

Women Hearts on the Line: Exploring the Correlation Between Anthropometric Parameters, Blood Pressure, and Peripartum Cardiomyopathy

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Abstract:

Background: Peripartum cardiomyopathy (PPCM) is a life-threatening heart muscle disease of unknown aetiology that affects women during the peripartum period, particularly in sub-Saharan Africa. While many studies have observed normal blood pressure (BP) in PPCM patients, none have explored whether their BP is appropriate for their body size. This study investigated the correlation between body anthropometric parameters and BP in PPCM patients, comparing the findings with those of age-matched normal peripartum controls. **Methods:** A cohort of 105 women, each from PPCM and matched normal peripartum control groups, were recruited from three healthcare facilities in Sokoto. Blood pressure (BP) parameters were assessed in relation to their anthropometric measurements, and the findings were compared between the two groups. **Results:** The PPCM patients were significantly smaller in body weight (57.0 ±11.6 Kg vs 66.8 ±13.8 Kg, P <.0001), body mass index (BMI) (21.9 ±4.1 Kg/m² vs 25.4 ±5.4 Kg/m², P <.0001), body surface area (BSA) (1.3 ±0.7 m² vs 1.7 ±0.2 m², P <.0001), Lean body mass (LBM) (45.3 ±7.0 Kg vs 49.4 ±4.1 Kg, P <.0001) and Percentage body fat (BF) (23.5 ±10.9 % vs 31.2 ±6.9 %, P <.0001). Similarly, PPCM patients had significantly higher systolic BP (SBP), Pulse pressure (PP) and Mean arterial blood pressure (MABP) compared to the normal peripartum PPCM control. Further, linear regression analysis showed that there was higher slope of the relationship between anthropometric indices and SBP and PP in the PPCM cohort, compared to the normal peripartum control group. A similar trend of the slope was seen in the Pearson's coefficient of the relationship of the anthropometries and BP parameters. **Conclusions:** This study found that women with peripartum cardiomyopathy (PPCM) exhibited disproportionately higher systolic blood pressure (SBP) and pulse pressure (PP) for each unit increase in anthropometric measurements compared to normal peripartum controls. Notably, PPCM patients had significantly lower anthropometric measures, potentially attributable to poverty and chronic undernutrition. Additionally, the effects of poor antenatal care, lack of immunization and recurrent infection should be considered. These findings suggest an abnormal relationship between anthropometry and blood pressure in PPCM patients, which may have detrimental effects on their cardiovascular health. This abnormal relationship may contribute to the development of heart failure (HF) in PPCM patients and potentially increase the risk in women susceptible to PPCM. Even-though our assumption, yet to be proven. To address this concerning trend in vulnerable populations, improvements in nutritional status, socioeconomic determinants health, adequate antenatal care (ANC), immunization, and infection prevention should be considered.

Keywords: Peripartum Cardiomyopathy, Anthropometry, Blood Pressure, Sub-Clinical Heart Disease, Poverty, Chronic Undernutrition

1. Introduction

Peripartum cardiomyopathy (PPCM) is a life-threatening heart muscle disease that occurs exclusively in childbearing women during or shortly after pregnancy [1, 2]. Its incidence and outcomes vary significantly across populations, with higher rates observed in sub-Saharan Africa (North-western Nigeria) compared to developed nations [2,3,4]. In North-western Nigeria, PPCM poses a significant public health challenge due to its increasing incidence and poor patient outcomes [3-7].

This region, characterized by extreme poverty, faces numerous challenges that exacerbate the burden of PPCM. These include low socioeconomic status, inadequate education, unemployment, economic deprivation, poor nutrition, and stunted growth, often compounded by limited access to quality antenatal care [3,5-9].

Poverty is a significant social determinant of health, with a strong association with cardiovascular disease, even surpassing traditional risk factors [10]. Chronic undernutrition, a common consequence of poverty, further contributes to the vulnerability of women in this region to PPCM [11].

The high prevalence of poverty, chronic undernutrition, and stunted growth among PPCM patients in North-western Nigeria highlights the urgent need for effective interventions to address this critical maternal health issue.

Peripartum cardiomyopathy (PPCM) typically presents as heart failure (HF) in the last month of pregnancy or within 5-6 months postpartum, with approximately 75% of cases occurring within this timeframe [1,2]. This disease is linked to an increased risk of cardiovascular complications, including venous and systemic thromboembolism, arrhythmias, sudden cardiac death, re-hospitalizations, and higher morbidity and mortality rates. In the past five decades, our understanding of PPCM has evolved, leading to changes in the paradigms used to comprehend this cardiomyopathy. However, questions regarding its etiology remain unanswered [5], and management outcomes remain suboptimal [4]. Furthermore, the diagnostic criteria for PPCM have seen several revisions, with the latest definition provided by the Heart Failure Association of the European Society of Cardiology (ESC) working group on PPCM as idiopathic cardiomyopathy leading to heart failure due to left ventricular (LV) systolic dysfunction occurring late in pregnancy or within months after delivery, with no other heart failure causes identified. It is a diagnosis of exclusion. While the left ventricle may not show dilation, the ejection fraction typically falls below 45% [12].

Several theories have been proposed to explain the etiopathogenesis of peripartum cardiomyopathy (PPCM). One theory posits that an imbalance in angiogenesis interacts with individual susceptibility, influencing the progression to overt PPCM [5,13]. Additionally, risk factors such as poverty and nutritional deficiencies have been identified as contributing to the development of PPCM [3,5]. Low socioeconomic status, coupled with chronic undernutrition and stunted growth, has been frequently reported in PPCM patients [6,9]. One study also linked significant weight gain during pregnancy to a higher risk of developing PPCM [14]. It is hypothesized that some patients with underlying subclinical heart disease, exacerbated by poverty and chronic undernutrition, may progress to decompensated heart failure due to plasma volume expansion caused by the physiological changes that occur during pregnancy and the peripartum period [1,15].

