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Original article

Impact of Birth Weight and Vitamin D Levels on Anthropometric Measurements of Infants in Benghazi, Libya: A Cross-Sectional Study

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Abstract
Birth weight significantly influences infant health, affecting vulnerability to illnesses and survival chances. Infants weighing <2.5 kg are at a higher lifelong risk of health problems. Vitamin D, a vital nutrient, plays an essential role in infant growth and development. This study aimed to examine the effect of birth weight and vitamin D status on anthropometric measurements of infants under one year. A cross-sectional study was conducted from November 2023 to June 2024 on 434 healthy infants born in public and private hospitals in Benghazi. Data collection occurred between December 2023 and March 2024 using a structured questionnaire covering socioeconomic data, anthropometrics, knowledge-attitude-practice (KAP), and infant behavior. The sample included 50.7% females and 49.3% males. Mean birth weight was 2935.83 ± 725.60 g. Normal birth weight (2500–<4000 g) was observed in 55.3% of infants born to mothers aged 18–35 years and 46.5% delivered via Caesarean section. Present weight correlated significantly with length ($r=0.762$, $p<0.001$), head circumference ($r=0.720$, $p<0.001$), and chest circumference ($r=0.608$, $p<0.001$). Vitamin D level showed strong associations with crawling onset, teething ($p<0.001$), and sleep quality ($p=0.008$), as well as infant age, maternal education, and family income. Gender correlated with vitamin D, birth weight, and wasting ($p<0.05$). Birth weight was strongly associated with BMI ($r=0.824$), wasting ($r=0.850$), and stunting ($r=-0.766$) (all $p<0.001$). Birth weight and vitamin D status significantly influence infant growth indicators and developmental milestones, highlighting their critical role in early health outcomes.
Keywords: Birth Weight**,** Vitamin D, Anthropometric Measurements, Infants.

Introduction

Birth weight is a key determinant of an infant's health, growth, and survival. Newborns under 2.5 kg face about 20 times higher mortality risk, with increased chances of undernutrition, impaired immunity, reduced muscle strength, and later diabetes or heart disease. Vitamin D is essential for bone mineralization, muscle function, and overall development. Anthropometric measurements—height, weight, and body composition—reflect an infant's growth and nutritional status. This study aimed to investigate how birth weight and vitamin D levels affect these measurements and their associations with other influencing factors in children under one year, highlighting vitamin D's crucial role in optimal infant growth and development [1].

Small for gestational age (SGA) describes newborns with birth weights below the 10th percentile for gestational age and sex, categorized as symmetrical or asymmetrical. Genetic factors may influence postnatal development. Research suggests SGA infants often show rapid "catch-up" growth in the first year, increasing later obesity risk, particularly with early accelerated weight gain, while breastfeeding offers protection [2]. Vitamin D may affect infant growth and body composition, but evidence from interventional studies remains limited. A 2016 Italian study found maternal supplementation raised cord blood 25(OH)D, and a 2018 study linked maternal vitamin D status with neonatal growth. Maternal 25(OH)D levels fluctuate during pregnancy, affecting the interpretation of associations with growth. Only one study measured 25(OH)D twice (before 16 weeks and at 24–28 weeks), showing an inverse association with newborn knee–heel length [3]. Lack of longitudinal data limits understanding of how maternal vitamin D influences fetal growth during critical periods.

Five of eight studies reported a negative association between maternal vitamin D deficiency (VDD) and neonatal problems, while four of seven linked VDD to low birth weight (LBW), and two of three associated it with small-for-gestational-age (SGA) infants. One study related VDD to suppressed growth post-delivery [4], and one of five linked it to preterm birth. No significant associations were found with Apgar scores, NICU admission, mortality, or head circumference. A 2023 study in *JCEM* reported that higher maternal 25(OH)D levels correlated with increased birth weight. VDD may impair placentation and skeletal growth, increasing fetal growth restriction risk [4].

A 2007 study reported that maternal vitamin D insufficiency, prevalent among black and white women, was linked to adverse outcomes like low birth weight (LBW) and SGA infants, particularly in black women [5]. A 2011 study associated early pregnancy deficiency with reduced birth weight and severe preeclampsia, while a 2013 study confirmed increased LBW risk with low vitamin D [6]. LBW is a major stunting risk; Kisumu et al. (2018) noted higher developmental delays [7], and Danaë et al. (2016) estimated that reducing LBW could prevent 20% of global stunting [8]. Vitamin D deficiency also raises risks of developmental delays and wasting [9].

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Methodology

Study Design and Participants

A cross-sectional study was conducted from November 2023 to June 2024 on infants born in public and private hospitals in Benghazi, Libya. Data collection occurred between December 2023 and March 2024. Participation was voluntary, with occasional withdrawals due to time constraints. A total of 434 randomly selected infants (214 males, 220 females) were included. The study assessed birth weight, current weight, height, head and chest circumferences, stunting, wasting, BMI, and vitamin D levels in one-year-old infants. Participants were informed about data privacy, confidentiality, and the study's significance in preventing malnutrition and promoting child health.

Benghazi Epidemiology Infant 2023-2024According to the World Bank, the birth rate for Libya in 2023 was 16.718 births per 1000 people, a 2.66% decline from 2022. In Benghazi during 2023, according to civil registration, the total live births were 20092. The number of normal births reached 14,593, cesarean sections reached 5,499 [10].

