Original Article

Relationship between placental weight, birth weight, maternal biosocial characteristics and placental-to-birth-weight ratio

Abiodun S. Adeniran, Kikelomo T. Adesina, Grace G. Ezeoke, Adegboyega A. Fawole, Abiodun P. Aboyeji, Munirdeen A. Ijaiya

Obstetrics & Gynaecology Department, University of Ilorin/ University of Ilorin Teaching Hospital, Ilorin, Nigeria.

ABSTRACT

Background: The placental weight is routinely measured at birth and its relationship to birth weight and maternal biosocial characteristics can provide information on both neonatal and maternal health status.

Aim: To determine the relationship between placental weight (PW) at birth, birth weight (BW), maternal biosocial characteristics and placental-to-birth-weight ratio (PBWR) as well as generate a reference range in an African population.

Methods: A cross-sectional study involving parturient who had singleton deliveries at ≥32weeks gestation with comparison of maternal biosocial parameters, PW, BW and PBWR. Deliveries <32weeks gestation, multiple gestation and incomplete placenta were excluded from the study. Data was retrieved from the institutional birth registry; data management included determination and comparison of mean values and ratio of individual parameters using SPSS version 21.0.

Result: Among the 8645 participants, the mean PW was 589.2±146g and it increased with maternal age. The mean BW increased with maternal age with a decline from 35years while PBWR declined until age 30years with a rise afterwards. The mean PW increased with parity, the BW increased till the fourth delivery when it began to decline but PBWR did not follow a regular pattern with parity. The PW and BW increased with gestational age while PBWR increased till 36th week, declined from 37th to 42nd week with a rise from 43rd week. The mean PW and BW increased with maternal educational status while booked participants had higher PW and BW but lower PBWR compared to unbooked women.

Conclusion: The placental weight is a central index for the interpretation of measurements at birth and the relationship to maternal biosocial characteristics; therefore, reference ranges should be generated for various populations.

INTRODUCTION

Available routine data at delivery include maternal biosocial characteristics, birth weight (BW) and placental weight (PW). The human placenta is responsible for promoting pregnancy and foetal development by facilitating materno-foetal transfer of food and nutrients.[1] At term, the placenta is a round disc-shaped organ of 22cm in diameter, central thickness 2.5cm and weighs 450-500g although the weight varies with the mode of delivery.[2] The placenta physiology, function and

Corresponding author:
Abiodun Adeniran
Obstetrics & Gynaecology Department,
University of Ilorin PMB 1515, Ilorin, Nigeria.
Tel: +234 805 753 4788
E mail: acrowncord@hotmail.com

Keywords: *Placenta; placental weight; biosocial characteristics; placental-to-birth weight ratio.*

weight can be a reflection of the maternal nutrition, foetal growth status and effect of environmental stressors.[3,4] The placental and foetal weights are affected by maternal or foetal disorders including maternal severe anaemia, hypertension and foetal hydrops among others; thus it may be an indicator for the presence of these and other complications.[5] A relationship has been established between placental and birth weight with chronic diseases such as hypertension and diabetes in later life.[6] However, although PW at delivery is routinely measured and documented, the interpretation and evaluation for foetal weight abnormalities and probable risk for chronic diseases in later life is rarely explored.[7] Therefore the value of placental and birth weights as well as the relationship to a reference range provides a reference for comparison to detect abnormalities in a particular population.[6]

In a longitudinal study from Northern Finland, there were significant positive associations between placental size (weight, surface area and placental-to-birth-weight ratio) especially increased PW and mental health problems i.e. probable psychiatric disturbance and antisocial behavior among boys at age 8 and 16 years of life.[8] There have been suggestions that the placenta may be significant in translating maternal influences to the foetus in-utero which may affect the development and adult life.[9] Also, evidence suggests that the placenta responds to alterations in the maternal environment with structural and functional adaptations including changes in placental growth.[10] Alterations in foetal nutrient and hormone supply can result in abnormal placental growth which may cause adaptations in the foetus with a risk for developing diseases in adult life.[11] Comparison of PW and its relationship to BW based on trimmed, formalin-fixed placentas have been described as inaccurate for routine delivery room interpretations and practical delivery room application.[6] In clinical practice, weights of placentas are derived from fresh, wet, placenta without trimming of the membranes and umbilical cord; for the purpose of establishing population reference scales therefore, fresh PW in unselected population are preferred.[12] A 45-year longitudinal follow up study from birth to adulthood reported that PBWR was positively associated with cardiovascular disease mortality later in life with disproportionately large placenta relative to birth weight being associated with increased risk of cardiovascular deaths.[13] While such longitudinal studies are unavailable in low-income countries, a starting point will be the generation of population reference ranges as a baseline for further studies.

