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ORIGINAL ARTICLE

DIETARY BEHAVIOR OF PREGNANT WOMEN IN THE PROVINCE OF EL JADIDA AND IMPACT OF LOW BIRTH WEIGHT ON THE ANTHROPOMETRIC STATUS OF NEWBORNS. CASE-CONTROL STUDY

Houda Elfane[1], Khadija Sahel[1], Sanaa El-Jamal[1], Imane Barakat[1], Halima Daif[1], Mohammed El-Ayachi[1], Rekia Belahsen[1,]*

[1]Laboratory of Biotechnology, Biochemistry and Nutrition, Training and Research Unit on Nutrition and Food Sciences, Department of Biology, Faculty of Sciences, Chouaib Doukkali University, El Jadida 24 000, Morocco
[2]Upper Normal School, Hassan II University, Casablanca, Morocco

ABSTRACT

Background. Low birth weight (LBW) is a major health problem responsible for neonatal mortality and morbidity such as diabetes, obesity and cardiovascular disease in adulthood.
Objective. This case-control study aims to compare data on the intake of energy, macro and micronutrient in two groups of pregnant women, who gave birth to low birth weight (LBW) babies named cases and those who gave birth to babies of normal weight (NW) called controls.
Material and methods. The collection of information was done using an established questionnaire for 400 pregnant women, allowing the collection of data on socio-demographic and obstetrical factors. Nutritional intake was obtained by recording food consumption using the 24-hour recall method. Anthropometric measurements of parturient and fundal height (FH) were measured before delivery.
Results. The mean FH of the cases was 25.69±0.13 and that of the controls was 31.83±0.06. The gestational age of the cases was on average 31.65±0.21 week of amenorrhea (WA) against 38.04±0.08 WA for the controls. 37% of LBW newborns had an Apgar score < 7 ($p < 0.001$) and 71% were hospitalized in neonatal intensive care ($p<0.001$). Micronutrient deficiency was raised and concerned calcium 34.02% vs 60.65%, folates 48.32% vs 68.01% and iron 50.85% vs 66% in cases and controls respectively. Newborns from NW had a weight of 3395.5±15.99 against 1957.25±30.72 for those from LBW.
Conclusion. This study shows that the nutritional intake did not cover all the nutrient needs of the pregnant women studied and that newborns with LBW are associated with an altered anthropometric status. Improving the living conditions of mothers, good monitoring of pregnancy, and good nutritional education can significantly improve the nutritional status with the same food intake and should be integrated into the nutritional intervention strategies.

Key words: *anthropometric measurements, dietary habits, low birth weight, nutritional intake, Morocco*

INTRODUCTION

Low birth weight (LBW) is a major health problem responsible for neonatal mortality and morbidity such as diabetes, obesity and cardiovascular disease in adulthood [1]. In the medium term, babies with LBW are more likely to experience health and developmental problems, including cognitive and physical development deficit with learning difficulties, hearing and visual impairments[2]. Globally, low birth weight contributes 60-80% of all neonatal deaths. During the year 2017, nearly 20.5 million children were registered with low birth weight, of which 96.5% were born in developing countries [3]. Millennium Sustainable Development Goal 4 aims to reduce the mortality rate of children aged 0 to 5 by two thirds and more specifically to reduce underweight among this age group of children [4]. However, the care of newborns with a growth deficit by the health system of developing countries is very expensive and, in general, remains insufficient or inadequate [5].

A diversified and balanced diet for pregnant women would contribute to the prevention of LBW and must therefore meet criteria of adequacy in terms of quantity and quality. The relationship between food consumption and health has been demonstrated by the

Corresponding author: Rekia Belahsen, Laboratory of Biotechnology, Biochemistry and Nutrition, Training and Research Unit on Nutrition and Food Sciences, Department of Biology, Faculty of Sciences, Chouaib Doukkali University, El Jadida 24 000, Morocco, e-mail: rbelahsen@yahoo.com or b.rekia@gmail.com

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association of the status of certain nutrients with the development of certain pathologies. The complexity of the relationships between these and food intake cannot be attributed to a single nutrient but rather to the interaction of several nutrients and foods. It is for this reason that the analysis of food consumption is the approach used to study the relationship between food and LBW [6].

