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RESEARCH

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Neonatal anthropometric measurements and its relation to maternal anthropometry and demographics

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Abtsract

Background Healthy pregnancy and maternal health status influence fetal growth. Studies linking maternal and neonatal anthropometry showed confounding results.

Objectives To study the relationship between maternal and neonatal anthropometry.

Methods This cross-sectional study included 491 full-term healthy newborns born to healthy mothers with uncomplicated pregnancy. Neonatal and maternal anthropometric measurements as well as detailed perinatal history were recorded.

Results Third trimester weight, body mass index (BMI), and mid upper arm circumference (MUAC) were positively related to neonatal birth weight (BW), length and head circumference (HC) ($p < 0.001$ for all of them except for MUAC with length, $p = 0.021$). Maternal education was inversely related to BW ($p = 0.031$) and positively related to HC ($p = 0.001$). Consanguinity had a positive relation to HC ($p < 0.001$).

Conclusions Maternal 3rd trimester weight, MUAC, BMI, education, and consanguinity can be related to different neonatal anthropometric measurements.

Keywords Maternal anthropometry, Education, Neonatal anthropometry

Background

Anthropometry is a non-invasive, easy, and cheap simple measurement of different lengths, widths, skinfolds, and circumferences of the human body for the purpose of evaluation of the body sizes and proportions [1].

Especially in developing countries, the anthropometric indicators can be of great help due to being non-invasive, easy to perform and cheap [2]. Birth weight and length are the most widely used measurements just after birth [3]. Smaller neonates are at higher risk of several morbidities and mortality [4]. Maternal health and nutrition as well as environmental influences and antenatal care have been linked to neonatal birth weight in some studies [2]. Educational status and different sociodemographic parameters have a direct impact on maternal health, nutrition and body composition [5]. Simple antenatal indicators of neonatal size could greatly affect the neonatal outcome especially in developing countries where access to specialized health services may be difficult.

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Methods

This study included 491 healthy full-term newborns (≥ 37 weeks of gestation) born at Obstetrics hospital, Cairo University to healthy mothers (with no preexisting illness, pregnancy-associated illness, or complication) who were 20 to 35 years old with uncomplicated singleton pregnancy. Cairo University hospitals are tertiary care referral centers serving Cairo and its surrounding suburbs and villages.

Mothers who had any chronic illness, pregnancy complications, received any drugs other than vitamins, whose reproduction was assisted or their newborns had major congenital anomalies were excluded from the study.

Maternal history was recorded (age, consanguinity, educational level and assisted reproduction for the current pregnancy, weight before pregnancy). Paternal age and education were documented.

Maternal weight was measured before and after delivery using a digital scale. Her weight prior to the pregnancy and height were also documented. Body mass index (BMI) was calculated according to this formula: BMI = weight in kilograms (kg) divided by square of height (m^2).

Mid upper arm circumference (MUAC) was measured using a firm non-stretchable measuring tape at the level of the midpoint of the line between the olecranon process and the acromion.

4. Neonatal history (sex, mode of delivery, Apgar score, gestational age assessment using Ballard score [6] and Neonatal anthropometric measurements (birth weight, length and HC) were recorded.

Statistical analysis of patients' data

Sample size calculation was based on the correlation between maternal weight, height, BMI and MUAC versus neonatal birth weight in healthy neonates. Prior data indicated that the correlation coefficient of the above maternal parameters and the neonatal birth weight were 0.165, 0.149, 0.112, and 0.0171 respectively [7]. If we assumed that this was the true population coefficients, the calculated sample size will be 223, 274, 489, and 207 respectively. Based on these calculations we decided to study a minimum of 490 neonates with their mothers to be able to reject the null hypothesis with 80% power setting type I error probability to 0.05. Sample size calculation was done using G*power software version 3.1.2 for MS Windows, Franz Faul, Kiel University, Germany. Data were statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies and percentages when appropriate.

Numerical data were tested for the normal assumption using Kolmogorov–Smirnov test. Comparison of numerical variables between the study groups was done using Student t test for independent samples in comparing 2 groups of normally distributed data/large enough samples, and Mann–Whitney *U* test for independent samples for comparing not-normal data. Comparison between more than two groups was done using Kruskal–Wallis test. Correlation between various variables was done using Spearman rank correlation equation for non-normal variables/non-linear monotonic relation. Multivariate linear regression analysis was used to test for the significant independent predictors of neonatal weight in relation to gestational age. Two-sided *p* values less than 0.05 were considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp., Armonk, NY, USA) release 22 for Microsoft Windows.

