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Reproductive Hormone Profiles and Infertility Risk in Heat-Exposed Female Kitchen Workers in Ilorin, Nigeria

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ABSTRACT

The kitchen environment is considered as a potential risk area of heat stress and the kitchen workers are likely victims of infertility disorders due to heat stress. Unlike many other causes of infertility in black communities, hormonal factors have been least researched. This study aimed to investigate the effect of heat stress on female reproductive hormones and FBG among female kitchen staff working within the Ilorin metropolis. It was a cross-sectional comparative study. A purposive sampling technique was used to draw 80 participants comprising 40 female kitchen staff and 40 non-kitchen staff (control). Semi-structured questionnaire was used to obtain information while 5mls of blood was collected from each subject through venipuncture to estimate hormones. Hormones were estimated by ELISA technique while data were analysed using SPSS. Data were significant at $p \leq 0.05$. Results revealed that FSH ($p=0.01$) and progesterone ($p=0.039$) increased significantly while oestrogen ($p<0.0001$) and FBG ($p<0.0001$) decreased significantly compared to the control. A significant correlation was seen between marital status and prolactin level ($p=0.02$). Also, a significant correlation was found between parity and prolactin levels ($p=0.01$). LH ($p=0.003$) and FBG ($p=0.01$) increased significantly while prolactin level decreased significantly ($p=0.02$) in participants exposed to combined heat sources compared to others, indicating a significant correlation between sources of heat and the hormones and FBG. The length of occupation as a kitchen staff also had a significant association with the oestrogen level (0.003). The drastic increase in FSH and progesterone levels, along with the tremendous decrease in oestrogen and FBG, indicates a potential threat to fertility in female kitchen staff.

Keywords: Heat, female kitchen staff, reproductive hormones.

INTRODUCTION

Temperature is one of the most important ecological factors that directly affect the behaviour, growth, reproduction, and survival of all animals [1]. High temperature is associated with heat stress, which can induce molecular and physiological changes in mammal reproductive organs and therefore affect their reproduction [2]. Heat stress poses numerous risks to the health of experimental animals, such as organ damage, oxidative stress, disordered endocrine regulation, suppressed immune function, and reproductive disorders, ultimately inducing a decreased production performance and increasing their mortality [3].

Estrogen and progesterone are often called “female hormones” because they play an important role in women’s menstrual cycle, sexual development, pregnancy, and childbirth. These two hormones in turn are regulated by another two hormones secreted by the pituitary gland, namely, luteinizing hormone (LH) and follicle-stimulating hormone (FSH) by feedback mechanism [4]. Follicle stimulating hormone (FSH) stimulates the growth of follicles, and luteinizing hormone (LH) stimulates ovulation; both of which are produced in the pituitary gland. Estrogen, on the other hand, is produced in the ovaries. It encourages the growth of the endometrium during the menstrual cycle. An elevated estrogen level mid-cycle causes an increase in LH, which triggers ovulation. Progesterone is produced by the corpus luteum in the ovaries after ovulation and in the adrenal glands located near the kidney, as well as inside the placenta during pregnancy [5]. Increased progesterone levels indicate ovulation has occurred and progesterone levels will peak in the mid-luteal phase

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of the cycle. Prolactin, also produced in the pituitary gland, interacts with the breasts and ovaries. It stimulates the growth of the mammary glands during pregnancy, as well as milk production after birth [6].

The work environment of the food service industry is considered to be severe due to working and standing in a hot environment, in addition to irregular working hours [7]. Previous studies reported that commercial kitchen work is performed under high ambient temperatures [8]. Heat stress, a well-established phenomenon from extreme heat exposure, is known to exacerbate health-related risk threats. Heat stress affects both female and male reproductive function [9]. Over the years, it has been proven in occupational heat exposure research that heat exposure threatens the health of workers, consequentially leading to a high mortality rate [10].