The birth of a normal weight (NW) child therefore depends solely on two parameters of the evolution of fetal weight during gestation. Indeed, the latter physiologically depends on the duration of gestation and the rate of fetal growth. The duration of pregnancy quantifies the period of development between the fertilization of the egg by the sperm and delivery. Fetal growth is defined by the physiological evolution of the weight and size of the fetus during pregnancy. For many years, anthropometric indicators have been used to assess the nutritional status of populations in surveys, as part of surveillance systems. They are rightly regarded as both valid and convenient indicators of the general socio-economic and environmental context of populations [7]. Indeed, the biometric variability observed in newborns is attributed to several factors. If we exclude the variations due to pathologies of fetal or maternal origin, the factors implicated in this variability are multiple and often intertwined. These are genetic (height of the parents, etc.), physiological (placental efficiency, maternal nutritional status) and socio-economic (material and sanitary conditions of pregnancy) factors [8]. Therefore, anthropometric measurements of the newborn objective of the from the first hour of life are needed as a primary screening measure.

The present study was therefore to compare the data on the intake of energy and various nutrients and to the nutritional recommendations and to describe the dietary habits of two groups of pregnant women, those who had given birth to low birth weight newborns birth and those giving birth to babies of normal weight

MATERIAL AND METHODS

Sampling

The study was conducted at the maternity ward of the provincial hospital of El Jadida (PHE) in the greater Casa-Settat region over a period from March 10, 2018 to December 31, 2019. The hospital (PHE) is a 2nd level public health structure with a high influx of rural population.

This cross-sectional case-control study included 400 pregnant women who presented to the maternity ward of PHE for childbirth. Sampling is done by reasoned choice divided into two groups:

1. A control group of 200 women defined as parturient who have just given birth and who gave birth to newborns of normal weight between 2600 g to 4000 g.
2. A group made up of cases with 200 women who are parturient who have just given birth to newborns with a low weight of less than 2500 g.

Only women who gave birth and gave birth to live infants were included in this study. Those with stillbirths or fetal deaths in utero and those with twin and multiple pregnancies were excluded from the study.

Information collected

The collection of information was done using an established questionnaire, making it possible to collect data on socio-demographic and obstetrical factors. Nutritional intake was obtained by recording food consumption using the 24-hour recall method. Participants were asked to report the list of foods they had eaten in the 24 hours preceding the interview. A detailed description of all food and beverages consumed along with the quantities, type of meal, methods of food preparation and cooking, trademarks and place of meal preparation. All foods are coded according to the Bilnut computer software directory (version 2.01, nutrisoft, France) used to determine the composition of foods. The BILNUT program (version 2.01, nutrisoft, France) was used for the conversion of food consumed in terms of energy and nutrients. The food recall was carried out one day before the delivery so that it is a usual day for the pregnant woman and to avoid the announcing signs of the delivery such as nausea and vomiting which can influence the results.

Measurements of anthropometric variables and fundal height of pregnant women before delivery

Anthropometric measurements

Maternal weight and height were measured before delivery. The weight in kg ±100 grams was measured using a SECA® type 761 mechanical scale, and the height in meters ±1 millimeter with a measuring instrument of the SECA® body meter 206 type. The body mass index (BMI) or Quetelet index is calculated by dividing the weight in kg by the square of the height expressed in meters (kg/m^2). An individual is said to be thin when their BMI is strictly less than 18.5 kg/m^2, normal if the BMI is in the interval 18.5-25 kg/m^2, overweight if the BMI is in the interval 25-30 kg/m^2 and obese for a BMI greater than or equal to 30 kg/m^2 [9].

Measurement of fundal height (FH)

Fundal height (FH) is measured using a tape measure, placed between the upper edge of the pubic symphysis and the fundus, identified by manual palpation.

Data collection after childbirth

- In the woman,
- Information on the mode of delivery was collected from the women,
- In the newborn

Anthropometric measurements

The collection of data concerning the sex of the newborn, the weight, the height, the cranial circumference, the arm circumference and the thoracic circumference is collected from newborns in the first two hours following delivery. Newborn weight is measured at10gclosely using a SECA® brand baby scale. Height is measured using a measuring rod graduated in centimeters with the naked newborn lying on its back, its head firmly held against the fixed headrest board and the thighs and knees stretched out by the interviewer. Head circumference is measured at its largest diameter. The chest circumference is measured at the level of the nipples and the arm circumference on the left arm at mid-distance between the acromion and the olecranon. All these measurements were taken in centimeters using an inextensible tape measure. Ponderal index (kg/m^3) was calculated for all newborns [10].

Apgar score

The Apgar score measures the state of a newborn's vital functions. It is designed to assess signs of hemodynamic compromise such as cyanosis, hypoperfusion, bradycardia, hypotonia, respiratory depression or apnea. The elements that constitute are skin color, heart rate, reflexes, muscle tone and breathing. Each element is scored 0, 1 or 2 depending on the conditions observed, then added together to give an overall score out of 10. The maximum result is 10 points, equivalent to the best possible health condition. The Apgar score is normal if it is ≥7 at 1 minute and 5 minutes after the infant is born. A score <7 should lead to appropriate management requiring neonatal resuscitation [11].

