Cell. Mol. Biol. (ISSN: 1165-158X)

Journal Homepage: www.cellmolbiol.org

Cellular and Molecular Biology

Original Article

Molecular and cellular effects of chronic low-dose X-ray exposure on thyroid function and blood cell parameters in radiology staff

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Article Info

Article history:

Received: Octobre 25, 2025
Accepted: May 12, 2025
Published: June 30, 2025

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Abstract

This study investigated the impact of long-term, low-dose occupational exposure to X-rays on thyroid function and hematological parameters in radiology staff. A cross-sectional analysis was conducted on 136 radiology and radiation-related employees. Thyroid status, assessed via ultrasonography and serum T3, T4, and TSH measurements, was compared with complete blood counts (CBC). While no significant gender-based differences in thyroid hormones or structure were observed, TSH levels correlated significantly with occupational group (P=0.016), and T3 levels correlated with working hours (P=0.03). Radiologists exhibited higher RDW-CV compared to radiographers and other staff (P=0.009). Significant gender differences were noted in lymphocyte counts, hemoglobin, red blood cells, and hematocrit. In males, WBC and MCHC fluctuated significantly with increased working hours. These findings suggest that chronic, low-dose X-ray exposure may influence thyroid hormone regulation and hematopoiesis in radiology professionals. Further research is warranted to elucidate the underlying cellular and molecular mechanisms and to refine radiation safety protocols.

Keywords: Long-term exposure, X-ray, Blood cells, Thyroid profile, Radiology staff.

1. Introduction

Damage caused by radiation in adversative health possessions within hours to weeks, and hindered effects may be apparent several months/years after contact [1]. In medical fields, ionizing and nonionizing radiation mainly implemented for diagnosis/treatment. However, ionizing-electromagnetic radiation can generate enough energy for ionization[2], which includes general radiography, fluoroscopy, computed tomography (CT), nuclear medicine (NM), mammography and Positron Emission Tomography/Computed Tomography (PET/CT). Hence, CT and NM are the most dangerous modalities due to greater doses of radiation than conventional X-rays [2, 3].

The thyroid gland's function is under the control of the hypothalamic-pituitary axis, which preserves the thyroid hormones, including triiodothyronine (T3) and thyroxine (T4), and these hormones are controlled by the thyroid-stimulating hormone (TSH) [4]. The thyroid gland is a primary target organ for radiation-related destruction. More research has focused on the possible risk of cancer linked to this exposure [5], primarily through ionizing radiation [6]. The pathophysiological damage is related to the reserve of follicular epithelial physiology and following progressive changes in the endothelium that increases over time [7].

Some epidemiologic groups have studied the relationship between CT/NM inspections and the risk of thyroid cancer. The prospective risk from CT scans has been concluded using victims from atomic bomb survivors, which guesses a thyroid cancer risk of 390 patients per million related to neck CT scans [8]. In 2013, medical records showed that 40% of thyroid-increased malignancies allied to CT scans during childhood and adolescence [9]. Hematopoietic cells are the most sensitive cells against radiation, and the peripheral blood analysis may aid as a biological sign of that damage [10]. In addition, several studies have emphasized the importance of the complete blood count (CBC) correlation with the effects of partial/total radiation. Accordingly, CBC can be used in investigating the damage caused by radiation [11] and is commonly used as a bio-dosimeter for occupational exposure [10, 12].

The primary health concern is protecting people from relatively low dose, constant or fractionated exposures,

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Doi: http://dx.doi.org/10.14715/cmb/2025.71.6.2

especially those received by radiology staff. The influence of ionizing radiation on the thyroid gland has been widely investigated, especially with the fear of developing thyroid nodules. The radiographers of the diagnostic and therapeutic sections were inevitably exposed to long-term and low-dose radiations even if the personal protective equipment was used appropriately and the rules/regulations were performed [11]. Therefore, this study was designed to investigate the correlation between long-term occupational exposure to X-rays and thyroid profile/blood parameters among radiology staff in different departments/hospitals.

