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ORIGINAL ARTICLE

PRE-PREGNANCY NUTRITIONAL STATUS VERSUS MATERNAL WEIGHT GAIN AND NEONATAL SIZE

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ABSTRACT

Background. Maternal weight during pregnancy may affect both, the course of pregnancy and the anthropometric parameters of the newborn. The steadily growing problem of excessive weight in reproductive-age women is associated with the risk for gestational obesity and its negative consequences for the infant.

Objectives. The aims of the study were to analyze the following: (i) maternal weight gain as compared to the pre-pregnancy BMI, and (ii) the link between maternal weight and other environmental factors versus neonatal size.

Material and methods. The study was conducted among 94 women in singleton term pregnancy, who delivered at the Department of Obstetrics, Gynecology and Oncology, Medical University of Warsaw. The American Institute of Medicine criteria for the recommended weight gain were followed. Multivariate logistic regression model and multiple regression analysis were used for statistical analysis.

Results. Normal weight gain was observed in only one-third of the subjects, while excess weight gain was detected in as many as 42.5% of the women. Active smokers were at a 4-fold higher risk for excess weight gain as compared to non-smokers (OR 4.13, 95% CI 1.19 - 14.34, p = 0.026). Infants born to mothers with insufficient weight gain (24.5% of the mothers) were lighter by 302 g (p=0.0405) and shorter by 2.4 cm (p=0.0025) as compared to those born to mothers with normal weight gain.

Conclusions. Maternal weight gain in most of our subjects was not compliant with the current recommendations, regardless of the pre-pregnancy BMI. Inadequate pregnancy weight gain negatively affects the anthropometric parameters of the newborn.

Key words: *pregnancy; body mass index; weight gain; anthropometric neonatal parameters*

STRESZCZENIE

Wprowadzenie. Masa ciała matki w okresie ciąży może mieć wpływ na przebieg ciąży i parametry antropometryczne noworodka. Narastający, już u kobiet w wieku rozrodczym problem nadmiernej masy ciała niesie ze sobą ryzyko otyłości ciężarnych i jej konsekwencji u dziecka.

Cel. Celem badania była analiza przyrostu masy ciała kobiet, w zależności od przedciążowego wskaźnika BMI oraz analiza związku, pomiędzy przyrostem masy ciała i innymi czynnikami środowiskowymi, a wielkością noworodków.

Materiał i metody. Badanie przeprowadzono wśród 94 kobiet w ciąży pojedynczej, które urodziły w terminie w Klinice Położnictwa, Chorób Kobiecych i Ginekologii Onkologicznej Warszawskiego Uniwersytetu Medycznego. Zalecany przyrost masy ciała przyjęto według kryteriów opracowanych przez amerykański Institute of Medicine. W analizie statystycznej wyników wykorzystano wielowymiarową analizę regresji logistycznej i wieloczynnikową analizę regresji.

Wyniki. Prawidłowy przyrost masy ciała miała tylko 1/3 pacjentek, a największy odsetek dotyczył przyrostu nadmiernego (42,5%). Kobiety palące w czasie ciąży miały ponad 4-krotnie większe ryzyko zbyt dużego przyrostu masy ciała, w porównaniu do kobiet ciężarnych niepalących (OR 4.13, 95% CI 1.19 - 14.34, p = 0,026). Noworodki matek z małym przyrostem masy ciała (24,5% matek) były o 302 g lżejsze (p=0,0405) i o 2,4 cm krótsze (p=0,0025), niż noworodki matek z przyrostem prawidłowym.

Wnioski. Ciążowy przyrost masy ciała większości badanych kobiet odbiegał od aktualnych zaleceń, niezależnie od przedciążowego wskaźnika BMI. Negatywny wpływ na parametry antropometryczne noworodków miał zbyt mały przyrost masy ciała matek.

Słowa kluczowe: *ciąża, masa ciała, parametry antropometryczne noworodków*

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INTRODUCTION

Pre-pregnancy weight and its gain during pregnancy are two factors which might significantly affect the course of pregnancy and neonatal health. Women who are too slim before conception are at a higher risk for delivering a low birth weight (LBW) or a small for gestational age (SGA) infant, while overweight or obese women are at risk for gestational diabetes, fetal macrosomia, or a large for gestational age (LGA) infant [13, 14, 18, 26, 34]. Inadequate and excess pregnancy weight gain may both have negative consequences but, in the era of global obesity, the research has visibly focused on the latter. Excess weight gain during pregnancy is associated with numerous complications, e.g. gestational diabetes, arterial hypertension [19, 23, 28], and fetal macrosomia [14, 29, 34]. Currently, it is believed that excess neonatal weight intensifies the problem of obesity both, in childhood and later in life [3-5, 10, 14].

