JOHNSON'S formula for predicting birth weight in pregnant mothers at Jimma university teaching hospital, South western Ethiopia

By

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Abstract

Background: Accurate assessment of fetal weight is mandatory for obstetric management of labouring mothers. Among the methods of fetal weight estimation, Symphysis fundal height measurement is an easier method of fetal weight estimation and has been shown to be as good as ultrasound estimation at term, giving estimates that are correct to within 10% of the birth weight in 60% to 70% of cases. The values of SFH are converted by using Johnson's formula to estimate fetal weight, where birth weight in gm = (SFH in cm–12)×155, with further adjustments based on engagement of the fetal head and maternal obesity.

Objective: the objective of this study is to validate Johnson's formula for predicting birth weight in pregnant mothers at JUSH, south western Ethiopia, 2014.

Methods: A prospective cross sectional study was conducted in Jimma University Hospital. 334 mothers admitted to the labor and maternity ward who fulfill all the inclusion criteria were selected till the desired sample size is achieved. Data on socio-demographic and obstetric characteristics were collected using a pre-tested structured questionnaire. Data was analyzed using Statistical Package for Social Sciences for windows version 20.

Results: The accuracy of Johnson's formula was thirty eight percent. The mean percentage error in fetal weight estimation using the formula is 17.5 percent. Gestational age , SFH and birth weight have significant effect on accuracy of Johnson's formula. Simple linear regression between SFH and birth weight gave a correlation coefficient (r) of 0.623. Gestational age , Symphysis fundal height , BMI, sex of the neonate and membrane status are significantly associated with birth weight. Substituting the mean SFH (35.58cm) to the derived formula Weight in Gm= 2600 + 115(SFH(cm)- 30) will give us an estimated birth weight of 3175 gms while the mean estimated fetal weight by Johnson's formula is 3565. The mean birth weight was 3244 gms.

CONCLUSION

Johnson's formula was found to be inaccurate in this study particularly in LBW babies. But in macrosomic babies it is considered accurate although the small sample size in this group precludes a firm conclusion. The formula inaccurately predicts birth weight in preterms and at terms between gestational age thirty seven and fourty one weeks and six days. But is accurate at gestational age greater than 42 completed weeks despite small sample size in this group. Birth weight is strongly correlated with SFH which can be transformed by a simple clinical formula

where: Weight in Gm= 2600 + 115(SFH(cm)- 30) for estimation of fetal weight between SFH of 30 and 43 cm.

Recommendation

Johnson's formula should not be used for our community. This is because birth weight is associated with maternal sociodemographic and obstetric factors in addition to SFH, and engagement and any derived formula can be utilized only for that specific community. Based on this we recommend using the formula: Estimated fetal weight (gm)= 2600 + 115(SFH(cm)- 30) between SFH of 30 and 43 cm which is derived based on our maternal sociodemographic and obstetric factors .

Acknowledgment

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List of Acronyms

ANC-Ante Natal Care

LMP-last menstrual period

BMI-body mass index

BPD - biparietal diameter

EDHS-Ethiopian Demographic and Health Survey

EFW-estimated birthweight

FWE-fetal weight estimation

JU-Jimma University

JUSH-Jimma university specilized hospital

LNMP-last normal menstrual period

LBW- low birth weight

PPH-post partum haemorrhage

PPV-Positive predictive value

SFH- Symphysis-fundal height

WHO-World Health Organization

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Definition of terms

- LBW- having a weight of less than 2500 grams at birth
- VLBW- having a weight of less than 1500 grams at birth
- Macrosomia - refers to growth beyond a specific threshold ; in this research ,greater than 4000gm
- PNMR- is the sum of fetal deaths (≥28 weeks gestation in Ethiopian context) plus early neonatal deaths (ie, deaths within the first seven days of birth) during a year divided by the sum of live births plus late fetal deaths during the same year, expressed per 1000 live births plus late fetal deaths.
- Dystocia-Difficult labour characterized by abnormally slow progress of labor. Generally, abnormal labor is common whenever there is disproportion between the presenting part of the fetus and the birth canal.
- Shoulder dystocia - the need for additional obstetric maneuvers to effect delivery of the fetal shoulders at the time of vaginal delivery.
- Obstructed labour- failure descent of the presenting part for mechanical reason despite adequate uterine contraction
- Maternal mortality-is death of woman while pregnant or with in 42 days of termination of pregnancy, irrespective of the duration or site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.
- Maternal mortality ratio (MMR) is the ratio of the maternal deaths per 100,000 live births.