There is substantial evidence highlighting the significant role of elevated systolic blood pressure (SBP) and pulse pressure (PP) in the pathogenesis of heart diseases [16-18]. Abnormal blood pressure during pregnancy, a key indicator of preeclampsia, is a well-

known risk factor for peripartum cardiomyopathy (PPCM) [4,5]. Additionally, preeclampsia has been reported to overlap with PPCM [3,5]. However, it remains unclear what constitutes appropriate blood pressure levels for PPCM patients, especially considering their smaller body sizes. While some studies indicate elevated blood pressure in PPCM patients [19,20], others report their blood pressure to be within the normal range for adults [6,9,21]. Our literature search did not reveal any studies examining blood pressure variables in relation to body size among PPCM patients. We hypothesize that what is considered normal blood pressure for PPCM patients may actually be disproportionately high relative to their body size, potentially leading to adverse effects on the hearts of susceptible women, resulting in decompensated heart failure. This hypothesis stems from the understanding that despite significant advancements, the underlying causes of peripartum cardiomyopathy (PPCM) remain poorly understood. Further research is crucial to elucidate the complex mechanisms that contribute to its development. Key areas of investigation include: (1) The precise roles of hormonal and immunological factors in triggering PPCM, (2) The influence of genetic factors on both the susceptibility and severity of the condition, and (3) The interplay between poverty, chronic undernutrition, and blood pressure variables and the risk of developing PPCM. By addressing these knowledge gaps, future research can significantly improve our understanding of PPCM and pave the way for more effective prevention and treatment strategies. In our current study, we analysed variations in blood pressure parameters in relation to increases in certain anthropometric measurements of PPCM patients, comparing these results with a cohort of matched normal peripartum controls using both linear regression and correlation models.

2. Materials and Methods

This study was carried out in accordance with the principles and guidelines for human research outlined in the Helsinki Declaration [22]. Ethical approval was granted by the relevant institutional ethics review committees of Medi-Stop Clinical Diagnostic Sokoto, Specialist Hospital Sokoto, and Usmanu Danfodiyo University Teaching Hospital Sokoto with the following reference numbers: (MCD/SUB/012/Vol.II), (SHS/SU8JB/133/Vol.I), (NHREC/UDUTH-HREC/30/03/2023). Informed consent was obtained from all participants, adhering to the guidelines stipulated in the Helsinki Declaration [22].

We conducted a study involving 105 consecutive women of childbearing age (15 years and older) who met the European Society of Cardiology (ESC) Working Group diagnostic criteria for Peripartum Cardiomyopathy, as idiopathic cardiomyopathy leading to heart failure due to left ventricular (LV) systolic dysfunction occurring late in pregnancy or within months after delivery, with no other heart failure causes identified. It is a diagnosis of exclusion. While the left ventricle may not show dilation, the ejection fraction typically falls below 45% [12]. Participants were recruited from three healthcare facilities. A control group of 105 age-matched normal peripartum women attending postnatal clinics were recruited using linear systematic sampling technique. We collected socio-demographic, anthropometric, clinical data through a structured questionnaire. Additionally, we enquired about pregnancy specific cultural practices, such as traditional hot baths and the consumption of dried lake-salt enriched pap (DLEP), known as 'Kunun kanwa' in the Hausa dialect [6].

2.1. Blood pressure measurement

Blood pressure (BP) measurements were conducted following standard procedures using an Accoson mercury sphygmomanometer with the appropriate cuff size on the left or right arm. Participants rested for ten minutes before three readings were taken, and the average was calculated for brachial systolic and diastolic BP at Korotkoff sounds 1 and 5, respectively, while in a sitting position [23,24]. In this study, hypertension in adults was

defined as having a systolic BP (SBP) of 140 mmHg or higher and/or a diastolic BP (DBP) of 90 mmHg or higher, measured on three separate occasions one week apart, due to the natural variability of BP, or by the use of any known antihypertensive medication in individuals with established hypertension. Participants with BP readings below 140/90 mmHg were classified as normotensive.

2.2. The anthropometric measurements

Standard procedures were employed to measure body weight (in kg) using a calibrated weighing scale, with participants standing in light clothing.

Height (m): Height was measured with a stadiometer (Seca 213, UK), ensuring participants stood barefooted with their heels, back, and occiput against the scale, while looking straight ahead.

Body Mass Index (BMI): BMI was calculated by dividing weight (kg) by the square of height (m²).

Body Surface Area (BSA): BSA was estimated in square meters (m²) using Jacobson's equation $BSA, m^2 = (Wt(kg) + HT (cm) - 60)/100$, which are well-validated in previous studies on adults. This method was chosen for its user-friendliness [25].

Body Fat (BF): Body fat percentage was calculated using the participant's BMI, age, and sex (coded as male=1, female=0) based on the validated Deurenberg's equation for women: $BFI (in \%) = (1.20 \times BMI) + (0.23 \times Age) - (10.8 \times gender) 5.4$. For men: $BFI (in \%) = (1.20 \times BMI) + (0.23 \times Age) - (10.8 \times gender) 5.4$ [26].

Lean Body Mass (LBM): LBM was estimated using established relationships validated by Yu and colleagues, $LBM = 22.93 + 0.68 (weight) - 1.14 (BMI) - 0.01 (age) + 9.94$ [26], which took into account body weight, BMI, age, and sex of the participants.

2.3. Echocardiography

All patients with PPCM underwent echocardiographic examinations using the Sonascope SSI-5000 ultrasound imaging system equipped with a 1-6 MHz transducer. The assessments included two-dimensional guided M-mode imaging, as well as colour and spectral Doppler studies, conducted following the guidelines set by the American Society of Echocardiography (ASE) [27,28].

2.4. Other Investigations

Haemoglobin (Hb) levels, fasting blood sugar (FBS), fasting lipid profile (FLP), and serum levels of urea, electrolytes, and creatinine (E/U/Cr) were measured using validated commercial laboratory facilities.

2.5. Inclusion criteria

The study included women of childbearing age (15 years and older) who visited three health facilities with a clinical diagnosis of heart failure occurring during the last month of pregnancy or within five months postpartum. These women underwent diagnostic echocardiography and met the ESC criteria for peripartum cardiomyopathy [12]. The control group comprised age-matched normal peripartum subjects (n=105) attending postnatal clinics at the same healthcare centers.

