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Original Research Article

Evaluation of Haematological Indices and Trace Elements in Leukaemia Patients Receiving Care at the University of Port Harcourt Teaching Hospital

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Abstract

Leukaemia is a malignant condition of the haematopoietic system marked by the uncontrolled proliferation of leukocytes and the interruption of normal blood cell formation. Changes in haematological indices and trace element levels may affect the development of the disease, the response to treatment, and the clinical consequences. This study examined haematological indices and specific trace elements in leukaemia patients undergoing treatment at the University of Port Harcourt Teaching Hospital (UPTH), Rivers State, Nigeria. A cross-sectional study was performed with 63 people, including 32 males and 31 females diagnosed with leukaemia, alongside seemingly healthy persons serving as controls. Each participant had five millilitres of blood taken from a vein. Two millilitres were put into EDTA tubes for blood tests, and three millilitres were allowed to clot, spun at 3000 rpm for 10 minutes, and the serum was taken out for trace element tests. An automated haematology analyser was used to find out the haematological parameters, and colorimetric methods were used to find out the serum trace elements. We used SPSS version 21 to look at the data, and the results were given as mean ± standard deviation. A p-value of less than 0.05 was deemed statistically significant.The average white blood cell (WBC) count in leukaemia patients (33.37 ± 63.30 $\times 10^9$/L) was much greater than in controls (5.91 ± 2.34 $\times 10^9$/L; $p = 0.001$). In contrast, red blood cell count (4.06 ± 1.27 $\times 10^{12}$/L), packed cell volume (30.82 ± 10.97%), mean corpuscular volume (28.04 ± 3.69), eosinophils (0.85 ± 1.33%), basophils (0.10 ± 0.30%), and serum iron (62.40 ± 42.63 µg/dL) were significantly lower in leukaemia patients compared to controls (4.58 ± 0.73 $\times 10^{12}$/L, 37.17 ± 6.68%, 29.71 ± 3.24, 2.67 ± 2.50%, 0.25 ± 0.51%, and 98.61 ± 22.47 µg/dL, respectively; $p < 0.05$). Serum calcium (Ca^{2+}) levels were considerably elevated in leukaemia patients (2.27 ± 0.21 mmol/L) relative to controls ($p = 0.018$). In leukaemia patients, iron had a strong positive association with haemoglobin ($r = 0.296$, $p = 0.019$) and a strong negative correlation with platelet count ($r = –0.403$, $p = 0.001$). Leukaemia patients have substantial changes in haematological parameters and trace element concentrations. These metrics may function as significant biomarkers for disease surveillance, prognosis, and therapeutic decision-making in the management of leukaemia at UPTH.

Keywords: *Haematological indices, trace elements, leukaemia subjects, portharcourt.*

INTRODUCTION

Leukaemia is a collection of malignant diseases of the haematopoietic system marked by the uncontrolled growth of aberrant white blood cells. Alfred Armand Louis-Marie Velpeau first defined leukaemia in 1827. It starts in the bone marrow and causes immature and defective leukocytes, which are often called blasts, to build up. These atypical cells disrupt normal haematopoiesis, resulting in diminished formation of red blood cells, platelets, and functional white blood cells, consequently predisposing individuals to anaemia, haemorrhage, and infections [2].

Leukaemia is generally categorised into acute and chronic variants, which are further separated into lymphocytic and myelogenous kinds. Lymphocytic leukaemia is characterised by the aberrant proliferation of lymphoid precursor cells, whereas myelogenous leukaemia originates from myeloid lineage cells that typically differentiate into erythrocytes, granulocytes, and platelets [3]. The precise aetiology of leukaemia is yet unidentified, however both genetic and environmental variables have been associated. Known risk factors include being around ionising radiation, benzene and other petrochemicals, smoking cigarettes, having chemotherapy in the past, and having genetic disorders such Down syndrome [4].
In a clinical setting, leukaemia manifests with symptoms like fever, tiredness, bone pain, recurring infections, and a propensity for bleeding. The burden of leukaemia differs globally based on area and socioeconomic development level. In 2018, the age-standardized incidence and death rates were elevated in nations with high and very high Human Development Index (HDI) compared to those in low and medium HDI areas [5].