Inclusion and Exclusion Criteria

Inclusion criteria comprised healthy infants aged 0–12 months born in 2023–2024, from clinics, hospitals, and community facilities in Benghazi, with parental consent. Exclusion criteria included chronic diseases, disabilities affecting measurements, refusal to remove heavy clothing, or wet diapers preventing accurate anthropometric assessment.

Sampling Size Calculation

The researchers use Steven k. Thompson [11] equations to calculate the sample size. The result of the sample size equation was n = 377, which means that our sample of 434 was representative.

The Questionnaire

In this study, the questionnaire included four basic sections, the first section covered socioeconomic information such as age, gender, arrangement of the infant among the siblings, parent's educational level, income level, number of children The second section covered the anthropometric measurements, the anthropometric measurements recorded and taken in this were: (Birth weight, Present height, Present weight, Head circumference (HC), and Chest circumference (CC).

Figure 1: Demonstrates the Process for Anthropometric Measuring of Infants

The third section covered the KAP information, which includes the knowledge, attitude, and practice of the mother.

Laboratory Investigation: Results of vitamin D levels were obtained within three months.

Data Calculations Manually

Growth Charts: Anthropometric measurements must be compared to WHO growth charts, assessing weight-for-length, length-for-age, wasting, stunting, and BMI.

Statistical Analysis

The data was entered into a Microsoft Excel sheet and analyzed using SPSS version 23 software. Data were analyzed to measure the normal distribution using the Kolmogorov-Smirnov test. The data will be represented as descriptive statistics such as frequency, percentages, mean, and standard deviation. The

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correlation coefficient (r) for individual anthropometric measurements concerning birth weight, present weight, and other factors was calculated. Statistical significance was assessed at a 95% confidence level ($p < 0.05$).

Ethical Considerations
The research is conducted in compliance with ethical principles and regulations. Before data collection, approval from the Institutional Review Board (IRB) is secured. To guarantee the confidentiality and anonymity of participants, everyone is given a unique identification code. All data is kept secure and can only be accessed by authorized personnel.

Results
This cross-sectional study included 434 healthy infants born in Benghazi, Libya (2023), with nearly equal gender distribution (50.7% female, 49.3% male).

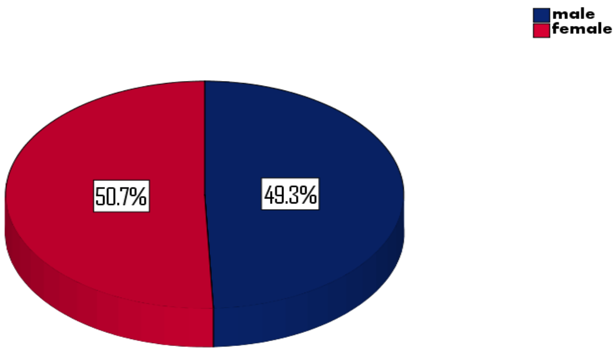

Figure 2: Gender Distribution for the Sample (N=434)

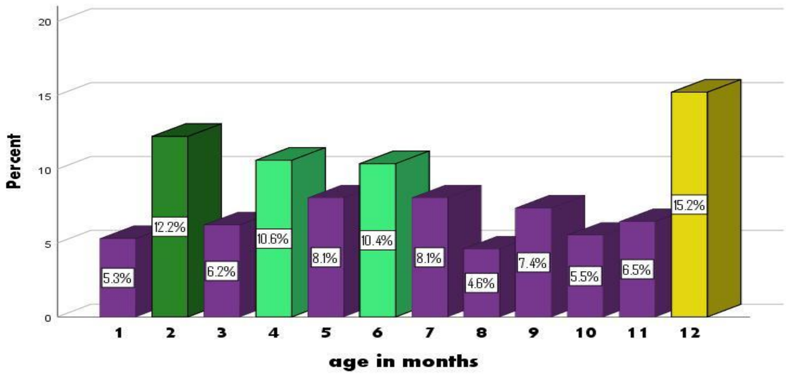

Figure 3: Age Distribution for the Sample (N=434)

Figure 3 shows that most infants were 12 months (15.2%), followed by 2, 3, and 6 months, likely due to vaccination visits.

Table 1: The Demographic Data of the Sample (N=434)

Variables	Frequency	Percent
Gender		
Male	214	49.3
Female	220	50.7
Total	434	100.0
Type of Birth		
Normal	180	41.5
caesarean	254	58.5
Total	434	100.0
Mothers' age in years		
≥18-35	324	74.7

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36-45	110	25.3
Total	434	100.0
Family income		
≤ 580	4	.9
> 589-2300	344	79.3
> 2300-10.200	86	19.8
Total	434	100.0
Number of children		
1-3	282	65.0
4-6	139	32.0
>7	13	3.0
Total	434	100.0

Table 1 shows maternal ages ranged ≥18–45 years, with 74.7% between 18–35. Cesarean deliveries were 58.5%. Most families (79.3%) earned 589–2300 DL. Family size: 65% had 1–3 children, 32% had 4–6, and 3% had ≥7 children.