2.6. Exclusion criteria

Pregnant women under the age of 15 were excluded from the study. Additionally, those with comorbidities such as diabetes, hyperthyroidism, sickle cell anemia (SCA), or Human Immunodeficiency Virus (HIV) infection were also not included. Women with a history of substantial alcohol consumption were excluded as well.

2.7. Statistical Methods

Data analysis was conducted using both IBM SPSS software (version 23.0) and Microsoft Excel (Windows 10 Pro, 2017). Continuous variables were reported as Mean \pm standard deviations. SPSS was utilized to calculate the frequencies of nominal variables and perform stepwise multivariate regression analysis to control for confounding factors. Additionally, the Pearson correlation coefficient (r) for continuous variables was calculated using SPSS. Microsoft Excel was employed to perform the Chi-square goodness of fit test to assess significant differences in proportions. It was also used to determine the slope of the relationships between quantitative variables (β -coefficients) and the dependent variable. The corresponding R-squared values (coefficient of determination) were calculated to estimate the percentage of agreement between the data points and the trend line derived from the slope. The significance level was set at $p < 0.05$.

3. Results

One hundred and five (105) PPCM patients were compared with age-matched normal peripartum women, in the present study. The respective mean ages of the patients and the controls were not significantly different (27.3 ± 7.7 years and 26.3 ± 5.3 years, $P = .2504$) See [Table 1](#). Our data also showed the Hausa/Fulani ethnicity being the dominant, typical of a Northwestern Nigerian setting. This was more obvious in the PPCM cohort, emphasizing the preponderance of this heart disease in this ethnic group.

Table 1. Demography of the participants (n=105)

	PPCM	Control	P -value
Age \pm SD (years)	27.3 \pm 7.7	26.3 \pm 5.3	.2504
Tribes: Hausa/Fulani	103 (98.1%)	75 (71.4%)	-
Igbo	-	12 (11.4%)	-
Yoruba	-	11 (10.5%)	-
Others	2 (1.9%)	7 (6.7%)	-

3.1. Comparing The Anthropometric Parameters between the PPCM Patients and Normal Peripartum Controls

In [Figure 1](#) to [3](#), anthropometric parameters of the PPCM patients were determined and the results were compared with the normal peripartum control group. In [Figure 1](#), we presented weights and BMI of the PPCM patients side-by-side with those of the normal peripartum control. The figure revealed that the PPCM patients were significantly lower in weight and in weight indexed to the height, BMI (weight: 57.0 ± 11.6 Kg vs 66.8 ± 13.8 Kg, $P < .0001$, BMI: 21.9 ± 4.1 Kg/m² vs 25.4 ± 5.4 Kg/m², $P < .0001$).

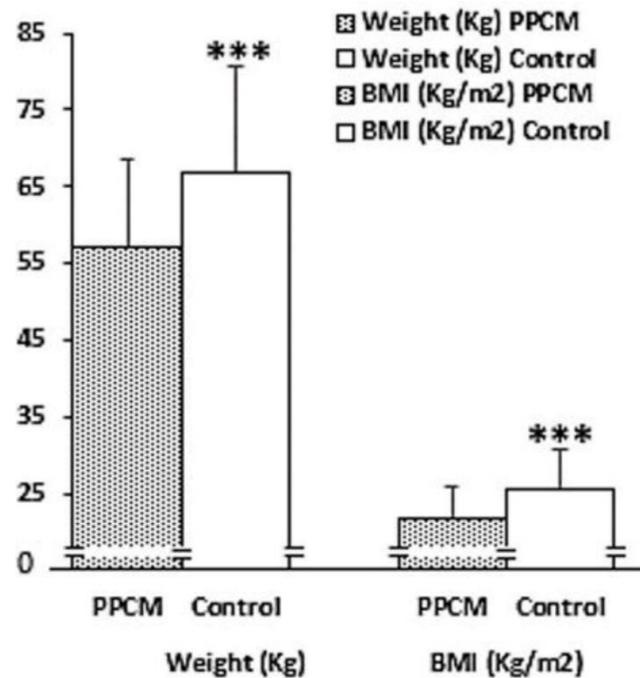


Figure 1. Comparison of the weight and BMI of the PPCM patients and normal peripartum controls. *** $P < 0.001$, BMI=Body mass index.

While in [Figure 2](#), compared the heights and BSA of both groups. The BSA was significantly higher in the normal peripartum controls compared with the PPCM patients ($1.3 \pm 0.7 \text{ m}^2$ vs $1.7 \pm 0.2 \text{ m}^2$, $P < 0.0001$). Although, in this figure there was no significant difference in height between the two groups, the normal peripartum controls were taller ($1.61 \pm 0.05 \text{ m}$ vs $1.62 \pm 0.05 \text{ m}$, $P = 0.0988$).

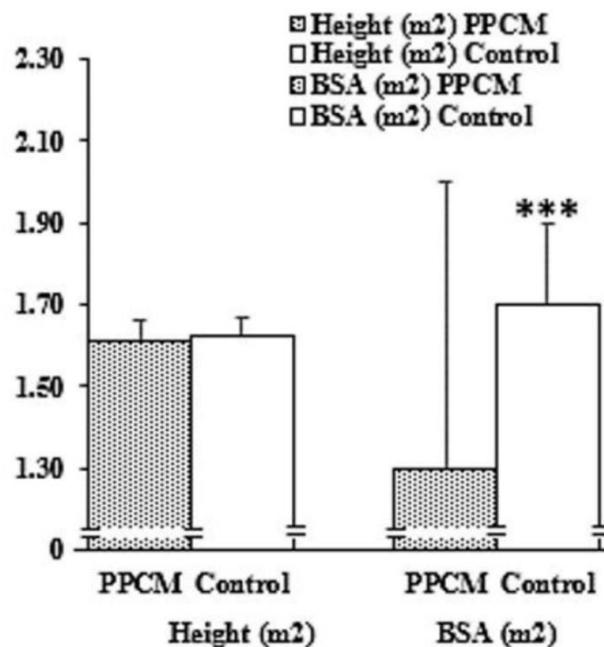


Figure 2. Comparison of the height (m) and BSA (m²) of the PPCM patients and normal peripartum controls. *** $P < 0.0001$, BSA= Body surface area

Indeed, in [Figure 3](#), we showed that resolving the body weight into its component LBM and BF and comparing both groups, the normal peripartum controls group was significantly bigger than the PPCM patients in both measures (LBM: 45.3 ± 7.0 Kg vs 49.4 ± 4.1 Kg, $P < .0001$, BF: 23.5 ± 10.9 % vs 31.2 ± 6.9 %, $P < .0001$).