Results

This is a descriptive cross-sectional study that included 491 healthy full-term neonates born to healthy mothers at the Obstetric hospital of Cairo University, during the period from April to September 2021. Regarding the different sociodemographic characteristics of the parents, illiteracy was higher in fathers compared to mothers as shown in Fig. 1.

Maternal age ranged from 20 to 35 years with a mean of 26.82 ± 14.32 years while paternal age ranged from 21 to 65 with a mean of 33.02 ± 7.58 years.

Of the parents, 137 were consanguineous (27.9%) and 74 out of them were cousins (15.1%). One hundred and sixty four (33.4%) mothers had previous CS deliveries. The other 327 mothers had previous normal deliveries or were primigravidae (66.6%). Only 329 (67%) mothers had regular antenatal care. The median number of antenatal care visits in the 1st, 2nd, and 3rd trimester was 2, 3, and 4 visits respectively. Two hundreds and sixty two

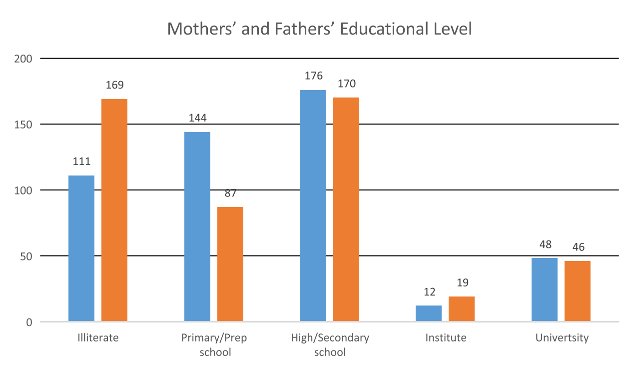

Fig. 1 Comparative chart of mothers' and fathers' educational levels

Table 1 Parents' demographic data

	Mean ± SD	Range
Mother's age (years)	26.82 ± 14.32	(20–35)
Pre-pregnancy weight (kg)	71.45 ± 14.32	(41–130)
3rd trimester weight (kg)	83.530 ± 16.03	(50.2–153.2)
Post-delivery weight (kg)	77.516 ± 15.81	(44.4–146)
Maternal weight gain (kg)	12.082 ± 5.23	(−13.8–31.2)
Pre-pregnancy BMI	28.556 ± 5.62	(16.5–54.1)
3rd trimester BMI	33.386 ± 6.19	(20.9–63.8)
Post-delivery BMI	30.975 ± 6.09	(18.8–60.8)
Height (cm)	158.25 ± 6.44	(141–176)
MUAC (cm)	30.475 ± 4.21	(20.9–44.7)
Father's age (years)	33.02 ± 7.58	(21–65)

BMI body mass index, *MUAC* mid upper arm circumference

Table 2 Neonatal demographic data

	Mean ± SD/median	Range
GA (history) (weeks)	38.43 ± 1.28	(37–41)
GA (Ballard) (weeks)	38.29 ± 1.19	(37–41)
Apgar score	10	9–10
Neonatal birth weight (kg)	3.361 ± 0.51	(1.9–5.5)
Neonatal length (cm)	49.740 ± 2.05	(45.7–54.9)
Neonatal head circumference (cm)	34.98 ± 1.60	(29–40)

GA gestational age

(53.4%) newborns were born vaginally and 229 (46.6%) were born by CS. They were 306 males (62.3%) and 185 (37.7%) females. According to birth weight, 335 neonates were appropriate for gestational age (68.2%), while 97 (19.8%) and 59 (12%) neonates were large and small for gestational age respectively according to world health organization (WHO) fetal growth charts [8].

Maternal anthropometric measurements are shown in Table 1.

Neonatal anthropometric measurements are shown in Table 2.

Upon correlating the different maternal and neonatal data, mother's education level was inversely related to neonatal weight and positively related to neonatal head circumference, while it was statistically insignificant in relation to neonatal length. Consanguinity only had positive relation to neonatal head circumference. Both maternal and paternal age had a positive relation to neonatal birth weight and length and no statistically significant relation to neonatal HC (Table 3).

