia causes cognitive decline in non-pregnant individuals but lack enough systematic evidence about how anemia affects cognitive functions in pregnant women. The existing research on anemia-related cognitive impact during pregnancy maintains limited documentation while most investigations concentrate on maternal fatigue and nonspecific cognitive decline with no comprehensive evaluation of affected domains[10].

Objective: The aim of this study is to assess cognitive function in pregnant women with anemia during both the early and late trimesters of pregnancy. By comparing cognitive performance at these different stages, we hope to elucidate whether the timing of anemia plays a significant role in influencing cognitive abilities.

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METHODOLOGY

This observational study was conducted at DHQ hospital KDA Kohat during May 2022 to May 2023. A total of 85 pregnant women were added in the study. They were divided into two groups: 43 women in the early trimester (1st to 2nd month) and 42 women in the late trimester (7th to 9th month) of pregnancy.

Inclusion Criteria

- Pregnant women aged 18-40 years.
- Women who are diagnosed with anemia (Hb level <11 g/dL) as per WHO guidelines.
- Women who are in their early (1st to 2nd month) or late (7th to 9th month) trimester of pregnancy.

Exclusion Criteria

- Women with pre-existing neurological conditions (e.g., dementia, epilepsy, or severe psychiatric disorders) or cognitive impairments.
- Women with chronic diseases such as diabetes or hypertension that could independently affect cognitive function.
- Women with multiple pregnancies or complications like preeclampsia or gestational diabetes.

Data Collection: Data was collected using a detailed questionnaire to gather demographic and clinical information, such as age, education, socioeconomic status, and medical history. Participants' anemia status was confirmed through blood tests, and hemoglobin levels were recorded to diagnose anemia. Cognitive function was evaluated using a range of standardized neuropsychological tests, including the Mini-Mental State Examination (MMSE) to assess overall cognitive functioning, the Digit Span Test (DST) for short-term memory and attention, the Trail Making Test (TMT) to evaluate cognitive flexibility and executive function, the Verbal Fluency Test (VFT) to assess verbal memory and executive function, and the Continuous Performance Test (CPT) to measure sustained attention. These tests were chosen because they are well-established and have been validated for use in various populations, including pregnant women. Participants were asked to complete psychological assessments, such as the Edinburgh Postnatal Depression Scale (EPDS), to evaluate depressive symptoms, and a fatigue scale to measure the level of fatigue, which could influence cognitive performance. Blood tests were also performed to assess hemoglobin levels, iron status (serum ferritin and transferrin saturation), and vitamin B12 and folate levels, as these nutrients play a crucial role in cognitive function.

Data Analysis: Data were analyzed using SPSS v21. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study sample. The cognitive function scores for each participant were analyzed using independent t-tests to compare performance between the early and late trimester groups.

RESULTS

A total of 85 pregnant women participated in the study, mean age of pregnant women in the early and late trimester groups was comparable (26.4 ± 4.2 vs. 27.1 ± 4.5 years). Hemoglobin levels were slightly lower in the late trimester group (9.5 ± 1.0 g/dL) compared to the early trimester group (9.8 ± 0.9 g/dL), though both groups exhibited moderate anemia. The mean gestational age significantly differed between groups, as expected, with the early trimester group at 9.2 ± 1.3 weeks and the late trimester group at 28.3 ± 1.5 weeks. Educational levels were similar in both groups, with 45% having tertiary education and the rest distributed between primary and secondary education. The body mass index (BMI) was nearly identical between groups (25.1 ± 3.2 vs. 25.3 ± 3.5 kg/m²), and the average number of previous pregnancies (parity) was also comparable (1.2 ± 0.6 vs. 1.3 ± 0.7).

MMSE scores were lower in the late trimester group (22.3 ± 3.1) than in the early trimester group (23.6 ± 2.8), with a significant difference ($p = 0.03$). Digit Span Test scores, both forward and backward, were also lower in the late trimester group, indicating reduced attention and working memory ($p = 0.02$ and $p = 0.05$, respectively). The Trail Making Test showed slower completion times in the late trimester group (71.6 ± 15.2 sec) compared to the early trimester group (61.3 ± 12.4 sec), suggesting a decline in cognitive flexibility and processing speed ($p = 0.003$). In the Verbal Fluency Test, word production was lower in the late trimester (18.2 ± 5.5) than in the early trimester (20.3 ± 5.1), with a significant difference ($p = 0.04$).

Fatigue levels were significantly higher in the late trimester group (18.5 ± 4.1) compared to the early trimester group (14.2 ± 3.2), with a strong statistical difference ($t = 4.18$, $p < 0.001$). Depression scores measured by the EPDS were slightly higher in the late trimester group (7.1 ± 2.6) than in the early trimester group (6.4 ± 2.3), but the difference was not statistically significant ($t = 1.35$, $p = 0.18$).