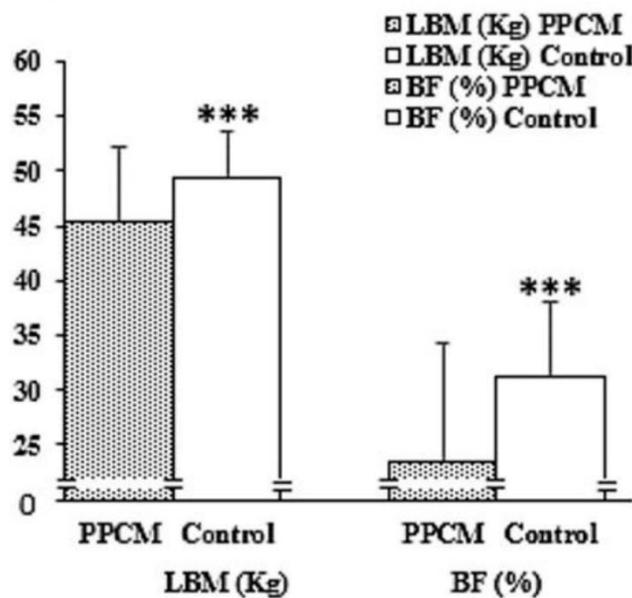


Figure 3. Comparison of the LBM (Kg) and BF (%) of the PPCM patients and normal peripartum controls. *** $P < .0001$, LBM= Lean body mass, BF= Body fat

[Figure 1-3](#): Comparison of anthropometric parameters of the PPCM patients with the normal peripartum controls

3.2. Comparing The BP Parameters of The PPCM Patients and Normal Peripartum Controls

[Figures 4](#) and [5](#) showed that the SBP, PP and MAP were significantly lower among the PPCM patients compared to the normal peripartum control group. However, the DBP though higher in the PPCM group, was not significantly different from the control group.

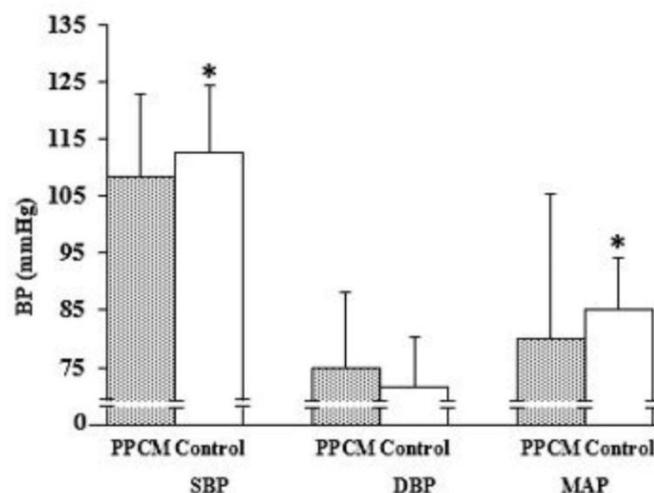


Figure 4. Comparison of the BP parameters (SBP, DBP and MAP) of the PPCM patients with the normal peripartum controls. * $P < .05$, SBP= Systolic blood pressure, DBP= Diastolic blood pressure and MAP= Mean arterial Pressure

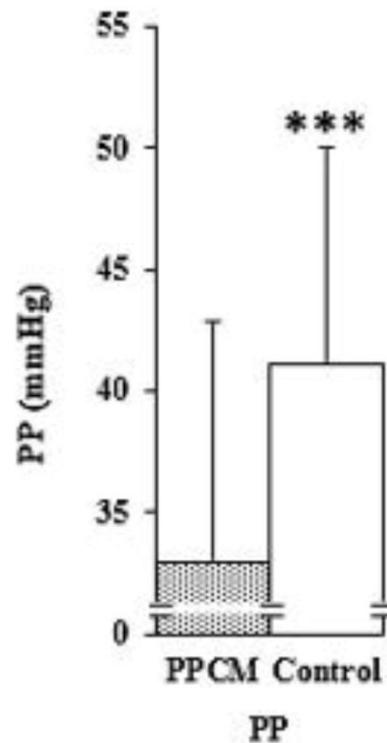


Figure 5. Comparison of the BP parameter (PP) of the PPCM patients with the normal peripartum controls. *** $P < .0001$, PP= Pulse pressure

3.3. Comparison of BP-Anthropometric Relationships Between the PPCM Patients and Normal Peripartum Controls

Table 2, showed the slopes of the relationship between the anthropometric models evaluated and the BP parameters. In this table, except for LBM and BSA, the PPCM patient tends to have more increase in the SBP and PP for every unit increase in the anthropometric models, compared to the normal peripartum subjects. This was even as the PPCM group had significantly lower anthropometries (Figure 1-3) and lower BP parameters (figures 4 and 5). However, evaluating these parameters with DBP and MAP, the increases in the dependent BP parameters to every unit increase in the independent variable is higher in the control group.