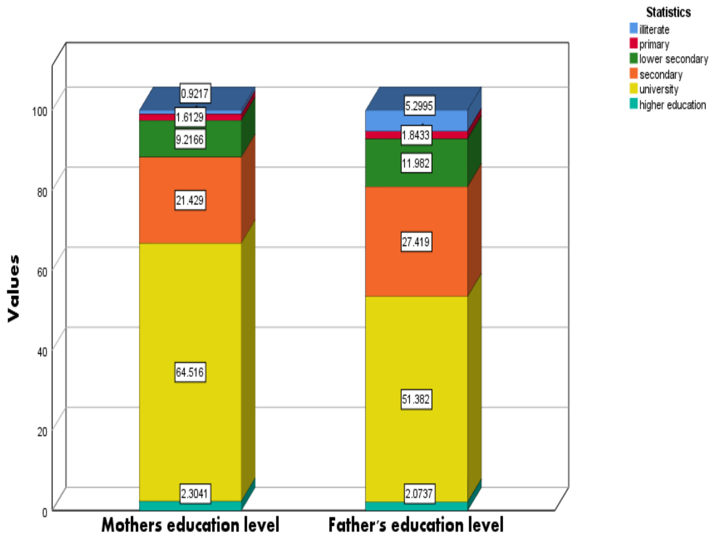

Figure 4: Educational Levels of Parents for the Sample (N=434)

Figure 4 shows parents' education levels: most mothers (64.5%) and fathers (51.4%) had university education, followed by secondary level (mothers 21.4%, fathers 27.4%). Higher education was 2.3% for mothers and 2% for fathers, while the lowest percentage of mothers was illiterate (0.9%).

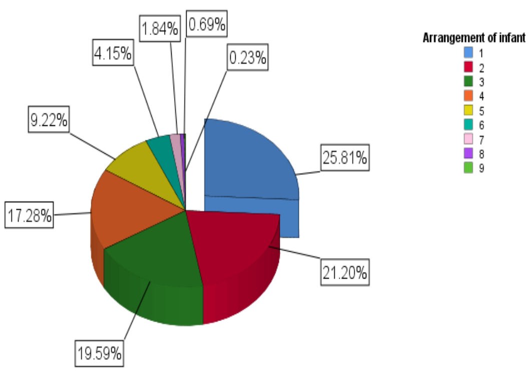

Figure 5: Distribution of infants according to their rank among their siblings

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(Figure 5) displays the ranking of the infants who participated in this study among their siblings, where 25.8% of the infants were classified as the first child, 21.2% as the second child, followed by 19.6% for the third-ranked child, then 17.3% for the fourth-ranked child. The lowest percentage was for children whose rank is in the ninth family (0.7%).

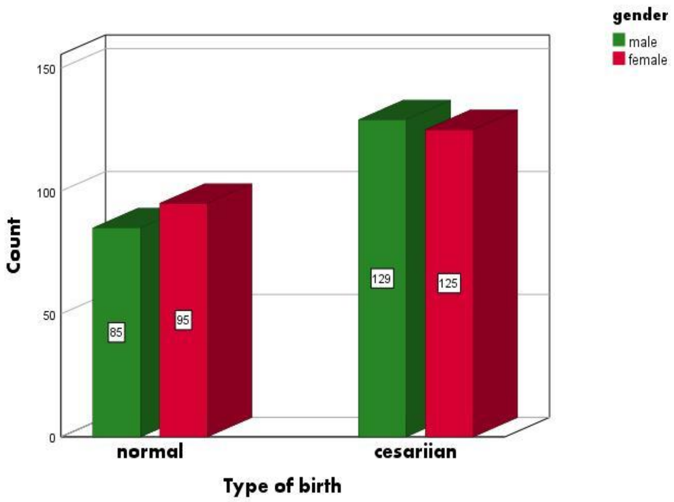

Figure 6: Determining the Type of Birth by Gender

As shown in (Figure 6), cesarean delivery represents the highest percentage for both genders, according to cluster Bar count of type of birth by gender: Normal birth 85 male, 95 female, and cesarean birth 129 male, 125 female.

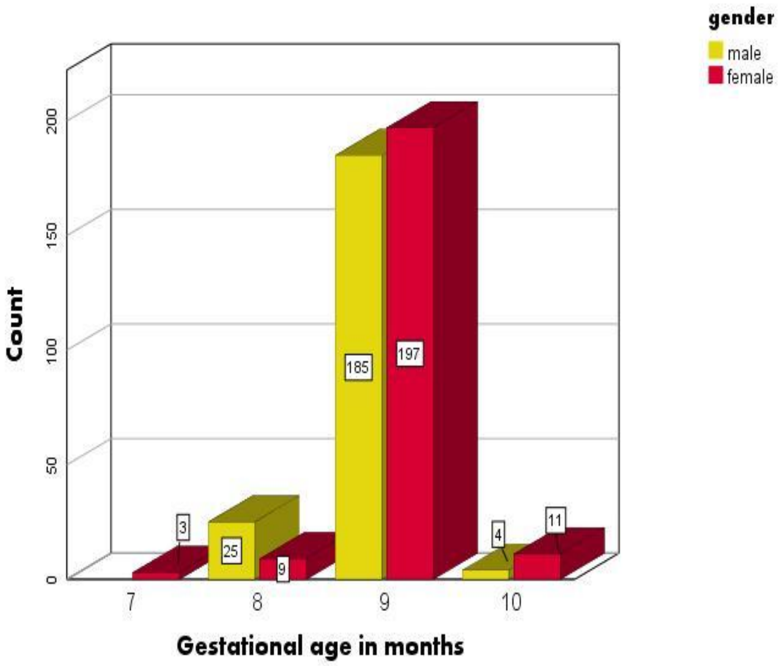

Figure 7: Distribution of the Infant's Gestational Ages by Gender

Most births occurred in the ninth month, with more girls (197) than boys (185). Premature and post-term births were fewer, with males predominating in the eighth month and females in the tenth month, as shown in (Figure 7).