Free and informed consent

This survey was approved by the Greater Casablanca regional office of the Moroccan Ministry of Health under number: 1934. Participation in the survey was subject to the free and informed consent of the women selected. After receiving a detailed explanation of the conduct and conditions of the survey, the women respondents were free to refuse or withdraw from the survey at any time. Blood samples were taken by a qualified medical team before delivery.

Data analysis, computer and statistical processing

Data entry and purification were carried out using Excel software and then exported to SPSS software (Statistical Package for the Social Sciences, version 25) for statistical analysis of the results. The comparison of the frequencies was carried out by the *Chi*-square test and the comparison of the means by an analysis of variance (ANOVA). In the presence of a statistically significant F-test, the unadjusted or adjusted means were tested against each other using *Tukey's* test respectively. Thus, the analyzed results are expressed as unadjusted means ± standard error means. The associations between different variables were determined by the "Binominal Correlation" procedure; thus the *Pearson* correlation coefficient was calculated for the study of correlation between parametric variables.

The one-sample t-test was used to compare the mean of a sample to a known standard mean.

The level of significance applied to the statistical tests is $p<0.05$.

RESULTS

Analysis of the data from the questionnaire on socio-economic data and reproduction and the outcome of pregnancy made it possible to establish the characteristics of the distribution of pregnant women according to several parameters grouped together in Table 1. The sample of women studied was on average 25.28±0.40 for the controls and 26.13±0.43 for the cases. The distribution according to place of residence shows a similarity in the distribution of controls and cases with a predominance of rural areas representing rates of 77.5% for controls and 84% for cases. In addition, almost half of the controls (49.5%) and more than half of the cases (61%) are illiterate, while the highest levels of education concerned only 6% of the female controls and 1.5% cases. The results also reveal that the average family size (number of people living in the same household, which may include members other than parents and children) is 4.40 ± 0.15 for controls compared to 5.53 ± 0.18 for cases. In addition, study participants who lived in precarity with a low monthly income represented a relatively larger proportion in the case group (77.5%) compared to controls (54%).

The anthropometric parameters of the study population show that the control women surveyed had an average weight of 73.91±0.55kg, a size of about 1.63±0.05mand a corpulence estimated by the rather satisfactory body mass index (average BMI = 27.80±0.19 kg/m^2) with high prevalence of overweight (55%) and obesity (29%). In the cases, the weight was on average 67.41±0.53 kg, height 1.60±0.03m and the mean BMI was 26.17±0.19 kg/m^2. According to the BMI, parturient in the case group, 37.5% are classified as "normal", 50% overweight and only 12.5% of cases who are obese.

Table 1. Socio-demographic and obstetric characteristics of the population studied and outcome of pregnancy and anthropometric measurements of the newborn of controls and cases

Socio-demographic characteristics	Witnesses (N=200) N (%)	Cases (N=200) N/ (%)	p-value
Mean age (mean ± SE) of women (years)	25.78±0.40	26.13±0.43	0.315
Origin of women			
Urban	45(22.5%)	32(16%)	0.128
Rural	155(77.5%)	168(84%)	
Level of studies			
None	99(49.5%)	122(61%)	0.029
Primary	56(28%)	47(23.5%)	
Secondary	33(16.5%)	28(14%)	
Superior	12(6%)	3(1.5%)	
(Mean ±SE) family size	4.40±0.15	5.53±0.18	0.004
Monthly income level			
Low (< 3000 MAD)	108(54%)	155(77.5%)	< 0.001
Medium (3000 – 5000 MAD)	74(37%)	36(18%)	
High (≥ 5000 MAD)	18(9%)	9(4.5%)	
Women's FH (Mean ±SE) (cm)	31.83±0.06	25.69±0.13	< 0.001
Women's parity			
Primiparous	91(45.5%)	113(56.5%)	0.036
Multipara	113(54.5%)	87(43.5%)	
Gestational age (GA)			
< 28 WA	0	34(17%)	< 0.001
28-32 WA	0	73(36.5%)	
33-37 WA	0	82(41%)	
≥ 37 WA	200	11(5.5%)	
Anthropometric characteristics			
Weight (Mean ± SE) of women (Kg)	73.91±0.55	67.41±0.53	0.328
Height (Mean ± SE) of women (m)	1.63±0.003	1.60±0.002	< 0.001
BMI classes			
Normal	32(16%)	75(37.5%)	< 0.001
Overweight	110(55%)	100(50%)	
Obese	58(29%)	25(12.5%)	
Mode of delivery			
Low way	183(91.5%)	160(80%)	0.001
caesarean section	17(8.5%)	40(20%)	
Newborn sex			
Feminine	129(64.5%)	122(61%)	0.535
Male	71(35.5%)	78(39%)	
Neonatal intensive care			
Yes	6(3%)	142(71%)	< 0.001
No	194(97%)	58(29%)	
APGAR score at 5 min of life			
< 7	12(6%)	74(37%)	< 0.001
≥ 7	188(94%)	126(63%)	
Anthropometric measurements (Mean ± SE)			
Weight(g)	3395.5±15.99	1957.25±30.72	< 0.001
Height (cm)	49.72±0.04	42.23±0.24	< 0.001
Ponderal index (kg/m3)	2.75±0.007	2.55±0.014	< 0.001
Head circumference (cm)	34.79±0.02	29.45±0.03	< 0.001
Arm circumference (cm)	11.81±0.02	10.41±0.03	0.007
Chest circumference (cm)	32.79±0.02	26.01±0.17	< 0.001