Table 2. Linear regression analysis of the relationship between BP indices and some anthropometric variables among the PPCM patients, compared with the normal peripartum subjects

			PPCM		Control	
			β -coefficient	R^2	β -coefficient	R^2
SBP	vs	Weight	0.305	.059	0.196	.052
		Height	0.660	.056	0.386	.031
		BMI	0.577	.027	0.351	.025
		LBM	0.615	.089	0.826	.081
		BF	0.297	.050	0.284	.027
		BSA	4.476	.045	20.002	.067
DBP	vs	Weight	0.086	.005	0.154	.053
		Height	0.387	.021	0.426	.063
		BMI	0.053	.000	0.245	.020
		LBM	0.486	.017	0.711	.100

<i>vs</i>		<i>BF</i>	0.173	.006	0.186	.019
<i>vs</i>		<i>BSA</i>	10.785	.012	17.737	.087
<i>PP</i>	<i>vs</i>	<i>Weight</i>	0.235	.073	0.036	.003
<i>vs</i>		<i>Height</i>	0.376	.038	-0.048	.001
<i>vs</i>		<i>BMI</i>	0.092	.002	0.094	.003
<i>vs</i>		<i>LBM</i>	-0.042	.000	0.091	.002
<i>vs</i>		<i>BF</i>	-0.107	.006	0.088	.005
<i>vs</i>		<i>BSA</i>	-3.777	.003	2.283	.002
<i>MAP</i>	<i>vs</i>	<i>Weight</i>	-0.028	.000	0.166	.061
<i>vs</i>		<i>Height</i>	0.335	.004	0.410	.058
<i>vs</i>		<i>BMI</i>	-0.203	.001	0.276	.026
<i>vs</i>		<i>LBM</i>	0.108	.000	0.741	.107
<i>vs</i>		<i>BF</i>	-0.127	.001	0.215	.026
<i>vs</i>		<i>BSA</i>	2.196	.000	18.498	.094

Similarly, in [Table 3](#), there were stronger correlations between SBP and PP of the PPCM group with the anthropometric models, compared to the relationship seen in the normal control groups. Whereas regarding DBP and MAP, the control group showed stronger relationship.

Table 3. Pearson's relationship of BP indices and some anthropometric variables among the PPCM patients, compared with the normal peripartum subjects

			PPCM		Control	
			R	p-value	R	p-value
<i>SBP</i>	<i>vs</i>	<i>Weight</i>	0.234	.015	0.227	.010
<i>vs</i>		<i>Height</i>	0.236	.014	0.177	.036
<i>vs</i>		<i>BMI</i>	0.163	.065	0.159	.052
<i>vs</i>		<i>LBM</i>	0.286	.004	0.284	.002
<i>vs</i>		<i>BF</i>	0.191	.038	0.165	.046
<i>vs</i>		<i>BSA</i>	0.275	.005	0.266	.003
<i>DBP</i>	<i>vs</i>	<i>Weight</i>	0.071	.261	0.230	.009
<i>vs</i>		<i>Height</i>	0.157	.077	0.251	.005
<i>vs</i>		<i>BMI</i>	0.009	.469	0.143	.075
<i>vs</i>		<i>LBM</i>	0.135	.110	0.315	.001
<i>vs</i>		<i>BF</i>	0.075	.249	0.139	.078
<i>vs</i>		<i>BSA</i>	0.115	.149	0.295	.001
<i>PP</i>	<i>vs</i>	<i>Weight</i>	0.283	.004	0.064	.257
<i>vs</i>		<i>Height</i>	0.205	.030	-0.024	.404
<i>vs</i>		<i>BMI</i>	0.238	.014	0.063	.260
<i>vs</i>		<i>LBM</i>	0.298	.003	0.052	.299
<i>vs</i>		<i>BF</i>	0.202	.032	0.075	.223
<i>vs</i>		<i>BSA</i>	0.304	.002	0.049	.309
<i>MAP</i>	<i>vs</i>	<i>Weight</i>	0.085	.212	0.250	.005
<i>vs</i>		<i>Height</i>	0.194	.033	0.242	.006
<i>vs</i>		<i>BMI</i>	0.018	.432	0.163	.048
<i>vs</i>		<i>LBM</i>	0.155	.072	0.331	.000
<i>vs</i>		<i>BF</i>	0.046	.333	0.163	.048
<i>vs</i>		<i>BSA</i>	0.140	.094	0.310	.001

4. Discussion

The study found that peripartum cardiomyopathy (PPCM) is more prevalent among the Hausa/Fulani ethnic group, the largest in Northwestern Nigeria, a region with high poverty rates [6,8]. Compared to healthy pregnant women, PPCM patients were smaller in stature, shorter, lighter, and had lower Body Mass Index (BMI), Body Surface Area (BSA), Body Fat (BF), and Lean Body Mass (LBM). The study suggests that these lower anthropometric measurements in PPCM patients might be related to stunted growth due to poverty and chronic undernutrition, which are common in the region and known risk factors for heart disease [6,10]. Peripartum cardiomyopathy patients experienced greater increases in systolic blood pressure (SBP) and pulse pressure (PP) with each unit increase in their anthropometric measurements compared to normal peripartum controls. In contrast, the control group showed a more significant rise in diastolic blood pressure (DBP) and mean arterial pressure (MAP) in response to the same increases in anthropometric measurements.

Although PPCM is diagnosed by exclusion, requiring the ruling out of all other known causes of heart failure in peripartum period [2,6,12], these findings suggest that PPCM patients might have higher baseline blood pressure levels relative to their body size. Elevated SBP and PP are well-established risk factors in the development of heart diseases [16-18].

In Nigeria, hypertension accounted for over 70% of hospital admissions due to heart failure [29,30,31]. Notably, systolic blood pressure (SBP) and pulse pressure (PP), reflecting the pulsatile component of cardiovascular hemodynamic, has been significantly linked to the development of cardiovascular end-organ damage [16,17]. In contrast, diastolic blood pressure (DBP) and mean arterial pressure (MAP) primarily measure steady-state pressures, which help enhance coronary blood flow and perfusion to other organs [32,33]. This study suggests that while the control group exhibited better hemodynamic advantages for tissue perfusion, including that of the heart, the group with peripartum cardiomyopathy (PPCM) demonstrated higher levels of harmful hemodynamic indicators. This raises the possibility that individuals with hidden subclinical heart disease, at risk of developing PPCM, might progress to overt decompensated heart failure due to significant plasma volume increases, particularly during the third trimester of pregnancy [15], likewise after delivery [1,2]. This may also explain the frequent occurrence of decompensated heart failure in PPCM patients both in postpartum and afterward [1,2].

