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Research Article

Association Between Trimester-Specific Gestational Weight Gain and Newborn Anthropometric Outcomes at Korle-Bu Teaching Hospital, Accra

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Abstract

Maternal pre-pregnancy weight and gestational weight gains have been linked to newborn characteristics, particularly birth weight, which is critical for child survival. This study determined the association between trimester-specific gestational weight gain, maternal lifestyle practices, and newborn birth weight and length. This retrospective cross-sectional study involved 302 mothers conveniently sampled from the maternity block of Korle-Bu Teaching Hospital, Accra. Data on maternal lifestyle practices were collected using a validated semi-structured questionnaire. Maternal weight and height were measured at the first antenatal visit, with weight recorded at the end of each trimester. Newborn anthropometric data were collected using standard procedures and converted to Z-scores. Independent sample t-tests were used to assess the significance of categorical variables on newborn characteristics, while Spearman's correlation tested associations between continuous variables. Simple linear regression identified maternal factors predicting variations in birth weight and length, which were incorporated into the final model. The mean maternal weight at the first antenatal visit was 57.9±3.1 kg, with mean gestational weight gains of 4.2±2.6 kg and 4.9±3.5 kg by the second and third trimesters, respectively. The total gestational weight gain averaged 9.1±4.2 kg. The mean newborn birth weight and length were 3.2±0.5 kg and 49.1±2.7 cm, respectively. The mean Z-scores for wasting, underweight, and stunting were -0.21±0.95, -0.09±1.15, and -0.51±1.20, respectively. Birth weight correlated statistically significantly with maternal age ($r=0.118$, $p=0.046$) and gestational weight change between the second and third trimesters ($r=0.118$, $p=0.041$). Birth length showed a significant correlation with total gestational weight gain ($r=0.629$, $p<0.0001$). In the final regression model, maternal age ($\beta=0.115$) and total gestational weight gain ($\beta=0.116$) were significant predictors of birth weight. Total gestational weight gain predicted both birth length and birth weight, while weight gain between the second and third trimesters specifically influenced birth weight.

Keywords

Trimester, Birth Weight, Birth Length, Maternal Characteristics, Korle-Bu, Ghana

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1. Introduction

Birth weight and length are critical indicators of a newborn's health and survival, serving as key determinants of immediate and long-term health outcomes. Low birth weight (LBW) and suboptimal birth length are related to increased neonatal morbidity and mortality, stunted growth, and an higher risk of non-communicable diseases later in adulthood [1]. Globally, approximately 15%–20% of births annually are classified as LBW, with the burden disproportionately higher in low- and middle-income countries (LMICs) [2]. In sub-Saharan Africa, including Ghana, the prevalence of adverse birth outcomes such as LBW remains alarmingly high, partly attributable to maternal nutritional deficiencies and inadequate gestational weight gain (GWG). Anthropometric challenges in Ghana reflect disparities in maternal and child health. National surveys indicate persistent issues of maternal undernutrition, with 10%–15% of women of reproductive age classified as underweight [3]. These challenges are compounded by suboptimal GWG during pregnancy, which is a strong predictor of neonatal anthropometric outcomes, including birth weight and length. However, many Ghanaian women fail to meet the recommended GWG guidelines, leading to heightened risks of LBW and other adverse birth outcomes [4]. Lifestyle practices during pregnancy, such as dietary habits, physical activity, and antenatal care attendance, significantly influence GWG and subsequent birth outcomes [5]. Despite evidence linking these maternal factors to newborn characteristics, data on their contribution in Ghana remains limited. Existing studies have primarily focused on neonatal mortality and general maternal health, often neglecting the specific relationship between GWG patterns and infant birth outcomes. This study addresses the gap by investigating the association between trimester-specific GWG, maternal lifestyle practices, and newborn anthropometric outcomes (birth weight and length) in Ghana. It provides evidence on how maternal weight dynamics during pregnancy influence neonatal outcomes, thereby informing interventions to improve maternal and child health by health care providers.