Haematological indices furnish critical data regarding bone marrow functionality and disease activity in leukaemia. For diagnosis, prognosis, and therapeutic monitoring, it is common to employ parameters such the concentration of haemoglobin, the volume of packed cells, the counts of red and white blood cells, the count of platelets, and the indices of red cells [6]. Furthermore, derived indices such as the neutrophil-to-lymphocyte ratio (NLR), red cell distribution width (RDW), and platelet distribution width (PDW) have been identified as valuable indicators of inflammation, disease severity, and prognosis in haematological malignancies [7].

Trace elements are micronutrients that are needed in minute amounts but are very important for keeping normal biochemical and physiological processes going. They are cofactors for many enzymes and are very important for immunological function, controlling oxidative stress, and cellular metabolism [8]. A lack of or imbalance of trace elements including iron, zinc, magnesium, and calcium can cause problems with metabolism and enzymes that may affect the growth and spread of cancer. [9, 10]

In Nigeria, leukaemia continues to pose a considerable public health concern; nevertheless, there is a paucity of local data regarding the concomitant changes in haematological indices and trace elements in affected patients. The University of Port Harcourt Teaching Hospital (UPTH) serves as a primary referral facility for haematological illnesses in the Niger Delta region, rendering it a suitable location for our study.

This study sought to assess haematological indices and specific trace elements in leukaemia patients receiving treatment at UPTH. The results are anticipated to yield significant insights into disease-related modifications, enhance the monitoring of therapy responses, and facilitate evidence-based clinical care of leukaemia patients in the region.

MATERIALS AND METHODS

Study Area

This study was conducted at the Haematology Day-Care Clinic of the University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Rivers State, Nigeria. UPTH is a tertiary health institution and a major referral centre for the management of haematological disorders, including leukaemia, in the Niger Delta region. The hospital is located in Alakahia, Obio/Akpor Local Government Area of Rivers State.

Port Harcourt is the capital city of Rivers State, situated in the southern region of Nigeria. The state is ethnically diverse, with several indigenous languages such as Ikwerre, Ekpeye and others. Rivers State is one of Nigeria's most economically significant states due to its large petroleum and natural gas reserves. It also has a rapidly growing population, extensive urbanization, and well-developed healthcare and industrial infrastructure. The state covers approximately 11,077 km² and lies within the eastern Niger Delta region (RSHDA, 2012).

Ethical Consideration

Ethical approval for the study was obtained from the Ethics and Research Committee of the University of Port Harcourt Teaching Hospital following submission of a detailed research proposal. Permission was also obtained from the Head of the Haematology Department. Informed written consent was obtained from all participants or their legal guardians prior to sample collection. Participants were adequately informed about the purpose and procedures of the study, and confidentiality was maintained throughout the research. Health education was provided before each sample collection session.

Subject Selection
The test subjects were confirmed leukaemia patients attending the Haematology Day-Care Clinic at UPTH. Most patients presented with symptoms such as abdominal swelling, weight loss, fever, excessive night sweating, fatigue, splenomegaly, and general body weakness.

Inclusion Criteria
Participants were included if they:

Had a confirmed diagnosis of leukaemia
Had attended the clinic for at least six months
Were aged between 2 and 75 years
Gave informed consent

Exclusion Criteria
Participants were excluded if they:

Refused to give consent
Were below 2 years or above 75 years of age
Had other haematological disorders such as sickle cell anaemia or thalassemia
Were pregnant or lactating

Study Design
This was a cross-sectional case-control study conducted between February and August 2024. A total of 63 confirmed leukaemia patients (both males and females) attending the UPTH haematology clinic were recruited. Sixty-three apparently healthy age-matched individuals from Port Harcourt served as the control group.

Sample Collection
Five millilitres (5 mL) of venous blood was collected aseptically from each participant via antecubital venipuncture using sterile needles and syringes. Two millilitres were dispensed into EDTA bottles for haematological analysis, while three millilitres were transferred into plain tubes, allowed to clot, and centrifuged at 3000 rpm for 10 minutes. The serum was separated and stored at −20°C until analysis of trace elements.

Laboratory Analysis
All reagents were commercially obtained, and manufacturers' standard operating procedures were strictly followed.

Haematological Analysis
Haematological parameters including Haemoglobin (Hb), Red blood cell count (RBC), Packed cell volume (PCV), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), Total white blood cell count (WBC), Differential counts (neutrophils, lymphocytes, eosinophils, basophils, monocytes), and Platelet count were measured using an automated haematology analyser (Mindray BC-3150, China). The analyser operates on the electrical impedance principle, where blood cells suspended in an electrolyte pass through an aperture and generate electrical pulses proportional to their size and number.

