



ASSESSMENT OF PLASMA PROTEINS, SODIUM, POTASSIUM, GLUCOSE, HEMOGLOBIN AND BODY MASS INDEX AMONG MALNOURISHED DISPLACED CHILDREN FROM AFFECTED AREAS WITH WAR IN KOSTI CITY, WHITE NILE STATE

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ABSTRACT

Malnutrition results from an insufficient or unbalanced diet, leading to nutrient deficiencies and, in all grades, subsequent malabsorption. This study aimed to investigate and compare plasma total protein, albumin, globulin, haemoglobin, sodium, potassium, circumference, and BMI between malnourished and well-nourished displaced children. We included 100 cases and 100 control subjects. Plasma total protein, albumin, globulin, hemoglobin, MUAC and BMI were measured. The results showed significantly decreased levels of estimated age and body mass index; the study group were (2.98±1.20) (22.0±4.63), and the control group were (3.29±1.31) (23.99±7.0) (p=0.097) (p=0.022), respectively. Additionally, the results showed significantly decreased levels of estimated plasma total protein, albumin, haemoglobin, and mid-upper arm circumference in the study group compared with the control group (p=0.000, p=0.000, p=0.000, and p=0.000), respectively, and significantly increased levels of calculated globulin in the study group compared with the control group (p=0.000). There was an insignificant increase in the levels of plasma total protein, globulin, hemoglobin and circumference among malnourished males compared to malnourished females, and an insignificant increase in the levels of albumin in malnourished females compared to malnourished males. The study findings highlighted the link between plasma total protein, albumin, globulin, haemoglobin, and BMI and malnutrition, which is significant for predicting and assessing nutritional status in malnourished children under five years of age. Early detection and rapid screening for displaced children help reduce the harmful effects and progression of malnutrition.

KEYWORDS: Plasma proteins, Glucose, Sodium, Potassium, Hemoglobin, Malnutrition, Displacement, Refugees, Sudan.

INTRODUCTION

Malnutrition, or undernutrition, is a condition that results from an insufficient, inadequate, or unbalanced diet, leading to nutrient deficiencies. Malnutrition in all grades leads to simultaneous and subsequent malabsorption.^[1] Malnutrition has a pervasive and debilitating effect on the human body, disturbing the harmonious functioning of various body systems, and it is a severe issue, especially in children who need a

multifaceted approach for effective intervention and treatment.^[2]

BMI categories are generally regarded as a useful tool for assessing nutritional status for persons who are underweight, overweight, or obese, with exceptions such as athletes, children, the elderly, and the infirm.^[3]

Low haemoglobin and blood indices, in addition to electrolyte disturbances related to many diseases, were reported in White Nile State in Sudan.^[4]

The impact of malnutrition on different body systems and their functions observed in clear statements, the weakens in the immune system making the body more susceptible to infections and diseases, lack of essential nutrients like amino acids and vitamins can result in muscle wasting in musculoskeletal system,^[5] weakened cardiac muscles, cognitive delays and mental retardation observed in central nervous system, diarrhea and gut inflammation in digestive system, hormonal imbalances and weakness in respiratory muscles reduce the respiratory output.^[6-9] The biochemical disturbance associated with protein metabolism is mainly hypoproteinemia, hypoalbuminemia, hypoglycemia, hyponatremia, hypokalemia and low concentration of hemoglobin,^[10] the occurrence is observed in which children not intake their rich supply of protein in diet particularly less than half amount of requirements, measurement of serum proteins, glucose and serum electrolytes (sodium and potassium) and hemoglobin is widespread for assessment of malnutrition status, whenever albumin was traditionally measured.^[11,12]

MATERIALS AND METHODS

The study was a case-control study conducted at Kosti Teaching Hospital in Kosti city, White Nile State, from September 2024 to December 2024. The study was approved by the Ethics Committee of the University of Imam El Mahdi and by Kosti Teaching Hospital. All participants were individually informed and consented; ethical permission was obtained from the CEO, Kosti Social Welfare Department, and the Health Services Manager in Kosti Locality.

The study aimed to estimate plasma protein levels, Haemoglobin, Glucose, Sodium, Potassium, and BMI in Malnourished displaced children. It included 100 malnourished displaced children (study group) compared with 100 well-nourished children (control group), subdivided into males and females through convenience sampling.

Sampling: We collected 5 ml of blood from all participants in clean, dry, sterile containers with lithium heparin and EDTA, labelled them, and transported them to the laboratory without delay. We separated the lithium heparin sample by centrifugation.

Statistical analysis: Data obtained were computerized and analyzed using package for social (SPSS) version 21 (statistical sciences), Data assessed by independent sample T test and Correlation Test, Data were expressed as mean (m) with standard deviation (SD) and p-value of < 0.05 was considered as significant.