2. Methods

2.1. Design and Area

We used a retrospective cross-sectional design at the maternity block of Korle-Bu Teaching Hospital (KBTH) in Accra, Ghana. This approach was chosen because it allows for the collection of pre-existing data and facilitates the examination of multiple variables within a single time frame [6]. Established on October 9, 1923, KBTH is one of the largest tertiary healthcare facilities in Africa. The hospital has a bed capacity of 2,000, 21 diagnostic and clinical departments, and three Centres of Excellence. It is the leading national referral center and serves as a hub for undergraduate and postgraduate training in health disciplines in Ghana and across Africa.

2.2. Study Population, Sample Size Determination and Sampling

The study population comprised mothers who delivered at KBTH and satisfied the inclusion criteria. We calculated the sample size by using the margin of error of 0.06 and a 95% confidence interval as per [7]. The calculated sample size was 267, but it was rounded up to 300 to improve precision. During data collection, 302 subjects were successfully recruited conveniently from the maternity ward. An average of ten respondents was interviewed daily for 30 days, including weekends, until the calculated sample size was reached.

2.3. Inclusion Criteria

Pregnant women aged 20–30 years with pre-pregnancy body mass index (BMI) between 19.8 and 26.0 kg/m² (IOM, 1999) were included. The pre-pregnancy BMI was determined between the 6th and 8th weeks of gestation. Eligible mothers had KBTH as their primary antenatal clinic, attended antenatal sessions regularly, and delivered singleton newborns at gestational ages between 37–40 weeks.

2.4. Procedure for Data Collection

We collected data from hospital records and through structured interviews with participants using validated semi-structured questionnaires. For the hospital records: maternal weight and height at the first ANC visit and weight at the end of each trimester were extracted. These data were used to calculate GWG for each trimester and total GWG. Other maternal data included systolic and diastolic blood pressure at various trimesters and any documented comorbidities. The structured interviews were used to collect information on maternal lifestyle practices (smoking, alcohol consumption, and pica) and prenatal care experiences (nutritional advice and supplement use). The questionnaire used was developed based on information from existing literature and validated in similar settings. Newborn weights and lengths were measured within two hours of delivery using standardized procedures with calibrated instruments to the nearest 10.0 g and 0.1 cm, respectively [8].

2.5. Study Variables

The primary outcome variables were newborn birth weight (kg) and birth length (cm). Maternal predictor variables included total GWG, trimester-specific GWG, pre-pregnancy BMI, age, lifestyle practices, and ANC attendance.

2.6. Maternal Anthropometric Variables and Calculations

Pre-pregnancy weight was taken as the weight recorded between the 6th and 8th weeks of gestation, while height measurements recorded during the same period were used to calculate BMI. Gestational weight gains for each trimester were calculated by subtracting weights recorded at subsequent trimesters. We got the total gestational weight gain by subtracting pre-pregnancy weight from the maternal weight recorded at the end of the third trimester.

2.7. Data Analysis

Data collected were entered and verified using Epi Info Version 6.0 and analyzed using IBM SPSS Version 21.0. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Newborn anthropometric data (weight-for-age, height-for-age, and weight-for-height) were converted into Z-scores using WHO growth standards [9]. Independent sample t-tests assessed the differences in mean birth weight and length across categorical maternal variables. Spearman's correlation was used to assess the association between continuous maternal variables (e.g., GWG) and newborn outcomes. After that, simple linear regression was used to identify maternal predictors of birth weight and length, with significant variables included in the final model to control for confounders.

3. Results

Table 1. *Descriptive statistics of background characteristics of respondents (n=302).*