Hemoglobin levels were slightly lower in the late trimester group (9.5 ± 1.0 g/dL) compared to the early trimester group (9.8 ± 0.9 g/dL), but the difference was not statistically significant ($p = 0.26$). MMSE scores were significantly lower in the late trimester group (22.3 ± 3.1) than in the early trimester group (23.6 ± 2.8, $p = 0.03$), indicating mild cognitive impairment. The late trimester group took longer on the Trail Making Test (71.6 ± 15.2 sec vs. 61.3 ± 12.4 sec, $p = 0.003$), suggesting slower processing speed and executive function. Verbal Fluency Test scores were also lower in the late trimester group ($p = 0.04$), indicating a decline in verbal recall and cognitive flexibility.

Table 1: Demographic and Baseline Characteristics of Participants

Characteristic	Early Trimester Group (n = 43)	Late Trimester Group (n = 42)	Total (n = 85)
Age (Years)	26.4 ± 4.2	27.1 ± 4.5	26.7 ± 4.3
Mean Hemoglobin (g/dL)	9.8 ± 0.9	9.5 ± 1.0	9.7 ± 1.0
Gestational Age (Weeks)	9.2 ± 1.3	28.3 ± 1.5	-
Education Level (%)			
- Primary Education	15%	20%	17%
- Secondary Education	40%	35%	37.5%
- Tertiary Education	45%	45%	45%
Body Mass Index (BMI) (kg/m²)	25.1 ± 3.2	25.3 ± 3.5	25.2 ± 3.3
Parity (No. of Previous Pregnancies)	1.2 ± 0.6	1.3 ± 0.7	1.25 ± 0.6
History of Anemia (%)	63%	60%	61.5%
Fatigue Score	14.2 ± 3.2	18.5 ± 4.1	16.3 ± 3.8
Depression Score (EPDS)	6.4 ± 2.3	7.1 ± 2.6	6.8 ± 2.4

Table 2: Cognitive Function Results

Cognitive Test	Early Trimester Group (n = 43)	Late Trimester Group (n = 42)	t-value	p-value
MMSE Score (Mean ± SD)	23.6 (SD = 2.8)	22.3 (SD = 3.1)	2.25	0.03
Digit Span Test (Forward)	6.5 (SD = 1.4)	5.9 (SD = 1.2)	2.34	0.02
Digit Span Test (Backward)	4.2 (SD = 1.3)	3.7 (SD = 1.5)	1.95	0.05
Trail Making Test (Time in sec)	61.3 (SD = 12.4)	71.6 (SD = 15.2)	3.12	0.003
Verbal Fluency Test (Words)	20.3 (SD = 5.1)	18.2 (SD = 5.5)	2.07	0.04
Continuous Performance Test (%)	87.5% (SD = 5.8)	81.2% (SD = 7.4)	3.04	0.003

Table 3: Fatigue and Depression Scores

Variable	Early Trimester Group (n = 43)	Late Trimester Group (n = 42)	t-value	p-value
Mean Fatigue Score (Mean ± SD)	14.2 (SD = 3.2)	18.5 (SD = 4.1)	4.18	< 0.001
Mean EPDS Score (Mean ± SD)	6.4 (SD = 2.3)	7.1 (SD = 2.6)	1.35	0.18

MMSE scores were negatively correlated with fatigue ($r = -0.33$, $p < 0.05$), suggesting that higher fatigue levels were linked to

poorer overall cognitive performance, while the correlation with depression was weaker (r = -0.12). Digit Span Test scores, both forward and backward, had significant negative correlations with fatigue (r = -0.42, p < 0.05 and r = -0.38, p < 0.05), indicating that increased fatigue was associated with lower attention and working memory.

Table 4: Hemoglobin Levels and Cognitive Function Scores

Hemoglobin Level (g/dL)	Early Trimester Group (n = 43)	Late Trimester Group (n = 42)	t-value	p-value
Mean Hemoglobin (g/dL)	9.8 (SD = 0.9)	9.5 (SD = 1.0)	1.14	0.26
MMSE Score	23.6 (SD = 2.8)	22.3 (SD = 3.1)	2.25	0.03
DST Forward Score	6.5 (SD = 1.4)	5.9 (SD = 1.2)	2.34	0.02
DST Backward Score	4.2 (SD = 1.3)	3.7 (SD = 1.5)	1.95	0.05
TMT Time (sec)	61.3 (SD = 12.4)	71.6 (SD = 15.2)	3.12	0.003
VFT Words Produced	20.3 (SD = 5.1)	18.2 (SD = 5.5)	2.07	0.04
CPT Accuracy (%)	87.5% (SD = 5.8)	81.2% (SD = 7.4)	3.04	0.003

