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Original article

Lifestyle-induced maternal body composition changes and birthweight in overweight/obese pregnant women

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From the womb to the adult

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Abstract

Introduction: Obesity and excessive gestational weight gain (GWG) have been associated with higher occurrence of large for gestational age (LGA) babies, and several interventions have been proposed to limit GWG, which, however, does not reflect adequately the subtle changes in body composition that happens during pregnancy. The aim of this study is to evaluate if the variations of body composition, induced by a lifestyle program intended to limit GWG and measured through bioelectrical impedence analysis (BIA), could affect the newborns' weight in overweight/obese women.

Methods: One hundred and thirty-nine women with BMI ≥ 25 kg/m^2 were enrolled between 9th-12th week and a lifestyle program, consisting of low glycemic diet with caloric restriction and physical activity, was prescribed to them. BIA was performed at enrolment and at 35th-36th week. Data regarding the newborns' weight were collected from clinical charts after delivery.

Results: Women who exceeded recommended range of GWG had an higher occurrence of LGA babies. Analysing the body composition, fat free mass (FFM) showed a direct correlation with the birthweight centile, even after correcting for BMI at enrolment, age and gestational diabetes mellitus. Interestingly, women who had an increase in fat mass (FM) and visceral FM throughout pregnancy had an higher occurrence of small for gestational age (SGA) babies.

Conclusion: The increase in FM and visceral FM during pregnancy in overweight/obese women is linked to a higher occurrence of SGA babies.

Keywords

Obesity, pregnancy, bioelectrical impedence analysis, body composition, fat mass, small for gestational age.

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Introduction

Both the obesity and the excessive gestational weight gain (GWG) are associated with many unfavorable maternal and neonatal outcomes, either at short and long term [1-4]. The highest BMI categories are strongly associated with the high birth weight and subsequent childhood obesity in the offspring [5], as well as to a decreased risk of small for gestational age (SGA) babies. Moreover, the excessive GWG and gestational diabetes mellitus (GDM) have been defined as independent risk factors for large for gestational age (LGA) babies and macrosomia [6]. Several types of interventions have been proposed to limit the GWG, as recommended by Institute of Medicine [7] none of them emerging as being significantly more effective than others [8].

However, neither BMI, weight nor GWG reflect the subtle changes in body composition during pregnancy [9], namely the fat mass (FM) and fat free mass (FFM), because the GWG itself has to be considered as a composite parameter, since it accounts for the growing products of conception and enlarging uterus beside maternal weight increase.

The evaluation of these components and their modifications could be of the utmost importance during pregnancy, since they can vary on an individual basis, thereby affecting GWG to a variable degree.

Previous studies demonstrated the validity of tetrapolar bioelectrical impedance analysis (BIA) in estimating the body components, especially total body water (TBW) in adults, children, and pregnant women [9-11]. The BIA is a reproducible method that relies on the conduction of an alternate electrical current to determine the total conductor volume of the body [12, 13]. TBW can be used to estimate the FFM and, by the difference with total body weight, the FM.

Ghezzi et al. provided reference ranges for BIA during pregnancy and found impedance indices during the second trimester to be independently related to the birthweight [14]. Moreover, Valensise et al. previously reported a significant reduction in TBW during the third trimester in women who subsequently developed gestational hypertension [15], and recently the same group described a TBW increase in those patients affected by gestational hypertension who were treated with nifedipine [16].

The aim of this study is to evaluate if the lifestyle-induced variation of body composition during pregnancy in overweight/obese women could affect the newborn's weight.

Materials and methods

Study design

This observational study was approved by the local Ethics Committee. All volunteers gave written informed consent prior to the start of the study.

Pregnant women with a pre-pregnancy BMI ≥ 25 kg/m^2, age > 18 years and a single pregnancy were included. Exclusion criteria were: multiple pregnancy, chronic disorders (i.e., diabetes mellitus, hypertension, and untreated thyroid diseases), gestational diabetes mellitus (GDM) in previous pregnancies, a smoking habit, intake of dietary supplements or herbal products known to affect body weight.

Subjects were enrolled between the 9th and the 12th week of gestation at the Obstetric Unit of Policlinico Hospital – University of Modena, and were scheduled for a follow-up visit at 36th week of gestation.

At enrolment weight and height were measured using BIA (TANITA, BC418, Tokyo, Japan) and a stadiometer, respectively. BMI was calculated as weight(kg)/height(m)^2.