Table 2: Descriptive Statistics of Birth Weight and Other Anthropometric Measurements

Anthropometric Measurements	Mean ± S.D	Minimum	Maximum
Birth weight	2935.83±725.597	800	5500
Present weight	7.17±2.033	2	14
Present length	63.780±8.4168	39	83

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Head circumference	42.120±3.4216	17	49
Chest circumference	42.821±4.0295	30	56
Stunning	96.016±9.1367	53	171
Wasting	107.578±28.0972	44	266
Body Mass Index	17.5070±3.97206	6.38	36.98
Chest Head Ratio	1.0197±.10283	.76	2.53

(Table 2) shows anthropometric measurements: birth weight (800–5500 g), present weight (2–140), length (39–83), head (17–49), chest (30–56), stunting (53–171), wasting (44–266), BMI (6.38–36.98), and chest-to-head ratio (0.76–2.53).

Table 3: Distribution of Birth Weight Neonate According to Gestational Age.

	Weight	Preterm 28 wk.		Preterm 32 wk.		Full-term 38 wk.		Full-term 40 wk.		Total
		No.	%	No.	%	No.	%	No.	%	
Birth weight	<1000	0	0.0	0	0.0	1	100.0	0	0.0	1
	<1500	0	0.0	1	20.0	3	60.0	1	20.0	5
	<2500	1	1.2	7	82.3	71	83.5%	6	70.5	85
	2500 - <4000	2	0.6	25	7.5	294	89.3	8	2.4	329
	>4000	0	0.0	1	7.2	13	92.8	0	0.0	14
Total		37				397				434

According to the findings of the study mentioned in (Table 3), the researchers found that the highest rates of obesity (>4000) in birth weight were 92.8%, and the highest rates of excess birth weight (>4000) were at full term 38 weeks.

Table 4: Representation of Birth Weight According to Gender, Mother Age, Gestational Age, and Type of Delivery.

	Birth weight (kg)				
	<1000	<1500	<2500	2500 -<4000	>4000
Gender					
Male	0	5	44	163	2
Female	1	0	41	166	12
Total	1	5	85	329	14
Mothers age					
18-35	0	4	71	240	9
36-45	1	1	14	89	5
Gestational age					
7 months	0	0	1	2	0
8 months	0	1	7	25	1
9 months	1	3	71	294	13
10 months	0	1	6	8	0
Type of delivery					
Normal delivery	1	3	43	127	6
Caesarean delivery	0	2	42	202	8

Table 4 shows that 166 females and 163 males had normal birth weight. Most mothers were aged 18–35, 294 infants were full-term (9 months), and Caesarean section was the most common delivery type (202 births).

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Table 5: Distribution of Present Weight Infants According to Gender

Present weight	Weight	Male		Female	
		No.	%	No.	%
	Sever	30	56.6	23	43.4
	Moderate	10	55.6	8	44.4
	Mild	18	43.9	23	56.1
	Normal	107	51.0	103	49.0
	Overweight	49	43.8	63	56.3

(Table 5) shows male infants had higher percentages in severe underweight (56.6%) and normal weight (51%), while female infants had higher percentages in overweight (56.3%) and mild weight (56.1%), compared to males.

Table 6: Distribution of Gestational Age According to Type of Birth

Gestational age	Type of birth			
	Normal		Caesarean	
	No.	%	No.	%
	7	0	3	0.0
	8	85.3	29	14.7
	9	55.8	213	44.2
	10	60.0	9	40.0

According to (Table 6), the gestational age distribution of the sample for normal delivery was 9 months (44.2%), and the rest for 7,8, and 10 months respectively (85.3%, 55.8%, 60%). The gestational age distribution of the sample for Caesarean delivery was 7 months (0.0%), and the rest for 8,9, and 10 months respectively (0, 14.7%, 40%).

Table 7: Distribution of Gestational Age According to Gender

Gestational age	*No. of weeks*	*Birth weight according to the gender*			
		Male		Female	
		N %	mean±S.D	N %	mean±S.D
	Preterm 28 wk.	0.0%	0.0	100.0%	3333±577
	Preterm 32 wk.	73.5%	2628±808	26.5%	3394±848
	Full-term 38 wk.	48.4%	2929±657	51.6%	2963±756
	Full-term 40 wk.	26.7%	2625±750	73.3%	2891±864

(Table 7) shows gestational age by gender: males were mostly preterm 32 wk (73.5%) and full-term 38 wk (48.4%), while females were mainly preterm 28 wk (100%) and full-term 40 wk (73.3%).

Table 8: Mothers' Attitude, Practice, And Knowledge Regarding Vitamin D Administration to their Infants.