N/%: Number (percentage); SE: Standard error; FH: fundal height; WA: Week of Amenorrhea;
BMI: Body Mass Index; ANOVA test; Chi^2 test; Student test for independent samples; $p<0.05$

In the obstetric register, it was revealed that 56% of the cases are primiparous against 45.5% in the controls. The mean FH of the cases is estimated at 25.69±0.13 against the controls which is 31.83±0.06. 17% of cases have a gestational age < 28 WA against only 5.5% who have a gestational age ≥37 WA, while all the control parturient have a gestational age ≥37 WA.

Considering the mode of delivery, a rate of 20% of cases having delivered by caesarean section was noted. The Apgar score seems to be influenced by LBW with 37% of LBW neonates having an Apgar score <7 (p<0.001). A fortiori, 71% of these newborns were hospitalized in neonatal intensive care just after delivery (p<0.001). The results also show an assessment of the anthropometric parameters of LBW newborns, which appear to be significantly lower than those of normal-weight newborns and standard anthropometric norms.

The daily intakes of micronutrients as well as their percentages in relation to the RDA in the sample studied are presented in Table 2. The table shows that in the controls, with the exception of calcium 60.65% (t=-16.41), the nutritional intakes of iron 66% (t=-17.35), folates 68.01% (t=-28.40) and zinc 81.72% (t=-13.37), exceeded far from the recommended daily values. For the cases, on the other hand, apart from proteins, carbohydrates and phosphorus, all the micronutrients as well as energy were below the recommended values with a more marked deficiency for calcium 34.02% (t=-59 .56), folates 48.32% (t=-59.56) and iron 50.85% (t=-29.74). In general, the total population had low intakes and RDA coverage rates of 47.33% for calcium, 58.16% for folates, 58.42% for iron and 79.63% for zinc.

The results reported in Table 3 show that the gestational age and fundal height of mothers who gave LBW newborns are positively correlated with all anthropometric measurements of newborns (p<0.001). A positive correlation has also been found between the height of the mother and the chest circumference of LBW newborns on the one hand, and between the weight index of these newborns and the gestational age of the mothers on the other hand. However, a negative correlation was noted between the weight and the height of the mothers with the weight, the height and the chest circumference of the LBW newborns. The results also reveal a statistically significant association between all the anthropometric measurements with hospitalization in neonatal intensive care of newborns with LBW and between the Apgar score and weight (p=0.002), height (p=0.001) and head circumference (p=0.002) of these newborns.

For newborns of normal weight, weight, arm circumference (r=0.153) and ponderal index (r=0.220) are correlated with the household size of the mothers of these newborns (r=0.163). A positive correlation

Table 2. Daily energy and nutritional intake of cases, controls and the total population compared to the recommended daily allowances (RDA)

Energy and nutrients	RDA	Average intake of controls (N=200)	Average intake of cases (N=200)	*P-value*	(%±SE) of mean intake of controls relative to RDA	(%±SE) of average intake of cases compared to RDA	*t* Controls	*t Cases*
Energy (Kcal)	2500	2617.60±53.11	2083.04±39.52	**< 0.001**	104.70±2.12	83.32±1.58	2.21	-10.55
Protein (g)	71	106.80±5.26	81.74±3.68	**0.001**	150.42±7.40	115.12±5.18	6.8	2.91
Lipids (g)	ND	92.82±4.08	81.81±2.65	**< 0.001**				
Carbohydrates(g)	175	338.74±7.21	256.03±6.45	0.225	193.56±4.12	146.30±3.68	22.69	12.54
Vit B1 (mg)	1.4	1.42±0.03	0.74±0.02	**< 0.001**	101.42±2.14	52.85±1.42	0.62	-29.59
Vit C (mg)	80-85*	111.26±4.11	54.24±1.90	**< 0.001**	130.89±4.83	63.81±2.23	6.37	-16.16
Vit E (mg)	15	19.61±0.29	13.95±0.22	**< 0.001**	130.73±1.93	93±1.46	15.62	-4.6
Phosphorus (mg)	1250-700*	1699.88±33.73	1089.92±38.54	**0.011**	242.84±4.81	155.70±5.50	29.63	10.11
Calcium (mg)	1000	606.50±23.97	340.20±11.07	**< 0.001**	60.65±2.39	34.02±1.10	-16.41	-59.56
Iron (mg)	27	17.82±0.52	13.73±0.44	**< 0.001**	66±1.92	50.85±1.62	-17.35	-29.74
Folates (µg)	600	408.06±6.75	289.93±5.77	0.103	68.01±1.12	48.32±0.96	-28.4	-53.65
Magnesium (mg)	400-350*	459.24±9.39	327.99±7.27	**0.001**	131.21±2.68	93.71±2.07	11.62	-3.02
Zinc (mg)	12-11*	8.99±0.17	8.53±0.18	0.09	81.72±1.54	77.54±1.63	-11.7	-13.37