In humans, studies on the effects of thermal stress on reproductive efficiency are very scarce; this is because of the many additional social, economic, cultural, and religious variables that must be taken into consideration concerning potential interference with procreative output in addition to thermal stress [11]. The primary aim of this study was therefore to investigate the effect of heat exposure on the levels of female reproductive hormones (i.e. oestrogen, progesterone, FSH, LH, and prolactin) and fasting blood glucose (FBG) among the heat-exposed female kitchen staff. The secondary aim was to investigate the association between sources of heat source, and the duration of occupation as kitchen staff.

METHODOLOGY

Study design

The design of this study was a cross-sectional comparative study. It was conducted for 12 months in Ilorin metropolis, Kwara State following obtaining ethical approval from the Kwara State Ministry of Health, Ilorin.

Study Site/Target Population

The study was conducted among female kitchen staff of eateries within the Ilorin metropolis. Ilorin, the state capital of Kwara State is located on latitude 8º30'and 8º50'N and longitude 4º20' and 4º35'E of the equator. Ilorin city occupies an area of about 468 km^2 and it is situated in the transitional zone within the forest and the Guinea savannah regions of Nigeria [12]. The city which lies along the Lagos-Kaduna highway is about 306km from Lagos, 600km from Kaduna, and about 500km from Abuja, the Federal Capital city of Nigeria. At present, the city of Ilorin cuts across three (3) Local Government Areas namely Ilorin West, Ilorin East, and Ilorin South Local Government Areas, and it has about twenty (20) political wards [13]. The Ilorin population was projected with an annual growth rate of 2.84% [14] and at the 2006 headcounts; the city's population was 766,000 [15][13].

The city is a confluence of cultures, populated by the Yoruba, Igbo, Hausa, Fulani, Nupe, Bariba, and Kanuri tribes, as well as other Nigerians and foreign nationals. It also has a large population of Muslims and Christians.

Study Duration

This study lasted for 12 months from sample collection to report writing.

Sample Determination

The Sample size for this study was determined by using the sample size formula below

$$N = \frac{Z^2 P\,(1-P)}{e^2} \qquad [16]$$

where;

N = required sample size.

Z = standard normal corresponding to 95% confidence level set at 1.96.

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P = Assumed prevalence of Female infertility (30% = 0.3) [31].

e = level of error tolerance (10%).

$$N = \frac{(1.96)^2(0.3) \times (1-0.3)}{0.1^2}$$

$$N = \frac{3.8416 \times 0.3 \times 0.7}{0.01}$$

$$N = \frac{0.806736}{0.01}$$

N = 80

Study Population

A total number of eighty (80) female participants were recruited for this study. Forty (40) healthy adult female kitchen staff and forty (40) age-matched healthy adult female non-kitchen staff.

Inclusion criteria

Healthy females within the age range of 18 and 40 years shall be recruited for this study.

Healthy females working in the kitchen exposed to fire shall be recruited for this study

Exclusion criteria

1. Anyone in the inclusion criteria who did not give their consent.
2. Anyone in the inclusion criteria who was nursing any form of reproductive ailment.
3. Anyone in the inclusion criteria who had attained menopause.
4. Anyone in the inclusion criteria who was menstruating.
5. Anyone in the inclusion criteria who was on fertility treatment/medication.
6. Anyone in the inclusion criteria who was pregnant.

Sampling Technique

This study was based on a purposive sampling technique. Our participants were selected based on specific criteria spelled out under the inclusion and exclusion criteria. Using a purposive sampling technique gives us a subjective choice of participants to meet the purpose or goals of our study.

Research Instrument for obtaining demographic data

A semi-structured questionnaire was developed by the authors to generate data from the participants. Socio-demographic characteristics, occupational, medical, and reproductive history were taken from the participants.

Ethical Approval and Ethical Considerations

Ethical approval was sought from the Ministry of Health, Kwara state with the approval number ERC/MOH/2023/12/173. Also, an informed consent of each participant was sought before data and sample collection. The respondents were given a detailed description of the study and the principles of privacy and confidentiality were upheld.