As for maternal height, it was not significantly related to neonatal length ($p = 0.103$). Third trimester weight, BMI and MUAC were positively related to neonatal birth weight, length and HC (Table 3).

Maternal weight gain in pregnancy was also positively related to neonatal birth weight and head circumference but it was not statistically related to neonatal length (Table 3).

Using multivariate logistic regression, the measured maternal parameters (age, pre-pregnancy weight, maternal weight gain, height and MUAC) could not predict weight-for-age of the newborns (Table 4).

Discussion

A healthy woman is more likely to give birth to a healthy newborn, unless there are pregnancy or birth complications. Birth weight is commonly used to assess baby's growth but it is also an important indicator that reflects maternal health, nutrition, genetics, socioeconomic status, environmental influences, and the quality of antenatal services [2]. Particularly, it is strongly associated with fetal, neonatal, post-neonatal mortality, and also with infant and child morbidity [9].

Table 3 Relation of neonatal anthropometry to maternal demographics, history, and anthropometry

	Neonatal birth Weight		Neonatal length		Neonatal head circumference	
	R	*P* value	*R*	*P* value	*R*	*P* value
Mother's age	0.135	0.003*	0.128	0.004*	−0.009	0.834
Mother's education	−0.098	0.031*	−0.080	0.076	0.153	0.001*
Father's age	0.108	0.016*	0.102	0.024*	−0.002	0.972
Consanguinity	−0.011	0.807	0.070	0.119	0.162	< 0.001*
2nd degree	0.076	0.379	−0.061	0.482	0.128	0.135
Third trimester weight (kg)	0.279	< 0.001*	0.249	< 0.001*	0.254	< 0.001*
Maternal weight gain (kg)	0.123	0.006*	0.026	0.567	0.183	< 0.001*
Third trimester BMI	0.224	< 0.001*	0.214	< 0.001*	0.172	< 0.001*
MUAC (cm)	0.162	< 0.001*	0.104	0.021*	0.209	< 0.001*

* Significant *P* value < 0.05, *MUAC* mid upper arm circumference

Table 4 Different maternal parameters and prediction of neonatal weight for age

	Weight for gestational age		
	P value	95% confidence interval for B	
		Lower	Upper
Mother's age	0.217	−0.005	0.022
Pre-pregnancy weight	0.670	−0.007	0.005
Maternal weight gain	0.303	−0.006	0.019
Height	0.116	−0.018	0.002
MUAC	0.497	0.013	0.028

MUAC mid upper arm circumference

Regarding mode of delivery in the current study, 46.6% of newborns were delivered by CS and 33.4% of them had previous CS deliveries. A recent study involving 13 public hospitals in 4 Egyptian governorates documented an overall CS delivery rate of 54.2% (ranging from 22.9 to 94.3%) among the different centers. The most common medical indication was previous CS (50%) and in 10% of the cases no medical indication was reported [10].

In the current study, the mean neonatal birth weight, length and HC were 3.36 ± 0.51 kg, 49.74 ± 2.05 cm and 34.98 ± 1.60 cm respectively. This is quite similar to another study of the Egyptian newborns 12 years ago [11]. This is in accordance with the WHO charts where the average birth weight is 3.346 kg, average length is 49.88 cm and average HC is 35.81 cm for males [12] while for females the average birth weight is 3.232 kg, average length is 49.14 cm [13] and average HC is 34.71 cm [14]. However, it was higher than a recent study comparing birth weights between global regions (south Asia, sub-Saharan Africa, Central America) [15].

Body measurements at birth usually include BW, length, and HC which is a simple tool that reflects infant's brain growth and development. In this study, HC was positively related to maternal education. This is similar to Bouthoorn, et al. [16] who found infants born to mothers who received low education to have smaller head circumferences throughout the first 6 months of life. This may be explained by the association between high level of education, high socioeconomic level, better antenatal care, and less adverse obstetric outcome or that mothers with larger head circumferences who had higher intelligence and education transmit this genetic based character to their siblings but we did not document maternal head circumferences in this study.