Background

Weight at birth is a good indicator of the newborn's chances for survival, growth, long-term health and psychosocial development.

Fetal weight is a very important factor based on which decision must be made concerning labor and delivery. Macrosomic foetuses are associated with dystocia and by far obstructed labour which are common problems in developing countries. The incidence of obstructed labour at JUSH, our study area, is 12.2%.[1] Neonatal morbidities associated with macrosomia are cerebral edema, neurological damage, hypoxia and asphyxia during or after the delivery. Another major concern in the delivery of macrosomic infants is shoulder dystocia and attendant risks of permanent brachial plexus palsy.

On the other hand with LBW or VLBW foetuses, fetal death, birth asphyxia, meconium aspiration, neonatal hypoglycaemia and hypothermia are all increased because the fetal organs are not only smaller in size but also immature in function.

A retrospective study done in Jimma Hospital (South West Ethiopia) showed that the overall PMR was about 139 per 1000 total births; obstructed labor was the single most important factor contributing to 37.4% of the total perinatal deaths. [3]Neonatal mortality rate is 46 per 1,000 live births. Between 40 and 80% of neonatal deaths occur among LBW babies. The incidence of LBW is 11% in Ethiopia.[4] The prevalence of LBW observed in Jimma zone where the hospital in which this study was conducted , was 22.5%. [5]

Statement of problem

To prevent or treat the fetal, neonatal and maternal morbidities and mortalities associated with LBW and macrosomic neonates, accurate estimation of fetal weight is very important. In these circumstances diagnosis of macrosomic and LBW fetuses can result in timely referral of diagnosed cases to well-equipped hospitals.

There are 2 common methods to estimate fetal weight; clinical methods (includes palpation method, SFH measurement) and sono graphic evaluation .Ultrasound study forms a very important tool in modern obstetrics. In-utero fetal biometric assessment made by obstetric ultra sonography provides an attractive 'objective' method of estimating birth weight, in addition to providing in detail the anatomy of the fetus, the uterus and the volume of the amniotic fluid.

The accuracy of clinical methods of fetal weight estimation was similar to sonographic estimation at term.[(6-8)]Clinical methods of estimation of fetal weight has been shown to be as good as ultrasound at term, giving estimates that are correct to within 10% of the birth weight in 60% to 70% of cases. Ultrasound, if performed at term, is reported to properly estimate neonatal weight within 10% in 55 to 75% of cases. In developing countries, ultrasonography may be unavailable or may not be affordable by patients. Even if available, such measurements may be inaccurate during labour and at term.[(9)] Clinical palpation of the abdomen in estimating fetal weight requires considerable experience and training. SFH measurement with a tape - measure seems a simple clinical method because it is cheap, readily available, non-invasive and acceptable to patients.[(10)]Furthermore it is a reproducible technique that is easily learned.

After taking the SFH yet it still presents problems with conversion of a measurement to fetal weight estimate. A prediction formula for birth weight has been first deduced from SFH by Johnson .Johnson's and Toshach (1954), determined that a fetal birth weight of 3300 corresponded more closely with a fundal height of 34 cm and a centimeter change in fundal height corresponded more closely with a 150 g change in fetal birthweight.[(11,12)] They introduced a refinement to this method by correcting for descent of the present part into the pelvis and maternal obesity, factors which may distort fundal height. To make the correction, one centimeter is added or subtracted from fundal height if the presenting part is above or below the ischial spines (respectively), and another centimeter is subtracted from fundal height if the mother weighs over 90 kg. Johnson's and Toshach reduced the calculation with all the correction terms to the following equation: estimated birthweight(EFW)= 3300 + (SFH + S+O- 34)(150) where Sis the correction term for station and 0 is the correction term for obesity. In1957, Johnson's simplified the equation to , EFW= 155(SFH+ S+O- 12) for the same variables. The standard deviation for both equations is 353 g; therefore, the method should predict birthweight with an error of not more than 706 g in 95% of all cases. Such a formula can be remembered easily by midwives and doctors and has been validated and found to be useful for estimating fetal weight particularly in limited resource countries where ultrasound facilities are not easily available. No research has been done to validate this simple formula in Ethiopia except one comparative study done in 2008. This simple formula therefore offered the possibility of a simple calculation for estimated fetal weight for use by midwives and doctors in Ethiopia. For this to gain favour, the formula required validation in Ethiopia.

In our country most of our population are rural based who have no access to ultrasonography or who cannot afford the cost even when USG is available. In these groups of population, we can assess the birth weight beforehand by measuring SFH by using Johnson's formula.