As far as pregnancy weight gain is concerned, many countries – including Poland – follow the American guidelines which were designed to minimize the risk for delivering either an underweight or an overweight infant [21, 31]. In light of the guidelines in question, weight gain during pregnancy is determined by maternal pre-pregnancy body mass index (BMI). Noteworthy, lately the American criteria about nutritional status for reproductive-age women have been adjusted to the guidelines for the general population created by the WHO [31]. After nearly 20 years, the recommended BMI for such women has been lowered from ≥19.8 to ≥18.5, which was caused by a dramatic increase in the number of American women with pre-pregnancy obesity, more advanced maternal age, and a higher number of multiple gestations.

In accordance with the standards of the medical care for pregnant women in Poland, patient BMI should be established at the first antenatal visit and patient weight must be monitored until pregnancy completion [17]. Also, it has been emphasized in the same document that maternal obesity is one of the risk factors for perinatal complications. UK belongs to the group of countries which question the validity of routine weigh-ins for pregnant women and maternal weight policies. The United Kingdom's National Institute for Health and Clinical Excellence firmly claims that data on the link between maternal weight gain and neonatal health are inconclusive and that the limits give rise to unnecessary concern among the mothers-to-be [21].

The aims of the study were to analyze the following: (i) maternal weight gain as compared to the pre-pregnancy BMI and (ii) the link between maternal weight and other environmental factors versus neonatal anthropometric parameters (weight, length, head and chest circumference).

MATERIAL AND METHODS

Study Design

The study included 94 pregnant women who delivered at the Department of Obstetrics, Gynecology and Oncology, Medical University of Warsaw, in 2014-2015. Only pregnant women of Polish nationality in singleton term (≥ 37 gestational weeks) pregnancy, with no history of chronic diseases, were recruited. Written informed consent was obtained from all participants. Local Ethics Committee approved of the study (no. 10/162/KB/2014). Maternal characteristics are presented in Table 1.

Data Collection

Direct interviewing (face-to-face) was used to collect data on maternal weight, pregnancy weight gain and lifestyle. In accordance with the American Institute of Medicine National Academy of Science guidelines, the following values of normal weight gain were accepted: 12.5–18 kg for underweight, 11.5–16 kg for normal weight, 7.0–11.5 kg for overweight, and 5–9 for obese women [31]. Values below or above recommendations were considered as insufficient or excessive, respectively. Nutritional status of women on admission was defined by the BMI, based on the either self-reported height and body weight or registered in the maternity notes. Due to a relatively small sample size, overweight and obese subjects were placed in one group (excess weight) and the ranges for overweight women were applied. Maternal weight gain was calculated as the difference between the body weight measured after admission to the delivery ward and the pre-pregnancy weight. As the study was a survey, pre-pregnancy weight and pregnancy weight gain were measured in kilograms (+/- 1kg accuracy).

Data on pregnancy duration and neonatal anthropometric measurements (weight, length, head and chest circumference) were obtained from the hospital medical records. The anthropometric measurements were taken by the midwives immediately upon delivery. Weight was measured using a physician beam scale. The remaining measurements were taken with the use of a tape measure. The total neonatal length was measured from the vertex of the head to the soles (with the feet kept vertical at 90 degrees). The occipital-frontal head circumference (tape was placed on the maximum protrusion of the occiput and supraorbital ridges) and the chest circumference (tape was placed horizontally on the sternum and lower tip of the shoulder blade) were measured.

The study considered also a few dietary factors which might affect neonatal size, in it maternal caffeine consumption (coffee, tea, and energy drinks), vitamin D (fish, eggs, butter, margarine, milk and dairy products), calcium (milk and dairy products) and vitamin/mineral supplementation during pregnancy.

The questionnaire, and the "Photo Album of Meals and Products" were used for data collection.

Statistical Analysis

Multivariate logistic regression model was used to analyze a possible relationship between selected variables (pre-pregnancy BMI, age, education, place of residence, gravidity, smoking, supplementation with vitamin and mineral preparations) and maternal weight gain. Backward elimination (p=0.1) was used to select statistically significant features. The level of statistical significance was set at 5%. The relationship between the investigated features and the matter in question was expressed using odds ratio (OR) and a 95% confidence interval.