In low-income countries, the importance of routine birth measurements is mostly limited to identification of low birth weight and macrosomic babies. There is sparse information on the relationship between the placental-to-birth-weight ratio (PBWR), as well as the correlation between PW and maternal biosocial characteristics; population reference scales are unavailable while available studies contain comparable small sample size.

The study aimed to establish a reference range of PW and BW across gestational ages for the study population, the PBWR as well as the relationship of the PW to maternal biosocial characteristics.

METHODS

The study was a cross-sectional study conducted at the University of Ilorin Teaching Hospital (UITH), Ilorin, Nigeria. Participants were women who delivered at the facility over a ten year period while the study data was obtained from the birth registry of the hospital which contains details of all deliveries conducted at the centre. The inclusion criteria were singleton pregnancies delivered at $\geq$32 weeks of gestation with available records in the institutional registry. The exclusion criteria included multiple gestation, congenital anomaly at birth and missing data for gestational age at delivery, BW or PW. Also, deliveries where PW was not measured or deemed inaccurate due to presence of morbidly adherent placenta, placenta praevia, incomplete placentas and those requiring uterine curettage after delivery were excluded from the study. The institutional protocol involves measurement of PW immediately after

delivery using standardized computerized weighing scale together with the membranes and umbilical cord after removing obvious blood clots to verify completeness. The BW was measured immediately after delivery using standardized computerized infant weighing scale.

After calculation of the mean values for placental and birth weight, the PBWR was calculated as the ratio of PW to BW multiplied by 100.[6] Institutional ethical approval for the study was obtained from the ethical review committee of the University of Ilorin Teaching Hospital (UITH) before commencement of the study. The data was analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 and presented in tables of mean values for comparison.

RESULTS

There were 8645 participants in the study and the mean PW was 589.2±146g. From table 1, the mean PW increased with maternal age being lowest for teenagers (535±132g) and it was lower for women <35years (560g±113g vs. 580±370g) compared to those ≥35years old. The mean BW increased with maternal age with a decline from ≥35years. There was a gradual decline in the mean placenta-to-birth-weight ratio (PBWR) until age 30years when it began to increase; however, the PBWR was higher for women <35years (18.0 vs.18.5) compared to those ≥35years. The mean PW increased with parity (except for para 4 women) while the mean BW increased gradually up to the fourth delivery when it began to decline. However, the PBWR did not follow a regular pattern although it was lowest for fourth delivery 4 (17.6) and highest for the seventh delivery (37.6). The PW increased gradually with gestational age from 442±154g at 32weeks to 626±366g at 44weeks gestational age. The BW increased with gestational age while the PBWR increased with gestational age till the 36th week, declined from 37th to 42nd week with a gradual rise from 43rd week of gestation. The mean PW and BW increased with the level of formal education; however, the PBWR was highest for women with secondary (18.6) and lowest for tertiary (17.6) education. The mean PW was higher for booked (596±112g vs. 575±217g) compared to unbooked women; the mean BW was higher for booked women (3341±392g vs. 3056±457g) while the PBWR was lower for booked (17.8vs. 18.8) compared to unbooked women.

Table 2 represents a reference range for the study population with the median (50th percentile), the 5th percentile as well as 95th percentile for gestational ages 32 to 44 weeks for the PW, BW and PBWR for population comparison. PW measurements beyond the 95th percentile represent the limit that requires individualized neonatal follow up.