2. Materials and Methods

2.1. Participants and study design

This cross-sectional, hospital-based study was carried out on 136 employees in radiology departments, including radiologists and radiographers at the different hospitals of Sulaimaniyah city, Iraq (Sulaimani Teaching Hospital, Faruq Medical City, Kallar Public Hospital, Ranya General Hospital, and Shorsh General Hospital) from July 14, 2021, to April 28 2022. Also, employees of other radiation-related departments, such as general X-ray departments, CT scans, mammography, and fluoroscopy, were included.

2.2. Inclusion criteria

Employees that worked in radiology departments for at least >1 year and were continuously exposed to X-rays (>4 times per week) at hospitals were included in this study regardless of age, gender, ethnicity, and nationality.

2.3. Exclusion criteria

Participants with thalassemia, hemophilia, thrombocytopenia, or any blood-related illness and those on medications or chemicals that influence blood cells were excluded.

2.4. Questionnaire

Sociodemographic factors such as gender, marital status, occupation, residency, education level, hospital type, department, smoking habits, and alcohol use history were collected using a well-designed, self-prepared questionnaire.

2.5. Study procedure

The neck of each participant was examined using real test waves. Then, the thyroid gland's size, position, symmetry, nodules and texture with its echo structure were reported using ultrasonography. Patients with swelling or having a lump or some kind of mass were considered to be abnormal, while other than that, were considered to be normal.

Additionally, 5.0 mL of blood was collected from each participant, of which 3.0 mL was submitted to the Biochemistry laboratory to check thyroid hormones (TSH, T3, and T4) using a Cobas e411 analyzer (Roche, Germany). While 2.0 mL of the blood was sent to the Hematology laboratory to investigate CBC using an automated cell counter (Sysmex-XN-350, compact 5-part differential analyzer, Germany).

2.6. Data analysis

The acquired data were analyzed using descriptive Statistical Package for Social Science (SPSS, Chicago, USA, version 26). Student's t-test and the ANOVA was used to determine the correlation between variables (age, smoking, BMI, other medical conditions), with a significance threshold of P-value <0.05.

3. Results

3.1. Participant demographics

The mean age of participants was 37.7±8.2 years, and the mean working hours were 7.1±2.6. Among 136 participants, the majority were males (64%), married (71.3%), radiographers (75.7%), lived in an urban area (74.3%), had a diploma (85.3%), and were from public hospitals (86%) and the general X-ray department (62.5%). At the same time, most of them (76.5%) had never smoked and were never alcoholics (91.2%) (Table 1).

3.2. Exclusion criteria

Participants with thalassemia, hemophilia, thrombocytopenia, or any blood-related illness and those on medications or chemicals that influence blood cells were excluded.

Table 1. Distribution of the basic socio-demographic characteristics of the enrolled participants.

Socio-demographical Data	Characteristic	Frequency	Percent
Gender	Male	87	64
	Female	49	36
Marital status	Married	97	71.3
	Single	39	28.7
Occupational type	Radiographer	103	75.7
	Radiologist	13	9.6
	Others	20	14.7
Residency	Urban	101	74.3
	Rural	35	25.7
Education level	Diploma degree	116	85.3
	Bachelor degree	9	6.6
	Master degree	8	5.9
	Doctorate degree	3	2.2
Type of hospital	Public	117	86
	Private	19	14
Department/ Unit	CT scan	28	20.6
	Fluoroscopy	2	1.5
	General x-ray	85	62.5
	Mammography	6	4.4
	MRI	3	2.2
	Others use x-ray	12	8.8
Smoking status	Current smoker	19	14
	Never smoke	104	76.5
	Former smoker	13	9.6
Alcohol drinking history	Current drinker	6	4.4
	Never drink	124	91.2
	Former drinker	6	4.4
Total		**136**	**100**

3.3. Thyroid status by gender

Thyroid status (hormones and structures) was determined and compared between genders. The results showed that normal and abnormal values of TSH (P=0.37), T3 (P=0.48), and T4 (P=0.64) were not significantly correlated. Also, there were no significant differences between normal and abnormal thyroid shape and size (P=0.53), lesion or mass (P=0.41), and cervical LAP (P=0.39) between genders (Table 2).