Variables	Frequency	Percent
At what age should a vitamin D supplement be given to the child?		
not consumed	52	12.0
Since birth - 4 months	367	84.6
>4 month-8 month	11	2.5
>8 months	4	.9
Total	434	100.0

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Which of the following statements applied to a child regarding taking a vitamin D supplement		
not consumed	52	12.0
daily	347	79.9
3-4 times/week	27	6.2
1-4 times/monthly	9	2.1
5	1	.2
Total	434	100.0
What is the dose of the vitamin D supplement used		
not consumed	52	12.0
200	52	11.9
400	299	68.9
others	33	7.6
Total	434	100.0
How many drops do you give the child		
not consumed	52	12.0
1	277	63.8
2	41	9.4
3	14	3.2
4	53	12.2
Total	434	100.0
Do you give vitamin D with fatty food		
Not consumed	52	8.1
yes	90	20.7
no	184	42.3
others	78	18.0
not always	30	6.9
Duration of use of vitamin D supplement in months		
Not consumed	52	8.1
<1	29	6.7
1-3	80	18.4
4-6	96	22.1
7-9	66	15.2
>9-10	111	25.6
prescribing a vitamin D supplement for children		
Not consumed	52	8.1
doctor	354	81.5
dietitian	7	1.6
friends	4	.9
mother	15	3.5
family	2	.5
Total	434	100.0

(Table 8) shows that 84.6% of infants began vitamin D supplementation from birth to 4 months; 97.9% took it daily, mostly 400 IU (68.9%) as one drop (63.8%). Most (42.3%) consumed it without food, 22.1% continued for 4–6 months, and 81.5% followed doctors' prescriptions.

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Table 9: The Health Status of Mothers During Pregnancy and their Intake of Vitamin D

Variables	Frequency	Percent
During the Mother's Pregnancy with The Child, was She Exposed to the Sun Directly		
Yes	121	27.9
No	313	72.1
Total	434	100.0
During the Mother's Pregnancy With the Child, Did the Mother Suffer from Vitamin D Deficiency		
Yes	310	71.4
No	124	28.6
Total	434	100.0
During the Mother's Pregnancy with The Child, Did the Mother Take a Vitamin D Supplement		
Yes	406	93.5
No	28	6.5
Total	434	100.0
Chronic Diseases in The Mother During Pregnancy		
Non	389	89.6
Diabetes	27	6.2
Hypertension	15	3.5
Thyroid diseases	3	.7
Total	434	100.0

Table 9 shows that 72.1% of mothers had no sun exposure, and 71.4% were vitamin D deficient during pregnancy. Among them, 93.5% took supplements, while 6.5% did not. Most (89.6%) reported no health issues; diabetes (6.2%), hypertension (3.5%), and gland disease (0.7%) were the most common conditions.

Table 10: Motor Development in Infants and Behavioral Outcomes

Variables	**Frequency**	**Percent**
At What Age did your Child Start Crawling		
Don't crawl	245	56.5
5-7	147	33.9
8-10	42	9.7
Total	434	100.0
At What Age did your Child Sit		
Hasn't sat down yet	185	42.6
4-6	212	48.8
7-9	34	7.8
10-12	3	.7
Total	434	100.0
At What Age do Teeth begin to Appear		
not appeared yet	272	62.7
4-6	75	17.3
7-9	69	15.9
10-12	18	4.1
Total	434	100.0
Has the Baby Started to Walk		
Yes	37	8.5
No	397	91.5
Total	434	100.0

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Behaviours Outcomes		
Crying a lot	108	24.9
Moving a lot	48	11.1
Nervous	85	19.6
Sleep peacefully	149	34.3
Others	44	10.1
Total	434	100.0

(Table 10) shows 56.5% of infants had not crawled; 39.5% started at 5–7 months. Sitting began mostly at 4–6 months (48.8%), while 42.6% had not sat. Teeth appeared mainly after 6 months; 62.7% had none. Most (91.5%) had not walked. Behaviors included peaceful sleep (34.3%), crying (24.9%), and nervousness (34.3%).

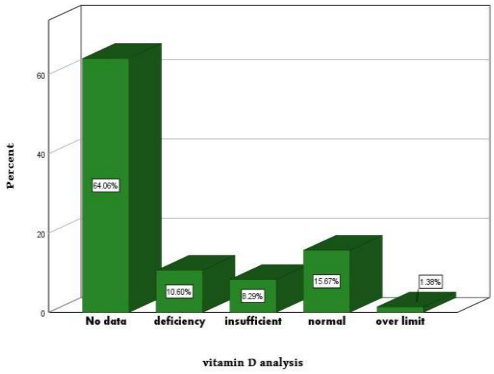

Figure 8. Vitamin D Analysis for the Sample (N=434)

According to the finding that is explained in the (Figure 8) for vitamin D, for both genders (64.06 %), no data is available. 15.67% of the sample had normal vitamin D analysis, while 10.6% and 8.29% complained of deficiency and insufficient, respectively. 1.38% of the sample had a vitamin D level.