Table 1: Relationship between maternal biosocial characteristics, placental and birth weight

Parameter	Frequency (%)	Mean Placental weight (g) (SD)	Mean birth weight (g) (SD)	Placental-to-Birth-weight Ratio
Maternal Age				
<20	62 (0.7)	535 (132)	2641 (564)	20.3
20-24	1485 (17.2)	548 (136)	2844 (349)	19.3
25-29	4188 (48.4)	561 (959)	3056 (397)	18.4
30-34	1545 (17.9)	577 (118)	3118 (456)	18.5
35-39	1264 (14.6)	585 (119)	3103 (373)	18.8
=40	101 (1.2)	663 (985)	3031 (583)	21.9
<35	7884 (91.2)	560 (113)	3104 (414)	18.0
=35	761 (8.8)	580 (370)	3144 (403)	18.5
Parity				
0	3996 (46.2)	552 (102)	2948 (353)	18.7
1	2252 (26.0)	553 (116)	3101 (420)	17.8
2	1078 (12.5)	580 (119)	3114 (419)	18.6
3	502 (5.8)	589 (140)	3117 (548)	18.9
4	682 (7.9)	581 (113)	3295 (404)	17.6
5	83 (1.0)	600 (152)	3194 (498)	18.8
6	36 (0.4)	604 (162)	3127 (661)	19.3
7	16 (0.2)	638 (448)	3028 (757)	37.6
Gestational Age				
32	24 (0.3)	442 (154)	2204 (851)	20.1
33	11 (0.1)	505 (119)	2350 (665)	21.5
34	69 (0.8)	511 (113)	2412 (651)	21.2
35	46 (0.5)	529 (152)	2474 (689)	21.4
36	563 (6.5)	545 (284)	2511 (415)	21.7
37	439 (5.1)	556 (193)	2632 (289)	21.1
38	6351 (73.5)	566 (165)	3069 (409)	18.4
39	902 (10.4)	569 (267)	3261 (389)	17.5
40	57 (0.7)	571 (114)	3487 (440)	16.5
41	35 (0.4)	580 (133)	3507 (468)	16.5
42	37 (0.4)	589 (86)	3544 (362)	16.6
43	85 (1.0)	612 (412)	3588 (314)	17.1
44	26 (0.3)	626 (366)	3604 (409)	17.4
Education				
Primary	1445 (16.7)	546 (138)	3019 (414)	18.1
Secondary	3388 (39.2)	596 (198)	3204 (442)	18.6
Tertiary	3812 (44.1)	615 (105)	3494 (382)	17.6
Booking Status				
Booked	5842 (67.6)	596 (112)	3341 (392)	17.8
Unbooked	2803 (32.4)	575 (217)	3056 (457)	18.8

Table 2: Range for placental weight, birth weight and placental-birth-weight ratio relative to gestational age among participants

GA (weeks)	5th percentile			50th percentile			95th percentile		
	Mean PW g (SD)	Mean BW g (SD)	PBWR	Mean PW g (SD)	Mean BW g (SD)	PBWR	Mean PW g (SD)	Mean BW g (SD)	PBWR
32	200 (150)	1350(690)	0.15	400 (150)	2920 (690)	0.14	750 (140)	3800 (690)	0.19
33	300 (110)	1500(620)	0.20	500 (110)	2600(620)	0.19	700 (110)	3400 (620)	0.21
34	300(110)	2100(560)	0.14	550 (110)	3100(560)	0.18	700 (110)	3600 (560)	0.19
35	300 (140)	2000(530)	0.15	600 (140)	3400 (530)	0.80	720 (140)	3600 (530)	0.20
36	450 (100)	2600(380)	0.17	600 (100)	3300 (380)	0.18	700 (100)	3550 (380)	0.20
37	300(190)	2630(280)	0.12	550(195)	2700(280)	0.20	700 (190)	3450 (280)	0.20
38	400 (180)	2500(380)	0.16	550 (180)	3200(380)	0.17	750 (180)	3700 (380)	0.20
39	400 (80)	2500(390)	0.16	550 (80)	308 (390)	0.18	650 (80)	3500 (390)	0.19
40	400 (120)	2500(340)	0.16	600 (120)	3020(340)	0.20	750 (120)	3700 (340)	0.20
41	380 (130)	2590(450)	0.17	600 (130)	3250(450)	0.19	750 (130)	4050 (450)	0.19
42	420 (90)	2700(370)	0.16	600(90)	3200 (370)	0.20	700 (90)	3900 (370)	0.18
43	500(60)	2700(320)	0.19	560 (60)	3000 (320)	0.18	600 (60)	3500 (320)	0.17
44	500 (70)	2800(440)	0.18	600 (70)	3250 (440)	0.19	800 (70)	4600 (440)	0.17