Collection of blood sample

Five millimeters (5 ml) of venipuncture blood was collected into a plain vacutainer bottle and this was kept to clot to obtain serum for the estimation of hormones. Thereafter, all samples were centrifuged at 5000 rpm for five minutes to obtain serum that was then aspirated in small aliquots into clean vials and stored at -20°C until analysis was done.

Determination of hormones

Serum FSH, LH, oestrogen, progesterone, and prolactin hormones were estimated by Enzyme Linked Immunosorbent Assay (ELISA) (Immunometric UK Limited) by following the methods described by [18].

Principle

The assay is an immunometric (sandwich) design, utilizing two anti-hormone monoclonal antibodies. The first was directed against the alpha chain of the hormone and attached to a magnetic particle. The second was directed against the beta chain (LH/FSH/prolactin) and labelled with alkaline phosphates. The samples were incubated with magnetic anti-hormones and hormones in the sample bound to the magnetic particles. The magnetic particles were incubated with labelled anti-hormones. The labelled antibody then reacted with any hormones bound to the magnetic particles after immune extraction. The magnetic particles were incubated with a coloured enzyme substrate. The intensity colour formed was a measure of the amount of alkaline phosphatase labelled antibody.

METHOD OF DATA ANALYSIS

All completed questionnaires were screened for completeness. The Statistical Package for Social Science (SPSS) software version 20.0 was used for the analysis of data. Student t-test was used to find significant differences in the mean and standard deviation. P value less than 0.05 ($p < 0.05$) was considered significant.

RESULTS

Table 1: Sociodemographic Characteristics of the Participants

Variables		Control (N=40) N (%)	Test (N=40) N (%)	Total (N=80) N (%)	
Age	17-24	38 (95%)	10 (25%)	48 (60%)	X= 41.33**
	25-34	2 (5%)	14 (35%)	16 (20%)	df= 2
	35 and above	-	16 (40%)	16 (20%)	p-value<0.001
Ethnicity	Yoruba	40 (100%)	37 (92.5%)	77 (96.3%)	X= 3.117
	Hausa	-	2 (5%)	2 (2.5%)	df= 2
	Others	-	1 (2.5%)	1 (1.3%)	p-value=0.210
Level of education	None	2 (5%)	3 (7.5%)	5 (6.3%)	X= 67.61**
	Primary	-	3 (7.5%)	3 (3.8%)	df= 6
	Secondary	-	24 (60%)	24 (30%)	p-value<0.001

	OND	-	6 (15%)	6 (7.5%)	
	HND	-	2 (5%)	2 (2.5%)	
	1st degree	37 (92.5%)	2 (5%)	39 (48.8%)	
	2nd degree	1 (2.5%)	-	1 (1.3%)	
Marital status	Single	39 (97.5%)	11 (27.5%)	50 (62.5%)	X= 41.82**
	Married	1 (2.5%)	27 (67.5%)	28 (35%)	df= 2
	Separated/ Divorced	-	2 (5%)	2 (2.5%)	p-value<0.001
Number of children	None	38 (95%)	10 (25%)	48 (60%)	X= 42.03**
	1	1 (2.5%)	2 (5%)	3 (3.8%)	df= 4
	2	1 (2.5%)	10 (25%)	11 (13.8%)	p-value<0.001
	3	-	6 (15%)	6 (7.5%)	
	4 and above	-	12 (30%)	12 (15%)	
BMI (kg/ m2)	<18.50	8 (20.5%)	5 (12.5%)	13 (16.5%)	X= 13.45**
	18.50-24.99	28 (71.8%)	18 (45%)	46 (58.2%)	df= 3
	25.00-29.99	2 (5.1%)	5 (12.5%)	7 (8.9%)	p-value=0.004
	$\geq$30	1 (2.6%)	12 (30%)	13 (16.5%)	

Age, level of education, marital status, parity, and BMI distribution of participants varied significantly among the participants. *Correlation is significant at $p \leq 0.05$ level (1-tailed). **Correlation is significant at $p \leq 0.01$ (1-tailed).

