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Impact of Pre-pregnancy Body Mass Index on Neonatal Outcome

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ABSTRACT

Background: Pre-pregnancy body mass index (BMI) during the gestation period is a major factor that predicts fetal weight and development. It is also positively associated with an increase in fetal head circumference and femur length. To assess the impact of pre-pregnancy BMI on neonatal anthropometry

Methods: This multicenter observational study was conducted from July 2010-July 2011. A total of 1,000 mothers were enrolled, and their antenatal records were screened for pre-pregnancy weight, height, and other details. They were assigned to four categories as per their BMI: underweight: BMI<18.5kg/m2, normal:18.5-24.99kg/m2, overweight: 25-29.9kg/m2, and obese: ≥30kg/m2 group. The neonatal anthropometric measurements and other information were retrieved from the neonate's files. Neonates who were admitted to the neonatal intensive care unit (NICU) were followed till their discharge from hospital or mortality.

Results: Out of 1,000 cases, 170 (17%) belonged to underweight, 224 (22.4%) to overweight, 86 (8.6%) to obese, and 520 (52%) to the normal group. Overweight and obese women were at a higher risk of developing gestational diabetes mellitus, hypertensive complications during pregnancy, and undergoing cesarean sections. They also had a higher risk of delivering large for gestational age and post-term neonates, whereas underweight women had a significantly higher risk of delivering small for gestational, low birth weight, and premature newborns. Furthermore, a positive correlation was observed between maternal BMI and neonatal anthropometric measurements.

Conclusion: As evidenced by the obtained results**,** both low and high pre-pregnancy BMI is associated with adverse maternal and perinatal outcomes.

Keywords: BMI-Body mass index, Neonatal outcome, Pre-pregnancy

Introduction

The pre-pregnancy body mass index (BMI) during the gestation period is a major factor that predicts fetal weight and development (1, 2). It is also positively associated with an increase in fetal head circumference and femur length (1, 2). The birth size and postnatal growth also affect the health of children later in life. Neonatal anthropometry is a rapid, inexpensive, and non-invasive method for monitoring growth and assessing nutritional status in newborns (3). The detection of causes of low birth weight (LBW) and preterm birth remains the most important goal in developing countries where the proportion of LBW neonates is higher (4).

Despite the large body of literature on maternal BMI and maternal-fetal outcomes, there is a paucity of data from the Indian subcontinent where malnutrition is very much prevalent, especially among women and children (4). Nutrition extremes in women adversely affect their children. Obesity is emerging as a major health problem, escalating into an epidemic at least in the rich urban society of India where approximately 8% and 26% of pregnant women are obese and overweight, respectively (5). Maternal obesity is strongly correlated with adverse pregnancy and perinatal outcomes, including hypertensive complications, longer gestation, higher rates of cesarean section, postpartum hemorrhage, birth defects, fetal macrosomia, and increased rate of neonatal intensive care unit (NICU) admissions (4, 5, 6, 7, 8,

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9, 10, 11).

Obesity can lead to undiagnosed diabetes and hyperglycemia, resulting in an increased risk of congenital malformations (8). Obesity is also associated with nutritional deficiency, particularly of folic acid, which may lead to neural tube defects and other congenital malformations observed in neonates of these mothers (8). On the other hand, maternal undernutrition in early pregnancy has detrimental effects both on the mother and fetus. It is the leading risk factor for some adverse outcomes, including maternal anemia, LBW, preterm birth, small for gestational age (SGA), and stillbirths (11,12,13,14,15,16). Therefore, the nutritional status of women has a key role to play in determining the perinatal outcome.

Preterm birth has consistently been associated with low maternal pre-pregnancy weight; nonetheless, its relationship with high pre-pregnancy weight is inconsistent, complex, and influenced by race/ethnicity, gestational age, and parity (17, 18, 19, 20). Since obesity is a modifiable variable, the causative role of maternal obesity in preterm births needs to be thoroughly investigated so that this information can be incorporated into strategies aimed at the mitigation of preterm births. In light of the present study, the present prospective study aimed to delve into the relationship between maternal BMI and anthropometry of newborns in a sample of Indian mothers.