Trace Element Analysis
Iron
Serum iron was determined by the Ferene colorimetric method. Absorbance was measured at 560 nm and iron concentration calculated accordingly.

Magnesium
Magnesium was measured using the xylidyl blue colorimetric method. Absorbance was read at 520 nm.

Calcium
Serum calcium was determined using the o-cresolphthalein complexone method. Absorbance was measured at 570 nm.

Zinc
Serum zinc was analysed using the 5-Bromo-PAPS colorimetric method. Absorbance was read spectrophotometrically.

Statistical Analysis
Data were analysed using the Statistical Package for Social Sciences (SPSS) version 21. Results were expressed as mean ± standard deviation (SD). Differences between groups were analysed using the independent Student's *t*-test. Pearson correlation was used to determine relationships between haematological parameters and trace elements. A p-value <0.05 was considered statistically significant.

Table 4.1 Mean + Standard (SD) deviation values of haematological indices in leukaemia subjects (test) versus control.

Parameters (Units)	Test group (n=63)	Control group (n=63)	t-test	p-value
WBC ($x10^9$/L)	33.37±63.30*	5.91±2.34	3.441	0.001
RBC($x10^{12}$/L)	4.06±1.27*	4.58±0.73	-2.821	0.006
Hb (g/dl)	11.74±8.85	12.83±2.12	-0.951	0.343
PCV (%)	30.82±10.97	37.17±6.68	-3.917	0.001
MCV (%)	80.08±13.79	81.98±14.91	-0.737	0.463
MCH (%)	28.04±3.69*	29.71±3.24	-2.695	0.008
MCHC (%)	49.44±71.46	36.04±8.47	1.478	0.142
PLT (x 10^9/L)	242.26±233.69	210.73±100.05	0.983	0.327
NEU (%)	50.10±27.79	45.67±10.55	1.182	0.240
LYM (%)	40.05±30.08	46.60±10.50	-1.632	0.105
MONO (%)	6.31±9.38	5.37±5.04	0.700	0.485
EOSIN (%)	0.85±1.33*	2.67±2.50	-5.055	0.001
BAS (%)	0.10±0.30*	0.25±0.51	-2.117	0.037

Key: WBC = White Blood Cell Count, RBC = Red Blood Cell, Hb = Hemoglobin, PCV = Packed Cell Volume, MCH = Mean Cell Hemoglobin, MCHC = Mean Corpuscular, Hemoglobin Concentration, MCV = Mean Cell Volume, PLT = Platelets, NEU = Neutrophils, LYM = Lymphocytes, MONO = Monocytes, EOSIN = Eosinophil, BAS = Basophil n= number of sample size.

* = Value is statistically significant at P<0.05

Table 4.1 shows the mean ± SD values of haematological indices in leukaemia subjects versus control

The mean ± SD values of WBC (33.37±63.30$x10^{9/L}$) was significantly higher (P = 0.001) in leukaemia subjects compared to the mean± SD values of the control group (5.91±2.34$x10^{9/L}$).

However the mean ± SD value of RBC (4.06±1.27$x10^{12/L}$), PCV (30.82 ±10.97%), MCV (28.04 ± 3.69$x10^{15/L}$), Eosinphil (0.85 ± 1.33%) and Basophil (0.10 ± 0.30%) were significantly lower. (P = 0.0006, P = 0.001, P = 0.008, P = 0.001, P = 0.037) respectively in leukaemia subjects compared to that of the control group (4.58± 0.73$x10^{12/L}$, 37.17± 6.68%, 29.71 ± 3.24%, 2.67 ± 2.50% and 0.25 ± 0.51%). However, the mean ± SD values of HB (11.74 ± 8.85g/dl, MCV (80.08 ± 13.79%), MCHC (49.44 ± 71.46%), Platelet (242.26 ± 233.69$x10^{9/L}$), Neutrophil (50.10 ± 27.79%), Ly,phicyte (40.05 ± 30.08%) and Monocyte (6.31 ± 9.38%) showed no statistical significant difference (P = 0.343, P = 0.463, P = 0.142, P = 0.327, P = 0.240, P = 0.105, P = 0.485) respectively in leukaemia subjects compared with the mean ± SD values (12.83 ± 2.12 kg/dl, 81.98 ± 14.91%, 36.04 ± 8.47%, 210.93 ± 100.05$x10^{9/L}$, 45.67 ± 10.55%, 46.60 ± 10.50%, 5.37 ± 5.04%) of that of the control group.