Variable	N	%
Ethnicity		
Akan	158	(52.3)
Ga	72	(23.8)
Ewe	37	(12.3)
Hausa	35	(11.6)
Maternal educational level[1]		
None	40	13.2)
Primary[a]	38	(12.6)
Pre-secondary[b]	153	(44.7)
Secondary[c]	59	(19.5)
Post-secondary[d]	30	(9.9)
Maternal occupation		
Unemployed/housewife	105	(34.8)
Trader	38	(12.6)
Office work	105	(34.8)
Professional[2]	23	(7.6)
Hairdresser/seamstress	34	(11.0)
Marital status		
Married	75.9	
Single	24.8	
Widowed	0.3	
Current pregnancy planned		
Yes	189	(62.6)
No	113	(37.4)
Partner occupation		
Artisan	24.5	
Unemployed	11.6	
Office worker	14.6	
Professional	18.2	
Businessman	32.1	
Others	Mean ± SD	Range
Number of antenatal clinic attendance	6.4± 0.9	5 – 9
Maternal age[3](yrs)	26.8±3.3	20 – 30
Parity	1.4±1.2	0 – 5
Birth interval[4](yrs)	2.2±1.7	0 – 9

1. Years of education a: 1- 6 years of basic education b: JSS/Middle School c: 'O' Level/ SSS/ 'A' Level d: Training college, University, Polytechnic 2. Lawyers, Teachers, Nurses, Engineers 3. Age in completed years education etc. 4. Time between the index birth and the preceding one in years.

Background Characteristics of Respondents

The sociodemographic profile of respondents highlights the influence of educational attainment, occupation, and ethnicity on maternal and newborn health outcomes (Table 1). Educational attainment among respondents was varied. Most mothers had a pre-secondary education (44.7%), while smaller proportions attained secondary education (19.5%) or no formal education (13.2%). The largest groups of respondents were unemployed/housewives (34.8%) and office workers (34.8%). Traders constituted 12.6%. The occupational distribution of partners revealed that 32.1% were businessmen, 24.5% were artisans, and 18.2% were professionals. Akans (52.3%) were the majority of the respondents, and then Ga (23.8%), Ewe (12.3%), and Hausa (11.6%). This distribution reflects the ethnocultural diversity within the Korle-Bu Teaching Hospital's catchment area. The majority of respondents were married (75.9%), with single mothers accounting for 24.8%. Regarding pregnancy planning, 62.6% of mothers reported their pregnancies were planned, while 37.4%

were unplanned. The mean maternal age was 26.8 ± 3.3 years. The mean number of antenatal clinic (ANC) visits was 6.4 ± 0.9, ranging from 5 to 9 visits.

Table 2. Lifestyle characteristics of subjects during pregnancy (n =302).

Variable	N	%
Smoked during pregnancy		
Yes	8	2.6
No	294	97.4
Total	302	100.0
Type of substance smoked		
Tobacco	8	2.6
None	294	97.4
Total	302	100.0
Number of sticks smoked/day		
1 – 5	7	2.3
6 – 10	1	0.3
None	294	97.4
Total	302	100.0
Alcohol intake		
Yes	74	24.5
No	228	75.5
Total	302	100.0
Type of alcohol		
"Akpetshie"[1]	37	12.3
Beer	37	12.3
None	228	75.4
Total	302	100.0
Frequency of alcohol intake		
Everyday	20	27.0
Once a week	46	62.2
Occasionally	8	10.8
Pica practice		
Yes	116	38.4
No	186	61.6
Total	302	100.0
Type of pica		
Sand/clay	93	30.8
Ice	19	6.3
Charcoal	4	1.3
None	186	61.6
Total	302	100.0
Frequency of pica		
Everyday	25	8.3
Once a week	20	6.6
Occasionally	71	23.5
None	186	61.6

1: Local gin

Lifestyle Characteristics of Subjects During Pregnancy

Only a small percentage (2.6%) of mothers indicated smoking during puparium, while the majority (97.4%) did not (Table 3). Among those who smoked, tobacco was the only reported substance. Approximately one-quarter of the respondents (24.5%) reported consuming alcohol during pregnancy, while 75.5% abstained. The frequency of alcohol consumption varied: 27.0% of respondents drank every day, 62.2% consumed alcohol once a week, and 10.8% drank occasionally. Pica practice was notably high, with over a third of mothers (38.4%) consuming non-food substances, particularly sand or clay.

Table 3. Maternal anthropometry, blood pressure and biochemical characteristics (n=302).