Methods

This multi-center observational study was conducted at Swaroop Rani Nehru Hospital, Kamala Nehru Hospital, S.N. Children Hospital and Nazareth Hospital, Uttar Pradesh, India from July 2010-July 201. Both public and private hospitals were selected to ensure the uniform distribution of mothers of each BMI strata in the study. The Institutional Ethical Committee approved the study protocol. A total of 1,000 mothers with spontaneously conceived singleton pregnancies were enrolled within 48 h of delivery during the data collection period from August 2010-February 2011. They were recruited consecutively every three days on duty days of the author (AB) .

The pre-pregnancy records were screened for required data, and a structured medical history was taken. The following data were extracted: age, body height, weight before and during pregnancy, parity, mode of delivery, gestational age at delivery, urine dipstick results, blood dextrose values, blood pressure readings, and details related to gestational morbidity if present. If the pre-pregnancy weight was not available, the weight on the first antenatal visit was recorded, provided that the first visit was within 3 months of conception. If the height record was not available, it was measured at the time of enrolment. The exclusion criteria were as follows: unavailability of antenatal records, presence of chronic medical illnesses before pregnancy, use of anticonvulsant drugs during pregnancy, and giving birth to neonates with recognizable chromosomal malformations.

Neonatal data was also collected their medical files within 48 h after birth, and the following information was noted: birth weight, crown heel length, head circumference (taken after 24 h after birth), gestation in weeks, weight for gestational age, gross congenital and chromosomal malformations, need for resuscitation at birth, the five-minute Apgar score, and the need for neonatal intensive care unit (NICU) admission. Newborns admitted to NICU were followed, and their outcome was recorded in terms of discharge or mortality. The BMI was calculated as maternal weight [kg]/ maternal height [m]2 and divided into underweight: BMI<18.5kg /m2, normal/control group 18.5-24.99kg/m2, overweight: 25-29.9kg/m2 and obese: ≥30kg/m2 group (21). Newborns exhibiting a birth weight below the 10th percentile on Fenton's gender-specific chart were regarded as SGA, and those above the 90th percentile were considered large for gestational age (LGA).

Aims and Objectives

The primary objective of the present study was the assessment of the impact of pre-pregnancy BMI on neonatal anthropometric parameters. Secondly, the study aimed to find the association of pre-pregnancy BMI and maternal medical complications during pregnancy with neonatal morbidity and mortality. The following maternal medical and neonatal complications were assessed: gestational diabetes, hypertensive complications (gestational hypertension and pregnancy-induced hypertension), the incidence of cesarean section, preterm delivery, neonatal death, congenital malformations, low birth weight, macrocosmic, small and large for gestational age babies, need for resuscitation at birth with low 5-min Apgar score (< 7), and risk of NICU admission.

Statistical Analysis

Data were analyzed in SPSS software (version 17). Qualitative data were analyzed by using chi-square or Fisher exact, while continuous data were analyzed by student's t-test. The associations of maternal BMI with maternal and fetal parameters were assessed by multivariate logistic regression analysis adjusted for maternal age, smoking, educational status, full antenatal care (4 or more antenatal visits, at least one tetanus toxoid (TT) injection, and consumption of iron-folic acid (IFA) for a minimum of 100 days in India), parity, neonate's gender, and gestational age. These covariates were selected based on literature describing the influence of these parameters on pregnancy outcomes. A 5% significance level was taken. The Pearson correlation test was used to obtain the correlation between maternal BMI and neonatal anthropometric measurements. The provided odds ratios used mothers with normal BMI as references.

Results

According to BMI, mothers were assigned to four categories; Underweight (n=170;17%), Overweight (n= 224; 22.4%), Obese(n= 86; 8.6%) and healthy group (n=520; 52%). A significant positive correlation was detected between maternal BMI and neonatal anthropometric parameters, such as birth weight, length, and head circumference. The result of the Pearson correlation test is depicted in Table 1, and scatter plots of maternal BMI and neonatal anthropometric parameters are displayed in figures 1, 2, and 3. The results of logistic regression analysis to assess the impact of pre-pregnancy BMI on maternal and neonatal outcomes are illustrated in Table 2 The incidence of hypertensive complications (pregnancy-induced hypertension and preeclampsia) was 3-4 fold higher in overweight and obese mothers, while underweight mothers were not significantly different from normal-weight mothers. The risk of developing gestational diabetes was two times higher in obese mothers, as compared to that in normal-weight mothers. Regarding obstetric outcomes, overweight and obese mothers were more likely to undergo a cesarean section, as compared to mothers with normal BMI, whereas for underweight mothers, such association was not detected. Underweight mothers had an increased risk of delivering low birth weight and SGA neonates; almost twice that.