Most of the test group population fell within the age group of 35 years and above (40%) while the age group 17-24 years comprised the least population (10%). On the contrary, the majority of the control group population was aged 17-24 years (95%), while the least were aged 35 years and above (0%). The difference in age distribution between the control and the test groups was statistically significant ($p < 0.001$). Also, the participants were predominantly Yoruba by tribe in both the test (92.5%) and the control (100%) groups. Furthermore, most of the control participants were educated to the level of first degree (92.5%) whereas, most of the test group participants were educated to the level of secondary school (60%). There was a significant difference in education levels between the test and the control groups ($p < 0.001$) (Table 1).

The participants in the control group were predominantly single (97.5%) while those of the test group are predominantly married (67.5%). There was a high level of significant difference ($p < 0.001$) between the two groups. Majority of the participants in the control group have no children (95%), while most of the test group participants had 4 children and above (30%). In addition, there was a significant difference ($p < 0.001$) in the variation of the number of children between the two groups. Also, majority of the participants in both the test and the control groups have a BMI of 18.50 - 24.99 (71.8%). However, there was a statistically significant variation between the two groups ($p<0.05$) (Table 1).

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Levels of Female Reproductive Hormones (i.e. oestrogen, progesterone, FSH, LH, testosterone, prolactin, and FBG) Among Heat-Exposed Female Kitchen Staff Compared with the Control Group.

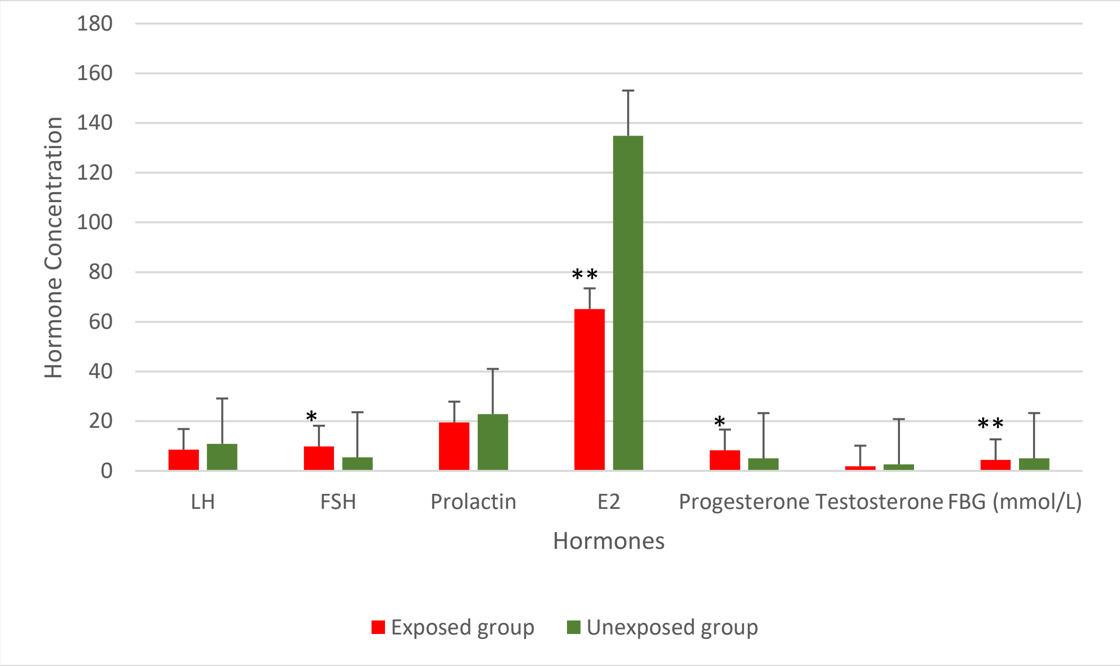

Figure 1**:** Level of Female Reproductive Hormones among Heat Exposed and the Control Groups

Compared to the control, FSH and progesterone increased significantly while E2 and FBG decreased significantly. *Correlation is significant at p≤0.05 level (1-tailed). **Correlation is significant at p≤0.01 (1-tailed).