GA: Gestational age; BW: Mean birth weight; PW: Mean placental weight;

PBWR: Placental-to-birth-weight ratio

DISCUSSION

The mean placental weight for the study was 589.2±46g; it increased with maternal age, parity, gestational age at delivery, increasing level of formal education and was higher for booked participants. The mean birth weight increased with maternal age (with a decline from 35 years of age), gestational age at delivery, and increasing level of formal education and booking status; it increased till the fourth delivery when it began to decline. The mean PBWR increased with maternal age, it was higher for the unbooked patient, it rose then followed a decline with increasing level of formal education, it decreased with gestational age at delivery and did not show a linear pattern with parity

The mean placental weight in the study compares with previous reports of 529±119g,[14] 590±82g,[15] 630g[16] and 657.5±96.1g[17] from Nigeria, 537±96g from Mexico,[4] 588g from Asia[6] and 643g from western Europe[18] with a sharp contrast to 384.5±81.6g from India[19] and 470g from Ukraine.[20] The variation may be due to genetic factors, variations in study methodology, differences in weighing and cord clamping time as well as some other undetermined factors.[12] However, reports indicated that dry or wet placental to birth weight ratio can be interchanged due to their high correlation, however wet placental weight was used in the study being the routinely available data in most delivery rooms.[12] Another report concluded that while the blood holding capacity of the placenta and maternal-dietary factors influence placental weight, variations in the hormonal environment in utero as well as pathologic adaptation of the placenta due to racial factors significantly contributed to the size of the newborn baby.[14]

In this study, placental weight was lowest among teenagers and increased with maternal age until age 35 years when it began to decline. In a similar study, placental weight increased with maternal age with most low weight placentas recorded among teenage women while another report corroborated an increased placental weight with maternal age until age 35 years when it began to decline.[14,17] This can explain the adverse pregnancy outcome associated with advanced maternal age and may be attributed to the sub-optimal physiological adaptation to pregnancy manifesting as poorly compliant maternal blood vessels which hinders the formation of a healthy placenta.[21]

Maternal booking status influenced placental weight, birth weight and PBWR in this study. The unbooked women had smaller placenta, lower birth weight and lower PBWR similar to a similar study in Nigeria which recorded lower mean values for placental weight (664±495g vs. 751±213g), birth weight (2545±982g vs. 3225±545g) and PBWR (4.30±2.29 vs. 4.61±2.00) among unbooked compared to booked women.[22] However, another study reported higher mean placental weight for booked women (715.9±204.3 vs. 707.6±111.1).[17] Unbooked women run the risk for pregnancy complications which may not be recognized early nor allow initiation of treatments thereby resulting in feto-placental problems.[23]

Placental overgrowth is often a compensatory response to intrauterine insults from maternal problems.[10,24] It was hypothesized that an enlarged placenta may reduce its nutrient supply to the foetus leading to foetal adaptations that may jeopardize foetal structure and physiology with increased risk for diseases.[8] Therefore, a large placental size from adverse maternal environment may alter foetal nutrient supply and foetal brain development with risk of psychiatric problems in later life.[25] While this may present as high PBWR, compensatory mechanisms may result in the delivery of a normal weight baby. Thus, an enlarged placenta is the strongest predictor of psychopathological disorders and may represent an important link between disturbances in the maternal environment, disturbed foetal brain development and mental disorders in later life.[8]

The increase in placental weight with parity observed in this study corroborates reports of earlier authors; placentas from multiparous women from 32 weeks onwards had been reported to be heavier than those from Primipara.[17] Other authors report a rise in placental weight with parity until the sixth delivery after which it began to decline and an increase in mean placental weight with parity up to the third delivery after which the placental weight began to decline.[15,14]