Table 1. Correlation between pre-pregnancy body mass index and neonatal anthropometric parameters, including birth weight, length, and Head circumference

Anthropometric parameter	Correlation coefficient	P-value *
Birth weight	0.31	< 0.01*
Length (Crown heel length)	0.23	<0.01*
Head circumference	0.25	< 0.01*

* = P< 0.05

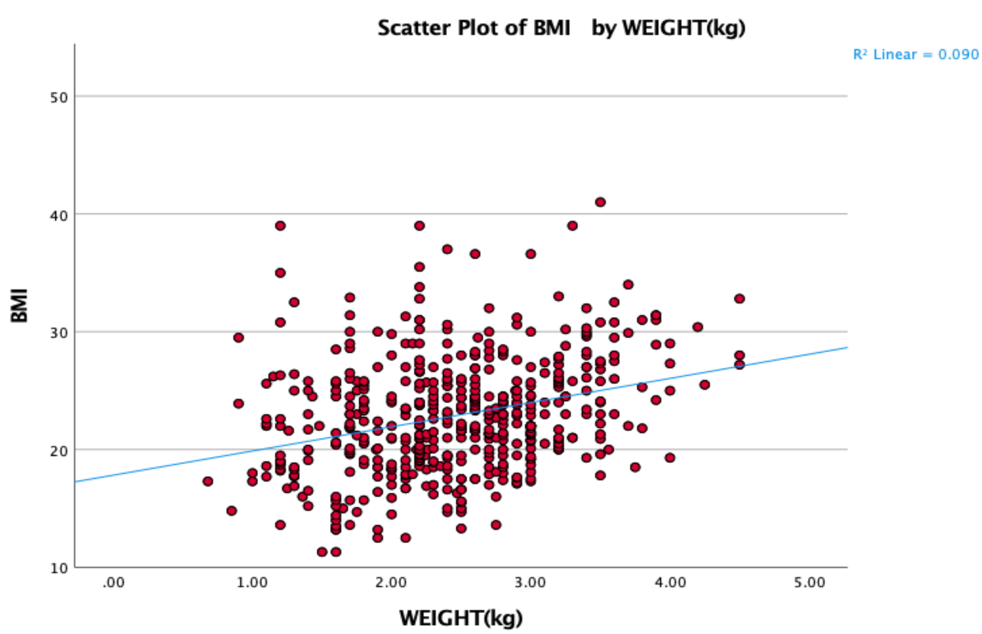

Figure 1. Scatter plot of maternal body mass index and neonatal birth weight

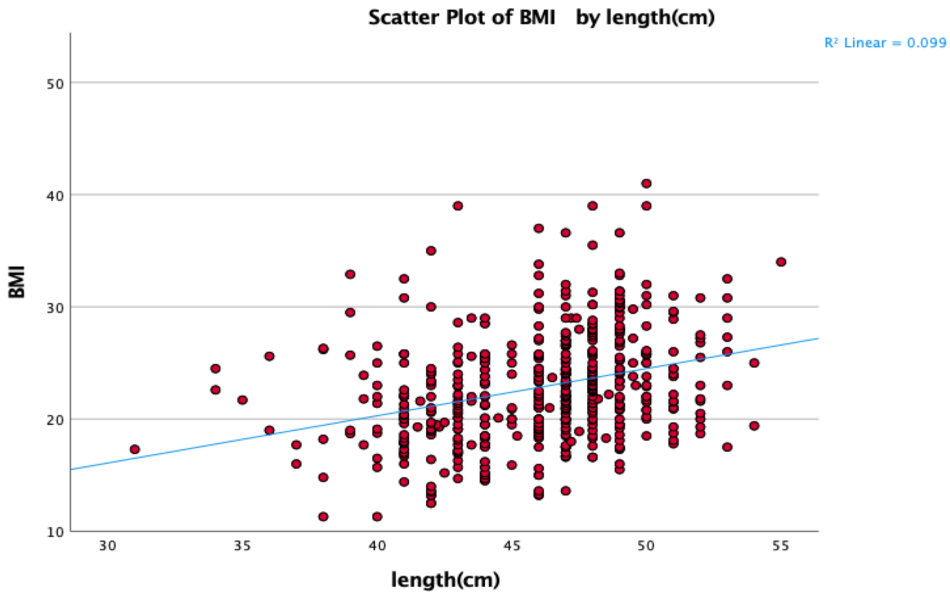

Figure 2. Scatter plot of maternal body mass index and neonatal length

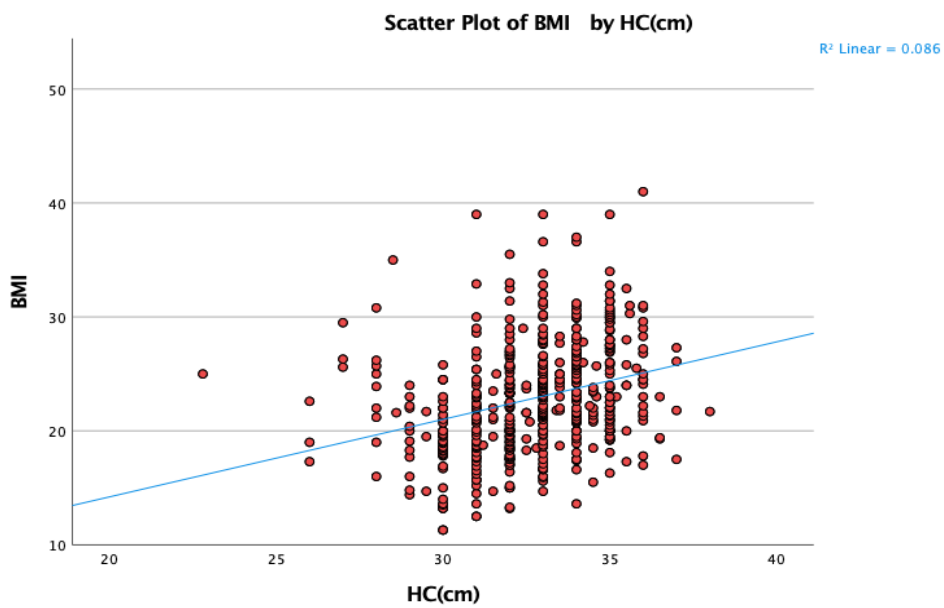

Figure 3. Scatter plot of maternal body mass index and neonatal Head circumference

of normal-weight mothers, whereas overweight and obese women had a significantly increased risk of delivering macrosomic (birth weight >4000g) and LGA newborns.

Underweight mothers had a markedly elevated risk for preterm delivery (OR:1.9), whereas overweight and obese mothers were demonstrated to have a high risk for post-term delivery. The percentage of newborns requiring NICU admission was significantly higher in neonates born to underweight women. The percentage of newborns with congenital malformations was highest in obese mothers; nevertheless, it was statistically insignificant. The neonates born to obese mothers were three times more likely to require resuscitation at birth with low APGAR scores, as compared to those born to mothers with normal BMI. The risk of neonatal mortality was significantly higher (OR=3.2) among the newborns delivered to underweight women, as compared to mothers with normal BMI.