Another parameter positively related to HC was parental consanguinity. Consanguinity is known to have a potential risk for many adverse health outcomes because it promotes the expression of rare recessive deleterious genes that runs in families [17]. Consanguineous marriage has declined remarkably from many parts of the western world, but it is still widespread in the Middle East, especially among Arab communities [18]. In the current study 27.9% of neonates were siblings of consanguineous marriage and consanguinity had a positive relation to neonatal head circumference only. This is in contrast to other studies [19, 20] which reported no association between neonatal anthropometric measurements and consanguinity.

Neonatal birth weight had been associated with short as well as long health consequences that may extend into adulthood [21]. Regarding neonatal birth weight in this study, 19.8% were large for gestational age (LGA). The incidence of LGA newborns increased in the last decades and is estimated to be around 10% [22]. In this study, the higher percentage of LGA newborns may be explained by the high percentage of obese mothers. Thirty six percent of the studied mothers had pre-pregnancy BMI ≥ 30; of which 8% had morbid obesity according to WHO definitions [23]. Not surprisingly that 44% of women, who gave birth to LGA babies, were obese. Obesity is a problem in low and middle income countries as well as developed countries. Surprisingly, 62% of obese people are found in low and middle income countries [24].

In this study, neonatal birth weight was inversely related to maternal education. This may be explained by awareness about healthy life style and access to healthy food options.

In this study, maternal age had a positive relation to neonatal birth weight as well as length. The relation between maternal age and birth weight was similar to other studies which confirmed a positive relation between maternal age and birth weight [25, 26].

When comparing maternal and neonatal measurements, the results were variable. In this study, 3rd trimester weight and BMI were positively related to neonatal birth weight, length and HC. In the same line, maternal weight gain in pregnancy was also positively related to neonatal birth weight and HC but not to neonatal length. In an Egyptian study which included full-term singleton neonates born to healthy mothers, maternal weight as well as height had a significant positive relation to neonatal birth weight, length, and head circumference, while maternal BMI showed a significant positive relation only to birth weight and length [11]. Similarly other studies indicated that neonatal growth was mostly influenced by maternal size [25, 26]. In contrast to these findings, Shiferaw et al. [27] did not report significant relation between neonatal birth weight and maternal anthropometric measures.

MUAC has been increasingly used to assess the nutritional status of adults, especially pregnant women, as it offers the merits of being a simple measure that can be performed in both facility- and community-based settings, requiring minimal equipment [28]. In this study, MUAC was positively related to neonatal birth weight, length and HC. This was similar to Vasundhara et al. who measured MAUC at 3 antenatal visits and found it to be positively related to BW, HC and length [29]. Moreover, MUAC was shown to be a good predictor for low birth weight [29, 30] and stunting during the first 3.5 months of life [28].

In this study, neonatal length was not significantly correlated with maternal height which comes in agreement with Zhang et al. [31] study that referred the observed association between maternal height and birth length to the genetics of the fetus acquired from both maternal and paternal origin.

The different findings of the various studies about maternal and neonatal anthropometry may be due to different sampling approaches, for example, some studies included preterm neonates too and mothers with medical conditions.

One of the limitations of this study that we could not study the relation between various maternal diseases and neonatal measurements. Nevertheless, this study contributes to the existing literature by further supporting the hypothesis that several maternal anthropometric variables are associated with the anthropometry of newborns and it tried to exclude many of the variables that could affect maternal neonatal interaction.

Conclusions

Maternal anthropometry can be related to different neonatal anthropometric measurements. However, no single parameter could predict weight for age of the newborn. Further studies are warranted to further explore the possible prediction of small for gestational age newborns by different anthropometric measures of the mother. Studies involving mothers from a more diverse social, educational and regional background are needed to evaluate the possible role of these different factors on both the mother and the neonate.

Abbreviations

BMI	Body mass index
BW	Birth weight
GA:	Gestational age
HC	Head circumference
kg	Kilograms
LGA	Large for gestational age
MUAC	Middle upper arm circumference
SD	Standard deviation
WHO	World health organization

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Authors' contributions

AT generated idea, interpreted the data, and revised the manuscript. IS collected, analyzed the data, and wrote the manuscript. MS wrote and revised the manuscript. EE interpreted the data, wrote and revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

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

Declarations

Ethics approval and consent to participate

The study was approved by the research ethics committee with ethical approval no. MS-214–2021. Consents were given by the newborns' mothers.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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