DOI:10.35845/abms.2025.2.462

ORIGINAL ARTICLE

Advances in Basic Medical Sciences

Measuring body composition of primigravida females with Bioelcetrical impedence analysis- a randomized control Trial

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ABSTRACT

OBJECTIVES: To evaluate body composition changes (body mass, bone mass, fat mass, hydration, and BMI) during pregnancy in primigravida's using bioelectrical impedance analysis.

METHODOLOGY: A total of 40 primigravida females included in a single-blinded randomized controlled trial conducted in the tertiary care hospitals of KPK. They were further divided into a placebo and lipid based nutritional supplement (LNS)group of 20 each from ≤12 weeks' gestation (first antenatal checkup). Sample size calculation was done using OpenEpi ®software. Whole-body composition was measured with a foot-to-foot eight-electrode, single-frequency bioelectrical impedance analysis (BIA) scale (50 kHz reference) at ≤12 weeks (V1), 16-20 weeks (V2) and postnatally (V3). Data were analyzed using IBM SPSS Statistics (version20).Repeated-measures ANOVA was used to assessed time effects and within group effects. ($\alpha = 0.05$).

RESULTS: Across both groups, a significant time effect was observed for weight ($F = 36.3$, $p < 0.001$; $\eta^2 = 0.51$), BMI ($F = 44.8$, $p < 0.001$; $\eta^2 = 0.57$). Mean weight ($F = 3.180$, $p < 0.048$; $\eta^2 = 0.086$) and bone mass estimate ($F = 3.63$, $p = 0.05$; $\eta^2 = 0.096$) differed between the supplement and placebo groups. Fat-mass and hydration displayed the expected trimester specific trends but did not reach statistical significance after correction.

CONCLUSION: BIA showed reliable changes in weight, BMI, and bone mass during pregnancy. When properly used, it can be a useful tool in routine antenatal settings, especially where resources are limited.

KEY WORDS: Pregnancy; bioelectrical impedance; body composition; bone mass; gestational weight gain; maternal nutrition.

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Submission Date:23-07-2025
Acceptance Date:22-09-2025
Publication Date:31-12-2025

INTRODUCTION

As pregnancy progresses, the mother's body composition significantly changes. [1] In order to comprehend the physiological changes that promote fetal growth and maternal health, it is essential to track the mother's body composition throughout pregnancy.[2] Preeclampsia, gestational diabetes mellitus (GDM), tiny or large for gestational age infants, and later-life metabolic illness are all associated with excessive or insufficient prenatal weight gain. Conventional monitoring of body composition uses BMI and scale weight, which do not differentiate between fat, lean, bone, and water compartments. Bioelectrical impedance analysis (BIA) has become more well-known due to its non-invasiveness, affordability, and ease of use.[3] It can be efficaciously used in both malnourished [4], and obese people.[5] When a pregnant woman has high risk of gestational diabetes mellitus, an evaluation of her body composition can yield crucial hints for the diagnosis. One of the additional examinations used to determine the risk of preeclampsia and gestational hypertension is BIA.[3]

BIA uses a low-level electrical current (<1 mA) to measure the resistance and reactance of bodily tissues, such as fat, bones, and muscle, in order to assess body composition. In BIA impedance rises with fat mass, estimates total body water, bone, fat, lean mass, and basal metabolic rate; measurements should be avoided during dehydration, within 4 hours of meals or fluids, after voiding, or following prolonged exercise.3 Although BIA is regarded as a rapid, pregnancy-safe, and easy-to-use method, it is unable to differentiate between the tissues

This Article may be cited as: Tariq K, Khan H, Inayat B,Zafar H, Sher N.Measuring Body Composition of Primigravida Females with Bioelcetrical Impedence Analysis- a Randomized Control Trail.Adv Basic Med Sci.2025;9(2): 101-106 DOI:10.35845/abms.2025.2.462

of the mother and the fetus .[6] Even so, a significant amount of water is found in the trunk during pregnancy.[7] Pregnant women may therefore benefit from a segmental impedance assessment, especially in the latter stages of pregnancy.[8] Its use during pregnancy necessitates careful interpretation because of fluid shifts and hormonal changes, even though it has been extensively validated in general populations.