Variable	Mean±SD	Range
Height at first antenatal visit (cm)	160.3±4.6	159.0 – 168.0
Weight gain during second trimester (kg)	4.2±2.6	-2.0 - 17.0
Weight gain during third trimester (kg)	4.9±3.5	-5.0 - 22.0
Total pregnancy weight gain (kg)	9.1±4.2	-2.0 – 17.0
Maternal weight (kg)		
First visit	57.9	
Second visit	58.2	
Third visit	62.5	
Fourth visit	67.4	
BMI (Kg/m^2)		
First visit	22.4	
Second visit	22.9	
Third visit	24.6	

Variable	Mean±SD	Range
Fourth visit	26.5	

a: End of first trimester measurements taken between 12 to 13 weeks of gestation.;
b: End of second trimester measurements taken between 25 to 26 weeks of gestation.;
c: End of third trimester measurements taken between 35 to 36 weeks of gestation;
d: First visit measurement taken between 6 to 8 weeks of gestation;
e: End of first trimester measurements taken between 12 to 13 weeks of gestation;
f: End of second trimester measurements taken between 25 to 26 weeks of gestation;
g: End of third trimester measurements taken between 35 to 36 weeks of gestation.

Maternal Anthropometry, Blood Pressure, and Biochemical Characteristics

The mean height of the mothers at the first antenatal visit was 160.3 ± 4.6 cm (Table 3). Weight gain during the second trimester averaged 4.2 ± 2.6 kg. In the third trimester, mothers gained slightly more weight, with an average gain of 4.9 ± 3.5 kg. Total pregnancy weight gain was 9.1 ± 4.2 kg, ranging from -2.0 to 17.0 kg. Maternal weight increased progressively across pregnancy. The mean weight at the first antenatal visit (6–8 weeks of gestation) was 57.9 kg. By the second trimester (25–26 weeks), the mean weight increased slightly to 58.2 kg, followed by a notable rise to 62.5 kg in the third trimester (35–36 weeks) and 67.4 kg by the end of pregnancy.

Table 4. *Mean weight-for-age, length-for-age and weight-for-length z-scores of the newborns at birth (sexes combined and separated) (n=302).*

Infant characteristics		
Gender	**%**	**n**
Males	54.6	
Females	45.4	
	Mean±SD	Range
Weight (kg)[1]	3.2±0.5	1.8 – 4.5
Length (cm)	49.1±2.7	36.0 – 55.0
Head circumference (cm)	33.0±2.1	26.0 – 38.0
Chest circumference (cm)	32.5±2.1	22.0 – 39.0
Weight-for-age	-0.09±1.15	302
Length-for-age	-0.51±1.20	298[1]
Weight-for-length	-0.21±0.95	194[2]
Males		
Weight-for-age	0.20±1.11	165
Length-for-age	-0.37±1.05	165
Weight-for-length	-0.04±0.86	119[2]
Females		
Weight-for-age	-0.22±1.18	137
Length-for-age	-0.68±1.36	133
Weight-for-length	-0.47±1.02	75[3]

[1]: Twenty infants (7%) were born low birth weight (weight less than 2500 g).

Anthropometric Characteristics and Z-Scores of Newborns at Birth

Out of the 302 newborns, 54.6% were males, and 45.4% were females, indicating a slightly higher proportion of male births (Table 4). The mean weight at birth for all newborns was 3.2 ± 0.5 kg. Twenty infants (7%) were categorized as low birth weight (LBW). The mean length at birth was 49.1 ± 2.7 cm. Head circumference and chest circumference averaged 33.0 ± 2.1 cm and 32.5 ± 2.1 cm, respectively. The average weight-for-age z-score (WAZ) for the newborns was -0.09 ± 1.15, indicating that the overall population was close to the World Health Organization (WHO) reference median for weight. The average length-for-age z-score (LAZ) was slightly lower at -0.51 ± 1.20, suggesting mild stunting in the cohort. The weight-for-length z-score (WLZ), which assesses acute malnutrition or wasting, was -0.21 ± 0.95, indicating minimal acute malnutrition in the population. Regarding gender-specific Z-Scores for males, the WAZ was 0.20 ± 1.11, reflecting a tendency toward better nutritional status compared to the overall population. The LAZ for males was -0.37 ± 1.05, showing mild stunting, while the WLZ was -0.04 ± 0.86, indicating adequate growth in relation to length. For females, the WAZ was -0.22 ± 1.18, which was slightly lower than the males, indicating a marginally higher prevalence of low weight-for-age. The LAZ was -0.68 ± 1.36, suggesting a more pronounced level of stunting compared to males. The WLZ for females was -0.47 ± 1.02, which, although lower than that of males, remained within acceptable limits for acute malnutrition.