N: Number; SE: Standard Error; RDA: Recommended Dietary Allowance; ND= Not determined; student test for independent sample; single t-test; P<0.05

Table 3. Association of the characteristics of the mothers, and those of the newborns and the intakes of certain nutrients of the cases and the controls

	LBW newborn (N=200)							NW newborn (N=200)						
Characteristics of mothers		Weight (g)	Size (cm)	HC (cm)	AC (cm)	CC (cm)	PI (kg/m^3)		Weight (g)	Size (cm)	HC (cm)	AC (cm)	CC (cm)	PI (kg/m^3)
Mother weight	R	-0.149*	-0.110	-0.06	-0.027	-0.166*	-0.096	R	0.009	0.021	0.021	-0.025	0.018	-0.012
	P	0.036	0.121	0.398	0.7	0.019	0.175	P	0.897	0.771	0.771	0.728	0.805	0.87
Mother height	R	-0.192**	-0.167*	-0.115	-0.04	-0.167*	-0.057	R	-0.083	-0.073	0.071	0.740*	-0.064	-0.071
	P	0.006	0.018	0.106	0.577	0.018	0.422	P	0.243	0.302	0.392	< 0.001	0.368	0.315
Gestational age in WA	R	0.856**	0.789**	0.717**	0.500**	0.970**	0.178*	R	-0.062	-0.075	-0.107	-0.135	-0.111	-0.027
	P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.012	P	0.386	0.294	0.132	0.057	0.117	0.706
FH	R	0.420**	0.353**	0.382**	0.344**	0.449**	0.186**	R	0.026	0.018	0.036	0.018	0.058	0.031
	P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	P	0.711	0.801	0.376	0.802	0.412	0.665
household size	R	0.062	0.004	0.035	0.219**	0.044	0.168*	R	0.163*	0.066	0.071	0.153*	0.073	0.220**
	P	0.385	0.959	0.618	0.002	0.534	0.018	P	0.021	0.355	0.316	0.031	0.306	0.002
Characteristics of newborns														
APGAR score	N	(Mean ± SE)												
< 7	74	1786.49 ±54.18	40.83±0.43	29.07±0.20	10.35±0.05	25.12±0.29	2.56±0.02	12	3387.5 ±80.03	49.60±0.18	34.81±0.11	11.79±0.10	32.81±0.11	2.77±0.040
≥ 7	126	2057.54 ±34.06	43.04±0.26	29.67±0.10	10.44±0.04	26.53±0.19	2.55±0.01	88	3396.01 ±16.29	49.73±0.04	34.79±0.02	11.81±0.02	32.79±0.02	2.75±0.007
	P	0.002	0.001	0.002	0.636	0.05	0.318	P	0.363	0.952	0.8	0.803	0.8	0.239
Newborn intensive care	N	(Mean ± SE)						N	(Mean ± SE)					
Yes	142	1824.65 ±36.39	41.35±0.30	29.13±0.12	10.32±0.04	25.23±0.19	2.53±0.01	6	3483.33 ±114.50	49.78±0.29	34.90±0.16	11.81±0.15	32.90±0.16	2.81±0.054
No	58	2281.90 ±27.15	44.36±0.21	30.21±0.13	10.63±0.03	27.93±0.15	2.61±0.02	194	3392.78 ±16.12	49.72±0.04	34.79±0.02	11.81±0.02	32.79±0.02	2.75±0.007
	P	< 0.001	< 0.001	0.007	0.001	< 0.001	< 0.001	P	0.633	0.805	0.732	0.687	0.732	0.449
Nutrient intake														
Vitamin C	R	0.142*	0.181*	0.142*	0.102	0.129	- 0.095**	R	-0.113	-0.044	-0.054	-0.136	-0.054	-0.153
Calcium	R	0.116	0.153*	0.147*	0.041	0.168*	- 0.115	R	-0.063	-0.094	-0.039	-0.036	-0.041	-0.016
Magnesium	R	0.224**	0.194**	0.176*	0.148*	0.210**	0.093	R	0.012	0.02	-0.017	0.002	-0.015	0
Zinc	R	-0.101	- 0.043	- 0.128	0.082	-0.134	- 0.146**	R	0.066	0.075	0.094	0.049	0.099	0.037