Plasma proteins, haemoglobin, and glucose were measured by spectrophotometry (Mindray BA-88A),

while Electrolytes (sodium and potassium) were measured using ion-selective electrodes with an electrolyte analyser (model: AC9100).

RESULTS

The study enrolled 200 subjects (100 malnourished displaced children and 100 malnourished displaced children as controls), aged 1 to 5 years; males were more common than females. The study shows that the estimated level of mean value $\pm$ SD of age in the study group was (2.80 $\pm$ 1.20 years), while in the control group it was (2.91 $\pm$ 1.31 years) (p=0.097). The difference between the two groups was not significant. The estimated mean value $\pm$ SD of BMI in the study group was (22.0 $\pm$ 4.63), while in the control group it was (23.99 $\pm$ 7.0) (p=0.022). The difference between the two groups was significantly lower in the study group than in the control group. The mean circumference ($\pm$ SD) in the study group was 11.3 $\pm$ 0.76 cm, while in the control group it was 14.2 $\pm$ 0.66 cm (p=0.000). The difference between the two groups was significantly lower in the study group than in the control group (Table 1). The results showed the frequency of participants: 100 malnourished displaced children (64 males and 36 females) and 100 well-nourished displaced children (52 males and 48 females). Males were more frequent than females (Figure 1). The estimated mean value $\pm$ SD of plasma total protein concentration in the study group was (6.4 $\pm$ 0.51 g/dl), while in the control group it was (7.3 $\pm$ 0.49 g/dl) (p= 0.000). The difference between the two groups was significantly lower in the study group than in the control group. The estimated mean value $\pm$ SD of plasma albumin concentration in the study group was (3.0 $\pm$ 0.55g/dl), while in the control group it was (4.5 $\pm$ 0.51g/dl) (p= 0.000). The difference between the two groups was significantly lower in the study group than in the control group. The estimated mean $\pm$ SD of globulin concentration in the study group was (3.4 $\pm$ 0.60g/dl), while in the control group it was (2.8 $\pm$ 0.58g/dl) (p=0.000). The difference between the two groups was significantly higher in the study group than in the control group. The mean $\pm$ SD haemoglobin concentration in the study group was (9.8 $\pm$ 1.4g/dl), while in the control group it was (11.8 $\pm$ 1.6g/dl) (p=0.000). The difference between two groups was significantly decreased in the study group than control group, also results showed significant decrease in sodium and glucose level in case compare with control (134.2 $\pm$ 4.5) (137.65 $\pm$ 3.38) (82.5 $\pm$ 14.0) (131.5 $\pm$ 17.6), (p=0.00), (p=0.00) respectively and no significant change in potassium level between study group (4.1 $\pm$ 0.84) (4.2 $\pm$ 0.66) (p=0.133). Table (2). The results showed that the estimated level of mean value of plasma total protein, albumin, globulin, hemoglobin and circumference among malnourished male were (6.46 $\pm$ 0.48) (2.98 $\pm$ 0.61) (3.48 $\pm$ 0.62) (9.9 $\pm$ 1.5) (11.3 $\pm$ 0.74) and among malnourished female were (6.42 $\pm$ 0.55) (3.0 $\pm$ 0.44) (3.35 $\pm$ 0.55) (9.6 $\pm$ 1.3) (11.2 $\pm$ 0.79), (P=0.702) (P=0.451) (P=0.308) (P=0.340) respectively. There was an insignificant increase in the levels of plasma total

protein, globulin, hemoglobin and circumference among malnourished male compared to malnourished female and insignificant increased among the levels of albumin in malnourished female compared to malnourished male and showed insignificant defiance in Sodium, potassium, glucose and circumference between male children and female (133.7 ± 4.5) (135.1 ± 4.3) ($p=0.124$) (4.0 ± 0.81) (4.3 ± 0.86) ($p=0.101$) (81.5 ± 15.2) (84.3 ± 11.4) ($p=0.388$) ($p=0.340$), table (3). The results also showed a significant, strong positive correlation between circumference and total protein ($r=0.690$, $P=0.000$) and albumin ($r=0.770$, $P=0.000$), respectively, and a medium positive correlation between circumference and haemoglobin ($r=0.569$, $P=0.000$). Additionally, a weak negative correlation between circumference with globulin ($r=-0.381$, $P=0.000$) and showed a positive correlation between circumference and sodium level ($r=0.406$, $p=0.00$), also showed strong positive correlation between circumference and glucose level