BIA has been employed in numerous studies to track changes in chronic renal disease, obesity, malnutrition, and sports training. [9,10] It has been used to assess the effects of hydration levels, nutritional treatments, and gestational weight gain during pregnancy.[7] Because of changes in body conductivity and increased extracellular water, there are still questions over its accuracy during pregnancy, despite its potential. Systematic studies verify that when measuring circumstances are standardized, contemporary multi frequency equipment achieve sufficient reproducibility during gestation.[3]

The benefits of BIA increase during pregnancy because it can be done as frequently as prenatal visits, doesn't expose the patient to radiation, and provides compartmental data like lean mass, bone mass, fat mass, total and extracellular water that traditional weight or BMI can't measure. According to longitudinal cohorts, BIA-derived indices increase in tandem with anticipated plasma volume expansion and can predict newborn birth weight on their own in the second trimester. [11] The distinction of both extracellular and intracellular water shifts that define late pregnancy has been made possible by methodological advancements such multifrequency or segmental procedures, which have further increased precision.[7]

The growing use of BIA in obstetrics is highlighted by recent narrative updates, which range from screening for GDM and hypertensive diseases to tracking the accumulation of maternal fat per trimester.[2] Using direct segmental multi frequency platforms (e.g., InBody270), prospective cohorts show that up to four in-clinic BIA scans may safely track skeletal muscle, adipose tissue, and total body water without ionizing radiation. Postpartum glucose intolerance and future GDM have been independently predicted by the BIA's fat free mass index and early pregnancy phase angle.[12] Chinese case control research showed that phase angle and early gestation fat mass index were independent predictors of later GDM [12], providing a window for preemptive intervention between weeks 24th and 28th , far before the oral glucose tolerance test. Roughly half of prenatal weight growth is explained by trimester-specific decreases in resistance and reactance, which correlate to plasma volume expansion, according to longitudinal data from rural Bangladesh, Sweden, and the USA.[13] Following delivery, postpartum cohorts exhibit upward phase angle shifts as extracellular fluid shrinks and fat-free mass increases.[14]

According to a 2021 narrative review, BIA generates consistent estimates throughout gestation and the postpartum period when followed precisely.[3] However, the lack of bone mass validation information, fluid changes, and device interchangeability continue to be acknowledged constraints. The current study contributes to an expanding body of research demonstrating that BIA is sensitive enough to identify changes in body composition associated with pregnancy, such as weight increase, bone mass, fat mass, and hydration. The longitudinal changes in maternal body composition during pregnancy among our region's pregnant and postpartum women, who are typically underweight and stunted, have low levels of education, and become pregnant for the first time at a young age, have not yet been documented in any study. There is a lack of evidence addressing longitudinal body composition changes among underweight primigravidas in Pakistan using BIA, which is the gap this study addresses.

METHODOLOGY

A Randomized, single-blinded controlled trial was conducted at the main tertiary care hospitals, KPK, Pakistan (2018–2019). Ethical approval no. (DIR/KMU-EB/EH/000453) was obtained from the Ethical Committee of Khyber Medical University. Computer randomizer (Research Randomizer version 3) was used to randomly allocate the participants into two groups. Inclusion criteria was underweight primigravidas aged 18-35 yrs. having a BMI>18.5kg/m2, singleton, ≤12 weeks' gestation, normoglycaemic, no chronic disease or metal implants. Exclusion criteria included females having hyperemesis, pre-existing metabolic, bone disease, oedema at baseline. Written informed consents were obtained. Volunteers were given a 75 g daily lipid-based dietary supplement (MAAMTA) or a placebo for one week following delivery. The placebo consisted of two tablets of artificial sweetener (Canderal)[15], 35 grams of wheat flakes, and 40 milliliters of skim milk, It had 137.8 calories / 75 gms. While the supplement, which was created with peanut butter, had 400 kcal/75 gms of energy.