Whole and regional body impedance was measured using an eight-polar tactile-electrode BIA (TANITA, BC418, Tokyo, Japan). This instrument makes use of 8 tactile electrodes: two are in contact with the palm and thumb of each hand and two with the anterior and posterior aspects of the sole of each foot. The subject stands with his soles in contact with the foot electrodes and grabs the hand electrodes. No precaution was taken to standardize the subject's posture before BIA, as suggested by the manufacturer. This BIA measured the resistance, at 5, 50, 250 and 500 kHz frequencies, of arms, legs and trunk. Whole-body resistance was calculated as the sum of each segmental resistance (right arm + left arm + trunk + right leg + left leg). We obtained the equivalent FM and FFM (which included body water) in different regions (arms, trunk and legs) and in the whole body. The BIA analyzer computed resistance and reactance, which can be used to calculate the fluid changed in body. Measurements were performed in the morning at room temperature (21°C), after at least 12 hours of rest, and following an overnight fast.

Women were instructed to participate to a healthier lifestyle program during pregnancy including a proper nutrition, as explained below, and a daily mild physical activity as recommended [17, 18].

All women underwent an individualized one-hour counselling session with a dietitian who gave advices and instructions about a proper nutrition and physical. The dietitian also gave to each woman a sample diet, consisting of a Mediterranean style, hypocaloric low fat exchange diet with at least 1,700 kcal/day, that corresponds approximately to the baseline metabolism of a pregnant woman. The primary focus of the dietary intervention was decreasing consumption of foods with a high glycemic index and substituting them with healthier alternatives (fresh fruit and vegetables with low glycemic index). The second goal was to redistribute the number of meals throughout the day including the last snack two hours after dinner in order to avoid nocturnal hypoglycemia.

The entire cohort was administered the 75-g, 2-h oral glucose tolerance test (OGTT) at the 16^{th}-18^{th} week for the diagnosis of gestational diabetes mellitus (GDM). The testing was repeated at the 24^{th}-28^{th} weeks for the women who were negative for GDM by the first testing. The OGTTs were performed in labs outside the clinic.

At 36^{th} week weight was measured and the BIA was performed again, as described before.

The data regarding the delivery and newborn infants were collected from the clinical diaries.

Statistical Analysis

Data are reported as the mean ± SD and ranges for continuous variables or numbers with precentage for categorical variables.

Paired Student's t-test was used to compare continuous variables, such as GWG, FM and FFM measured at first and third trimester. A chi-squared test was used for categorical variables. The Pearson's correlation was used to evaluate the possible correlation between BMI, FM, FFM and the birthweight centile.

We considered p-values less than 0.05 as the threshold for statistical significance. The data were analyzed with SPSS® Statistics software v. 21.0.

Results

One hundred and eighty five women were eligible for the study and 139 of them accepted to participate and completed the study. Age at enrolment was 31.8 ± 4.9 years (20-43), 113 (81.3%) were Caucasian, 86 (61.9%) were nulliparous, 92 (66.2%) had high education, the mean BMI was 34.6 ± 5.7 (25.5-54.6), 81 women (58.3%) with BMI between 30-40 kg/m^2 and 21 (15.1%) with BMI ≥ 40 kg/m^2.

Weight and BIA analysis at enrolment and at third trimester are reported in **Tab. 1**.

Total FM and FFM showed a significant increase throughout pregnancy, while the mean visceral FM remained almost constant.

Table 1. Body composition evaluated by BIA at enrolment and repeated at 36^{th}.

Body composition (kg)	First trimester	Third trimester	p-value
Weight	93.2 ± 15.9	100.8 ± 15.4	< 0.001
FM	40.4 ± 11	44.1 ± 10.5	< 0.001
Arms FM	5.3 ± 2.1	6.3 ± 2.4	< 0.001
Trunk FM	20.2 ± 5.3	20.4 ± 5.2	0.725
Legs FM	15 ± 4.1	16.9 ± 4.5	< 0.001
FFM	53 ± 5.5	57.2 ± 6.1	< 0.001
Arms FFM	5.6 ± 1.2	6.3 ± 2.4	< 0.001
Trunk FFM	28.7 ± 3.1	30.2 ± 4.4	0.001
Legs FFM	18.5 ± 2.8	20.5 ± 2.9	< 0.001

Values are expressed as mean ± SD.
FM: fat mass; FFM: fat free mass.

Mean GWG was 7.8 ± 5.1 kg and 58 women (43.9%) had a GWG exceeding the Institute of Medicine (IOM) recommendations (considering the overweight and obese women having separated ranges). We also found that the total FM increased during pregnancy in 95 (68.3%) cases, while visceral FM alone increased only in 69 (49.6%) cases. In all the remaining cases FM and visceral FM were stable or showed a decrease.