Literature review

Numerous studies have been done to establish methods for clinical fetal weight estimation based on SFH measurements. Many studies found a good correlation between SFH measurements and actual birth weight. And even some of these studies have derived an equation which transforms SFH measurements to estimate fetal weight. But there are so many maternal sociodemographic and obstetric variables affecting the SFH measurements and in turn the actual birth weight. So these equations should be validated by a repeat study in the same and different population considering these variables. To the best of the authors knowledge there is no a simple and easy formula that transforms a SFH values accurately to estimated fetal weight that is validated and found to be clinically useful in a specific population.

A South African study, done by Bothner et al in 2000,showed good correlation between intrapartum SFH measurement and birth weight (r = 0.56). Their derived equation was: Birth weight = (SFH – fifths – 20) × (300). The findings of their work done in established labour, at gestational age ranges of 27 - 44 weeks by dates and 25 – 42 weeks by ultrasound, suggested that the level of status of membranes does not affect the SFH measurements. Engagement of the head was associated with a reduction in SFH measurements on average of about 1 cm per fifth of head above the brim from four-fifths to one-fifth. (9) According to this study values obtained by subtracting engagement of the head in fifth from the SFH showed a higher correlation with birth weight than SFH alone (r=0.64 VS 0.56 , p=0.000). SFH measurement of obese women exceeded thin women by 4 to 5 cm but combining these factors in to the SFH values did not reduce the error in fetal weight estimation. Finally, they concluded that SFH measurement for fetal weight estimation was not clinically useful using their formula.[9]

5 years later a similar study in south African revealed a similar correlation coefficient (r) of 0.56with the above study. Using the derived simplified formula: birth weight in g=100 ([SFH in cm]–5), 191 estimations (65.0%; 95% CI 59.2 - 70.4%) were accurate within 10% of the birth weight. A BMI of 30 kg/m2 or above was associated with greater mean SFH (38.4 cm v. 36.3 cm; p<0.0001) and greater mean birth weight (3 363 g v. 3 148 g; p=0.0009) than a BMI less than 30 kg/m2. The mean SFH was lower (35.8 cm v. 37.3

cm; p=0.001) with an engaged fetal head than with an unengaged fetal head. Rupture of membranes appeared to have no significant effect on SFH or birth weight (ruptured vs unruptured: 36.8 cm v. 37.1 cm respectively). But the derived formula should only be used at term in women in the active phase of labour and was not validated in other studies and other countries with different population[10]

A higher correlation coefficient of SFH measurements and infant birthweight of 0.84 was found in Thailand pregnant women. From these study SFH, weight before pregnancy, weight before delivery, weight gain during pregnancy, BMI before pregnancy and before delivery, and maternal height were significantly associated with infant birthweight. Weight and BMI before pregnancy were more correlated with prepregnancy than pre delivery period. There effect on SFH measurement was not determined .However there was no a derived equation that converts SFH to EFW, rather the investigator determine the correlation between SFH measurement and actual birth weight, factors affecting SFH measurement and the cut off values to predict LBW and macrosomia.[11]

A similar study done in India showed significant positive correlation between the two parameters (r = +0.740). [12]

The above studies showed that there is generally significant correlation between SFH measurements and birth weight and should be validated in specific populations which will have different socio demographic and obstetric variables which may affect the SFH measurement and in turn the actual birth weight.

Despite good correlation the above conversion formulas were not validated in subsequent study to be clinically useful.

But a simple conversion formula of Johnson's and Toshach, who claimed an accuracy within 240 g in 68 % and 375gm in 75% of 200 women examined[(13,14)] was validated in different countries and most studies done have confirmed that Johnson's formula correctly predicts actual birth weight from 61 to 72 %.[(15-17)]

According to a study done in Thailand, the overall positive predictive value of Johnson's formula with in10% of the actual baby weight was 71.5%.[15]But the EFW using Johnson's formula was not sufficiently accurate in LBW neonates , and has a tendency toward over estimation of baby weight in all groups of babies particularly in LBW cases.

The difference between the estimated weight using Johnson's formula was an average of 227 g higher than the actual baby weight.