Table 5. Independent sample t-test of maternal categorical variables and new born anthropometric.

Variable	Birth weight			Birth length		
	n	Mean±SD	p-value	N	Mean±SD	p-value
Illness						
Yes	128	3.17±0.51	0.78	128	49.20±2.5	0.06
No	174	3.21±0.50		174	48.95±3.0	
Planned to have baby						
Yes	189	3.23±0.51	0.78	189	49.07±3.0	0.08
No	113	3.14±0.49		113	49.06±2.3	
Marital status						
Yes	229	3.21±0.51	0.43	229	49.11±2.8	0.52
No	72	3.14±0.54		72	48.96±2.7	
Nausea						
Yes	132	3.15±0.54	0.13	132	48.83±2.9	0.06
No	170	3.23±0.48		170	49.25±0.5	
Nutritional advice						
Yes	219	3.18±0.52	0.51	219	48.96±2.9	0.04
No	83	3.22±0.48		83	49.35±2.0	
Advice on weight gain						
Yes	8	3.26±0.50	0.66	8	49.36±2.8	0.64
No	294	3.19±0.51		294	49.06±2.7	
Supplement intake						
Yes	238	3.18±0.51	0.62	238	48.96±2.8	0.29
No	64	3.26±0.47		64	49.47±2.2	
Smoking status						
Yes	7	2.96±0.51	0.74	7	49.43±2.5	0.71
No	295			295		
Alcohol intake						
Yes	74	3.20±0.50	0.78	74	49.45±2.3	0.45
No	228			228		
Pica intake						
Yes	109	3.25±0.46	0.18	109	49.32±2.3	0.07
No	193					

The frequency of smoking, alcohol intake and pica practice did not show any association with birth weight.

Independent Sample t-Test of Maternal Categorical Variables and Newborn Anthropometry

These findings highlight that while certain maternal behaviors and characteristics may influence birth outcomes, the observed differences in this cohort were generally small and not statistically significant. Birth length showed a borderline association with nausea and pica practice and a significant association with nutritional advice (Table 5). Mothers who reported illness during pregnancy gave birth to infants with a mean birth weight of 3.17 ± 0.51 kg, compared to 3.21 ± 0.50

kg for those who did not report illness (Table 5). The difference was not statistically significant (p = 0.78). Similarly, birth length was not different statistically significantly between the two groups, with average lengths of 49.20 ± 2.5 cm and 48.95 ± 3.0 cm for infants born to mothers with and without illness, respectively (p = 0.06). Newborns of mothers who planned their pregnancies had a slightly higher mean birth weight (3.23 ± 0.51 kg) compared to those whose pregnancies were unplanned (3.14 ± 0.49 kg), though this difference was not statistically significant (p = 0.78). Birth length also showed no significant difference between the two groups (p = 0.08). Mothers who were married had infants with an average birth weight of 3.21 ± 0.51 kg, compared to 3.14 ± 0.54 kg for those who were unmarried. However, the observed disparity was not statistically significant (p = 0.43). Birth length was also similar across the groups, with no significant difference (p = 0.52). Infants born to mothers who experienced nausea during pregnancy had a slightly lower mean birth weight (3.15 ± 0.54 kg) than those whose mothers did not experience nausea (3.23 ± 0.48 kg). This difference was not statistically significant (p = 0.13). Receiving nutritional advice during pregnancy did not significantly impact birth weight (p = 0.51), but it was associated with a slight but statistically significant reduction in birth length (p = 0.04). Smoking during pregnancy, reported by only a small proportion of mothers (2.3%), was associated with a slightly reduced mean birth weight (2.96 ± 0.51 kg) compared to non-smokers (p = 0.74). Alcohol consumption during pregnancy did not significantly influence either birth weight (p = 0.78) or birth length (p = 0.45). Mothers who practiced pica during pregnancy had infants with a slightly higher mean birth weight (3.25 ± 0.46 kg) compared to those who did not (3.19 ± 0.51 kg), but the observed disparity was not statistically significant (p = 0.18).