Mean birthweight was 3,448 ± 427 grams, and according to birthweight centile, there were 16 SGA (11.5%) and 9 LGA (6.5%).

BMI at enrolment didn't show any correlation with birthweight and neonatal's centile of weight at birth, and no difference was found in the rate of SGA (birthweight centile ≤ 10^{th}) and large for gestational age (LGA, birthweight centile ≥ 90^{th}) babies between overweight and obese women (**Tab. 2**).

Women with a GWG beyond IOM recommended ranges were 34.5%. The occurrence of SGA in this group (8.3%) was not different respect to the group of women who didn't exceed IOM recommendation (13.2%), while LGA were more represented among the women who had an excessive GWG (12.5% vs. 3.3%; p = 0.036) (**Fig. 1**).

A higher occurrence of SGA babies, on the contrary, was registered among the women who had an increase of FM during pregnancy (16.8% vs. 0%, p = 0.004) and those who had an increase of visceral FM (17.4% vs. 5.7%, p = 0.031), while the occurrence of LGA was not different (**Fig. 1**).

GDM occurred in 39 (28.1%) women. GDM occurrence was higher in obese (33.3%) than in overweight women (13.5%, p = 0.022). Women who developed GDM had babies with significantly higher birthweight (3,573 ± 364 vs. 3,400 ± 337 grams, p = 0.03) and higher occurrence of LGA babies (12.8% vs. 4%, p = 0.05), while occurrence of SGA was not affected (7% vs. 13%).

Table 2. Birthweight distribution between overweight and obese women.

	Overweight (37)	Obese (102)	p-value
Birthweight (g)[a]	3,380 ± 472	3,473 ± 410	0.258
SGA[b]	4 (10.8%)	12 (11.8%)	0.876
LGA[b]	2 (5.4%)	7 (6.9%)	0.758

[a]Values are expressed as mean ± SD; [b]numbers with % in brackets.

Birthweight centile showed a correlation with the variation of FFM during pregnancy (p = 0.006, r = 0.261) while there was no correlation with the variation of FM and visceral FM (**Fig. 2**).

At regression analysis, after correcting for BMI at enrolment, age and GDM, the increase of FFM maintained its relation with the higher birthweight centile (p = 0.003, $R^2 = 0.172$).

Conclusion

In our cohort of women, the birthweight and the occurrence of LGA and SGA babies are unrelated with the pre-pregnancy BMI or the body composition at enrolment. Other authors found

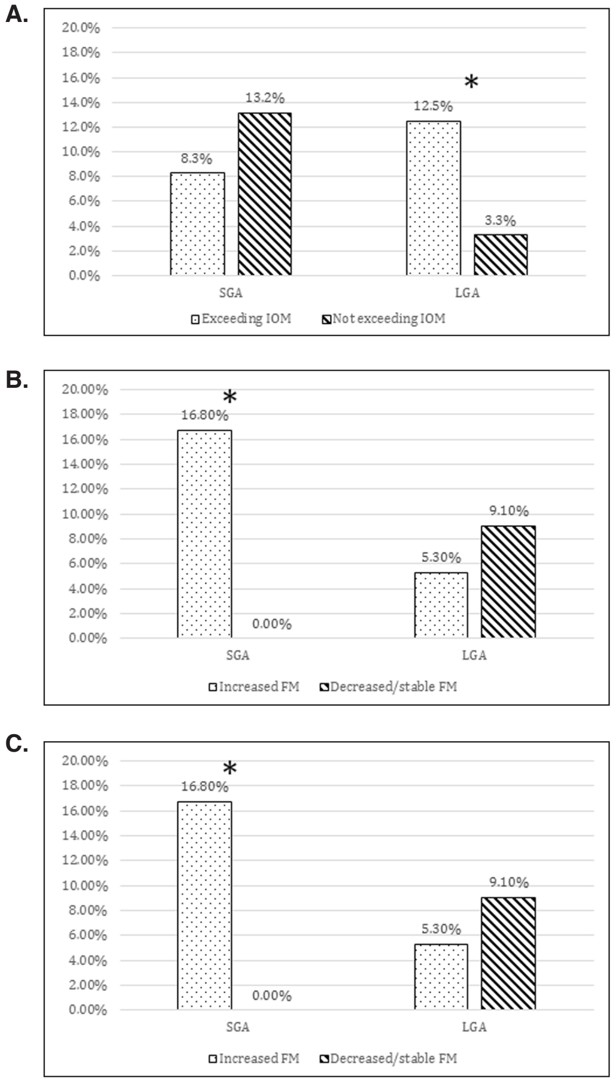

Figure 1. Percentages of small for gestational age (SGA) and large for gestational age (LGA) babies among women with a gestational weight gain (GWG) beyond Institute of Medicine (IOM) recommended ranges (**A**), among women who had an increase of fat mass (FM) during pregnancy (**B**) and among those who had an increase of visceral FM (**C**).