8 years later a similar study done in Thailand reveals that the rates of estimates within 10% of actual birth weight was only 35.71% overall: and the rates of estimates by baby weight category of high birth weight, appropriate birth weight, and LBW were 66.67 %,35.90%, and 16.67% respectively[16]. While a study done in Brazil shows that Johnson's formula accurately predicts birth weight in 61% over all. The researcher explained this due to shape difference between Thailand pregnant women and other similar studies with different populations.[17]

A comparative study done in India in 2010 showed that Johnson's formula correctly predicts birth weight in 71% over all. The PPV in low birth weight, appropriate birth weight and macrosomia groups were 55.3%, 86.6 % and 0% respectively. The average standard deviation prediction error was 185.1. The standard deviation of prediction error in low birth weight, appropriate birth weight and macrosomia groups were 262.8, 213.92 , 78.1 respectively.[18]While according to a similar study done 6 years before in India shows that Johnson's formula correctly predicts birth weight in 63.5% over all. The average standard deviation prediction error was 309.9.[19]

A Bangladesh study done 2 years back revealed that actual birth weight was significantly correlated with fetal weight (found by Johnson's Formula), SFH, pre-delivery weight and height of the patients. Among these fetal weight and SFH had shown highest correlation. Regression analysis showed that SFH, maternal height and maternal weight explained respectively 59%, .011% and .009% of observed variation of birth weight. And concluded that SFH-derived birth weight centiles are useful alternatives to ultrasonography especially in the birth weight range 2500-3999g.[20]

The only study done in Ethiopia by Belete W and Gaym showed a rate of estimates within 10% of actual birth weight by Johnson's formula was 38%.[21] For birth weights less than 2500 grams it overestimated the birth weight. In the 2500-3999 birth weight range Johnson's method systematically overestimated the birth weight.

Other variables which will affect the SFH measurement not considered in the above studies, are the inter and intra observer variability: previous papers have indicated that the inter and intra observer variability of SFH measurements is small, ranging from 0.52 cm to 1.72 cm. [22] on the other hand the SFH measured independently by two clinicians in 39 women differed by 2 cm or more in 19 participants.[23] However according to a recent study Johnson's formula yields results with minimal variation between observers and holds a very high predictive value.[24]. SFH is a useful tool for assessing fetal growth only if its reliability and validity are ensured by providing continuity and uniformity of technique. An important aspect of evidence based practice is evaluation of interventions for effectiveness. With delivery of the neonate, one is provided with a measurable outcome. In support of the idea of SFH measurement to determine baby weight, SFH derived Johnson's formula will be a useful substitute for ultrasound for preparturition estimation of baby weight estimate fetal weight in Ethiopia if the results of this study validated it.

Significance of the study

Correct estimation of fetal weight, along with gestational age and the adequacy of the mother's pelvis, is important information for managing labor and delivery. A macrosomic fetus whose size is underestimated may experience birth trauma against the bony structures of the pelvis. With small fetuses, fetal death, birth asphyxia, meconium aspiration, and neonatal hypoglycemia and hypothermia are all increased .

The two main methods for predicting birth-weight in current obstetrics are: (a) clinical techniques based on abdominal palpation of fetal parts and calculations based on fundal height and (b) ultrasound. Both methods have equal accuracy especially at term

Among the clinical methods Johnson's formula is widely utilized by different level of health professionals in Ethiopia but the formula needs validation because actual birth weight is affected by many sociodemographic and obstetric factors of a community other than SFH.

The present study aims in finding out whether Johnson formula is suitable for our regional specific population and an effort is also made to derive a simple formula for birth weight based on SFH of this particular regional Ethiopian population.

The development and validation of simple, effective and inexpensive tools for reproductive health are important worldwide and especially relevant in developing countries, where high-cost equipment like ultrasound and trained technicians are scarce.

OBJECTIVES

General objective:

- To validate JOHNSON'S formula for predicting fetal birth weight of pregnancies at JUSH, South western Ethiopia, 2014.

Specific objective:

(i) To determine the accuracy of Johnson's formula for the estimation of fetal weight of pregnancies at JUSH.

(ii) To determine the degree of error of fetal weight estimated by using Johnson's formula for pregnancies at JUSH.

(iii) To determine factors affecting accuracy of estimation of fetal weight by using Johnson's formula of pregnancies at JUSH.

(iv) To derive equation based on maternal sociodemographic and obstetric characteristics to predict birth weight in women who gave birth at JUSH.

METHODS

Background information of the study Area and period

Jimma is located 357 Kms South West of Addis Ababa and has total area of 4,623 hectares. The town is divided in to 3 Woreda or Higher and 13 Kebeles .The total projected population of the town is 207,573 according to 2011 central statistical agency of Ethiopia. It has 2 governmental hospitals (JUSH and Shenen gibe hospital), 4 health centers and one military hospital. The study was conducted in JUSH from May 1st to August 30, 2014 . JUSH is a tertiary hospital receiving referrals from the surrounding health centers and hospitals around Jimma town. The maternity building wards consists 40 beds serving for postnatal, post caesarean section, high risk women admitted for elective termination. The labor ward has 8 beds for following women in active first stage of labour and 4 beds to attend second stage. There is also a private room for patients opting for private care.