In this study, body composition parameters—including fat mass, bone mass, and hydration status—were assessed using a bioelectrical impedance device (Beurer GmbH, Soflinger Str. 218, 89077 Ulm, Germany; Art._Nr.748.13, Type BF220). All measurements were consistently taken with the same device throughout the study (Figure I).Prior to measurement, relevant data such as weight, height, parity, gender, and physical activity level were entered into the device. Participants stood upright on the scale with bare feet in contact with the electrodes, arms relaxed at their sides, and eyes facing forward. To minimize variability, participants were instructed to remove additional

S. No	Parameters	Visits	Supplement	Placebo	Group Effect	Time Effect
1.	Weight (kg)	1st	41.68±3.25	42.29±4.27	0.048*	<0.001***
		2nd	46.33±2.91	47.67±3.75		
		3rd	44.61±3.72	48.33±4.28		
2.	Bone mass (%)	1st	31.96±5.98	30.44±4.32	0.05*	0.103
		2nd	35.52±5.66	30.72±5.30		
		3rd	32.42±5.42	31.98±6.59		
3.	Body fat (%)	1st	25.66±5.40	24.02±5.53	0.920	0.409
		2nd	26.77±5.53	24.67±4.29		
		3rd	25.25±5.55	23.88±4.14		
4.	Hydration (%)	1st	50.81±7.06	53.97±6.15	0.51	0.22
		2nd	50.18±6.33	50.79±5.02		
		3rd	50.81±6.25	52.64±5.84		
5.	BMI(kg/m2)	1st	17.33±1.20	17.0±1.25	0.634	<0.001***
		2nd	19.97±2.26	19.09±2.19		
		3rd	20.19±2.09	19.55±2.26		

Table 1: Body composition measured by using BIA at different visits

clothing and accessories such as abayas, sweaters, socks, and jewellery. All measurements were conducted under standardized conditions, in a fasting state, and at a consistent time of day for every participant.

Data was organized on Microsoft Excel version 21. Statistical analysis was performed using version 20 of IBM SPSS ®. Standard deviation and Normality was determined using Shapiro-Wilk test. Greenhouse-Geisser correction applied if sphericity violated. Repeated measure ANOVA was used to evaluate within-subject (time) and between-group (supplement vs placebo) effects between the visits. A $p < 0.05$ was considered statistically significant.

RESULTS

No significant difference was observed between LNS and Placebo groups with respect of weight, bone mass, body fat & hydration at baseline visit. On second visit, there was a significant difference in bone mass in the LNS group; 35.52 ± 5.66% vs Placebo group ;30.72 ± 5.30%,P- value;0.05). while no significant difference was seen between the two groups in respect of weight, BMI, body fat, hydration. During the postnatal visit, there was a highly significant difference in the Placebo group in respect to weight as compared to the LNS group(LNS:44.61 ± 3.72kg and Placebo group; 48.33 ± 4.28kg, P-value:0.048). A two-way repeated measures ANOVA revealed a statistically significant effect of time on the participants' body mass index (BMI), F ratio (F)(2, 68) = 44.8, P-value < 0.01, Partial eta squared (ηp^2) = 0.57, indicating notable changes over the study period. However, the within-group effect of supplementation on BMI was not significant, F(2, 68) = 0.45, P-value = 0.634, ηp^2 = 0.013. Furthermore, the between-subjects test showed that supplementation accounted for only 3.9% of the variance in BMI, which was not statistically significant (P-value = 0.250).The two-way repeated measures ANOVA indicated a highly significant effect of time on participants' weight, F(2, 68) = 36.32, P < 0.01, ηp^2 = 0.51. A marginally significant within-group effect of supplementation on weight was observed, F(2, 68) = 3.180, P = 0.048, ηp^2 = 0.086. The between-subjects analysis showed that supplementation explained 9.5% of the variation in weight, which approached but did not reach statistical significance (P = 0.067).The two-way repeated measures ANOVA demonstrated that there was no significant effect of time on participants' body fat percentage, F(1.62, 55.1) = 0.85, P = 0.12, ηp^2 = 0.025. Likewise, the within-group effect of supplementation on body fat was not significant, F(1.62, 55.1) = 0.083, P = 0.88, ηp^2 = 0.002. The between-subjects analysis revealed that supplementation explained only 4.6% of the variation in body fat, which was also not statistically significant (P = 0.210).Results from the two-way repeated measures ANOVA indicated no significant effect of time on participants' hydration status, F(2, 68) = 1.53, P = 0.22, ηp^2 = 0.043. Similarly, there was no significant within-group effect of supplementation on hydration, F(2, 68) = 0.66, P = 0.51, ηp^2 = 0.019. The between-subjects analysis showed that supplementation explained only 3.8% of the variance in hydration, which was not statistically significant (P = 0.252).The two-way repeated measures ANOVA indicated that there was no significant effect of time on participants' bone mass, F(1.3, 46.7) = 2.59, P = 0.103, ηp^2 = 0.071. However, a significant within-group effect of supplementation on bone mass was observed, F(1.37, 46.7) = 3.63, P = 0.050, ηp^2 = 0.096. The between-subjects analysis