The levels of FSH ($p = 0.01$) and progesterone ($p = 0.039$; $p<0.05$) increased significantly in the heat-exposed group compared to the control while the levels of E2 ($p < 0.0001$) and FBG ($p < 0.0001$) decreased significantly compared to the control. (Figure 1)

Table 2: Association Between the Source of Heat Exposure and Female Reproductive Hormones/FBG

	Sources of Heat	Frequency (N=40)	Mean±SD	Min-Max	*X*	p-value
LH	Gas cooker	8	10.89±10.17	4 – 35	7.052**	0.003
	Firewood & charcoal	29	6.78±3.87	2 - 15.2		
	All of the above	3	19±5.90	15.2 - 25.8		
FSH	Gas cooker	8	9.91±6.70	4 – 25	2.088	0.138
	Firewood & charcoal	29	8.66±10.70	1 – 51		
	All of the above	3	21.07±9.78	10.3 - 29.4		
Prolactin	Gas cooker	8	25.73±7.03	12 - 35	4.333*	0.02
	Firewood & charcoal	29	18.45±7.27	5.6 - 29		
	All of the above	3	13.60±6.30	7.8 - 20.3		
E2	Gas cooker	8	39.50±29.02	18 - 100	1.896	0.165
	Firewood & charcoal	29	70.32±46.14	16 - 200		

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	All of the above	3	83.33±39.31	54 - 128		
Progesterone	Gas cooker	8	9.29±3.84	6 - 15.3	1.507	0.235
	Firewood & charcoal	29	8.63±6.80	2 – 30		
	All of the above	3	2.43±1.07	1.2 - 3.1		
Testosterone	Gas cooker	8	2.25±3.15	0.5 - 10	0.166	0.848
	Firewood & charcoal	29	1.81±4.29	0.3 - 24		
	All of the above	3	0.70±0.10	0.6 - 0.8		
FBG (mmol/L)	Gas cooker	8	4.08±0.99	3.2 - 5.7	5.021*	0.012
	Firewood & charcoal	29	4.32±0.63	3.4 - 5.7		
	All of the above	3	5.57±0.50	5.1 - 6.1		

There was a significant correlation between the heat sources and the level of LH, prolactin, and FBG. *Correlation is significant at $p \leq 0.05$ level (1-tailed). **Correlation is significant at $p \leq 0.01$ (1-tailed).

The levels of LH ($p = 0.003$; $p<0.05$) and FBG ($p = 0.01$; $p<0.05$) increased significantly in those that were exposed to heat through all the different sources combined, compared to others while the level of prolactin decreased significantly in those exposed to heat through all the different sources combined, compared to others ($p = 0.02$; $p<0.05$) (Table 5). Therefore, a significant association exists between sources of heat exposure and the level of female reproductive hormones.

Table 3: Correlation Between the Level of Female Reproductive Hormones/FBG and the Duration of Occupation as Kitchen Staff

		Frequency (N=40)	Mean± SD	Min - Max	F	p-value
LH	< 1 year	5	6.60±5.49	2 - 15.2	1.311	0.286
	1-3 years	29	9.68±7.03	2 – 35		
	4-6 years	3	5.77±1.27	4.3 - 6.5		
	7-9 years	3	3.20±1.04	2 - 3.8		
FSH	< 1 year	5	4.72±3.63	1 - 10.3	1.2	0.324
	1-3 years	29	11.68±11.48	1 – 51		
	4-6 years	3	6.93±1.36	5.5 - 8.2		
	7-9 years	3	3.50±1.32	2 - 4.5		
Prolactin	< 1 year	5	15.14±5.72	10.9 - 25	1.721	0.18
	1-3 years	29	21.19±7.49	7.8 - 35		
	4-6 years	3	14.07±10.28	5.6 - 25.5		
	7-9 years	3	16.40±8.50	8 – 25		
E2	< 1 year	5	73.98±39.19	20 - 128	5.548**	0.003