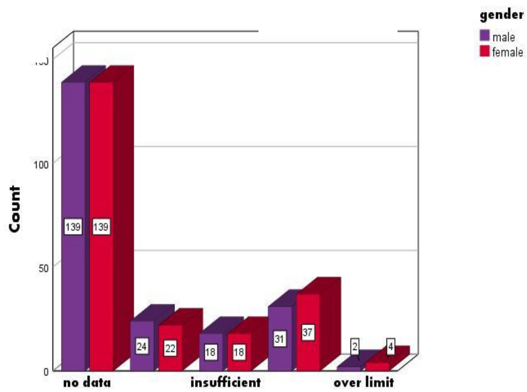

Figure 9: Vitamin D Analysis According to Gender

As per the analysis of vitamin D levels based on gender refer to (Figure 9), both males and females had the same number of cases with no data (139) and insufficient levels (18). However, the deficiency range was higher in males (24 females (22). Conversely, the normal range was higher in females (37) than in males (31), with only 6 cases exceeding the limit (2 in males and 4 in females).

Table 11: The Impact of Birth Weight on Anthropometric Measurements (N 434)

N=434	Neonatal Birth Weight	
	Correlation Coefficient	Sig. (2-tailed)
Present weight	0.77	.000*
Present height	-.598	.000*
Head circumference	-.159	.001*
Chest circumference	.021	.658

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Stunting	-.766	.000*
Wasting	.850	.000*
BMI	.824	.000*

**Sig; (p values <.005)*

Table 11 shows strong correlations between birth weight and present weight (r=0.77), BMI (r=0.824), and wasting (r=0.850) (all p<0.001). Significant negative correlations exist with height (r=-0.598), head circumference (r=-0.159), and stunting (r=-0.766) (p<0.001). No significant association was found with chest circumference (p=0.658).

Table 13: Relation of Birth Weight to Maternal History and Demographics Variables

N=434	Neonatal Birth Weight	
	Correlation Coefficient	Sig. (2-tailed)
Mother's age	-.116*	0.015*
Mother's education	.021	0.657
Gestational age	.001	0.989
Type of birth	.065	0.179
Chronic disease	-.011	0.816
Number of children	-.065	0.176
Arrange the infant in the family	-.065	0.174
During pregnancy, the mother suffers from vitamin D deficiency	.101	0.035*
During pregnancy, the mother is exposed to direct sunlight	.000	0.093
During pregnancy, the mother takes a vitamin D supplement regularly	.047	0.327

**Sig (p< 0.05).*

Table 13 shows a significant correlation between birth weight and mother's age (r=-0.116, p=0.015) and maternal vitamin D status (r=0.101, p=0.035). No associations were found with education, gestational age, type of birth, chronic diseases, number of children, infant order, sun exposure, or supplement use (p>0.05).

Table 14: Relationship between Vitamin D level and some Motor Development in Infants and Behavioral Outcome

N=434	Vitamin D level	
	Correlation Coefficient*	Sig. (2-tailed)
Starts of crawling	0.225	0.000*
Starts walking	0.074	0.125
Starts in sitting	0.145	0.24
Teeth begin to appear	0.218	0.000*
Nervous behavior	0.194	0.599
Sleeping well	0.211	0.008*

**Eta Sig (p< 0.05).*

(Table 14) shows significant relationships between vitamin D levels and motor development: crawling onset (r=0.225, p=0.000), teething (r=0.218, p=0.000), and sleeping well (r=0.211, p=0.008), indicating vitamin D plays a role in infant developmental milestones.

Table 15: The Relationship of Vitamin D to the Factors That May Be the Reason for the Family's Lack of Interest in Analyzing Vitamin D.

N=434	Vitamin D level	
	Correlation coefficient	Sig. (2-tailed)
Infant age	.212	0.000**

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Gender	.041	0.397
Family income	-.061	0.037**
Mothers' education	.146	0.002*
Fathers' education	.019	0.695
Number of children	.038	0.427
Arrange between children	.014	0.393

*Spearman's rho
**Pearson

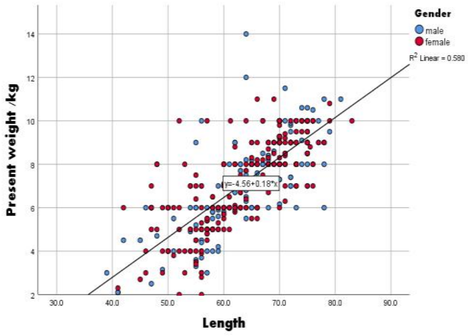
Table 15 shows significant relationships between lack of vitamin D analysis and infant age (r=0.212, p=0.000), family income (r=-0.061, p=0.037), and mothers' education, indicating socioeconomic and age-related influences.

Table 16: The Relationship of Gender with Anthropometric Measurements and Vitamin D Level.

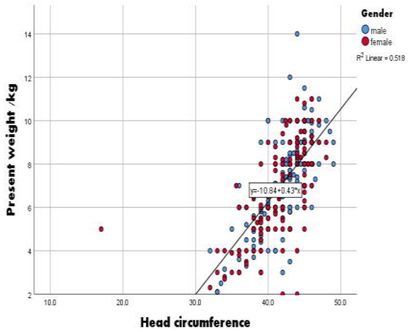
N=434	Gender	
	Correlation coefficient	p-value
Vitamin D level	.083	0.000*
Birth weight	.039	0.010*
Present weight	.034	0.481
Length	-.013	0.795
Head circumference	-.004	0.928
Chest circumference	.032	0.505
BMI	.036	0.259
Stunting	.106	0.454
Wasting	.054	0.027*

*Sig; (p values <.005)

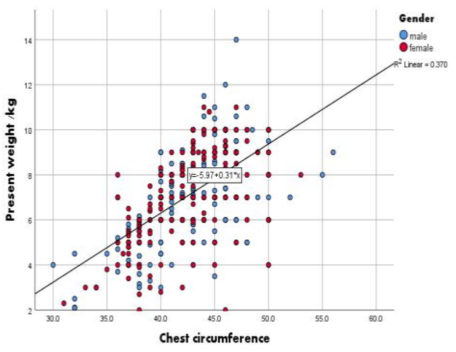
(Table 16) shows significant relationships between gender and vitamin D levels (r=0.083, p=0.000), birth weight (r=0.039, p=0.010), and wasting (r=0.054, p=0.027), indicating gender influences these measures.