($r=0.787$, $p=0.00$). and negative correlation between circumference and potassium level ($r=0.068$, $p=.338$) table (4). The results also showed a significant strong positive and medium correlation between Total protein and albumin and haemoglobin ($r=0.670$, $p=0.000$) ($r=0.606$, $p=0.000$), respectively, and an insignificant weak positive correlation between Total protein and globulin ($r=0.050$, $p=0.480$). The results also showed a significant medium positive correlation between estimated albumin and haemoglobin ($r=0.521$, $P=0.000$), a significant strong negative correlation between albumin and globulin ($r=-0.706$, $P=0.000$), and a significant weak negative correlation between albumin and globulin ($r=-0.128$, $P=0.070$). Also showed a weak positive correlation between sodium and potassium levels ($r=0.074$, $p=0.297$), a medium positive correlation between sodium and glucose levels ($r=0.414$, $p=0.000$) and a weak correlation between potassium and glucose ($r=0.052$, $p=0.463$) Table 5).

Table 1: Demographic data and clinical characteristics of malnourished displaced children (study group) and well-nourished displaced children (control group).

Variables	Study Group n=100 (Mean $\pm$ SD)	Control Group n= 100 (Mean $\pm$ SD)	P.value
Age (years)	2.80 $\pm$ 1.20	3.29 $\pm$ 1.31	0.007
BMI (kg/m ²)	22.0 $\pm$ 4.63	23.99 $\pm$ 7.0	0.022
Circumference (cm)	11.3 $\pm$ 0.76	14.2 $\pm$ 0.66	0.000

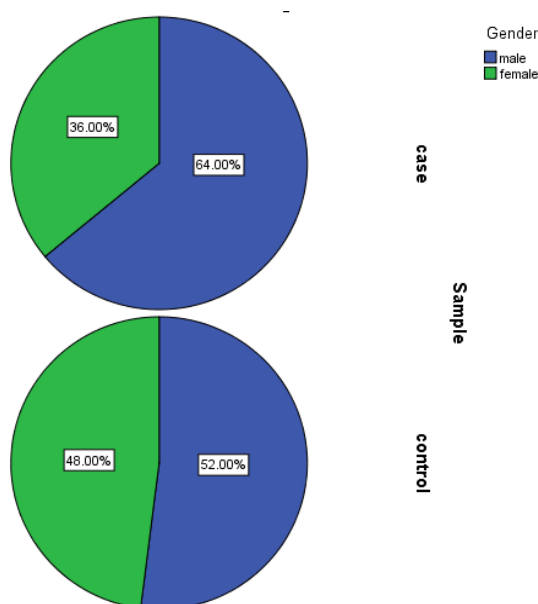


Figure 1: frequency according to gender in case and control.

Table 2: Comparison of Clinical and Hematological Parameters Between Malnourished Displaced Children (Study Group) And Well-nourished Displaced Children (Control Group).

Variables	Study Group (Mean $\pm$ SD) mg/dl	Control Group (Mean $\pm$ SD) mg/dl	P.value
Total protein (g/dl)	6.4 $\pm$ 0.51	7.3 $\pm$ 0.49	0.000
Albumin (g/dl)	3.0 $\pm$ 0.55	4.5 $\pm$ 0.51	0.000
Globulin (g/dl)	3.4 $\pm$ 0.60	2.8 $\pm$ 0.58	0.000
Hemoglobin (g/dl)	9.8 $\pm$ 1.4	11.8 $\pm$ 1.6	0.000

Sodium (mmol/l)	134.2±4.5	137.65±3.38	0.000
Potassium (mmol/l)	4.1±0.84	4.2±0.66	0.133
Glucose (mg/dl)	82.5±14.0	131.5±17.6	0.000

Table 3: Comparison of plasma proteins, hemoglobin and circumference between males and females in malnourished displaced children.

Gender	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Hb (g/dl)	Na+ mmol/l	K+ mmol/l	Glucose mg/dl	MUAC
Male (n=64)	6.46±0.48	2.98±0.61	3.48±0.62	9.9±1.5	133.7±4.5	4.0±0.81	81.5±15.2	11.3±0.74
Female (n=36)	6.42±0.55	3.0±0.44	3.35±0.55	9.6±1.4	135.1±4.3	4.3±0.86	84.3±11.4	11.2±0.79
P.value	0.702	0.451	0.308	0.341	0.124	0.101	0.338	0.340

Table 4: Correlation between Plasma Proteins, Hemoglobin and Electrolytes with Circumference.

Variable	Correlation coefficient	P.value
Circumference vs Total Protein	0.690	0.000
Circumference vs Albumin	0.770	0.000
Circumference vs Globulin	-0.381	0.000
Circumference vs Hemoglobin	0.569	0.000
Circumference vs Sodium	.406	0.000
Circumference vs Potassium	.068	0.338
Circumference vs Glucose	.787	0.000

Table 5: Correlation between Plasma Proteins, Hemoglobin, Glucose and Electrolytes with Each Other.