Table 2. Pre-pregnancy body mass index and maternal and neonatal outcomes

	Underweight n (%) 170 (17)	Overweight n (%) 224 (22.4)	Obese n (%) 86 (8.6)	Normal BMI n (%) 520 (52)
Maternal and Neonatal complications n (%) OR (95%CI)				
GDM	20 (12) 0.34 (0.20-0.55)*	72 (32) 1.2 (0.8-1.7)	40 (46) 2.2 (1.4-3.5)*	148 (28)
Hypertensive complications	5 (3) 0.49 (0.18-1.3)	29 (13) 2.4 (1.4-4.2)*	18 (21) 4.3 (2.3-8.2)*	30 (5.8)
Caesarian section	76 (45) 0.48 (0.34- 0.69)*	164 (73) 1.6 (1.2-2.3)*	68 (79) 2.3(1.3-3.9)*	324 (62)
Preterm births	40 (23.5) 1.9 (1.2-2.9)*	30 (13.4) 0.96 (0.60-1.5)	16 (19) 1.4 (0.78-2.6)	72 (13.8)
Post term births	0	4 (1.8) 1.8 (0.49-7.0)	6 (7) 7.7 (2.3- 25.9)*	5 (0.96)
LBW	90 (52.9) 2.0 (1.5- 2.9)*	58 (25.8) 0.65 (0.46-0.92)*	26 (30.2) 0.80 (0.49-1.3)	182 (35)
Macrocosmic babies	0	4 (1.8) 9.4 (1.0- 84.1)*	3 (3.5) 18.7 (1.9- 182.5)*	1(0.2)
SGA	58 (34.1) 2.9 (1.9-4.4)*	26 (12) 0.74 (0.46-1.2)	9 (11) 0.66 (0.32-1.4)	78 (15)
LGA	6 (3.5) 0.37 (0.16- 0.89)*	28 (12.5) 1.4 (0.89-2.4)	22 (25.5) 3.5 (2.0-6.2)*	46 (8.8)
Congenital malformations	16 (9.4) 1.3 (0.71- 2.4)	19 (8.5) 1.2 (0.66-2.0)	14 (16) 1.2 (0.66-2.0)	38 (7.3)
Low APGAR score at 5 min	11 (6.5) 0.71(0.36-1.4)	29 (13) 1.5 (0.93-2.5)	16 (18.6) 2.3 (1.3-4.4) *	46 (8.8)
NICU Admission	51(30) 2.5 (1.3-4.8)*	38 (17) 1.4 (0.95-2.0)	19 (22) 1.4 (0.95-2.0)	122 (23.4)
Neonatal mortality	16 (9.4) 3.3 (1.6-6.7)*	12 (5.3) 1.7 (0.82-3.8)	5 (5.8) 1.9 (0.69-5.4)	16 (3.1)

GDM: Gestational Diabetes Mellitus, LBW: Low birth weight, SGA: small for gestational age, LGA: large for gestational age; *= P<0.05

Discussion

The present study assessed the impact of pre-pregnancy BMI on maternal and neonatal outcomes, revealing that both lean and overweight/obese mothers are associated with adverse pregnancy outcomes, as compared to mothers with normal BMI. Moreover, in line with the literature, the results of this study indicated that increased maternal BMI was associated with an increased risk of gestational diabetes and hypertensive complications in pregnancy (4,8,9,20). The higher incidence of cesarean section was also observed in overweight and obese mothers possibly due to fetal macrosomia and associated cephalopelvic disproportion, fetal distress, and obstructed labor. As a result, the neonates born to obese mothers were found to be three times more likely to require resuscitation at birth, along with low APGAR scores, as compared to those born to healthy mothers (4,8,9,20,22).

Even in the absence of macrosomia, these mothers were at a higher risk of undergoing caesarian which can be ascribed to an obesity-related increase in soft tissue in the pelvis that narrows the pelvic outlet, as well as the negative effect of poor pelvic and abdominal tone on fetal position (23). A multicenter study carried out in rural India and Pakistan has reported similar adverse maternal, perinatal, and neonatal outcomes of high BMI in early pregnancy [4]. In terms of the risk of congenital malformations with elevated BMI, the neonates born to overweight mothers were found to have an increased risk of developing congenital malformations, while no such association was observed in obese mothers, and this may be attributed to inadequate power/sample size of the obese mother group.

Stothard et al. performed a systematic review to assess the relationship between elevated maternal BMI and the risk of congenital anomaly in offspring and found that maternal obesity was associated with an increased risk of a range of structural anomalies (10). The association between elevated maternal BMI and preterm delivery remains controversial. Some studies suggested that women with higher BMI have either the same or lower risk for preterm birth, as compared to normal-weight women, while the majority of studies and systematic reviews indicated that these women have an increased risk for preterm birth (12,17,18,19).

In the current study, it was found that mothers with high BMI were at a significantly higher risk of carrying pregnancy beyond term gestation, leading to post-mature delivery, whereas underweight women were found to have a higher risk of preterm delivery. The role of excessive maternal leanness in preterm delivery is well established in the literature, while that of elevated BMI is still controversial (12, 13, 14, 15). The mechanism underlying longer gestation in overweight and obese women is unclear; nonetheless, endocrine factors involved in the initiation of labor may be altered in these women since adipose tissue is considered to be a hormonally active tissue (12,24).