3.4. Thyroid status by occupation

The thyroid status (hormones and structures) was investigated according to occupation type. Among all variables, only TSH had a significant difference in normality and abnormality among the three occupational groups (radiographers, radiologists, and other employees). Most normal TSH cases (n=80) were reported in radiographers, followed by other employees of radiology departments (n=20), and then radiologists (n=13). The abnormal amount of TSH was only reported in radiographers (n=14), with none in the other groups (P=0.016) (Table 3).

3.5. Thyroid status by working hours

The thyroid status (hormones and structures) was investigated according to work hours. Only T3 had a significant difference in normality and abnormality among the three groups of working hours (<5 hours/day, 5-9 hours/day, and >9 hours/day). Regarding typical T3 cases, 19 individuals were reported in <5 hours/day, 90 cases in 5-9 hours/day, and 25 cases in >9 hours/day. The abnormal amount of T3 was reported only in two instances in >9 hours/day (P=0.03) (Table 4).

3.6. Thyroid status by work experience

The thyroid status (hormones and structures) was investigated according to work experience, and none of

Table 2. Distribution of the thyroid status (hormones and structures) among cases according to their gender.

Thyroid status and functions	Gender	Character	Frequency	P-value
Thyroid-stimulating hormone	Male	Normal	76	0.37
		Abnormal	11	
	Female	Normal	46	
		Abnormal	3	
Triiodothyronine	Male	Normal	85	0.48
		Abnormal	2	
	Female	Normal	49	
		Abnormal	0	
Thyroid hormone	Male	Normal	86	0.64
		Abnormal	1	
	Female	Normal	49	
		Abnormal	0	
Shape and size of thyroid	Male	Normal	79	0.53
		Abnormal	8	
	Female	Normal	44	
		Abnormal	5	
Lesion or mass in thyroid	Male	Normal	82	0.41
		Abnormal	5	
	Female	Normal	45	
		Abnormal	4	
Cervical lymphadenopathy	Male	Normal	81	0.39
		Abnormal	6	
	Female	Normal	47	
		Abnormal	2	

Table 3. Distribution of the thyroid status (hormones and structures) among cases according to their occupational type.

Thyroid status and functions	Occupational type						P-value
	Radiographer		Radiologist		Others		
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	
Thyroid-stimulating hormone	89	14	13	0.0	20	0.0	0.016*
Triiodothyronine	101	2.0	13	0.0	20	0.0	0.57
Thyroid hormone	102	1.0	13	0.0	20	0.0	0.75
Shape and size of thyroid	94	9.0	11	2.0	18	2.0	0.41
Lesion or mass in thyroid	96	7.0	11	2.0	20	0.0	0.35
Cervical lymphadenopathy	95	8.0	13	0.0	20	0.0	0.1

*: Significant difference using Independent T-test.

Table 4. Distribution of the thyroid status (hormones and structures) among cases according to their hours of work.

Thyroid status and functions	Hours of work per week						P-value
	<5		5 - 9		>9		
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	
Thyroid-stimulating hormone	16	3.0	82	8.0	24	3.0	0.43
Triiodothyronine	19	0.0	90	0.0	25	2.0	0.03*
Thyroid hormone	19	0.0	89	1.0	27	0.0	0.84
Shape and size of thyroid	17	2.0	83	7.0	23	4.0	0.35
Lesion or mass in thyroid	17	2.0	84	6.0	26	1.0	0.26
Cervical lymphadenopathy	16	3.0	86	4.0	26	1.0	0.1

*: Significant difference using Independent T-test.