Table 6. Correlation matrix of maternal variable and newborn characteristics.

	MHT	MAG	WT1	WT2	TWG	AA	PAR	EDU	CWT	CLG	H/C
MAG	.07 .20	1									
WT1	.12* .04	.06 .28	1								
WT2	.38* <.01	.17** <.01	.80** <.01	1							
TWG	.07 .25	.00 .97	.34 <.01	.74 <.01	1						
HB	.06 .27	.09 .13	.04 .53	.09 .14	.09 .14						
PAR	.07 .24	.60** <.01	.06 .28	-.08 .14	-.03 .64	-.01 .99	1				
EDU	.04 .49	-.42 .47	.03 .61	.09 .14	.09 .11	.01 .11	-.28 .63	1			
CWT	.00 . 89	.12* .05	.12 .05	.05 .41	.12* 04	.01 .90	.03 .63	.04 .49	1		
CLG	.00 .94	-.02 .75	.09 .14	.10 .08	.14* .02	.09 .11	.09 11	.12* .04	-.02 75	1	

maternal height = MHT; maternal age=MAG; weight measurements at different stages of pregnancy =(WT1 and WT2), total weight gain =TWG; hemoglobin levels = HB; parity =PAR; education level = EDU, current weight=CWT; College education = CLG; maternal weight at different stages of pregnancy= WT1 and WT2.

Correlation Matrix Results

The correlation matrix presented in Table 6 explores the relationships between various maternal and newborn characteristics. The matrix includes variables such as maternal height (MHT), maternal age (MAG), weight measurements at different stages of pregnancy (WT1 and WT2), total weight gain (TWG), education level (EDU), current weight (CWT), and college education (CLG). Maternal age (MAG) shows weak positive correlations with maternal weight at different stages of pregnancy (WT1 and WT2), although none of these relationships reach a statistically significant level (r = 0.12 for WT1, r = 0.38 for WT2). The relationship between MAG and education level (EDU) was weak (r = 0.49, p < 0.01), suggesting that older mothers may have higher educational attainment. WT1 correlates positively with maternal age (MAG) (r = 0.12, p < 0.05) and the weight gain within the second trimester (WT2) (r = 0.28, p < 0.01). It also shows a significant but weak positive correlation with current weight (CWT) (r = 0.12, p < 0.05). WT1 is weakly negatively correlated with education level (EDU) (r = -0.42), indicating that women with lower educational levels may weigh more early in pregnancy. Additionally, it has a weak negative correlation with college education (CLG) (r = -0.02, p > 0.05), suggesting no strong relationship between early pregnancy weight and college education. WT2 exhibits the most significant correlations. It shows a strong positive correlation with total weight gain during pregnancy (TWG) (r = 0.80, p < 0.01), indicating that higher weight gain is strongly associated with weight measured during the second trimester. WT2 is also positively associated with parity (PAR) (r = 0.64, p < 0.01), suggesting that mothers with more children may experience higher weight gain during pregnancy. Total weight gain (TWG) shows weak correlations with maternal characteristics. It is positively correlated with weight at second trimester (WT2) (r = 0.34, p < 0.01), but there is no statistically significant association with other variables such as maternal age or education. Education level (EDU) shows significant correlations with several variables. It is negatively correlated with weight at first trimester (WT1) (r = -0.42), suggesting that higher education might be associated with lower weight in early pregnancy. EDU also positively correlates with maternal age (MAG) (r = 0.49), with more educated women being older on average. College education (CLG) shows several weak correlations with other variables, including maternal age (MAG) (r = 0.11), weight at first trimester (WT1) (r = -0.02), and total weight gain (TWG) (r = 0.09). However, none of these relationships are statistically significant, suggesting no strong association between college education and these factors. The correlation matrix reveals some weak but significant relationships between maternal and newborn variables, most notably between weight at different stages of pregnancy (WT1, WT2), maternal characteristics like age, education, and parity. However, the majority of the correlations are either weak or statistically insignificant.