The finding of the present study was in contrast to what the majority of recent studies have shown; therefore, more adequately powered studies are warranted in the future to provide insights into the association between elevated maternal BMI and preterm births. In agreement with previous studies, the other extreme of malnutrition (i.e., undernutrition) in mothers was found to be associated with an increased risk for giving birth to LBW and SGA neonates (12,14,15,20). Underweight women with nutrient deficiency fail to provide adequate nutrition to the growing fetus in utero, leading to the delivery of LBW and growth-restricted neonates.

Salihu HM et al. analyzed the association between the severity of pre-pregnancy undernutrition and the risk of neonatal birth weight. They found that the risk of LBW and very low birth weight (VLBW) neonates increased in a dose-effect fashion with increasing severity of undernutrition, (16). The risk of mortality during the first 28 days of life was also significantly higher in neonates born to these underweight mothers corresponding to a higher prevalence of LBW, SGA, and premature birth which are known risk factors for neonatal mortality. Previous studies have pointed out that both extremes of malnutrition, undernutrition, and obesity before and during pregnancy were associated with an increased risk of their offspring's mortality during the first 28 days of life (4, 14, 25, 26).

In the current study, the neonates born to underweight mothers exhibited a significantly increased risk of being admitted to a neonatal ward, whereas mixed kinds of results were observed in the literature. Some studies suggested that the neonates born to underweight mothers were at risk, while some others demonstrated that the neonates born to obese mothers had a higher risk of being admitted to the neonatal ward (4, 14, 27, 28). Moreover, no significant association was detected between elevated maternal BMI and the risk of neonatal admission which may be ascribed to the small number of patients in the high BMI group. The nutritional status of mothers has a definitive impact on fetal growth which is reflected in neonatal birth weight, length, and head circumference.

A positive correlation was found between maternal BMI and neonatal anthropometric parameters, including birth weight, length, and head circumference. Nonetheless, the correlation was small, signifying that the extreme of malnutrition in either way could interfere with fetal growth and development (29). Among the notable strengths of the present study, we can refer to the inclusion of cases from both public and private hospitals to ensure the uniform distribution of mothers of each BMI strata in the study. In our country, the problem of obesity is more prevalent in people from the affluent class who prefer to visit private hospitals for medical support, whereas mothers from lower and middle socioeconomic classes where there is much poverty and malnutrition prefer to visit public sectors.

Every study has some limitations which should be addressed. Regarding the limitations of the present research, it should be stated that this study was performed before the release of the new BMI classification for Asian people which has a lower cutoff for overweight and obese categories, compared to the World Health Organization (WHO) classification (30). Its use in the Asian population is associated with a better correlation between obesity and disease manifestation, compared to WHO classification. A recent study from Low and Middle-income countries (LMICs) has pointed to an increased risk of adverse perinatal and maternal outcomes with higher maternal BMI (4). Therefore, further studies are needed to assess the association between high maternal BMI and neonatal outcomes using revised BMI classification in the Asian population to find out the effective ways to mitigate the increasing threat of overweight and obesity among pregnant women and their neonates in LMICs. The results of the present study suggested that both low and elevated pre-pregnancy BMI lead to adverse maternal and perinatal outcomes, emphasizing the importance of the good nutritional status of women before and during pregnancy for the achievement of healthy pregnancy outcomes.

Conclusion

As evidenced by the obtained results, it can be concluded that pregnancy complications related to maternal BMI are a growing problem. Both underweight and obese mothers carry an increased risk of adverse perinatal outcomes. Given the major economic and medical consequences of pregnancy in these women, all attempts should be made to maintain a normal BMI in women of childbearing age. Pre-pregnancy counseling, health programs, and appropriate multidisciplinary management should be put on the agenda.

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Statement of Ethics

The mother-infant dyad was enrolled in the study after obtaining written informed consent from mothers. The study protocol was approved by the Moti Lal Nehru Medical College Ethical Committee.

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Conflicts of interest

The authors have no conflict of interest to declare.

Availability of data and materials

The datasets used and /or analyzed during the current study are available from the corresponding author on request**.**

Author Contributions

RR- contributed to the conception, revised the manuscript AB- drafted the manuscript and contributed to acquisition, analysis, and interpretation

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