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	1-3 years	29	52.42±35.74	16 - 130		
	4-6 years	3	134.00±57.17	100 - 200		
	7-9 years	3	104.33±40.45	73 - 150		
Progesterone	< 1 year	5	6.48±5.56	1.2 - 15	1.072	0.373
	1-3 years	29	8.60±5.82	2 – 30		
	4-6 years	3	4.13±0.64	3.4 - 4.5		
	7-9 years	3	12.50±12.62	2 - 26.5		
Testosterone	< 1 year	5	0.98±0.54	0.3 - 1.8	0.192	0.901
	1-3 years	29	2.107±4.54	0.5 - 24		
	4-6 years	3	0.87±0.06	0.8 - 0.9		
	7-9 years	3	1.37±0.90	0.8 - 2.4		
FBG (mmol/L)	< 1 year	5	4.74±0.99	3.9 - 6.1	1.503	0.23
	1-3 years	29	4.21±0.77	3.2 - 5.7		
	4-6 years	3	4.67±0.40	4.3 - 5.1		
	7-9 years	3	4.93±0.25	4.7 - 5.2		

There was a significant correlation between the duration of occupation as kitchen worker and the level of E2. *Correlation is significant at p≤0.05 level (1-tailed). **Correlation is significant at p≤0.01 (1-tailed).

There was a statistically significant correlation between the level of oestrogen and the duration of occupation as kitchen staff exposed to heat (p = 0.003; P<0.01). The heat-exposed kitchen staff within the duration of 4-6 years on the job had the highest level of oestrogen while those within 1-3 years had the lowest level of oestrogen (Table 6).

DISCUSSION

In this study, most of the kitchen workers had secondary school education as compared to the control with majority having a first degree and the association was significant at p<0.05. This might influence their knowledge about the consequence of regular exposure of their body to intense heat. However, most of the participants in the control and test groups have healthy weight as evidenced in the BMI score reported in the result.

The level of luteinizing hormone (LH) was not significantly altered by heat exposure among the kitchen staff (Figure 1). This suggests that heat exposure may not have a substantial impact on LH levels, which are crucial for reproductive function in both males and females. LH plays crucial roles in steroid synthesis for both sexes and triggers ovulation and release of the ovum in females [19]. The finding is however in contrast with that of [34] who opined that heat stress had a negative effect on the level of LH.

The significant increase in follicle-stimulating hormone (FSH) level in the heat-exposed group (p = 0.01) suggests that heat exposure might stimulate the pituitary gland to release more FSH. FSH is critical for reproductive processes, including spermatogenesis in males and ovarian follicle development in females. Elevated FSH levels could indicate a compensatory response to heat-induced stress. This study was similar to the study of [20] as they observed an increased level of follicle-stimulating hormone (FSH) among workers exposed to heat of welding process when compared to the unexposed control. The heat from the welding process emit lead which affect the mobility and concentration of sperm cells among exposed subjects. Importantly, it is necessary to note that reproductive hormones such as follicle stimulating hormone, estradiol and progestrone affects the thermorgulatory system. The following hormones are found to change the body temperature, level of sweat production, rate of blood flow in the skin and metabolic activities. Studies by [21] and [22] reported an increased level of reproductive hormones such as follicle-stimulating hormone (FSH) among female, exposed to high level of heat which later transcend to heat stress.

Prolactin levels were slightly lower in the heat-exposed group but not significantly different from the control. Prolactin is involved in various physiological processes, including lactation and reproductive health. The minor decrease observed might be attributed to the stress response but is not likely to have significant clinical implications. This study does not confirm with study of [23] as they observed a significant increase in prolactin level of women exposed to a severe hyperthermia condition. Research has shown that increase in body temperetaure as a result of heat stress increases the level of prolactin production [24]. The increase in level of prolactin production will indirectly affect the production of estrogen, which is important in female reproductive activities [23].