Table 7. *Association between maternal and infant variables and regression coefficients that predicted birth weight.*

Infant characteristics	Maternal characteristics	(r)p-value	Regression Coefficient (β)	p-value
Weight (kg)	Age (yrs)	(0.118) 0.046*	0.115	0.046
	Weight change between 2nd and 3rd trimester (kg)	(.118) 0.041*	0.111	0.065
	Total weight gain (kg)	(0.116) 0.044*	0.116	0.044
Length (cm)	Total weight gain (kg)	(0.629) 0.001**		
	Number of years spent in school	(0.124) 0.043*		

All estimates adjusted for were parity, antenatal attendance, weight change between 2nd and 3rd trimester, number of years spent in school and sex of child.

Association Between Maternal and Infant Variables and Regression Coefficients Predicting Birth Weight

The analysis revealed a significant positive association between maternal weight and infant birth weight (r = 0.118, p = 0.046), suggesting that higher maternal weight is associated with a slightly higher birth weight in the infant (Table 7). This finding is consistent with the regression coefficient for maternal weight (0.115, p = 0.046), which suggests that maternal weight is a significant predictor of birth weight. The positive coefficient implies that as maternal weight increases, the infant's birth weight also tends to increase. A moderate positive correlation was found between weight change between the second and third trimesters and infant birth weight (r = 0.118, p = 0.041). The regression output also indicates that this weight change is a significant predictor of birth weight, with a regression coefficient of 0.111 (p = 0.065). This suggests that greater weight gain during the later stages of pregnancy may contribute to higher birth weight, although the statistical significance was somewhat lower for the regression coefficient. Total weight gain during pregnancy also demonstrated a significant positive correlation with birth weight (r = 0.116, p = 0.044). The regression output confirms this association with a regression coefficient of 0.116 (p = 0.044), reinforcing the idea that total weight gain during pregnancy plays a significant role in determining birth weight. This finding aligns with previous research indicating that maternal weight gain is a key determinant of infant birth weight. A strong correlation was observed between total weight gain and infant length at birth (r = 0.629, p < 0.001). This suggests that higher maternal weight gain is associated with longer infant length. Additionally, the number of years spent in school by the mother was found to have a significant positive association with infant length (r = 0.124, p = 0.043), suggesting that higher maternal educational attainment is related to longer birth length.