The observed increase in placental weight with advancing gestational age may be evidence of development of the foetus and other components. However, the proportional increase in birth weight is greater than that of placental weight; thus, the PBWR decreases with gestational age throughout pregnancy.[3.5.10,18] In another study, the placental weight increased from 504±84g at 37weeks to 631±55g at 42 weeks while the PBWR reduced from 19.1 to 18.2 although a general increase in birth weight, placenta weight and PBWR with gestational age has been documented.[5,19] In a population study in Norway, the mean placental weight for gestational age increased from 24 to 42weeks followed by a decline afterwards which is similar to this study.[7]

The increase in birth weight correlates with increase in placental weight as gestational age advances such that the PBWR serves as a reflection of the balance between foetal and placental growth.[14] Generally, feto-placental weight ratio rises steadily with gestational age with an abrupt decline from 42 weeks gestation as the foetus outgrows the placenta and then a sharp decline from 43weeks.[14,15] This shows that prolonged pregnancy represents an increased risk for foetal adverse effects due to placental insufficiency.[15] This information is a guide in planning delivery in pregnant women. A relationship between PBWR has been reported for each gram of placenta weight, but this relationship is not linear due to a higher increase in birth weight relative to placental weight.[4] Thus, the PWR is a useful marker for foetal nutrition and utero-placental function.[26] Reported mean PBWR ranges from 18.2% in Nigeria to 13.9% in Ukraine, 17.08% in Thailand, 19.5% in Asia and 20.0% in western Europe.[15,20,21,6,18]

There has been a concern about the influence of race on birth and placental weights in view of race-associated variations in size of humans. In a multi-country study, although birth weight and placental weight were lower in Asian women, the mean PBWR was similar in Asian (19.5%; SD3.3), European (20.0%; SD 4.0) and Afro-Caribbean women (20.4%; SD 5.3).[27] Also, the mean PBWR

was not significantly higher in women with gestational hypertension (20.4%; SD 4.5) and pre-eclampsia (23.3%; SD 7.3) than in normal women (19.8%; SD 3.8) thereby justifying their inclusion in population normogram.[8]

The study concludes that routine measurement of birth and placental weights can be harnessed to provide an insight into the intrauterine environment, an explanation for the observed measurement at birth and a source of information about maternal health status.

Sources of support: Nil

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

1. Addai FK. Association of histologic component volumes of shed human placentae with placental index and gestational age of neonates, and haemoglobin genotype of mothers. *West Afri J Anatomy* 1997; 5:21–22.
2. Huppertz B, Kingdom JCP. The Placenta and Foetal membranes. In: Edmonds DK (ed.). Dewhurst's Textbook of Obstetrics and Gynaecology. 8th edition. West Sussex, Wiley-Blackwell, 2012. Pp. 16-25.
3. Lao TT, Wong W. Placental ratio its relationship with mild maternal anaemia. *Placenta* 1997; 18:593–596.
4. Sanin LH, Lopez SR, Olivares ET, Terrazas MC, Silva MAR, Carrillo ML. Relation between birth weight and placenta weight. *Biol Neonate* 2001; 80:113-117.
5. Heinonen S, Taipale P, Saarikoski S. Weights of placentae from small-for-gestational age infants revisited. *Placenta 2001;* 22(5):399-404.
6. Burkhardt T, Schaffer L, Schneider C, Zimmermann R, Kurmanavicius J. Reference values for weight of freshly-derived term placentas and for placental weight-birth weight ratios. Eur J Obstet Gynaecol Reprod Biol 2006; 128:248-252.
7. Barker DJ. In utero programming of chronic disease. *Clin Sci (Lond)* 1998; 95(2):115–28.
8. Khalife N, Glover V, Hartikainen A, Taanila A, Ebeling H, Jarvelin R, et al. Placental size is associated with mental health in children and adolescents. *PLOs ONE* 2012;7(7):e40534. Doi:10.1371/journal.pone.0040534
9. Fowden AL, Forhead AJ, Coan PM, Burton GJ. The placenta and intrauterine programming. *J Neuroendocrin* 2008; 20:439-450.
10. Tegethoff M, Greene N, Olsen J, Meyer AH, Meinlschmidt G. Maternal psychosocial stress during pregnancy and placenta weight: evidence from a national cohort study. *PLoS ONE* 2010; 5: e14478. 10.1371/journal.pone.0014478.
11. Lewis RM, Poore KR, Godfrey KM. The role of the placenta in the developmental origins of health and disease–implications for practice. *Rev Gynaecol Perinatal Practice* 2006; 6:70-79. 10.1016/j.rigapp.2005.12.001
12. Leary SD, Godfrey KM, Greenaway LJ, Davill VA, Fall CHD. Contribution of the umbilical cord and membranes to untrimmed placental weight. Placenta 2003; 2:276–278.
13. Risnes KR, Romundstad PR, Nilsen TIL, Eskild A, Vatten LJ. Placental weight relative to birth weight and long-term cardiovascular mortality: Findings from a cohort of 31,307 men and women. *Am J Epidemiol* 2009; 170:622-631. Doi:10.1093/aje/kwp182.
14. Afodun AM, Ajao MS, Enaibe BU. Placental anthropometric features: Maternal and neonatal characteristics in North Central Nigeria. *Adv Anatomy* 2015. Article ID 790617. Doi: http://dx.doi.org/10.1155/2015/790617.
15. Panti AA, Ekele BA, Nwodo EI, Yakubu A. The relationship between the weight of the placenta and birth weight of the neonate in a Nigerian Hospital. *Niger Med J* 2012;53(2):80-84.
16. Adinma JI, Agbai AO. Foetal birth weight in Africa. *J Obstet Gynaecol* 1995; 15:295-297.
17. Nwogu CM, Adetuyi IE, Okunade KS, Osanyin GE, Oluwole AA. Placental weight and perinatal outcome among parturients at a university