Table 4.2: Mean ± Standard deviation in values of trace elements in leukaemia subjects (test) versus control

Parameters (Units)	Test group (n=63)	Control group (n-63)	t-test	p-value
Magnesium mmol/l	0.81±0.22	0.82±0.18	-0.327	0.744
Total iron (µg/dL)	62.40±42.63*	98.61±22.47	-5.918	0.001
Calcium (mmol/L)	2.27±0.21*	2.16±0.26	2.409	0.018
Zinc (µmol/L)	12.71±3.28	12.85±2.66	-0.255	0.799

Key: * = Value is statistically significant at P<0.05

n= number of sample size.

Table 4.2 shows the mean SD values of trace element in leukaemia subjects versus control. The mean ± SD value of total iron (62.40 ± 2.63µg/dl) was significantly lower (P = 0.001) in leukaemia subject compared to the mean ± SD values of the control group (98.61 ± 22.47 µg/dl). While the mean ± SD value of calcium (2.27 ± 0.21mmol/L) was significantly higher (P = 0.018) in leukaemia subjects when compared to the mean ± SD value of the control group (2.16 ± 0.26mmol/L). However, the mean ± SD value of magnesium (0.81 ± 0.222) and zinc (12.71 ± 3.28µmol/L) did not differ significantly (p=0.744) and (p=0.799) respectively in leukaemia subjects when compared to mean ± SD value of the control group (0.82 ± 0.18mmol/L and 12.85 ± 2.66µmol/L).

Table 4.3: Mean ± standard deviation values of haematological indices in males versus females leukaemia subjects

Parameters (Units)	**Female (n=31)**	**Male (n=32)**	**t-test**	**p-value**
WBC ($x10^9$/L)	32.39±65.57	34.28±62.14	-0.117	0.907
RBC($x10^{12}$/L)	4.23±1.43	3.90±1.11	1.018	0.313
Hb (g/dl)	12.90±12.40	10.65±2.80	0.997	0.323
PCV (%)	31.24±13.54	30.43±8.08	0.288	0.775
MCV (%)	77.93±16.31	82.11±10.80	0.288	0.775
MCH (%)	27.92±3.41	28.15±3.98	-1.196	0.236
MCHC (%)	54.41±84.90	44.63±56.55	-0.257	0.798
PLT (x 10^9/L)	276.706±292.72	209.97±158.38	0.531	0.597
NEU (%)	52.37±25.56	47.97±29.99	1.126	0.265
LYM (%)	36.70±27.23	43.12±32.65	0.619	0.538
MONO (%)	7.53±11.24	5.16±7.23	-0.847	0.401
EOSIN (%)	1.13±1.63	0.59±0.91	0.997	0.323
BAS (%)	0.10±0.31	0.09±0.30	1.619	0.111

Key: WBC = White Blood Cell Count, RBC = Red Blood Cell, Hb = Hemoglobin, PCV = Packed Cell Volume, MCH = Mean Cell Hemoglobin, MCHC = Mean Corpuscular, Hemoglobin Concentration, MCV = Mean Cell Volume, PLT = Platelets, NEU = Neutrophils, LYM = Lymphocytes, MONO = Monocytes, EOSIN = Eosinophil, BAS = Basophil

n= number of sample size.

Table 4.3 shows the mean ± SD values of hematological indices of male versus female leukaemia subjects. The mean ± SD WBC (32.39 ± 65.57$x10^{9/L}$) RBC (4.23 ± 1.43$x10^{12/L}$), Hb (12.90 ± 12.46g/dl), PCV (31.24 ± 13.54%), MCV (77.98 ± 16.31%), MCH (27.92 ± 3.41%), MCHC (54.41 ± 84.90%), PLT (276.706 ± 290.72$x10^{9/L}$), NEU (52.37 ± 25.56%), Lym (36.70 ± 27.23%) Mono (7.53 ± 11.24%) Eosin (1.13± 1.63%), Bas (0.10± 0.31%) did not differ significantly (P=0.907, P=0.313, P=0.323, P=0.775, P=0.775, P=0.236, P=0.798, P=0.597, P=0.265, P=0.265, P=0.538, P=0.401, P=0.323, P=0.323, P=0.111) respectively in female leukaemia subjects compared with the mean ± SD values (34.28± 62.14$x10^{9/L}$, 3.90± 1.11$x10^{12/L}$, 10.65± 2.80g/dl, 30.43± 8.08%, 82.11 ± 10.80%, 28.15 ± 3.98%, 44.63 ± 56.55%, 209.97 ± 158.38$x10^{9/L}$, 47.97 ± 29.99%, 43. 12 ± 32.65%, 5.16 ± 7.23%, 0.59 ± 0.91%, 0.09 ± 0.30%) of the male leukaemia subjects.