Table 1. Maternal and neonatal characteristics

Maternal characteristics	
Number of women	94
Pre-pregnancy maternal BMI (mean ± SD)	22.9 ± 3.7
Pre-pregnancy underweight, n (%) normal, n (%) overweight/obesity, n (%)	 8 (8.5%) 63 (67.0%) 23 (24.5%)
Age (in years) mean ± SD	29.9 ± 4.3
Education, n (%) higher other	 63 (67.0) 31 (33.0)
Gravidity, n (%) primiparas multiparas	 40 (42.5) 54 (57.5)
Gestational diabetes, n (%)	9 (9.5)
Smoking during pregnancy, n (%)	14 (15.0)
Professionally active during pregnancy, n (%)	54 (57.4)
Supplementation with vitamin/mineral preparations, n (%)	85 (90.4)
Daily vitamin D consumption – from diet (µg) median (min-max)	 2.1 (0.2-11.5)
Daily calcium consumption – from milk and dairy products (mg) median (min-max)	 596 (69-1872)
Daily caffeine consumption – from coffee, tea, and energy drinks (mg) mean ± SD	67 ± 51
Neonatal characteristics	
Number of newborns	94
Gestational age (weeks) mean ± SD	39.4 ± 1.0
Sex of the newborn male, n (%) female, n (%)	 48 (51.0) 46 (49.0)
Neonatal weight (g) mean ± SD	3515 ± 500
LBW neonates (<2500 g), n (%)	1 (1.1)
Macrosomia (>4000 g), n (%)	19 (20.2)
Neonatal length (cm) mean ± SD	55.4 ± 2.7
Neonatal head circumference (cm) mean ± SD	34.8 ± 1.4
Neonatal chest circumference (cm) mean ± SD	34.0 ± 1.9
Apgar score (points) mean ± SD	9.9 ± 0.1

Non-parametric *Spearman's* rank correlation coefficient was used to analyze the relationship between maternal pre-pregnancy weight (in kg) and pregnancy weight gain (in kg). A multiple regression analysis was used to investigate a possible relationship between selected baseline characteristics (pre-pregnancy BMI, weight gain during pregnancy, use of vitamin/mineral preparations, vitamin D and calcium consumption, caffeine consumption, smoking, maternal age and education, gravidity, professional activity during pregnancy, gestational diabetes, and sex of the neonate) and neonatal weight, length, and head and chest circumference. The p-value of < 0.05 was considered as statistically significant. Stata v. 14.1 was used for data analysis.

RESULTS

Weight gain and the related factors

Normal pre-pregnancy weight was observed in 67% of the investigated women, while 8.5% were underweight and 24.5% had excess weight – either overweight or obese (Table 1). During pregnancy, excess weight gain was found in 42.5% of the subjects and normal weight gain was observed in only one-third of the women (Table 2).

Table 2. Pregnancy weight gain in comparison with pre-pregnancy BMI

Pre-pregnancy BMI	Gestational weight gain below recommendations n (%)	Gestational weight gain within recommendations n (%)	Gestational weight gain above recommendations (%)	Weight gain (kg) mean, (min-max)
underweight BMI <18.5	4 (50)	3 (37.5)	1 (12.5)	13.6 (9 – 20)
normal BMI 18.5–24.9	17 (27)	21 (33.3)	25 (39.7)	15.7 (6 – 32)
overweight/obesity BMI ≥25	2 (8.7)	7 (30.4)	14 (60.9)	13.8 (4 – 30)
total n (%)	23 (24.5)	31 (33)	40 (42.5)	15.0 (4 – 32)

No statistically significant relationship was found between pre-pregnancy BMI and pregnancy weight gain. However, we observed a tendency for underweight women to be at a lower risk for excess weight gain during pregnancy (Table 3). We found that smokers are at a 4-fold risk for excess weight gain as compared to non-smokers (OR 4.13, 95% CI 1.19 - 14.34, p = 0.026), as well as multiparas as compared to primiparas, although borderline statistical significance was detected in the latter case (OR 2.48, 95% CI 0.97 - 6.32, p = 0.058) (Table 3).