The small body size observed in the current cohort of patients with PPCM may reflect the typical low socioeconomic status and chronic undernutrition associated with these patients, as noted in earlier studies [4,6]. Poverty (low socioeconomic status) is often linked to chronic undernutrition, which can lead to stunted growth [6]. Additionally, impaired growth during early development has been linked to cardiovascular diseases (CVD) [34].

Despite Nigeria being a global hotspot for both PPCM and poverty [6,8], the disease is relatively rare in the southern region, which is considered to have a higher standard of living compared to the northern parts of the country [6]. In this study, over 98% of the PPCM patients belong to the Hausa/Fulani ethnic group, in contrast to 71.4% of this group in the control population, with other ethnic groups making up the remaining 28.6%.

The clinical implications of this study highlight several important considerations:

Our findings indicate that patients with Peripartum Cardiomyopathy (PPCM) have significantly lower anthropometric measurements compared to a normal peripartum control group. This discrepancy is likely linked to widespread poverty, chronic undernutrition, and poor socioeconomic determinants of health affecting vulnerable childbearing women susceptible to PPCM in this region of the country. Improving

nutrition and economic conditions for young girls and women of childbearing age could potentially mitigate the burden of this disease.

The study also found that elevated systolic blood pressure (SBP) and pulse pressure (PP) per unit increase in anthropometric measures among PPCM patients or women at risk of PPCM may trigger heart failure, particularly during the substantial physiological weight gains that occur in pregnancy and postpartum periods. Thus, a well-balanced nutritional intervention may help restore the normal relationship between these measurements and blood pressure during the girl child developmental stage, pregnancy, and postpartum, potentially preventing the onset of PPCM.

Finally, tackling poverty, a significant risk factor for PPCM, stunted growth, and chronic undernutrition, could substantially decrease the prevalence of PPCM and other cardiovascular diseases in North-western Nigeria. Poverty has been shown to be a stronger predictor of cardiovascular diseases than traditional risk factors [10].

5. Conclusions

This study aimed to explore the relationship between anthropometric parameters and blood pressure correlates in patients with Peripartum Cardiomyopathy (PPCM), intending to shed light on the probable underlying etiopathogenesis of the disease. Key conclusions from the study include: (1) PPCM patients exhibited disproportionately higher blood pressure (systolic blood pressure and pulse pressure) per unit increase in anthropometric measures compared to normal peripartum controls, despite previous studies reporting normal blood pressure in PPCM patients. (2) Anthropometric measures were significantly lower in PPCM patients compared to the normal peripartum controls.

Based on these findings, we speculate that this abnormal relationship between anthropometry and blood pressure in PPCM patients may be detrimental to their cardiovascular health and likely constitutes the underlying pathophysiological mechanism triggering decompensated heart failure (HF) in PPCM patients and women at risk of PPCM, although this assumption requires further validation. While lower anthropometric measurements in PPCM patients are likely influenced by factors such as poverty, chronic undernutrition, and poor socioeconomic determinants of maternal health, we advocate for improved nutrition (balanced diet) and enhanced socioeconomic conditions for vulnerable girls and women of childbearing age at risk for PPCM, particularly in Northwestern Nigeria. This approach aims to promote optimal growth and help these women better adapt their anthropometric and blood pressure measures during peripartum period and beyond, ultimately mitigating the adverse effects of this abnormal relationship in PPCM and at-risk populations.

5.1. Limitations of the Study

The study's sample size of 210 participants, consisting of 105 patients with peripartum cardiomyopathy (PPCM) and 105 normal peripartum controls, may not have fully represented the PPCM population in the northwestern region of Nigeria. Nevertheless, we ensured that both study groups were in their peripartum period and matched for age. As this was a descriptive study, the ability to draw cause-and-effect conclusions is limited. Additionally, we did not calculate the relative risk or ratio for the various PPCM risk factors. However, our findings indicate that the risks are significantly more prevalent among the PPCM group compared to the control group.

5.2. Perspective

While we are not concluding that patients with Peripartum Cardiomyopathy (PPCM) in this study had pre-existing heart disease prior to pregnancy, the data indicates that their blood pressure levels, although seemingly normal, warrant further investigation in relation to their body size. Previous research has established a connection between weight gain and an increase in systolic blood pressure (SBP) in a proportional manner [35,36].

Notably, the current data reveal a steeper relationship between SBP and pulse pressure (PP) along with anthropometric measurements, with a higher Pearson correlation coefficient. This suggests that an elevated blood pressure, particularly in the systolic and PP components, relative to body size when left unaddressed could pose risks to the heart health of peripartum women who may have other risk factors for PPCM.

5.3. Recommendations

1. This study has identified several critical research areas that require further investigation: (a) Why do PPCM patients exhibit significantly lower anthropometric measurements, suggesting stunted growth? (b) What factors contribute to the high prevalence of PPCM in impoverished regions globally? Is PPCM primarily a consequence of poverty, chronic undernutrition, or a combination of both? (c) Does the observed abnormal relationship between anthropometric parameters and blood pressure play a significant role in the onset of decompensated heart failure in PPCM patients and those at risk? This connection warrants further clarification. In addition to poverty and chronic undernutrition, could genetic factors contribute to the higher prevalence of PPCM in northwestern Nigeria compared to southern regions?
2. Conducting a longitudinal, randomized controlled trial focusing on nutritional interventions could provide more robust evidence to support our findings.
3. Considering that poverty is a stronger predictor of cardiovascular diseases than traditional risk factors, could poverty eradication in northwestern Nigeria contribute to a significant reduction in PPCM incidence?
4. There is an urgent need to improve the nutritional status and socioeconomic determinants of health for vulnerable girls and women of childbearing age in northwestern Nigeria who are at risk for PPCM. This proactive approach may contribute to a substantial decrease in PPCM cases.