R: r correlation; *P*: P-value; N: Number; ES: Standard Error; LBW: Low birth weight; NW: Normal weight; WA: Week of Amenorrhea; FH: fundal height; HC: Head circumference; AC: Arm Circumference; Chest Circumference; PI: Ponderal Index; A: Pearson correlation; P<0.05.

was also raised between arm circumference and height of mothers (p<0.001).

Table 3 also shows significant correlations between mothers' magnesium intake and all anthropometric measurements of LBW newborns except weight index. In addition, vitamin C is positively correlated with weight, height and head circumference, while calcium is correlated with height, head circumference and chest circumference. Nevertheless, a strongly negative correlation seems to be identified between the *Ponderal* index of LBW newborns and vitamin C (r= -0.095**) and zinc (r= -0.146**) intakes. Recall that no correlation was found between these nutrients with the anthropometric measurements of newborns of normal weight.

The data in Table 4 reveal changes in the number of daily meals taken before and during pregnancy for both groups of women. In general, before pregnancy, women who consumed 3 dishes a day accounted for 83% of controls and 87.5% of cases. According to the trimesters of the pregnancy, visible changes in the number of dishes are noticed for the two groups of women and which increase with the evolution of the gestational age. Notwithstanding, a disparity in the distribution of the number of dishes was raised for the two groups of women with a higher rate of controls who consumed more than 3 dishes per day throughout gestation compared to cases.

Table 5 presents the list of foods declared by the pregnant women participating in the study as being recommended to be consumed during pregnancy. However, although they know the importance of dairy products in the bone growth of the newborn, it remains generally little consumed. Regarding "not recommended" foods, the women cited strong spices (69.5%), fenugreek (48.5%), tea and coffee (51%) and chili (11.5%). These ingredients are considered harmful by women for their health as well as for that of their child. Salt was also cited by 38% of women as a "not recommended" ingredient.

Table 4. Number of dishes/meals taken daily before and during pregnancy

Number of dishes/day	Controls (N=200)	Cases (N=200)	p-value
Before pregnancy			
< 3	5 (2.5%)	17 (8.5%)	< 0.001
= 3	166 (83%)	175 (87.5%)	
> 3	29 (14.5%)	8 (4%)	
In 1st trimester			
< 3	107 (53.5%)	129 (64.5%)	0.011
= 3	63 (31.5%)	58 (29%)	
> 3	30 (15%)	13 (6.5%)	
In 2nd trimester			
< 3	52 (26%)	70 (35%)	< 0.001
= 3	58 (29%)	93 (46.5%)	
> 3	90 (46%)	37 (18.5%)	
In 3rd trimester			
< 3	18 (9%)	35 (17.5%)	< 0.001
= 3	46 (23%)	64 (32%)	
> 3	136 (68%)	101(50.5%)	

N/%: Number (percentage); Chi^2 test; P<0.05

Table 5. Distribution of the general population of mothers studied according to
the food consumption during pregnancy

Foods recommended and not recommended during pregnancy	Total population (N=400)
Recommended food products N (%)	
Offal, red meat and fish	318 (79.5%)
fruits and vegetables	300 (75%)
Dairy products	320 (80%)
Not recommended food products N (%)	
Rass El Hanout and cinnamon	278 (69.5%)
Fenugreek	194 (48.5%)
Salt	78 (38%)
Tea and coffee	204 (51%)
Pepper	46 (11.5%)

DISCUSSION

Low birth weight contributes 60-80% of all neonatal deaths worldwide. The year 2017 was recorded nearly 20.5 million children affected by low birth weight, of which 96.5% were born in developing countries [3]. Morocco recorded during the same year an estimated proportion of 17.3% of births with low weight. In the present study, the prevalence was not defined due to the under-reporting of the weight of newborns in the birth registers.