Table 5. Distribution of the thyroid status (hormones and structures) among cases according to their work experience.

Thyroid status and functions	Work experience						P-value
	<10 years		10 - 20 years		≥21 years		
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	
Thyroid-stimulating hormone	83	9	31	4	8	1	0.47
Triiodothyronine	91	1	35	0	8	1	0.19
Thyroid hormone	92	0	35	0	8	1	0.05
Shape and size of thyroid	83	9	35	0	5	4	0.12
Lesion or mass in thyroid	86	6	34	1	7	2	0.27
Cervical lymphadenopathy	88	4	33	2	7	2	0.08

Table 6. Distribution of thyroid status (hormones and structures) among cases according to the number of participants.

Thyroid status and functions	Number of patients per day								P-value
	<10		10 - 20		21 - 30		≥31		
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal	
Thyroid-stimulating hormone	22	1.0	31	5.0	57	7.0	12	1.0	0.42
Triiodothyronine	23	0.0	36	0.0	64	0.0	11	2.0	0.008*
Thyroid hormone	22	1.0	36	0.0	64	0.0	13	0.0	0.16
Shape and size of thyroid	19	4.0	34	2.0	59	5.0	11	2.0	0.37
Lesion or mass 'thyroid	22	1.0	33	3.0	59	5.0	13	0.0	0.5
Cervical lymphadenopathy	20	3.0	33	3.0	62	2.0	13	0.0	0.03*

*: Significant difference using Independent T-test.

the variables related had significant differences in terms of normality and abnormality among the three work experience groups (<10 years, 10-20 years, and ≥21 years) (Table 5).

3.7. Thyroid status by number of patients

The thyroid status (hormones and structures) was investigated according to the number of patients referred to the radiology department. The results showed that T3 and cervical LAP had significant differences in normality and abnormality among the four groups based on patient numbers (<10 patients, 10-20 patients, 21-30 patients, and ≥31 patients). In this regard, 23 cases of normal T3 were reported in the <10 patients group, 36 cases in the 10-20 patients group, 64 cases in 21-30 patients, and 11 cases in the ≥31 patients group (P=0.008). Also, 20 cases of normal cervical LAP were reported in the <10 patients group, 33 cases in the 10-20 patients group, 62 cases in 21-30 patients, and 13 cases in ≥31 patients. The abnormal amount of T3 was reported in 2 cases in the ≥31 patients group, and the abnormal amount of cervical LAP was reported in 3 subjects in the <10 patients group, 3 cases in the 10-20 patients group, and 2 cases in the 21-30 patients group (P=0.03) (Table 6).

3.8. Blood parameters by gender

The distribution of blood parameters according to gender showed significant differences in the mean lymphocyte (P=0.005), Hb, RBC, and HCT (P=0.001) between genders, with higher values in males. Significant differences were also seen between genders for mean PLT (P=0.042), MPV (P=0.021), PDW (P=0.015), PCT (P=0.004), and P-LCR (P=0.028), but with higher values in females (Table 7).

Table 7. Distribution of the blood parameters among cases according to their gender.