Study design: A cross-sectional study design was employed.

Source population: All mothers admitted to the labour and maternity ward were considered as source population for the study.

Study population: The study population was all selected women admitted to the labour and maternity ward during the study period who fulfil the inclusion criteria and are not in the exclusion criteria.

Inclusion criteria: labouring mothers admitted to the labour ward for delivery who were either in true labour or delivery is decided and mothers admitted to the maternity ward when they are transferred to the labour ward for delivery due to onset of spontaneous labour, for elective induction and when they are prepared for elective or emergency cesarean section: singleton pregnancy, live fetus, with a longitudinal lie and cephalic presentation.

Exclusion criteria: abortus, known severe fetal congenital anomalies, polyhydramnios (amniotic fluid index greater than 24 cm or clinically assessed), known fibroid or congenitally abnormal uterus.

Sampling

Sample size determination

The sample size was determined using the following single population estimation formula:

$n= P(1-P)Z^2/d^2$

The following assumptions were used in determining the sample size:

- P – Taking the accuracy of Johnsons formula for estimation of fetal weight to be on average 68% [13,14] .
- Z=1.96 which is the standard normal variable at 95% confidence level
- d-is the margin of sampling error tolerated=5%: 334 mothers would be needed to give a precision of 5% around an observed percentage of estimated fetal weights correct to within 10% of the birth weight.
- n= 0.68x0.32x1.96x1.96/0.05x0.05=334

Sampling technique

All pregnant mothers who fulfil the inclusion and not in the exclusion criteria were involved during the period till the desired sample size was reached.

Research variables in the study

Dependent variable: Accuracy of Johnson's formula

Independent variables:

Age

Ethnicity

Marital status

Occupation

Educational status

Annual income

Gravidity

Gestational age

Prepregnancy BMI

SFH

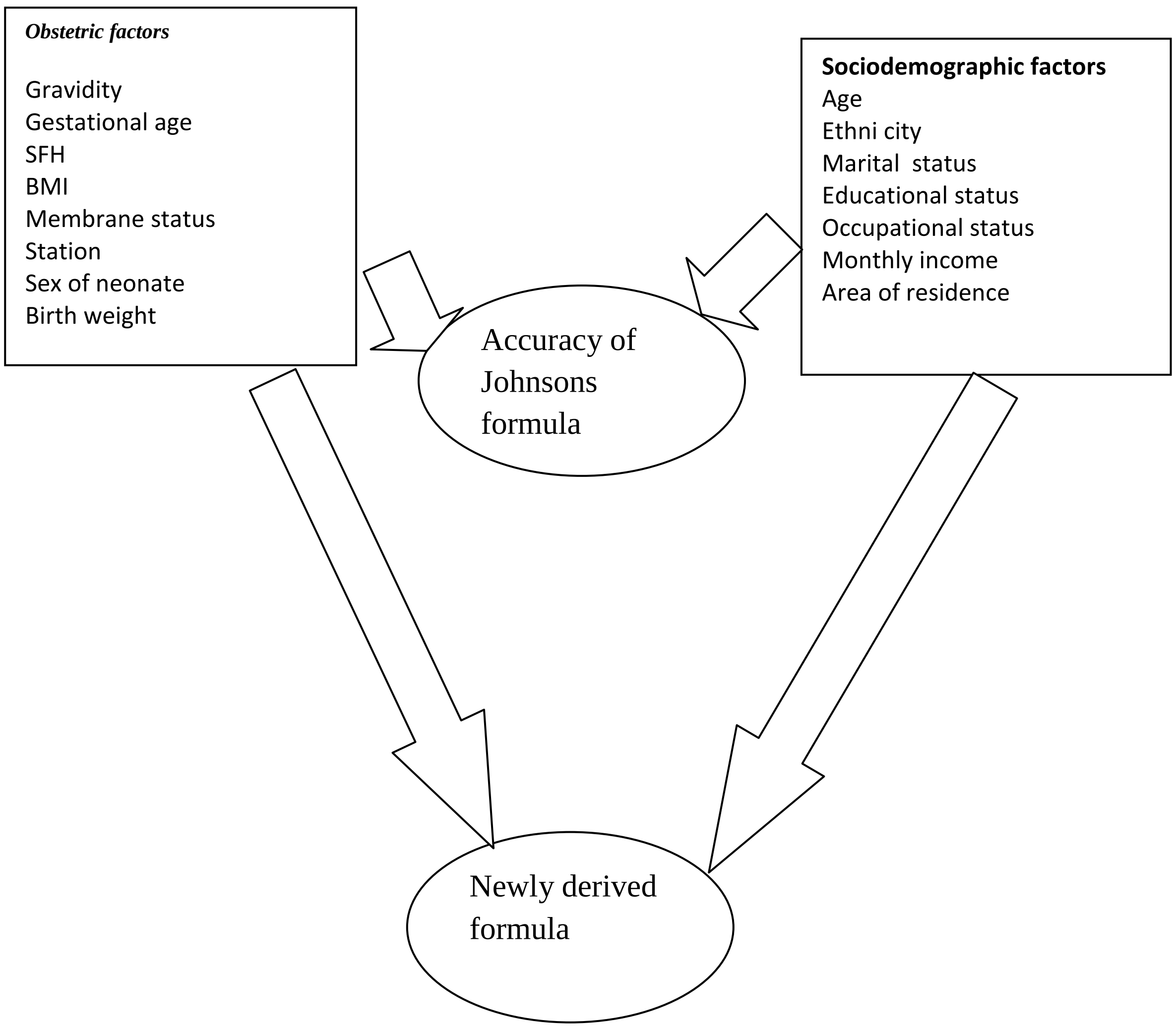
Membrane status

Station

Actual birth weight

Sex of neonate

Conceptual framework



Data Collection Instruments

Pretested structured interviewer administered questionnaire will be used to collect information on the socio demographic and obstetric factors.

Data collection

Women who met the criteria were recruited to participate in the study. Data collectors were residents assigned in the labour ward. Initially, verbal and written consent for inclusion in the study was obtained. Immediately after admission the data collectors record baseline data as shown on the datasheet (Annex2).

The gestational age in our study was found not only by LNMP but also many early pregnancy milestones which have comparable and even better accuracy than LNMP. The accuracy of dating pregnancies by LNMP compared with ultrasound dating was tested by many authors who all found that a BPD between fourteen and twenty weeks, was more reliable than a certain LMP [25].The BPD is the best studied biometric parameter because it is highly reproducible and can predict gestational age within ±7 days when measured between 14 and 20 weeks of gestation . The Correlation with true gestational age is within one week prior to 20 weeks gestational age, but falls to within 2.1 to 3.5 weeks in the third trimester.We can use LMP and ultrasound BPD from 26 to 30 weeks with equal accuracy.

Pregnant mothers with unknown LMP were also involved because we can determine gestational age retrospectively after delivery. Foetuses found to be less than 1000gm after delivery were not included in the study. After delivery, we estimate gestational age by postnatal assessment of the newborn by using the new Ballard score, which is often inaccurate by only ±2 weeks.

Next pre delivery weight was taken.

Abdominal examination was done between contractions with the woman in the supine position. All mothers were asked to void before measurements are taken. The SFH was measured from the upper border of the pubic Symphysis to the highest point of the uterus. Measurement was made to the nearest 0.5cm. A soft non-flexible tape was used for measuring the SFH. Following this vaginal examination findings were recorded which included cervical dilation, station of the presenting part, membrane status. After delivery, the actual infant’s weight was recorded. The birth weight was measured within 30 min after birth on the hospital baby scales by the resident. The author made frequent checks during the study to ensure that the scales are correctly zeroed and calibrated. Women's height was measured in standing position.

Operational definition

Validity: generally refers to the extent to which a measurement is well-founded and corresponds accurately to the real world**.** If this Johnson's formula gave ≥60% of predictions within 10% of the actual birth weight, it would be considered validated.

Engagement -the passage of the maximal diameter of the presenting part beyond the pelvic inlet A head that is only two-fifths palpable is usually considered to be engaged (and therefore fixed in the pelvis).Put simply, an easily palpable head is not engaged, whereas a head more difficult to palpate is more likely to be deeply engaged.

Reliable last normal menstrual period= considers a menstrual cycle coming monthly ,regularly, and discontinued contraceptive 3 months prior to LNMP.

Station: The level of the presenting fetal part in the birth canal in relationship to the ischial spines, which are halfway between the pelvic inlet and the pelvic outlet. When the lowermost portion of the presenting fetal part is at the level of the ischial spines, it is designated as being at zero (0) station. The long axis of the birth canal above the ischial spines was arbitrarily divided into thirds. Values above the ischial spines will be negative and values below the will be positive 1,2,3.