Table 4.4: Mean ± Standard deviation values of trace elements in male versus female leukaemia subjects

Parameters (Units)	**Female (n=31)**	**Male (n=32)**	**t-test**	**p-value**
Magnesium (mmol/L	0.81±0.28	0.81±0.14	-0.065	0.949
Total iron (µg/dL)	62.12±47.11	62.66±38.72	-0.049	0.961
Calcium (mmol/L)	2.24±0.21	2.29±0.20	-0.961	0.341
Zinc (µmol/L)	12.45±3.73	12.95±2.84	-0.599	0.552
Age (year)	39.33±20.19	37.50±21.91	0.342	0.734

n= number of sample size.

Table 4.4 shows the mean ± SD values of all the trace elements (Magnesium, Iron, Calcium and Zinc) of male versus female leukaemia subjects. The mean ± SD of magnesium (0.81 ± 0.28mmol/L), total iron (62.12 ± 47.11µg/dL), calcium (2.24 ± 0.21mmol/L) and zinc (12.45 ± 3.73µmol/L) showed no statistical significance difference (P=0.949, P=0.961, P=0.341, P=0.552) respectively in female leukaemia subjects compared with the mean ± SD values (0.81 ± 0.14mmol/L, 62.66 ± 38.72µg/dL, 2.29 ± 0.20mmol/L, 12.95 ± 0.84µmol/L) of that of the male subjects in test group.

Table 4.5: Correlation of some trace elements with some haematological variables in test group n=63

Parameters	Correlation	WBC	RBC	Hb	PCV	MCV	MCH	MCHC	PLT
Magnesium	r -value	-0.123	0.065	0.031	0.130	0.106	0.079	0.028	-0.116
	p-value	0.342	0.614	0.813	0.314	0.411	0.543	0.831	0.370
Iron	r -value	-0.085	0.185	0.296*	0.061	-0.153	0.056	0.195	-0.403**
	p-value	0.510	0.150	0.019	0.640	0.235	0.663	0.132	.001
Calcium	r-value	-0.034	-0.011	-0.156	-0.068	0.007	-0.177	-0.061	-0.007
	p-value	0.791	0.934	0.227	0.599	0.959	0.169	0.641	0.958
Zinc	r-value	0.080	0.044	0.123	0.143	0.111	0.223	0.046	-0.154
	p-value	0.536	0.732	0.341	0.266	0.390	0.082	0.726	0.233

Key: WBC = White Blood Cell Count, RBC = Red Blood Cell, Hb = Hemoglobin, PCV = Packed Cell Volume, MCH = Mean Cell Hemoglobin, MCHC = Mean Corpuscular, Hemoglobin Concentration, MCV = Mean Cell Volume, PLT = Platelets.

n= number of sample size.

*= Significant positive correlation at (p<0.05), **= Significant Negative correlation at (p<0.05).

Table 4.5 shows the correlation of some trace elements and some haematological variables in test group. There was a significant positive correlation of iron with Hb (r=0.296, =p0.019) in the test group. Also, there was a significant negative correlation of iron with platelet (r=-0.403, p=0.001) in the test group.

Table 4.6 Correlation of some trace elements with some haematological variables in control group n=63

Parameters	Correlation	WBC	RBC	Hb	PCV	MCV	MCH	MCHC	PLT
Magnesium	r	0.049	-0.008	0.234	0.138	-0.116	0.133	0.006	-0.225
	p-value	0.704	0.948	0.067	0.284	0.370	0.304	0.960	0.079
Iron	r	-0.101	0.048	0.215	0.147	0.048	0.154	-0.014	-0.055
	p-value	0.433	0.711	0.094	0.253	0.713	0.231	0.916	0.671
Calcium	r	0.083	0.328**	0.250	0.292*	0.081	-0.161	-0.123	0.010
	p-value	0.521	0.009	0.050	0.021	0.532	0.211	0.340	0.936
Zinc	r	0.070	-0.017	-0.147	-0.063	0.089	0.025	0.030	-0.246
	p-value	0.588	0.893	0.254	0.625	0.492	0.847	0.817	0.054

Key: * Significant correlation at (p<0.05).

n= number of sample size.