Blood Parameter	Gender	No.	Mean±SD	P-value
WBC×10^9/L	Male	87	7.11±1.52	0.937
	Female	49	7.13±1.70	
Neutrophils×10^9/L (Neu%)	Male	11	61.56±10.97	0.755
	Female	17	62.91±11.20	
Lymphocyte×10^9/L (Lym%)	Male	87	34.68±9.41	0.005*
	Female	49	29.64±9.84	
Monocyte×10^9/L (Mon%)	Male	18	6.83±2.75	0.625
	Female	21	6.63±3.16	
Eosinophil×10^9/L (Eos%)	Male	15	2.35±2.09	0.447
	Female	19	1.85±1.75	
Basophil×10^9/L (Bas%)	Male	12	0.62±067	0.583
	Female	17	0.49±0.52	
RBC×10^{12}/L	Male	87	5.19±0.47	0.001*
	Female	49	4.84±0.53	
Hb (g/dL)	Male	87	14.65±1.41	0.001*
	Female	49	13.18±1.53	
HCT%	Male	87	44.36±4.24	0.001*
	Female	49	39.93±3.95	
MCV (fl)	Male	87	84.19±7.64	0.1
	Female	49	81.97±7.36	
MCH (pg)	Male	87	30.98±11.79	0.59
	Female	49	29.91±1.85	
MCHC (g/dL)	Male	86	33.53±1.43	0.863
	Female	49	33.48±1.89	
RDW-CV	Male	87	13.07±4.75	0.697
	Female	48	13.31±2.41	
RDW-SD	Male	81	48.95±1.76	0.844
	Female	41	49.32±9.46	
PLT×10^9/L	Male	86	249.94±45.59	0.042*
	Female	48	272.77±68.33	
MPV	Male	81	8.33±0.9	0.021*
	Female	43	8.96±1.6	
PDW	Male	82	10.77±1.10	0.015*
	Female	43	11.38±1.4	
PCT	Male	81	0.20±0.04	0.004*
	Female	43	0.24±0.06	
P-LCR	Male	81	22.24±10.2	0.028*
	Female	40	27.47±12.83	
P-LCC	Male	36	59.85±36.68	0.624
	Female	15	63.80±19.93	

*: Significant difference using independent T-test

3.9. CBC parameters by occupation

The CBC parameters were investigated according to occupation type, and only the mean RDW-CV in employees with different occupations was significantly different. For example, in radiologists, the mean RDW-CV was higher than in radiographers and other staff (P=0.009). No significant correlations were observed for other CBC parameters (Table 8).

3.10. CBC values, gender, and working hours

The comparison of mean CBC values between genders according to the number of working hours per day was also investigated. Regarding the males, the mean WBC decreased significantly (P=0.039), and MCHC increased significantly (P=0.013) with more working hours. Also, the mean eosinophils/basophils in people with <5 working hours was higher than in other groups (P=0.001). In females, the mean basophil decreased with increasing working hours (P=0.04). Moreover, MPV (P=0.036), PDW and P-LCR (P=0.004) were positively correlated to different numbers of working hours in females, with a lower mean in 5-9 hours of work than other groups (Table 9).

Table 8. Distribution of the blood parameters among the participants according their job description.

Blood Parameter	Occupation type			P-value
	Radiographer	Radiologist	Others	
	Mean ± SD			
WBC×10^9/L	7.03±1.40	7.79±2.15	7.12±2.0	0.27
Neutrophils×10^9/L (Neu%)	61.83±9.89	73.1±22.91	60.42±11.08	0.357
Lymphocyte×10^9/L (Lym%)	33.67±8.58	28.59±13.62	31.50±12.54	0.172
Monocyte×10^9/L (Mon%)	7.05±2.77	5.36±2.17	4.82±3.70	0.183
Eosinophil×10^9/L (Eos%)	2.33±1.94	0.9±0.78	1.4±1.07	0.295
Basophil×10^9/L (Bas%)	0.62±0.63	0.4±0.26	0.33±0.42	0.545
RBC×10^12/L	5.08±0.53	5.08±0.37	5.00±0.56	0.836
Hb (g/dL)	14.20±1.62	13.86±1.32	13.89±1.79	0.618
HCT%	42.98±4.74	42.56±3.42	41.76±4.88	0.55
MCV (fl)	83.41±7.65	83.75±5.33	83.06±8.74	0.967
MCH (pg)	31.31±12.91	27.74±2.19	28.72±1.96	0.413
MCHC (g/dL)	33.56±1.55	32.98±1.07	33.6±2.10	0.461
RDW-CV	12.76±1.48	16.40±11.87	13.1±2.89	0.009*
RDW-SD	47.99±10.46	55.3±7.45	50.86±9.80	0.06
PLT×10^9/L	255.12±52.32	280.85±87.06	258.5±45.80	0.294
MPV	8.63±1.25	8.02±1.0	8.45±1.15	0.274
PDW	11.00±1.13	10.81±1.52	10.94±1.62	0.884
PCT	0.21±0.05	0.23±0.61	0.02±0.06	0.495
P-LCR	23.55±10.88	23.37±8.29	26.28±14.93	0.629
P-LCC	63.36±33.42	54.66±32.0	40±14.25	0.373

*: Significant difference using Independent T-test.