Variable	Correlation coefficient	P.value
Total Protein vs Albumin	0.670	0.000
Total Protein vs Globulin	0.050	0.480
Total Protein vs Hemoglobin	0.606	0.000
Albumin vs Globulin	-0.706	0.000
Albumin vs Hemoglobin	0.521	0.000
Globulin vs Hemoglobin	-0.128	0.070
Sodium vs Potassium	0.074	0.297
Sodium vs glucose	0.414	0.000
Potassium vs Glucose	0.052	0.463

DISCUSSION

Malnutrition is an imbalance between nutrient intake and requirements, resulting in cumulative deficiencies in protein, energy, and micronutrients that negatively affect overall body functions. Also known as undernutrition, it is described as abnormal nutrient utilisation that significantly affects body functions and reduces health outcomes.^[13] This case-control study was conducted in displaced centres (Schools and Housewives) in Kosti city, White Nile State, Sudan, during the period from September 2024 to October 2024. It included 100 malnourished displaced children (64 males and 36 females) and 100 well-nourished displaced children (52 males and 48 females), matched by age, to estimate plasma total protein, albumin, globulin, haemoglobin, and body mass index. The results showed significantly lower levels of estimated plasma total protein, albumin, haemoglobin, and mid-upper arm circumference (MUAC) among malnourished displaced children compared with well-nourished displaced children ($P \leq 0.001$, $P \leq 0.000$, $P \leq 0.001$, and $P \leq 0.001$). It showed a significantly higher level of calculated globulin among

malnourished displaced children compared with well-nourished displaced children ($P \leq 0.001$). This is due to decreased essential elements and a lack of nutritional support during the child's growth period. This finding was supported by Celine Bretscher *et al*, 2022, and Evans DC, *et al*, 2021,^[14,15] whom found that the serum albumin concentrations and The use of visceral proteins have been considered useful biochemical markers for nutrition assessment, and Hiba A. A. Abdallah *et al*, 2024,^[16] who found that the children having MUAC in range between ≥ 11.5 to <12.5 cm and having MUAC less than 11.5 those suffering from malnutrition according to MUAC measurement. Elevated globulin in malnourished children results from chronic inflammation associated with malnutrition and increased production of antibodies (Gamma globulins) and C-reactive protein (CRP). This finding was supported by Zhi Chen *et al.*, 2022.^[17] who found that the albumin-to-globulin ratio (AGR) is a useful inflammatory-nutritional biomarker. Additionally, Electrolyte imbalance is a common disturbance in malnourished children and a life-threatening condition. Malnutrition causes significant

losses of water and electrolytes, especially sodium and potassium. 44% with decrease in sodium level(hyponatremia) and 14% with decrease in potassium level(hypokalaemia) this indicate that malnutrition cause electrolyte imbalance in children under 5 year and this also was found out by studies done by Study conducted by Raza et al (2020).^[18] was found that Hypokalaemia, present in approximately 79.9% of the patients, was found to be the most common electrolyte abnormality they use potassium range(1.7-4.8) and my study use range (3.5-5.1). At the same time, Memon et al (2007).^[19] reported hypokalaemia in 48% of the cases. The same study conducted by Raza et al (2020).^[18] found that clinically significant hyponatremia was present in 48.9% of the children with SAM, using a sodium range (129.0-143.0). My study used the range (135_145). Another study by Subba Gangaraj et al. (2013).^[19] reported that 15.7% of hypernatremia cases had $\text{Na}^{+} > 145$ mEq/L. In another study by Yasmeen et al. (2007).^[20] only 3% had hypernatremia, defined as $\text{Na}^{+} > 150$ mEq/L. Hypoglycaemia is a serious defect that occurs in association because the body needs glucose as the main energy source for the brain. So any defect in it can cause serious complications. In this study, malnourished children were found with hypoglycaemia. The occurrence of hypoglycaemia among malnourished children is widely reported in other studies, including one conducted by Ashebir, Y. G., Godie et al (2023).^[21] The prevalence of hypoglycaemia in malnourished children was also reported in a study conducted by Barman et al.^[22] and also supported by Azimee et al(2021).^[23] found that hypoglycaemia occurs among malnourished children.

CONCLUSION

Malnutrition is a public health problem, especially in poor countries, reflecting an insufficient, inadequate, or unbalanced diet that leads to nutrient deficiencies.

Altogether, the study findings highlighted the link between plasma proteins, hemoglobin, circumference, BMI, glucose, sodium and potassium and malnutrition, which is significant in the prediction and assessment of nutritional status in malnourished displaced children.

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