Table 3**.** Analysis of the influence of pre-pregnancy maternal BMI and other factors on the risk for excess gestational weight gain

N=94	OR [95% CI]	p- value
pre-pregnancy BMI: underweight vs. normal overweight/obesity vs. normal	0.13 [0.01; 1.28]	 0.081 >0.1
age (years): >30 vs. ≤30		>0.1
education: secondary vs. higher		>0.1
place of residence: Warsaw vs. other		>0.1
gravidity: multiparas vs. primiparas	2.48 [0.97; 6.32]	0.058
supplementation with vitamin/mineral preparations		>0.1
smoking during pregnancy	4.13 [1.19; 14.34]	0.026

No linear connection was found between pre-pregnancy maternal weight and pregnancy weight gain (rho=0.0028, p=0.9785), although the highest weight gain (mean 15.7 kg) was detected among women with normal weight during the pre-conception period. Both, underweight and overweight women gained on average 2 kg less during pregnancy as compared to their normal-weight peers (Table 2).

Maternal weight gain and other environmental factors versus neonatal size

As far as newborn anthropometric parameters were concerned, we found that children born to mothers whose weight gain in pregnancy was below recommendations were 302 g lighter (p=0.0405), and 2.4 cm shorter (p=0.0025), as compared to infants born to mothers with normal weight gain (Tables 4 and 5).

One case of LBW was observed in a patient with normal weight gain. Macrosomia (>4000 g) was found in 20% of the neonates but it proved to be unrelated to maternal BMI and pregnancy weight gain.

Table 4. Relationship between selected parameters and neonatal weight

Parameter	Regression beta coefficient (SE)	95% CI	p- value
Pre-pregnancy BMI: underweight overweight/obesity	 15.69 (199.141) 70.77 (151.218)	 (-380.77; 412.15) (-230.28; 371.82)	 0.9374 0.6411
Low weight gain vs. normal gain	-301.77 (144.827)	(-590.10; -13.44)	0.0405
Excess weight gain vs. normal gain	55.03 (137.407)	(-218.52; 328.59)	0.6899
Supplementation with vitamin/mineral preparations	-232.65 (181.872)	(-594.73; 129.43)	0.2046
Vitamin D consumption	1.72 (2.951)	(-4.15; 7.59)	0.5616
Calcium consumption	5.90 (12.151)	(-18.29; 30.09)	0.6284
Caffeine consumption	-154.11 (138.210)	(-429.27; 121.04)	0.2683
Gestational diabetes	120.94 (176.572)	(-230.59; 472.47)	0.4954
Smoking	57.71 (159.212)	(-259.26; 374.67)	0.7180
Age	10.91 (13.953)	(-16.87; 38.69)	0.4365
Education	-144.76 (125.909)	(-395.43; 105.91)	0.2538
Gravidity	-57.38 (116.065)	(-288.44; 173.69)	0.6225
Professional activity during pregnancy	-60.90 (108.664)	(-277.24; 155.43)	0.5768
Neonatal sex	-28.27 (110.419)	(-248.10; 191.56)	0.7986

Table 5**.** Relationship between selected parameters and neonatal length

Parameter	Regression beta coefficient (SE)	95% CI	p- value
Pre-pregnancy BMI: underweight overweight/obesity	 -0.24 (1.078) -0.09 (0.82)	 (-2.39; 1.91) (-1.72; 1.55)	 0.8247 0.9176
Low weight gain vs. normal gain	-2.44 (0.784)	(-4.01; -0.88)	0.0025
Excess weight gain vs. normal gain	-0.29 (0.744)	(-1.77; 1.19)	0.6970
Supplement. with vitamin/mineral preparations	-0.99 (0.985)	(-2.95; 0.97)	0.3159
Vitamin D consumption	-0.01 (0.016)	(-0.04; 0.02)	0.5247
Calcium consumption	-0.04 (0.066)	(-0.17; 0.10)	0.5936
Caffeine consumption	-0.93 (0.748)	(-2.42; 0.56)	0.2189
Gestational diabetes	0.60 (0.956)	(-1.30; 2.51)	0.5295
Smoking	-0.14 (0.862)	(-1.85; 1.58)	0.8758
Age	-0.03 (0.076)	(-0.18; 0.12)	0.6666
Education	-0.68 (0.682)	(-2.04; 0.67)	0.3199
Gravidity	0.02 (0.629)	(-1.23; 1.27)	0.9740
Professional activity during pregnancy	0.26 (0.588)	(-0.91; 1.44)	0.6548
Neonatal sex	-0.07 (0.598)	(-1.26; 1.12)	0.9122

DISCUSSION

According to our findings, which are consistent with reports – albeit scarce – from other Polish authors, pregnancy weight gain among most pregnant women is either below or above recommendations. Over 42% exceeded and one-fourth did not reach the recommended weight gain for the respective BMI values. *Suliga* and *Adamczyk-Gruszka* reported similar results in their study: weight gain above and below recommendations was observed in 40% and 23% of their subjects, respectively [24]. *Wierzejska* et al., found an even higher number of pregnant women who gained excess weight (48%), especially among subjects who were overweight or obese before conception (61%) [33].