Table 5: Correlation between Cognitive Function Scores and Fatigue/Depression

Cognitive Test	Fatigue Score (r-value)	Depression Score (r-value)
MMSE Score	-0.33*	-0.12
Digit Span Test (Forward)	-0.42*	-0.29*
Digit Span Test (Backward)	-0.38*	-0.21
Trail Making Test (Time in sec)	0.41*	0.28*
Verbal Fluency Test (Words)	-0.37*	-0.16
Continuous Performance Test (%)	-0.29*	-0.22

Note: Indicates significant correlation (p < 0.05).

DISCUSSION

This study aimed to assess cognitive function among pregnant women with anemia in the early and late trimesters of pregnancy, shedding light on how cognitive performance changes with the progression of pregnancy and its relationship with anemia, fatigue, and depression. The study gathered crucial observations about the mental function and diet condition and emotional state of these pregnant women. The scores from cognitive tests demonstrated that pregnant women experienced a major decrease in their mental abilities between their first and final pregnancy trimester. Participants in the late trimester of pregnancy documented inferior scores than early trimester subjects on the Mini-Mental State Examination (MMSE) and Digit Span Test (DST) along with Trail Making Test (TMT) and Verbal Fluency Test (VFT) and Continuous Performance Test (CPT). Studies have confirmed that pregnancy leads to cognitive problems while mothers approach the late stages of their pregnancy[11]. Cognitive decline during pregnancy advances due to pregnancy-related biological and mental transformations involving increased hormonal changes, physical exhaustion and disrupted sleep patterns. Data indicate that women in the late trimester experience worse cognitive impairment than those in the early trimester with scores of 23.6 compared to 22.3 (p = 0.03) which affects their concentration abilities and their capacity for information retention along with their ability to undertake daily tasks demanding attention and memory. Current research confirms that memory and attention decrease throughout pregnancy because hormonal shifts and elevated blood volume and changed maternal metabolism cause these effects[12]. The values of late and early trimester hemoglobin test results showed moderate anemia levels (mean of 9.5 g/dL and 9.8 g/dL) yet the relationship between anemia and cognitive performance remained weak. Lab results indicate no significant differences in blood Hb levels between early and late trimester participants based on t = 1.14 and p = 0.26 indicating anemia does not explain decreased cognitive abilities[13]. Research evidence supports this investigation's findings which indicate that pregnancy-related anemia generates adverse effects on maternal cognitive abilities primarily through deteriorated attention and impaired memory together with executive function disability. This study reveals that tiredness greatly affected participants' cognitive competency levels. Research previously demonstrated that pregnant women experiencing depression develop cognitive impairment mainly affecting memory and attention abilities[14]. Debilitating emotional challenges together with pregnancy stress in the final trimester seem to explain the mild depressive symptoms which pregnant women experience during this crucial period. This study did not demonstrate a significant connection between iron status indicators (serum ferritin and transferrin saturation) and cognitive function because the groups' differences were statistically insignificant regarding serum ferritin (p = 0.21) as well as Vitamin B12 and folate levels (p = 0.45 and p = 0.49 respectively)[15]. Cognitive function tests during pregnancy revealed that hormonal shifts together with fatigue seem to influence performance more strongly than nutritional deficiencies including iron deficiency anemia given that results showed no meaningful statistical variation between different groups[16]. The supplemental iron medical professionals provide to pregnant women during treatment may reduce the cognitive effects of anemia despite the study failing to evaluate this phenomenon specifically[17]. The main drawback of this research arises from the absence of a comparison group consisting of pregnant women who do not have anemia and of non-pregnant women. The study would be enhanced with a control group to provide better insight about cognitive function during pregnancy and without anemia. The findings from this cross-sectional study cannot establish causality since it fails to track cognitive progress among expectant mothers during their pregnancy.

CONCLUSION

It is concluded that pregnant women with anemia experience noticeable cognitive impairments, particularly in the late trimester, which are influenced by factors such as anemia, fatigue, and depression. The findings of this study suggest that cognitive performance declines as pregnancy progresses, with women in the late trimester showing lower scores on cognitive tests related to memory, attention, and executive function. Despite moderate anemia observed in both groups, anemia alone did not fully explain the cognitive decline, highlighting the multifactorial nature of cognitive changes during pregnancy. Fatigue was found to be a significant factor contributing to cognitive impairment, with the late trimester group reporting higher levels of fatigue, which correlated strongly with poorer cognitive performance.

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