teaching hospital in Lagos, Nigeria. *Trop J Obstet Gynaecol* 2018; 35:322-326.

18. Barker DJ, Buull AR, Osmond C, Simmonds SJ. Foetal and placental size and risk of hypertension in adult life. *BMJ* 1990; 301:259-262.
19. Khanderao JB, Madhukar SS, Tukaram PH. Weight of human placenta and maternal and foetal parameters: An observational study. *Indian J Clin Anat Physiol* 2016; 3(2):117-119.
20. Little RE, Zadorozhnaja TD, Hulchiy OP, Mendel NA, Shkyryak-Nyzhnyk ZA, Chyslovska N, et al. Placental weight and its ratio to birth weight in a Ukrainian city. *Early Human Dev* 2003; 71:117-127.
21. Emuveyan EE. Normal physiology of pregnancy. In: Kwawukume EY, Emuveyan EE (Eds.).Comprehensive Obstetrics in the Tropics. 1st edition. Accra, Ghana: Asante and Hittscher Printing Press Ltd. 2002; p32.
22. Babah OA, Oluwole AA, Akinajo OR, Owie E, Ohazurike EO. Foeto-placental parameters in normal pregnancy and factors affecting them. *Niger Postgrad Med J* 2018; 25:234-238.
23. Awoleke JO. Olofinbiyi BA. Poor antenatal service utilization and pregnancy outcome in a tertiary health facility in southwest Nigeria. *PanAfrica Med J*. 2020; 35:28. DOI: 10.11604/pamj.2020.35.28.20426.
24. Hindmarsh PC, Geary MPP, Rodeck CH, Jackson MR, Kingdom JCP. Effect of early maternal Iron stores on placental weight and structures. *The Lancet* 2000; 356:719-723.
25. Kyle UG, Pichard C. The Dutch famine of 1944-1945: a pathophysiological model of long-term consequences of wasting disease. *Curr Opinion Clin Nutrition Metab Care* 2006; 9:388-394.
26. Cunningham FG, Leveno KJ. Bloom SL, Hauth JC, Gilstrap LC III, Wenstrom KD. Implantation, embryogenesis and placental development. Williams Obstetrics 22nd edition. New York: McGraw Hill; 2005.p.39-90.
27. Perry IJ, Beevers DG, Whincup PH, Bareford D. Predictors of ratio of placental weight to foetal weight in multiethnic community. BMJ 1995; 310:436-439.