The estradiol (E2) levels were significantly lower in the heat-exposed group compared to the control ($p < 0.0001$). Estradiol is a form of estrogen critical for reproductive and overall health, influencing various body systems. Significant reductions in estradiol could impact reproductive function and other estrogen-dependent processes. This study was similar to the study of [25] as they observed a reduced level of estradiol among women exposed to heat from smoking cigratte in a non-ventilated enivironment. In a new research conducted by [26], they observed that heat gotten from cigarette smoke initiate a destructive activity in the varies by disrupting the initiation of 152 miRNAs, this will inhibit the MAPK pathway. Research has shown that the increased production of the phosphorylated form of MAPK is commonly found in ovarian cancers [27][28].

Progesterone levels were significantly higher in the heat-exposed group compared to the control ($p = 0.039$; $p < 0.05$). Progesterone is essential for regulating the menstrual cycle and maintaining pregnancy. The increase suggests that heat exposure might influence the endocrine system's regulatory mechanisms which could be a stress-induced response, potentially as a mechanism to sustain reproductive readiness. This possibly is an adaptive response to ensure reproductive success under adverse conditions. This study was similar to the study of [23] as they observed a significant increased level of progesterone among women exposed increased heat stress when compared with control. This might be due to upregulation by estrogen during increased heat level state by activating the gonadotropin releasing hormone in the hypothalamus [23].

Testosterone levels were slightly lower in the heat-exposed group, but the difference was not statistically significant. Testosterone is crucial for male reproductive health and has various anabolic effects in both sexes. This might be due the fact that the subjects enrolled for this study are all females. However, this study was similar to [20] as they observed a significant decrease in testosterone level of subjects exposed to heat from welding process when compared with control. This signifies a dysregulation in male reproductive hormones which might later lead low sperm count and motility as observed in some studies [29].

The significant reduction in fasting blood glucose (FBG) levels in the heat-exposed group ($p < 0.0001$) indicates that heat exposure might enhance glucose utilization or impact insulin sensitivity. Heat exposure can increase metabolic rate and energy expenditure, potentially leading to lower blood glucose levels.

The significant increase in LH and FBG, and the significant decrease in prolactin in those exposed to heat from all sources ($p = 0.01$ for LH and FBG; $p = 0.02$ for prolactin) suggests that heat exposure from combined sources impacts these parameters (Table 2). Heat exposure can influence metabolic and hormonal pathways, potentially increasing stress hormones and altering metabolic rates. The reduction in prolactin may be related to heat-induced stress and its suppressive effects on prolactin secretion.

The significant association between oestrogen levels and the duration of heat exposure ($p = 0.003$; $p<0.01$), with those exposed for 4-6 years having the highest oestrogen levels (Table 3), could be due to long-term adaptation mechanisms to heat stress. Prolonged exposure might induce compensatory hormonal adjustments to maintain homeostasis.

Study Limitation

This study was delimited in scope due to limited resources in terms of fund and the time required to complete the research as the researchers would have loved to expand the scope of the study on male kitchen staff and in other sites outside Ilorin metropolis.

CONCLUSION

This research demonstrated the potential risk female kitchen staff are exposed to irrespective of age, ethnicity, education level, and or marital status. The observed hormonal and metabolic changes in the female kitchen staff exposed to heat suggest that heat exposure has significant physiological effects. The drastic increase in FSH and progesterone levels, along with the tremendous decrease in oestrogen and fasting blood glucose, indicates a potential threat to fertility. The associations between hormonal levels and various factors such as marital status, parity, sources of heat exposure, and heat exposure duration highlight the complex interplay between environmental, social, and physiological factors. These insights contribute to a broader understanding of how occupational and personal factors can impact health outcomes, particularly in environments with significant heat exposure. These findings underscore the need for further research to understand the mechanisms underlying these changes and their potential implications for health.

RECOMMENDATIONS

It is recommended that this research is replicated in male kitchen staff workers exposed to heat so as to be able to document findings on the effect of heat on male reproductive hormones.

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Conflict of interest

The researchers declare that there was no conflict of interest at all among them from conception to the draft of this manuscript.

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