Micronutrient deficiencies are key determinants of LBW. Indeed, the needs and nature of nutrients of maternal origin change at each stage of development and growth of the fetus. Newborns exposed to LBW are more vulnerable to neonatal and infant mortality [12] with a predisposition in the future to reduced physical capacity, an increased risk of lifelong disease and even to chronic nutrition-related diseases [13]. The results of the dietary survey of the sample studied showed a calcium deficiency and coverage rate not exceeding 1/3 of the recommended daily intake for the cases and more than half for the controls. This strong dietary calcium deficiency could expose pregnant women to a risk of decalcification or complications of pregnancy, including hypertensive disorders responsible for eclampsia [14]. These insufficient calcium intakes have also been reported in other populations of pregnant women who, like the present population studied, consumed few dairy products [15]. The results of studies of the effect of calcium during pregnancy on fetal weight are divergent. Several studies have proven [16] while others did not show an effect on birth weight and other neonatal parameters [17].

The present study, on the other hand, made it possible to highlight a significant association between iron and folates intake and birth weight. This confirms the results of several studies that have demonstrated a significant effect of these intakes on birth weight [18, 19]. In addition, anemia adversely affects the outcome of pregnancy and newborns. Anemia induced by zinc deficiency can also generate adverse effects for the mother by increasing the risk of preterm delivery and the risk of low birth weight in newborns [20]. Zinc intakes in our study were insufficient in both controls and cases. This trace element plays an important role in the transcription of several proteins essential for embryogenesis, cell differentiation and fetal growth. In addition, vitamin C and vitamin E intakes below the recommended daily intakes were noted in the cases while they exceeded the recommendations for the controls. These two vitamins are two main antioxidant substances in the body, their deficiencies would be involved in the genesis of pre-eclampsia and intrauterine growth retardation [21].

In the present study, the energy intakes reported in control parturient are sufficient to carry a normal pregnancy. These intakes are lower than those found previously in a study conducted on pregnant women in the same study region [15] and higher than those reported by the study of *Boufars* et al [22]. Moreover, in the group of cases, these energy intakes covered only 83% of the RDA, no doubt because of the high consumption of bread observed in the population studied. Adequate calorie intake contributes to the achievement of appropriate maternal weight gain, it self being a major predictor of newborn birth weight. Several authors have also reported that the mothers of LBW newborns had a lower energy intake than those who gave birth to babies of normal weight [23, 24, 25, 26]. In addition, in this study, the protein and carbohydrate intakes of controls and cases exceeded the RDAs. Indeed, proteins ensure the construction of the fetus and its annexes. A balanced energy/protein balance reduces the risk of low gestational age at birth. From the point of view of distribution of energy intake, protein overconsumption is observed (16.31% vs 15.65% of total energy intake (TEI) in controls and cases respectively, instead of what is recommended (11 -15%), a sufficient lipid intake (30.37% vs 34.78% of the TEI compared to the recommendations (30-35%) and a carbohydrate intake respecting the standards (53.30 vs 49.55% of the TEI) compared to the recommendations (50-55%).

On the other hand, different factors can also adversely affect the nutritional status of women and the proper course of pregnancy, directly or indirectly compromising the chances of the fetus to grow and develop normally. Indeed, several studies in the literature have demonstrated the effect of socio-economic status on diet quality [27, 28]. Thus, a low level of monthly income and the large size of the household may reflect a difficult financial situation, responsible for a limitation of purchasing power, resulting in an insufficient nutritional intake in the mother as well as a poor access to care, in quantity and quality [29], in particular obstetric care and antenatal consultations. An individual's food choices may result from his personal convictions but are also influenced by the socio-cultural factors of the environment in which he finds himself.

Fetal weight is a marker of fetal well-being, which not only makes it possible to estimate - a posteriori - harmonious growth in utero, but it also represents a determining marker of the risk of disease in adulthood [30]. In the present study, the mean weight reported for LBW was 1957.25±30.72 g and that of NW neonates was 3395±15.99 g, and this difference is statistically significant ($p<0.001$). In the group of cases studied, the average weight, height, head circumference, brachial circumference, thoracic circumference and weight index are lower compared to the controls. These results also show that vaginal delivery of newborns is largely predominant with a rate of 91.5% for controls and 80% for cases. On the other hand, the rate of cesarean sections identified was slightly higher in the cases (20%) compared to the controls (8.5%) with a statistically significant difference ($p=0.001$). This finding could be explained by the fact that low birth weight is generally present in premature children corresponding to newborns with immaturity of many functions (respiratory, thermoregulatory, immune, cardiovascular, hepatic, etc.). This immaturity is responsible for many fatal complications which can often be accompanied by a maternal pathology such as pre-eclampsia, retro placental hematoma, infection immediately involving the vital prognosis of the mother or the child and requiring a cesarean section. very urgent [31].