4. Discussion

In hospitals and other healthcare facilities, ionizing radiation poses a serious risk, particularly for staff members engaged in radiology, nuclear medicine, and radiotherapy [13]. The risk of developing certain conditions, including skin, breast, thyroid, bone marrow, and lung cancers, is higher in cases of radiation exposure [14]. Since different cell types respond differently to radiation, hematopoietic cells are the most sensitive [11]. Therefore, this study aims to investigate the effects of long-term exposure to X-rays on blood cells and thyroid function in employees working in different radiology departments.

Based on sociodemographic results in this study, most participants were females with diploma degrees that were married and lived in an urban area. These results are consistent with that of Shafiee et al. 2016 [15], Joudoh et al. 2018 [10], and Rehman et al. 2019 [16]. Also, most of the enrolled participants were nonsmokers and non-alcoholics, which is consistent with that of Surniyantoro et al. 2019 [17] which supported by certain studies that mentioned that smoking could have an immediate negative influence on endothelial cells, damage arterial walls, and decrease WBC/PLT functions [18, 19].

In this study, there were no significant differences in thyroid hormones, normal and abnormal thyroid shape and size, thyroid lesion or mass between both genders, which is consistent with Hodkinson et al. 2009 [20]. Furthermore, regarding the thyroid gland status and occupation of the participants, only TSH had a significant difference between all three groups (radiographers, radiologists and other employees) in terms of normality and abnormality, which is by that of El-Benhawy et al. 2022 in Egypt, who mentioned that TSH can have different values, among the three additional working hours that exposed to radiation [21]. However, our outcomes disagreed with that of Guo et al. 2021 in China, who mentioned that T3 levels increased with increasing radiation dose and exposure time, suggesting that there is a dose threshold at which T3 production and secretion are encouraged [22].

Regarding the thyroid gland status correlation to working hours of the enrolled participants, only T3 had a significant difference in terms of normality and abnormality among three different groups of working hours (<5, 5-9, and >9 hours/day) and these findings are consistent with that of Rehman et al. 2019 [16] and Taqi et al. 2018 [23]. Moreover, we examined the thyroid status of the subjects according to their years of work experience (<10, 10-20, and ≥21 years), and it was proven that none of the variables related to hormones and thyroid structure in terms of normality and abnormality among three groups with different work experience had significant correlations. These findings are in accordance with that of Elahimanesh et al. 2017 [24].

Consequently, blood testing revealed that men had higher mean lymphocytes, red blood cells (RBCs), eosinophil, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), hemoglobin (Hb), and hematocrit (HCT) values. In contrast, the mean platelets (PLT), PDW, MPV, P-LCR, and PCT were higher in women. These findings are compatible with Faraj et al. 2018 [25], Davoudi et al. 2012 [26], and Ryu et al. 2013 [27], but not with the findings of Tavakoli et al. 2012 [28]. The fact that men and women have different mean blood test values is not concealed physiologically. The limited sample size, the employment history that is connected to the amount of radiation exposure, and certain underlying disorders are

Table 9. The comparison of the blood parameters between both genders according to their working hours.