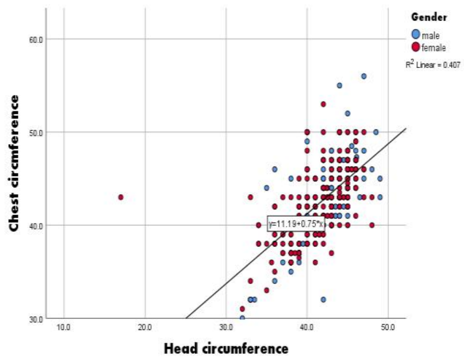
A



B



C



D

Chart 1: Scatter Plots Between Present Weight and Birth Weight and Other Anthropometric Measurements

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Chart 1 scatter plots show significant positive correlations: present weight with length (r=0.762, R^2=0.580), weight with head circumference (r=0.720, R^2=0.581), weight with chest circumference (r=0.608, R^2=0.370), and head with chest circumference (r=0.638, R^2=0.407), all p=0.000.

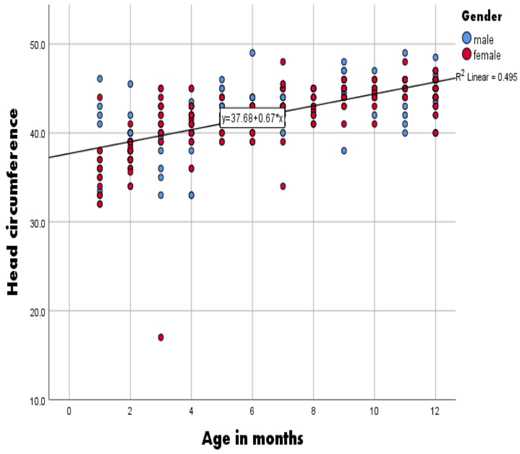

Chart 2: Scatter Plots Between Age and Head Circumference

The scatter plots presented in (chart 2) examined the relationship between the age of infants in months and the head circumference, depicting a highly positive correlation coefficient of .704 (R2 =0.495) with a p-value (0.000).

Discussion

This study provides comprehensive information regarding birth weight and vitamin D levels and their effect on anthropometric measurements in infants, and their relationship to various demographic factors such as age, gender, socio-economic status, and educational level, which was counted in Benghazi without any cultural discrimination (50.7% females and 49.3% males). The demographic analysis revealed that more than half of the participants (15.2%) were one year old, then two months old (12.2%), then four and six months in similar percentages (10.6%-10.4%) respectively, which are the ages designated for vaccination for one-year-old infants.

Although most infants in this study (n=329) had normal birth weight (2500–<4000 g), this is likely influenced by the high educational level of mothers, who were more aware of proper nutrition. However, some participants presented with low or excess birth weight, which may be related to gestational age, as more than half of the normal birth weight infants were born full-term (38 weeks). Excess birth weight (>4000 g) occurred more frequently in females (85.7%) than males (14.3%). Additionally, birth weight correlated with maternal age, as 55.3% of infants with normal birth weight were born to mothers aged 18–35 years. Regarding delivery type, infants born by cesarean section had a higher proportion achieving normal birth weight (46.5%) compared to vaginal delivery (29.3%). Present weight for both males and females were mostly within normal ranges, with 107 males and 103 females classified as normal.

Vitamin D status was predominantly within normal levels (≥20 ng/mL), though 65.06% of participants had not undergone testing, highlighting the need for parental education on vitamin D. Significant associations were found between vitamin D levels and infant motor development, including crawling onset (p=0.000), teething (p=0.000), and sleep quality (p=0.008). Vitamin D levels were also related to infant age (p=0.000), family income (p=0.037), and maternal education (p=0.002). Gender influenced anthropometric measurements and vitamin D, with significant correlations between vitamin D and gender (p=0.000), birth weight and gender (p=0.010), and wasting and gender (p=0.027). Weak or negligible correlations existed between gender and other anthropometrics, including present weight (p=0.481), length (p=0.795), head circumference (p=0.928), chest circumference (p=0.505), BMI (p=0.259), and stunting (p=0.454), reflecting minimal gender differences at one year, especially during the first six months of life.