Figure 1 - Portable Bioelectrical impedance scale used in this study

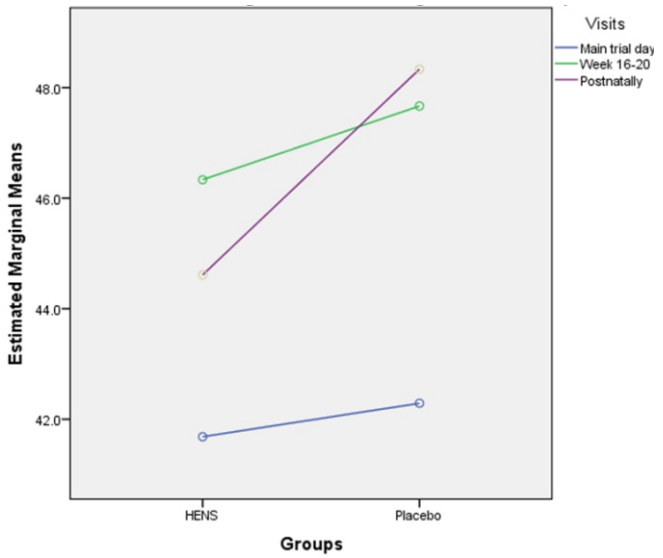

Figure 2 - Estimated Marginal Means of Weight of the Participants

showed that supplementation explained 5.6% of the variation in bone mass, which was not statistically significant (P = 0.166).

DISCUSSION

The current paper seeks to demonstrate the usefulness of BIA during pregnancy through an analysis of data gathered at three gestational time periods in a group of primigravidas who received nutritional supplements or a placebo. Also, these findings need to be contextualized in light of the available data that support or refute the routine use of BIA in obstetrics.

According to serial BIA investigations employing segmental In Body platforms, which show BMI 2.5–3.2 kg m² increases by 36 weeks in women of normal weight, the amount of the BMI growth (~3 kg) is

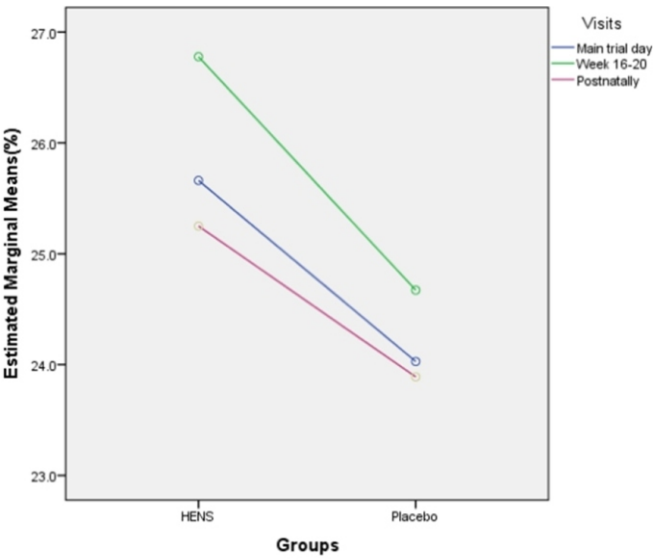

Figure 3 - Estimated Marginal Means of Body fat of the Participants

consistent with these findings.[3] Bangladeshi women's declining resistance and reactance (In BIA, resistance reflects opposition to current flow through body fluids, while reactance indicates the capacitive effect of cell membranes and tissue interfaces) in late pregnancy also match our hydration-adjusted profiles.[13] The average weight gain during pregnancy for our subjects is less than the weight gain recommended by the Institute of Medicine i.e; Total recommended gain (all trimesters): 12.5–18 kg (28–40 lbs). [16] In comparison to a study conducted by Marie Lof et al. on pregnant women utilizing BIA, in which the participants gained approximately 7 kg by 32 weeks above the recommended weight, our ladies acquired roughly 5 kg during the first 20 weeks of pregnancy.[7] Which was within the normal range for most women, especially if she started pregnancy at a healthy or underweight BMI.[17]