Abbreviations

PPCM: Peripartum cardiomyopathy, **BSA:** Body surface area, **BF:** Body fat, **LBM:** Lean body mass, **BMI:** Body mass index, **SBP:** Systolic blood pressure, **DBP:** Diastolic blood pressure, **PP:** Pulse pressure, **MABP:** Mean arterial blood pressure, **DLEP:** dried lake-salt enriched pap

Ethics approval and consent to participate

Is stated in the study methodology

Availability of data materials

The datasets generated and/or analyses during this current study are not publicly available but are available from corresponding author on reasonable request

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Competing Interest

The authors declare no conflicts of interest

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Author contributions

Conception and design of the study, Umar. H; Adamu JB; Isezuo SA, Cherukupalli R.; Provision of study material /patient, data collection and assembly Umar, H.; Adamu JB, Sanusi G ; Cherukupalli, R.; Validation, All the authors; Drafting of the manuscript and critical revision of the content All the authors; Data analysis and interpretation, All the authors; Writing–Review & Editing, All the authors; Supervision, Umar H, Adamu BJ, Nura MI; Project Administration, Umar H. Sanusi G; final approval of manuscript and responsibility for all the aspect of the study, All the authors; Funding Acquisition, Nil.

References

- [1] Soma-Pillay, P., Seabe, J., & Sliwa, K. (2016). The importance of cardiovascular pathology contributing to maternal death: Confidential Enquiry into Maternal Deaths in South Africa, 2011-2013. *Cardiovascular journal of Africa*, 27(2), 60–65. <https://doi.org/10.5830/CVJA-2016-008>
- [2] Lee, S., Cho, G. J., Park, G. U., Kim, L. Y., Lee, T. S., Kim, D. Y., Choi, S. W., Youn, J. C., Han, S. W., Ryu, K. H., Na, J. O., Choi, C. U., Seo, H. S., & Kim, E. J. (2018). Incidence, Risk Factors, and Clinical Characteristics of Peripartum Cardiomyopathy in South Korea. *Circulation. Heart failure*, 11(4), e004134. <https://doi.org/10.1161/CIRCHEARTFAILURE.117.004134>
- [3] Bello, N., Rendon, I. S. H., & Arany, Z. (2013). The relationship between pre-eclampsia and peripartum cardiomyopathy: a systematic review and meta-analysis. *Journal of the American College of Cardiology*, 62(18), 1715–1723. <https://doi.org/10.1016/j.jacc.2013.08.717>
- [4] Twomley, K. M., & Wells, G. L. (2010). Peripartum cardiomyopathy: a current review. *Journal of pregnancy*, 2010, 149127. <https://doi.org/10.1155/2010/149127>
- [5] Bauersachs, J., König, T., van der Meer, P., et al. (2019). Pathophysiology, diagnosis and management of peripartum cardiomyopathy: a position statement from the Heart Failure Association of the European Society of Cardiology Study Group on peripartum cardiomyopathy. *European journal of heart failure*, 21(7), 827–843. <https://doi.org/10.1002/ejhf.1493>
- [6] Karaye, K. M., Ishaq, N. A., Sa'idu, H., et al (2020). Incidence, clinical characteristics, and risk factors of peripartum cardiomyopathy in Nigeria: results from the PEACE Registry. *ESC heart failure*, 7(1), 235–243. <https://doi.org/10.1002/ehf2.12562>
- [7] Isezuo, S. A., & Abubakar, S. A. (2007). Epidemiologic profile of peripartum cardiomyopathy in a tertiary care hospital. *Ethnicity & Disease*, 17(2), 228–233. <https://pubmed.ncbi.nlm.nih.gov/17682350/>
- [8] Kazeem, Y. (2018). Nigeria has become the poverty capital of the world. *Quartz Africa*. Retrieved from <https://qz.com/africa/1313380/nigeria-has-become-the-highest-rate-of-extreme-poverty-globally>
- [9] Foster, E. (2023). *Peripartum (Postpartum) Cardiomyopathy (PPCM)*. In G. K. Sharma (Ed.), *Medscape*. Retrieved from <https://emedicine.medscape.com/article/153153-overview>
- [10] Kondro, W. (2002). Poverty is main predictor of heart disease, says Canadian report. *The Lancet*, 359(9318), 1679. [https://doi.org/10.1016/S0140-6736\(02\)08611-7](https://doi.org/10.1016/S0140-6736(02)08611-7)
- [11] Maleta, K. (2006). Undernutrition. *Malawi Medical Journal*, 18(4), 189–205. <https://www.ajol.info/index.php/mmj/article/view/10922>
- [12] Sliwa, K., Hilfiker-Kleiner, D., Petrie, M. C., et al. (2010). Current state of knowledge on aetiology, diagnosis, management, and therapy of peripartum cardiomyopathy: A position statement from the Heart Failure Association of the European Society of Cardiology Working Group on peripartum cardiomyopathy. *European Journal of Heart Failure*, 12(8), 767–778. <https://doi.org/10.1093/eurjhf/hfq120>
- [13] Hilfiker-Kleiner, D., & Sliwa, K. (2014). Pathophysiology and epidemiology of peripartum cardiomyopathy. *Nature Reviews Cardiology*, 11(6), 364–370. <https://doi.org/10.1038/nrcardio.2014.37>
- [14] Matsumiya, H., Saito, N., Minakami, H., & Kataoka, S. (2015). Gestational weight gain and peripartum cardiomyopathy in a twin pregnancy. *Case Reports in Obstetrics and Gynecology*, 2015, Article 317146. <https://doi.org/10.1155/2015/317146>
- [15] Ouzounian, J. G., & Elkayam, U. (2012). Physiologic changes during normal pregnancy and delivery. *Cardiology Clinics*, 30(3), 317–329. <https://doi.org/10.1016/j.ccl.2012.05.004>
- [16] Nichols, W. W., & Edwards, D. G. (2001). Arterial elastance and wave reflection augmentation of systolic blood pressure: Deleterious effects and implications for therapy. *Journal of Cardiovascular Pharmacology and Therapeutics*, 6(1), 5–21. <https://doi.org/10.1177/107424840100600102>
- [17] Nichols, W. W. (2005). Clinical measurement of arterial stiffness obtained from noninvasive pressure waveforms. *American Journal of Hypertension*, 18(1), 3S–10S. <https://doi.org/10.1016/j.amjhyper.2004.10.009>
- [18] Meeks, W. M. (2002). Pathophysiology of hypertension in the elderly. *Seminars in Nephrology*, 22(1), 65–70. <https://pubmed.ncbi.nlm.nih.gov/11785070/>
- [19] Huang, G. Y., Zhang, L. Y., Long-Le, M. A., & Wang, L. X. (2012). Clinical characteristics and risk factors for peripartum cardiomyopathy. *African Health Sciences*, 12(1), 26–31. <https://pubmed.ncbi.nlm.nih.gov/23066416/>