Maternal age ranged from ≥18 to 45 years, with 74.7% aged 18–35. Cesarean delivery occurred in 58.5% of mothers (n=254), exceeding the WHO-recommended ideal range of 5–15% [65,66]. Comparable studies in Iraq (2012) reported 24.2% cesarean rates [10], while a Saudi Arabian study (2021–2022) found 243 cesareans among 500 deliveries, predominantly among women aged 25–35, though not statistically significant (p=0.07) [11]. S. Subedi's study also supports these findings [12]. Most families (79.3%) had monthly incomes between 589–2300 DL, and the highest educational attainment was 64.5% for mothers and 51.4% for fathers, contributing to normal infant vitamin D status [12]. Higher maternal income has been linked to increased 25(OH)D concentrations in infants [13]. Full-term births were more common among females (197 vs. 185 males), consistent with studies showing preterm infants (<32 weeks) are at greater risk of low 25(OH)D levels, with ORs ranging from 2.2–2.4 [14-15].

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Vitamin D supplementation was provided daily to 347 of 434 infants, with 400 IU as the most common dose. This aligns with international guidelines recommending 400 IU/day for bone health in preterm and full-term infants, as higher doses offer no additional benefit [16-17]. Maternal sun exposure was limited (27.9%), but 93.5% of pregnant women took vitamin D supplements. A study in Tehran (2017) found supplementation (4000 IU/day) more effective than daily sun exposure for correcting deficiency [18-19].
Regarding developmental milestones, 272 infants had not yet developed teeth, likely due to age (<6 months) or vitamin D deficiency, while 245 had not begun crawling, consistent with typical age ranges. Birth weight correlated with maternal age (p=0.015), but not with maternal education (p=0.657), corroborating Gorakhpur study findings, which identified maternal age, inter-pregnancy interval, and education as significant determinants of low birth weight [20]. Norwegian research similarly reported no association with maternal education (p=0.05) [21].
The mean birth weight in this study was 2935.83±725.597 g, with most infants within the normal range but some exhibiting low or excess birth weight. Excess weight occurred more frequently in females, likely due to gestational age differences. Vaginal delivery percentages were higher among females, while 55.3% of normal-weight infants were born to mothers aged 18–35. These results align with a Jordanian study reporting higher low birth weight among mothers <20 years and increased macrosomia risk among mothers ≥35 years [22]. A UAE study similarly reported higher macrosomia risk among older mothers and lower mean birth weight among younger mothers [23]. Cesarean delivery was associated with higher birth weights, consistent with findings from Saudi Arabia and the UAE [24].
Vitamin D status by gender indicated 37 females and 31 males with normal levels. Saudi Arabian research found male infants more likely to be deficient (92% vs. 84% in females) [25], supported by UAE data showing 90% of males deficient vs. 81% of females [26]. Present weight distribution was predominantly normal for both genders (107 males, 103 females), consistent with Aydin and Banu Cuckmere [27]. Gender significantly influenced vitamin D levels (p=0.000) and birth weight (p=0.010), while weak correlations existed for present weight (p=0.481), chest circumference (p=0.505), and stunting (p=0.454), consistent with previous literature [28].
Strong correlations were observed between birth weight and present weight (r=0.77, p=0.000), height (r=-0.598, p=0.000), head circumference (r=-0.159, p=0.001), stunting (r=-0.766, p=0.000), wasting (r=0.850, p=0.000), and BMI (r=0.824, p=0.000). These findings align with studies from Saudi Arabia and the UAE, showing both low and high birth weight influence growth trajectories and BMI in infancy [29-30]. Mahmoud and Hamdi (2020) reported that low birth weight increased stunting (OR=3.2) and wasting (OR=2.8) risk during the first year [31].
Vitamin D showed no significant correlations with anthropometric measures, including present weight (r=0.061, p=0.447), height (r=-0.055, p=0.492), BMI (r=0.197, p=0.13), head circumference (r=-0.083, p=0.301), chest circumference (r=0.51, p=0.531), stunting, or wasting (r=0.05–0.61, p=0.4–0.95).[31-32] These findings are consistent with previous studies reporting limited influence of maternal or infant vitamin D on anthropometry at birth or early infancy [33-34]. Differences from longitudinal studies showing vitamin D effects on BMI or stunting may reflect that the current cohort included healthy infants with predominantly normal birth weight and BMI [35-36].
Scatter plots confirmed strong correlations between present weight and length (r=0.762, R^2=0.580, p=0.000), weight and head circumference (r=0.720, R^2=0.581, p=0.000), weight and chest circumference (r=0.608, R^2=0.370, p=0.000), and head and chest circumference (r=0.638, R^2=0.407, p=0.000), consistent with studies from Sudan and Oman [37-38].
In conclusion, the study demonstrated a clear relationship between birth weight and most anthropometric measurements, except chest circumference. Vitamin D had no significant effect on anthropometric outcomes but was strongly associated with infant motor development and behaviors, including crawling onset, teething, and sleep quality. These findings emphasize the importance of longitudinal studies to clarify vitamin D's long-term impact on growth and health.

Conclusion

The study of 434 healthy infants in Benghazi revealed that most had normal birth weight (mean 2935.83±725.597 g), normal vitamin D levels, and were full-term (67.74%). Vitamin D supplementation began early (84.6%), mainly per doctors' orders (81.5%). Parents were highly educated, and most families had an average income. Strong relationships were observed between vitamin D and motor development, including crawling (p=0.000), teething (p=0.000), and sleep (p=0.008), as well as with infant age, family income, and maternal education. Birth weight strongly correlated with present weight, stunting, wasting, and BMI, but vitamin D showed no correlation with anthropometric measurements.

Conflict of interest. Nil

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