In their study [7], average hydration, when the subjects were measured prior to the third trimester of pregnancy, matched well with equivalent data obtained using the reference methodology [isotope dilution techniques (^2H_2O and bromide dilution)]. However, compared to van Marken Lichtenbelt et al.'s findings in a group of young, healthy women, the Bland and Altman comparison revealed that the limits of agreement for hydration (TBW) were somewhat wider.18 However, there was no discernible change in our participants' levels of hydration based on time or the group×time impact. Given that a recent study found that the degree of body fatness influences the accuracy of BIA, this is most likely because their patients had more variation in their body weight and BMI than our subjects. [19] Additionally, the two research' populations differed. Therefore, in contrast to our participants, who were underweight, their individuals varied more in terms of body fat content before to pregnancy and also experienced higher gestational weight gains. [7]

A few researchers have used BIA to study bone mass (BM) during

pregnancy. In the third trimester, Lukaski et al. showed a steady phase angle but a diminishing reactance, suggesting changes in mineral density but providing no precise BM values.[20] The fact that BM increased among the group indicated that BIA might offer a secure substitute for dual-energy X-ray absorptiometry (DXA). [10] In this context, It is important to remember that Earthman et al. presented proof that BIA could reliably measure variations in body cell mass in HIV-infected patients. [21]

In contrast to a study by Rodríguez Atristain et al. [22], which showed an increase in body fat deposition and in TBW quantity in each pregnancy trimester in a sample of Mexican women, the current study found no statistically significant time(P-value;0.409) or group(P-value;0.920) influence on body fat. However, it's possible because the pregnant women in our study were underweight and malnourished.

Clinically, early risk categorization is made possible by the incorporation of BIA into regular prenatal consultations. Later gestational hypertension has been associated with elevated total body water values during the first trimester [23] , additionally, increased adipose tissue growth may be linked to premature birth, GDM, fetal macrosomia, and an increase in Caesarean sections [22], while larger extracellular to total body water ratios in twin pregnancies may indicate fluid retention issues.[24] All these findings suggesting that a simple screening threshold could flag women who might benefit from targeted lifestyle counseling.

Limitations: Bone-mass estimates were not cross-checked against DXA for device validity. The findings of this study may not extrapolate to multiparas or high-risk pregnancies. No long-term follow-up were made and also neonatal outcomes and postpartum composition were beyond the trial's scope.

Clinical implications: Single -frequency BIA should be adopted as part of routine antenatal visits where DXA is unavailable, ensuring strict protocoled (fasting, same time-of-day, voided bladder). BIA-derived bone-mass against DXA across trimesters should be validated. Links between maternal BIA metrics and neonatal bone density, growth, and metabolic markers should be investigated.

CONCLUSION

Bio electrical impedance analysis successfully detected statistically significant changes in weight, BMI, and bone mass during pregnancy. When used with a standardized protocol like ensuring a fasting state, an empty bladder, and consistent device usage, BIA can serve as a practical and affordable alternative to more advanced methods, especially in resource-limited, non-emergency antenatal settings.

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CONFLICT OF INTEREST

Author declared no conflict of interest

GRANT SUPPORT & FINANCIAL DISCLOSURE

Author declared no specific grant for this research from any funding agency in the public, commercial or non-profit sectors

AUTHORS CONTRIBUTIONS

KT: Conception, Design of the work, Data collection on, and Drawing, Reviewed, Final approval, Agreement to be accountable

HK: Conception, Design of the work, Acquistion on, Data Analysis, and Drawing, Reviewed, Final approval, Agreement to be accountable.

BI: Conception, Design of the work, Interpretation on of data for the work, and Drawing, Reviewed, Final approval, Agreement to be accountable.

HZ: Conception, Design of the work, Data collection on, and Drawing, Reviewed, Final approval, Agreement to be accountable .

NS: Conception, Design of the work, Data analysis, and Drawing, Reviewed, Final approval, Agreement to be accountable

DATA SHARING POLICY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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