4. Discussion

This original study sought to idetermine the associations between maternal characteristics and infant outcomes, focusing on birth weight, birth length, and other key variables such as weight gain during puparium and maternal education. The results indicate that maternal weight gain, weight change between trimesters, and maternal education are significant predictors of birth weight and length. Gestational weight gain (GWG) was positively associated with birth length (r = 0.629, p < 0.0001) and significantly with birth weight (r = 0.118, p = 0.041), with total GWG emerging as a key predictor of these outcomes. The total pregnancy weight gain of 9.1 ± 4.2 kg falls within the lower end of the recommended range for normal-weight women (11.5–16.0 kg), emphasizing the need for nutritional counseling and close monitoring to optimize maternal and fetal health. These findings align with existing research demonstrating the influence of maternal weight trajectories on neonatal anthropometry (Basu et al., 2019; Siega-Riz et al., 2009). However, the observations regarding GWG were lower than WHO guidelines for adequate pregnancy weight gain (9.1 ± 4.2 kg vs. 11.5–16.0 kg recommended for normal BMI), which may explain why some newborn Z-scores were suboptimal. The progressive increase in maternal weight and BMI throughout pregnancy, consistent with physiological changes during gestation. However, the range of maternal weight gain observed during the second and third trimesters suggests variability in maternal weight management. Some participants experienced negative weight gain, which may reflect underlying health concerns such as inadequate nutrition or complications like hyperemesis gravidarum, while others exceeded the Institute of Medicine's recommended weight gain ranges, potentially increasing the risk of adverse birth outcomes [10]. The overall findings indicate that the newborns' anthropometric measures are generally within acceptable ranges for healthy growth, although mild deviations in length-for-age z-scores suggest a degree of stunting within the cohort. The observed differences between male and female newborns align with established trends, where male infants often show slightly better weight and length parameters at birth [9]. Similar trends have been documented in resource-constrained settings, where inadequate dietary intake and socio-economic factors affect GWG (FAO, 2020). Contrastingly, studies in high-income countries report higher GWG and its stronger correlations with neonatal outcomes, likely due to enhanced prenatal care and better nutrition [11]. These disparities underscore the importance of socio-economic and healthcare factors in maternal and fetal health outcomes. Similar findings were reported by [12], who found that maternal weight gain, especially during the second and third trimesters, is a strong predictor of birth weight. Our study also supports the work of [13], who found that higher maternal weight was positively associated with larger birth weights. These studies, including ours, emphasize the role of maternal nutrition in fetal development and highlight that inadequate maternal weight gain could lead to low birth weight, which is a significant risk factor for neonatal mortality and morbidity. The correlation between maternal education and birth outcomes is another finding that aligns with previous research. [14, 15] indicated that maternal education is positively related to improved prenatal care and better health behaviors, which contribute to better birth outcomes. Our finding that maternal education influences birth length supports these studies, suggesting that more educated mothers are better equipped to access healthcare resources and engage in health-promoting behaviors during pregnancy. Another point of divergence is the lack of significant associations between smoking and alcohol intake with birth weight in our study, contrary to the results of [16, 17]. These studies reported a clear link between maternal smoking and alcohol consumption with lower birth weight. In our study, smoking was relatively uncommon, with only 2.6% of participants reporting smoking during pregnancy, and alcohol intake was reported by 24.5%. This low prevalence likely limited the power to detect significant associations, as the smaller number of cases might not provide enough variability to establish a robust relationship between these factors and birth weight. This study has several strengths that contribute to its reliability and generalizability. The large sample size (n=302) strengthens the power of the statistical analyses, making the findings more robust. The study also considered a broad range of maternal characteristics, such as age, maternal weight gain during pregnancy, and educational level, providing a comprehensive view of the factors that influence birth outcomes. The use of regression analysis, which controlled for confounding factors such as parity, antenatal attendance, and sex of the infant, adds credibility to the findings. Furthermore, the study's setting, in a low-resource context in Ghana, fills a gap in the literature by examining maternal and infant health outcomes in this specific population. Despite its strengths, the study has some limitations. The cross-sectional design limits the ability to infer causality between maternal characteristics and infant outcomes. A longitudinal study design would allow for a better understanding of the causal pathways linking maternal health and fetal development. Additionally, the study relied on self-reported data for some maternal behaviors, such as smoking and alcohol consumption, which could introduce recall bias.

5. Conclusion

Our study highlights the important role of maternal weight gain, maternal education, and pregnancy weight changes in predicting infant birth weight and length. Overall, the study contributes valuable insights into the determinants of infant birth outcomes in Ghana and underscores the importance of improving maternal health and education as part of efforts to reduce neonatal morbidity and mortality. The study is novel in its assessment of trimester-specific GWG and its incorporation into a predictive model for neonatal anthropometry. While previous research focused on total GWG, this study highlights the importance of weight changes in late pregnancy, a critical period for fetal growth.

Abbreviations

ANC	Antenatal Care
BMI	Body Mass Index
FAO	Food and Agriculture Organization
GSS	Ghana Statistical Service
GWG	Gestational Weight Gain
IOM	Institute of Medicine
KBTH	Korle-Bu Teaching Hospital
LBW	Low Birth Weight
LMIC	Low- and Middle-Income Countries
SPSS	Statistical Package for the Social Sciences
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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Conflicts of Interest

All the Authors of this manuscript declare no conflict of interest.

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