Moreover, a predominance of female newborns is observed in the present study without this difference being statistically significant. Indeed, the relationship between sex and birth weight is controversial. These results are not in agreement with *Ghani's* study [32] which show the influence of sex on birth weight, although other studies do not confirm this relationship [33, 34, 35]. To determine whether female malnutrition affects fetal growth, we assessed the influence of maternal weight on newborn anthropometric measurements. Moreover, a negative correlation was found between the weight of LBW newborns, the height and the chest circumference with the weight of the mother. Several studies have shown that a woman's weight during pregnancy is one of the important factors associated with fetal growth [36, 37].

According to the literature, physiologically small women give birth to low birth weight infants without there being a direct underlying pathological mechanism [38]. The WHO estimates that in developed countries, a short woman may risk obstetric complications that may prevent vaginal delivery of a normally developed newborn. While in developing countries, a short woman may on the other hand have a high risk of having an underdeveloped fetus [39]. According to our results, a negative correlation exists between the mother's height and certain anthropometric measures of LBW newborns such as weight, height and chest circumference.

Moreover, a strong correlation is found between the different anthropometric measurements of LBW newborns with gestational age and fundal height. The lower the gestational age, the greater the risk of neonatal complications, developmental delay and mortality [25, 40]. The low anthropometric status of the newborn, estimated from household size, shows a positive correlation between arm circumference and ponderal index. This correlation also seems to concern the controls, where we notice a positive correlation between this parameter with the weight of the newborns, the arm circumference and the ponderal index. According to the literature, women who live in large families integrate many environmental components, such as low diet quality, low purchasing power, poor sanitary conditions and difficult access to medical care [41].

In fact, the LBW values of newborns in other studies show differences of varying importance depending on the terms: lower than ours [42, 43] or higher [44, 45]. Concerning the height of newborns of normal weight, we find the same similarity in average height in the study of *Asse* et al. [46].

According to WHO data [47] which brought together the results of work done in several countries of the world, they allow to say that the low birth weight can be predicted with the thoracic circumference. Moreover, the values of the thoracic circumference of our controls far exceed those of cases with statistically proven significance. Thus, the chest circumference of LBW newborns in our study seems to be negatively correlated with the weight and height of the mothers.

Our study also revealed a positive correlation between weight, height, head circumference of LBW newborns and daily intake of vitamin C. This vitamin plays a role in stabilizing membranes and its antioxidant properties and on weight. At birth, its effects are mostly demonstrated in developed countries. While other studies attest that women who lack vitamin C have a higher risk of giving birth prematurely. Our results corroborate with those found in the literature [48].

In addition, pregnancy is a period of major disorders accompanied by physiological, metabolic and dietary behavior changes [49]. This is a special time in a woman's life that requires changes, especially in terms of eating behavior. The data from the study report changes in the number of meals/day depending on the trimester of pregnancy with a disproportion of consumption in cases compared to controls, probably related to eating disorders during pregnancy, vomiting during pregnancy and/or the unfavorable socio-economic conditions of parturient preventing these women from consuming food in sufficient quantity. Indeed, the eating behavior of the women in the study seems to be paradoxical. Contradicting, 80% of women are aware of the importance of consuming dairy products as recommended during pregnancy, but they do not consume a lot, especially during the third trimester of pregnancy because dairy products increase the size of the breast. The cranial circumference of the newborn thus rendering the delivery dystocia. Among the foods not recommended by the family/entourage during pregnancy, fenugreek was cited by women for its teratogenic effect during the first months of gestation, cinnamon for strong uterine contractions it causes, Ras El Hanout (mixture of dried and ground spices) which includes several stimulants not recommended during pregnancy, and chili for the accentuation of hemorrhoids. Salt has also been considered as a "not recommended" food for the edema of the lower limbs that it can cause in addition to arterial hypertension and eclampsia. Although these cultural attitudes are very rarely the main cause of malnutrition, some of them can promote behaviors leading to nutritional deficiencies. The prohibitions assigned to women during pregnancy have a protective function that differs according to the culture to which they belong, based on endogenous beliefs transmitted from generation to generation and have as their purpose the control of any complication of pregnancy and the ensuring a eutocritical birth for mother and child [49].

CONCLUSION

At the end of the analysis of the present data, it clearly appears that low birth weight has a significant negative impact on the anthropometric status of newborns at birth, constituting a threat factor for the survival of the child both during the neonatal and infantile period. There are several ways to improve the nutritional status of pregnant women that do not necessarily involve changing or improving the diet.

This includes examining how an adverse environment can limit access to maternal nutrient stores and impair fetal development. In addition, improving the living conditions of mothers, good monitoring of pregnancy, good nutritional education can significantly improve the nutritional status for the same food intake and should be integrated, if necessary, into the nutritional intervention strategies.

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Declaration of conflict of interest

The authors declare that they have no conflict of interest.

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