Similar tendencies have been observed also in other regions of the world. In the USA, excess weight gain was reported for 50% of all pregnant women [8, 12], and as many as 64-66% for women with pre-pregnancy overweight or obesity [6, 19]. Weight gain below recommendations was found in 20% of the subjects [12]. In China, weight gain above and below recommendations was reported for 62% and 12% of the pregnant women, respectively [22], and in Australia for 41% and 33% of the pregnant women, respectively [20]. According to a recent meta-analysis of worldwide reports on the matter, including over 1 million pregnant women, weight gain above and below recommendations was detected in 47% and 23% of the subjects, respectively [7]. The abovementioned findings question the applicability and usefulness of weight gain guidelines, which for now seem rather theoretical. Some experts believe that routine weigh-ins for pregnant women during antenatal visits do not address the problem, others claim it still remains the simplest, cheapest and commonly accepted way of focusing public attention on the importance of maintaining healthy weight [16].

Excess maternal weight gain is difficult to explain because studies demonstrate that equally in Poland and in other countries, what is found is rather the insufficient supply of energy during pregnancy [2, 9, 11].

In our study, as in other reports from Poland [1, 15, 27, 33] mean pregnancy weight gain among overweight/obese women is lower than normal-weight women, which is a positive finding. Regardless, it is important to bear in mind that the recommended weight gain decreases with increasing BMI of the subjects in the pre-conception period [31]. The most rigorous weight limits are typically set for obese pregnant women as adipose tissue is a storage of fats which are necessary for proper fetal development and, later on, lactation, and need not be increased during pregnancy. The maximum recommended weight gain for obese women is 7 kg lower than for women with normal BMI. For that reason, most sources report that the percentage of women with pre-pregnancy obesity/overweight whose weight gain during pregnancy is above recommendations – even despite lower weight gain in kilograms – is higher than the percentage of women with normal pre-pregnancy BMI but excess gestational weight gain [1, 19, 33].

In our study, we found a 4-fold higher risk for excess weight gain among active smokers, which is yet another negative consequence of smoking, and the solution proves problematic because, according to the literature, quitting smoking after conception – which is recommended to pregnant women – is associated with a 7-fold higher risk for excess weight gain [25]. Despite the fact that the highest (61%) number of women with weight gain above recommendations was observed among subjects with pre-pregnancy overweight and obesity, no statistically significant relationship between pre-pregnancy BMI and pregnancy weight gain was found, which might be due to a small sample size.

Maternal weight gain below recommendations had a negative impact on the newborn anthropometric parameters (weight, length). Infants born to those mothers were significantly smaller as compared to mothers with normal weight gain. *Szostak-Węgierek* et al., reported similar relationship [27], in contrast to *Wdowiak* et al. [30] *and Berner-Trąbska* et al. [1], who found no correspondence between maternal weight gain and neonatal weight at birth. According to a meta-analysis of worldwide reports, maternal weigh gain below recommendations increases the risk for small for gestational age newborn by 50% [7]. In our study there was no correlation between the anthropometric parameters of newborns and the estimated maternal nutrients intake, as well as supplementation with vitamin/mineral preparations during pregnancy.

It should also be emphasized that, a large percentage of neonatal macrosomia (20%) was found, which was not dependent on any of the factors under analysis. However, literature suggests that the risk of macrosomia is generally two to three times higher in women with excess weight gain [6, 7, 29, 33] and in women with gestational diabetes [10, 32].

Caution is advised when drawing final conclusions as our study was not without limitations, chief among them a small sample size and retrospective nature of the study, including self-reported pre-pregnancy weight. The latter might have affected the credibility of the BMI calculations and the later interpretation, although some authors claim that approximately 90% of pregnant women estimate their pre-pregnancy weight properly [20], which validates such methods of data collection.

CONCLUSION

Pregnancy weight gain in the majority of the subjects was either below or above recommendations, regardless of their pre-pregnancy BMI. Infants born to mothers with insufficient weight gain were smaller than those born to mothers with normal weight gain.

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Conflicts of interest

The authors declare no conflict of interest.

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