Blood Parameter	Hours of work per day							
	Male				Female			
	<5	5 - 9 Mean±SD	>9	P-value	<5	5 - 9 Mean±SD	>9	P-value
WBC×10^9/L	7.66±1.49	7.29±1.71	6.44±0.68	0.039*	7.50±2.55	7.14±1.53	6.22±0.06	0.47
Neutrophils×10^9/L (Neu%)	66.0±1.0	62.93±11.8	53.85±8.69	0.579	64.22±9.98	62.51±11.91	0.0	0.799
Lymphocyte×10^9/Ll (Lym%)	33.28±12.09	34.19±10.10	36.43±6.00	0.563	25.31±1.18	29.72±8.77	38.27±5.69	0.087
Monocyte×10^9/L (Mon%)	8.0±0.4	6.38±2.99	8.03±2.42	0.556	5.47±3.08	6.57±3.23	0.0	0.544
Eosinophil×10^9/L (Eos%)	6.9±1.41	1.45±0.87	2.75±1.20	0.001*	2.7±3..08	1.62±1.53	0.0	0.234
Basophil×10^9/L (Bas%)	1.8±1.5	0.27±0.20	0.85±0.91	0.001*	0.95±0.64	0.35±0.41	0.0	0.04*
RBC×10^{12}/L	5.046±0.45	5.25±0.51	5.13±0.38	0.351	4.79±0.47	4.83±0.57	5.04±0.3	0.735
Hb (g/dL)	15.02±0.88	14.67±1.36	14.45±1.71	0.574	13.3±1.27	13.03±1.59	14.25±1.35	0.32
HCT%	45.47±2.98	43.93±3.72	44.87±5.68	0.654	40.47±3.66	39.47±3.92	42.9±4.43	0.238
MCV (fl)	87.56±6.5	82.81±8.7	85.95±3.71	0.084	83.44±3.38	81.47±8.4	83.17±1.06	0.738
MCH (pg)	29.18±1.28	32.18±14.84	28.94±1.79	0.483	28.05±1.52	30.56±12.29	25.25±1.08	0.781
MCHC (g/dL)	32.29±0.86	33.67±1.59	33.73±0.92	0.013*	32.85±1.10	33.58±2.08	33.97±1.33	0.517
RDW-CV	12.37±1.22	13.58±5.94	12.19±0.99	0.445	13.23±0.96	13.34±2.78	13.25±0.56	0.991
RDW-SD	55.74±9.18	47.87±10.82	48.28±10.60	0.1	50.82±8.64	48.35±9.96	53.4±7.51	0.548
PLT×10^9/L	269.9±56.68	245.11±39.88	252.39±52.08	0.279	298.13±55.40	273.14±70.55	218.75±48.18	0.166
MPV	8.58±0.72	8.28±0.78	8.34±1.19	0.653	9.99±2.69	8.55±1.03	9.8±0.80	0.036*
PDW	10.92±0.47	10.80±1.22	10.61±10.03	0.723	11.47±1.05	11.08±1.27	13.47±1.48	0.004*
PCT	0.23±0.07	0.20±0.03	0.20±0.04	0.193	0.25±.061	0.24±0.06	0.20±0.04	0.464
P-LCR	22.92±9.81	22.78±11.12	20.61±8.13	0.703	31.01±11.51	23.98±9.35	44.8±22.27	0.004*
P-LCC	62.22±27.01	66.5±47.72	50.64±17.94	0.488	55.66±5.13	66.5±23.78	62.5±12.02	0.738

*: Significant difference using Independent T-test

the factors that might be the source of these differences. To clarify these ambiguities, more research is necessary to be conducted.

Compared to radiographers and persons in other occupations, radiologists had higher mean RDW-CV values with a significant difference. However, the changes in the mean RDW were not apparent and were not effective in the research by Khorrami et al. 2015 [29], while Güngördü et al. 2022 noted a significant rise in RDW [30]. These discrepancies may be due to laboratory errors.

Additionally, since the blood factor MCV is employed in the calculation of RDW [31], a mistake in the MCV measurement might result in erroneous RDW calculation. Consequently, it is essential to carry out more investigations with precision and fewer mistakes. Also, the results of this study showed a significant difference between 3 different groups with different work records in terms of the RDW-CV, which is consistent with the findings of Taqi's study [23].