Table 4.6 shows some hematological variables and some trace elements in control group. There was a significant positive correlation between calcium and RBC (r=0.328, p=0.009), calcium and PCV (r=0.292, p=0.021) in control group. However, other trace elements did not have any significant correlation with haematological variables in control group (p>0.05).

DISCUSSION

In this study, the mean total white blood cell (WBC) count of leukaemia patients was markedly elevated compared to the control group. This finding exemplifies the characteristic pathophysiology of leukaemia, encompassing uncontrolled proliferation of aberrant leukocytes, disrupted apoptosis, bone marrow infiltration, suppression of normal haematopoietic stem cells, dysregulated cytokine signalling, and oncogenic mutations that facilitate excessive leukocyte production. These pathways together cause leukocytosis, which is a key sign of leukaemia. This finding aligns with prior studies by [11].

The markedly diminished levels of red blood cell (RBC) count, packed cell volume (PCV), and mean corpuscular haemoglobin (MCH) in leukaemia patients signify the existence of anaemia. Anaemia in leukaemia may arise from the invasion of malignant cells into the bone marrow, diminished erythropoiesis, haemolysis, nutritional deficiencies (namely

iron, folate, and vitamin B_{12}), persistent inflammation, and the adverse effects of chemotherapy and radiotherapy. These results are consistent with those documented by [12].

Conversely, the mean corpuscular volume (MCV) exhibited no significant difference between leukaemia patients and controls. This is due to the fact that leukaemia largely impacts the white blood cell lineage, whereas MCV indicates red blood cell size, which can stay normal even in cases of anaemia, particularly in early or normocytic anaemia. This observation corroborates prior findings by [13]. In the same way, the mean corpuscular haemoglobin concentration (MCHC) did not reveal a significant difference, which means that the anaemia was mostly caused by a lower red cell mass rather than a change in haemoglobin concentration inside individual erythrocytes [14].

The markedly diminished eosinophil and basophil count in leukaemia patients may result from bone marrow suppression, immunological dysregulation, marrow fibrosis, and an elevated rate of programmed cell death among these cells. These results correspond with the findings of [15], which indicated that haematological cancers are frequently linked to diminished granulocyte subpopulations.

There were no significant variations in the numbers of neutrophils, lymphocytes, monocytes, and platelets between leukaemia patients and controls. This may indicate the variability of leukaemia subtypes, illness stage, and current medication, which can differentially influence these cell lines [16].

The markedly diminished serum iron levels in leukaemia patients may result from erythropoietin resistance, chronic inflammation, macrophage-mediated iron sequestration, heightened iron consumption by rapidly proliferating malignant cells, and blood loss, especially in menstruating females. Reduced iron availability adds to the anaemia associated with chronic illness frequently observed in leukaemia. This result corroborates the findings of [17]. The serum calcium levels were markedly elevated in leukaemia patients compared to controls. This may be attributed to heightened osteoclastic activity, infiltration of malignant cells into the bone marrow, altered vitamin D metabolism, and bone resorption, resulting in hypercalcaemia—a recognised metabolic consequence of haematological malignancies.[18] Magnesium and zinc levels did not exhibit significant differences between leukaemia patients and controls, indicating that these trace elements may be relatively conserved or affected by food consumption and supplementation throughout treatment [19].

There were no notable variations between male and female leukaemia patients regarding haematological parameters or trace element levels, suggesting that gender did not have a significant impact on these biomarkers in this study sample [20].

A notable positive connection was identified between blood iron and haemoglobin concentration in leukaemia patients, underscoring the essential role of iron in haemoglobin production, as previously shown by [21]. A notable positive association was identified between calcium levels and red blood cell count, potentially elucidated by the involvement of calcium-dependent signalling in the development of erythroid precursor cells [22]. Other trace elements did not exhibit significant relationships with haematological markers in either leukaemia patients or controls.

CONCLUSION

This study showed that people with leukaemia have far higher white blood cell counts than healthy people, which confirms the presence of leukocytosis. Even though they were getting medical therapy, leukaemia patients had much lower amounts of red blood cells, packed cell volume, mean corpuscular haemoglobin, eosinophils, and basophils. This showed that their bone marrow was still not working properly and they were still anaemic. Serum iron levels were dramatically decreased, leading to impaired haemoglobin synthesis, whereas serum calcium levels were significantly increased, indicating altered bone metabolism and a risk of hypercalcemia. These results emphasise the therapeutic significance of monitoring haematological indices and trace elements in the management of leukaemia patients.

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