Fetal Lie-is the relation of the long axis of the fetus to that of the mother, and is either longitudinal or transverse.

Fetal presenting part -that portion of the fetal body that is either foremost within the birth canal or in closest proximity to it. In longitudinal lies, the presenting part is either the fetal head or breech, creating cephalic and breech presentations, respectively.

True Labour; A woman is said to be in true labour when Contractions occur at regular intervals, Intervals gradually shorten, Intensity gradually increases, Discomfort is in the back and abdomen, Cervix dilates, Discomfort is not stopped by sedation.

Gravidity- number of pregnancies, including the current one.

Parity- number of births beyond 28wks gestation in the Ethiopian context.

Abortus-A fetus or embryo removed or expelled from the uterus before 28 weeks gestation in the Ethiopian context —or weighing less than 1000gm

Data analysis

All data analysis was done using SPSS version- 20 statistical software. Descriptive statistics included calculations of means ± standard deviations, medians with ranges, and frequencies expressed as percentages with 95% confidence intervals. The difference between a fetal weight estimate and the birth weight in each case was expressed as a percentage error, given as the difference divided by the birth weight, multiplied by 100. Mean percentage errors were calculated for all participants and for selected subgroups. Percentage errors were also grouped as being within 10%, 20% or 30% of the birth weight. Percentage error with in 10 % of the the birth weight is considered accurate. Multivariable linear regression analysis between the actual birth weight and maternal sociodemographic and obstetric factors was done. Statistical significance at $P<0.05$. Scatter plot and simple linear regression with derivation of a formula was done to describe the linear relationship between SFH and the actual birth weight.

Data quality control

Data collection format was pre-tested on 10% of the sample size out of study area in JUSH and necessary modifications were made. Participants who involved in the pre-test were excluded in the actual study analysis. Data collectors were trained for two days and every day the principal investigator checked the questionnaires for completeness and consistency.

Ethical Considerations

The proposal of this thesis was approved by Ethical clearance committee of College of health sciences of JU. Permission was taken from JUSH. Oral and written informed consent was obtained from every study participant before the interview by explaining the objective of the research. All the information collected from the study participants was handled confidentially through omitting their personal identification, and the data were used for the research purpose only.

Dissemination plan

The result of the study will be presented and submitted to JU. The final report will be communicated with different stakeholders including the Zonal health department, hospital, health center. Further effort will be made for publication on local or international journals.

Results

Socio demographic characteristics

Three hundred thirty four pregnant mothers were included in the study. As shown in table 1 the majority of women are between the age groups of 21-30 years and the mean age was 25.0±4.6 years; 96 % are married, 74% of them are oromo in ethinicity, 42.2 % did not attend formal education, 54.5% were house wife. The mean maternal height was 160.4±6.9 cm and the mean pre-pregnancy weight was 56.24±9.9 kg. The mean BMI is 21.8 Kg/m^2. Two third (65.6%) of women have normal BMI while 15.3 % are under weight, 16.8% were overweight, while 2.4 % were obese. Sixty three percent were living in Jimma town while the rest were out of the town.

Table1. Basic maternal sociodemographic characteristic of mothers who gave birth in JUSH, May-August 2014

Socio-Demographic characteristics	Number	Percent
Age (years)		
<21	78	23.4
21– 25	114	34.1
26 – 30	109	32.6
31-35	24	7.2
36-40	8	2.4
>40	1	0.3
Marital status		
Married	311	93
Divorced	10	3
Single	8	2.4
Widowed	5	1.5
Ethnicity		74
Oromo	247	12
Amhara	40	4.8
Gurage	16	3
Dawaro.	10	2.1
Yem	7	1.5
Tigrie	5	2.7
Others	9	
Level of education		
Cannot read and write	88	26.3
Read and write only	63	18.9
Grade 1-4	24	7.2
Grade 5-10	86	25.5
Grade11-12	35	10.5
University/college	39	11.7
Occupation		
House wife	182	54.5
Civil servant	59	17.7
merchant	39	11.7
Farmer	33	9.9
Daily labourer	9	2.7
NGO	6	1.8
student	6	1.8
Annual income in ETH Birr	73	21.8
<14400	253	75.7
14401_70000	8	2.5
>70000		
BMI(kg/m2)		
<18.5	50	15.3
18.5- 24.9	220	65.6
25-29.9	59	18.7
30-34.9	4	1.2
35-39.9	–	
≥40	1	**.3**
Residence		
Jimma	212	63.5
Out of Jimma	112	36.5

Obstetric characteristics

As shown in table 2 nearly half (49.7%) were primigravida, 76.3 % were at term and the mean gestational age was 39.3±2.45 weeks, with a range of 28^{+2}-46 weeks. The average length of SFH was 35.58±2.96 cm with a range of 25 -46 cm. The fetal head was engaged in 111 cases (33.2%), and fetal membranes were ruptured in 234 (70%). The mean cervical dilatation at the time of examination was 4.5±2.6 cm. Eighty eight percent have normal birth weight while 4.2 % have low birth weight and 7.5% are macrosomic. The mean birth weight was 3245.3±51.8 g, with a range of 1400 -5000g.