- [20] Arany, Z., & Elkayam, U. (2016). Peripartum cardiomyopathy. *Circulation*, 133(14), 1397–1409. <https://doi.org/10.1161/CIRCULATIONAHA.115.020491>
- [21] Behrens, I., Basit, S., Lykke, J. A., et al. (2019). Hypertensive disorders of pregnancy and peripartum cardiomyopathy: A nationwide cohort study. *PLOS ONE*, 14(1), e0211857. <https://doi.org/10.1371/journal.pone.0211857>
- [22] World Medical Association (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*, 310(20), 2191–2194. <https://doi.org/10.1001/jama.2013.281053>
- [23] Mirzaei, M., Mirzaei, M., Bagheri, B., & Dehghani, A. (2020). Awareness, treatment, and control of hypertension and related factors in adult Iranian population. *BMC public health*, 20(1), 667. <https://doi.org/10.1186/s12889-020-08831-1>
- [24] Perloff, D., Grim, C., Flack, J., Frohlich, E. D., Hill, M., McDonald, M., & Morgenstern, B. Z. (1993). Human blood pressure determination by sphygmomanometry. *Circulation*, 88(5 Pt 1), 2460–2470. <https://doi.org/10.1161/01.cir.88.5.2460>
- [25] Story, D. A., & Haase, M. (2008). A simple method to estimate body surface area in adults. *British Journal of Anaesthesia*, 101(1), 13–16. https://doi.org/10.1093/bja/el_3034
- [26] Yu, S., Visvanathan, T., Field, J., Ward, L. C., Chapman, I., Adams, R., Wittert, G., & Visvanathan, R. (2013). Lean body mass: the development and validation of prediction equations in healthy adults. *BMC pharmacology & toxicology*, 14, 53. <https://doi.org/10.1186/2050-6511-14-53>
- [27] Lang, R. M., Badano, L. P., Mor-Avi, V., Afilalo, J., Armstrong, A., et al. (2015). Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Journal of the American Society of Echocardiography: official publication of the American Society of Echocardiography*, 28(1), 1–39.e14. <https://doi.org/10.1016/j.echo.2014.10.003>
- [28] Zoghbi, W. A., Enriquez-Sarano, M., Foster, E., et al. (2003). Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography. *Journal of the American Society of Echocardiography : official publication of the American Society of Echocardiography*, 16(7), 777–802. [https://doi.org/10.1016/S0894-7317\(03\)00335-3](https://doi.org/10.1016/S0894-7317(03)00335-3)
- [29] Karaye, K. M., & Sani, M. U. (2008). Factors associated with poor prognosis among patients admitted with heart failure in a Nigerian tertiary medical centre: a cross-sectional study. *BMC cardiovascular disorders*, 8, 16. <https://doi.org/10.1186/1471-2261-8-16>
- [30] Ogah, O. S., Sliwa, K., Akinyemi, J. O., Falase, A. O., & Stewart, S. (2015). Hypertensive heart failure in Nigerian Africans: insights from the Abeokuta Heart Failure Registry. *Journal of clinical hypertension (Greenwich, Conn.)*, 17(4), 263–272. <https://doi.org/10.1111/jch.12496>
- [31] Ogah, O. S., Stewart, S., Onwujekwe, O. E., Falase, A. O., Adebayo, S. O., Olunuga, T., & Sliwa, K. (2014). Economic burden of heart failure: investigating outpatient and inpatient costs in Abeokuta, Southwest Nigeria. *PloS one*, 9(11), e113032. <https://doi.org/10.1371/journal.pone.0113032>
- [32] Seward, J. B., Chandrasekaran, K., Osranek, M., Fatema, K., & Tsang, T. S. M. (2008). Invasive physiology: Clinical cardiovascular pathophysiology and diastolic dysfunction. In A. L. Klein & M. J. Garcia (Eds.), *Diastology: Clinical approach to diastolic heart failure* (pp. 73–91). Philadelphia, PA: W.B. Saunders. <https://archive.org/details/diastologyclinic0000unse>
- [33] Feigl, E. O., Neat, G. W., & Huang, A. H. (1990). Interrelations between coronary artery pressure, myocardial metabolism and coronary blood flow. *Journal of molecular and cellular cardiology*, 22(4), 375–390. [https://doi.org/10.1016/0022-2828\(90\)91474-1](https://doi.org/10.1016/0022-2828(90)91474-1)
- [34] Calkins, K., & Devaskar, S. U. (2011). Fetal origins of adult disease. *Current problems in pediatric and adolescent health care*, 41(6), 158–176. <https://doi.org/10.1016/j.cppeds.2011.01.001>
- [35] Benjamin A. L. (2006). Community screening for high blood pressure among adults in urban and rural Papua New Guinea. *Papua and New Guinea medical journal*, 49(3–4), 137–146. <https://pubmed.ncbi.nlm.nih.gov/18389971/>
- [36] Elliott, S. S., Keim, N. L., Stern, J. S., Teff, K., & Havel, P. J. (2002). Fructose, weight gain, and the insulin resistance syndrome. *The American journal of clinical nutrition*, 76(5), 911–922. <https://doi.org/10.1093/ajcn/76.5.911>