A.

B.

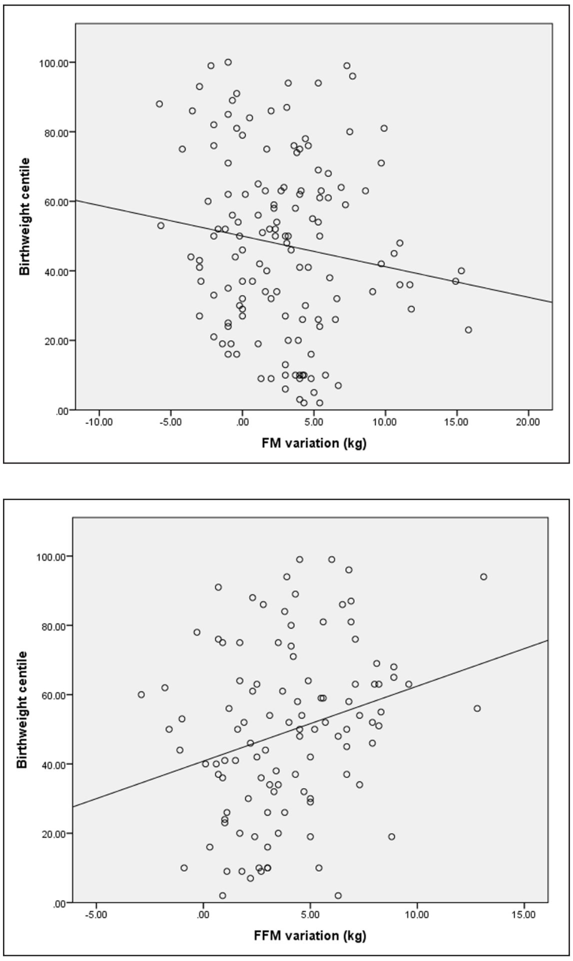

Figure 2. A. No correlation was found between birthweight centile and fat mass (FM) variation. **B.** A positive correlation was found between birthweight centile and fat free mass (FFM) variation (p = 0.006).

that a high pre-pregnancy BMI is a risk factor for delivering LGA babies, decreasing the risk of SGA [5]. However, in our study both GDM and the excessive GWG are associated with an increased occurrence of LGA, in accordance with other reports [5, 6], while they are unrelated with the occurrence of SGA.

Considering that the GWG alone is, in our opinion, an approximate, rough parameter of body change, we measured the FM and FFM through BIA. Our findings indicate that changes in FFM are positively related to the birthweight centile. This could be due to the fact that the large part of FFM changes are justified by the growing foetus, uterus and adnexes. At the best of our knowledge, no other findings are available in the literature to confute or support such conclusion.

FM also increased throughout pregnancy, although with a wide range of individual variation. Indeed, in a significant amount of cases, FM didn't show any increase, or it even showed a reduction. This could be related to the lifestyle intervention prescribed and perhaps to the closer adherence to such advices, in terms of diet and physical activity.

Interestingly, the rate of SGA babies was significantly higher in women who presented an increase in both FM and visceral FM, respect with those without such an increase. Thus, we speculated that the lowest gain of FM could be beneficial for the mother and the foetal growth. Several studies have linked the excessive body fat with a pro-inflammatory status and related endothelial dysfunction, which could be detrimental for the placental function [19, 20]. Abdominal visceral adiposity is associated with the systemic inflammation seen in obesity-induced diseases and have the potential to play a greater role than whole-body adiposity in obesity-related pregnancy complications. In fact, abdominal fat measured by ultrasound has been proven related to higher risk of GDM, cesarean delivery, and fetal macrosomia [21]. The chronic, low-grade, inflammation observed in obese subjects could explain the association we found between the increase in FM and the higher occurrence in SGA babies.

In conclusion, despite obesity is demonstrated as closely related to LGA newborns, our findings suggest that the FM and visceral FM evaluation during pregnancy could be useful in identifying those obese women at higher risk for fetal growth restriction.

Declaration of interest

The Authors report no conflict of interest.

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