According to the results, the mean lymphocytes were higher in men than in women. This finding is consistent with that of Ryu et al. 2013 [27]. The mean WBC decreased in men with more working hours, consistent with Farman et al. 2021 [32] and Shahid et al. 2015 [33]. Eosinophils and basophils were different in men and women with varying working hours, which is consistent with that of Taqi et al. 2018 [23] and Park et al. 2010 [34]. Shafiei et al. 2016 studied fluoroscopy medicine specialists and found that RBC, WBC, and PLT did not show significant changes over two years. However, among some specialists, MCH, MCHC, and HCT were low or high without significant differences [15].

Nevertheless, the findings of our study showed that the MCHC in men increases with increasing working hours. Also, the mean RBC in males with different numbers of clients, and extra working hours, significantly differ from each other. These findings support the outcomes of Mohamed et al. 2015 [35]. Besides, the mean Hb and HCT in females with different numbers of clients and different working hours per day were significantly other, which indicates the long or short-term Effect of radiation on these parameters. These findings are consistent with Ryu et al. 2013 [27] but incompatible with Joudoh et al. 2018 [10]. The reason for these inconsistencies is that these parameters have not been examined separately in men and women, nevertheless have been studied as a unit. The MPV, PDW, and P-LCR in women with different occupations varied daily. It indicates the Effect of radiation on these parameters, which was proven by Riahi-Zanjani et al. 2014 [29] and Khorrami et al. 2015 despite not separating the groups into males and females [29].

The limitations of this study including its cross-sectional design that cannot establish causality, and not examining the duration of exposure to ionizing radiation. Other limitations are the small number of people who had blood tests to check hormone levels (TSH, T3, and T4) and an ultrasound of the thyroid to see how healthy the gland was biologically and if there were any problems with it. Another area for improvement is the need to compare radiology department staff with other departments, which is suggested to be considered in other studies.

This study provides evidence that long-term, low-dose occupational exposure to X-rays can influence thyroid hormone levels and hematological parameters in radiology staff. Specifically, alterations in TSH and T3 levels were associated with occupation type and working hours, respectively, suggesting a disruption in thyroid regulation. Furthermore, differences in lymphocyte counts, hemoglobin, red blood cells, and hematocrit levels were observed between genders, potentially indicating radiation-induced effects on hematopoiesis. While RDW-CV was elevated in radiologists, potentially reflecting chronic exposure effects, these findings underscore the need for continued monitoring and optimization of radiation safety protocols to minimize cellular and molecular damage in radiology professionals. Future studies incorporating more detailed molecular analyses could elucidate specific pathways affected by chronic low-dose radiation, enhancing our understanding of its long-term health implications.

Ethical approval and consent to participate

The researchers first proceeded to the study area after receiving the required licenses from the research facility and hospital authorities (IRB). Additionally, the study protocol was revised and approved by the ethical committee of the College of Health and Medical Technology, Sulaimani Polytechnic University, Sulaimaniyah, Iraq, with approval No. CH00038 on Jun 02, 2021. The employees were enrolled in the study after being informed about the procedure and providing their written informed consent. All methods were carried out in accordance with relevant guidelines and regulations (Declaration of Helsinki).

Consent for publication

Not applicable.

Data availability

The data used to support the findings of this study are included within the article.

Competing interest

No conflicts of interest.

Funding

This work was not funded by any national/international agency, company, or organization.

Acknowledgments

We appreciate authorities of the radiology departments at various hospitals for their kind help and support to this study.

Author contribution

S.M., Methodology, data analysis, resources, validity, visualization, wrote the manuscript text. B.T. Conceptualization, supervision, study registration, editing the manuscript text. T.HS. Supervision, study administration, editing the manuscript text. All authors reviewed the manuscript.

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