Table 2.Obstetric characteristics of mothers who gave birth in JUSH, May-August 2014

Obstetric characteristics	Number	Percent
Gravidity		
Primigravida	166	49.7
Multigravida	168	50.3
Gestational age at delivery (wks)		
<37	44	13.2
$37\text{-}41^{+6}$	255	76.3
≥42	35	10.5
Symphysis Fundal height(cm)		
25_28	6	1.9
29-37	251	75
>37	77	23.1
Station		
-3	43	12.9
-2	86	25.7
-1	94	28.1
0	65	19.5
+1	31	9.3
+2	12	3.6
+3	3	0.9
Cervical dilatation		
0	14	4.2
1	14	4.2
2	48	14.4
3	55	16.5
4	68	20.4
5	33	9.9
6	34	10.2
7	7	2.1
8	19	5.7
9	5	1.5
10	37	11.1
Membrane status		
Ruptured	234	70.1
Intact	100	29.9
Birth weight (g)		
<2500	14	4.2
2,500-3999	295	88.3
≥4000	25	7.5
Sex of the neonate		
Male	**198**	59
Female	**136**	41

Table 3. Distribution of continuous variables by range and mean of mothers who gave birth atJUSH,May-August2014

Variables	Minimum	Maximum	Mean ±SD
Age	16	40	25.1±4.7
Monthly income in birr	250	10000	1784.9±1296
Gestational age in week	28.2	46.0	38.9±2.4
BMI	14.2	40.0	21.8±3.6
Neonatal birth wt	1400	5000	3247.5±504.1
SFH	25	46	35.5±2.9

Validation study

Prediction of birth weight using Johnson’s 's formula

The value of Johnson’s formula: birth weight in gm = 155 (SFH in cm – 11/12) , was investigated by transforming each averaged SFH measurement to an estimated fetal weight (EFW), with modification made based on engagement, and comparing this with the actual birth weight . One hundred and twenty-six estimations (37.7%) were within 10% of the birth weight which is the level accepted as accurate (table 3). Over all Johnson’s formula over estimated in eighty eight percent and under estimated in twelve percent of the cases. The mean percentage error of the entire sample was 17.5±13.1(table 4). LBW, normal birth weight and macrosomic babies has mean percentage error of 39.5±12.5, 16.5±12.3, 8.5±6.5 respectively. As shown in table 5 the level of accuracy increases progressively as fetal weight increases and the accuracy is 0%, 38%, and 64 % in LBW, normal birth weight and macrosomic babies respectively. The formula tends to overestimate in all LBW infants, in 91 percent of normal birth weight and in 47 percent of macrosomia.

Table 4. Distribution of percentage error in estimation of fetal weight using Johnson’s formula among pregnant mothers who gave birth in JUSH, may-august 2014

Estimation	Percentage error	N	Percent	Total [N(%)]
Overestimation	≥30.0	51	15.27	295(88.3)
	20.0 – 29.9	74	22.16	
	10.1– 19.9	74	22.16	
	≤10	96	28.74	
Exact estimate	0	1	0.3	0.3
Underestimation	≤10	29	8.97	38(11.4)
	10.1 – 19.9	6	1.5	
	20.0 – 29.9	2	0.6	
	≥30.0	1	0.3	

Table 5. Mean percentage error in estimation of fetal weight using the Johnson's formula in different weight category among pregnant mothers who gave birth in JUSH, may-august 2014

Birth weight category (gm)	N	Mean percentage error ± SD
<2500	18	39.5±12.5
2500-3999	290	16.5±12.3
≥4000	26	8.5±6.5
Total	334	17±13.1

Table 6.Frequency and percentage by accuracy and estimation values among baby weight classification of mothers who gave birth in JUSH, May- August 2014.

Birth weight (g)	Accuracy		Over estimation(%)	exact estimation (%)	Under estimation(%)
	n	%			
< 2,500	0/18	0	100	0	0
2,500-4,000	110/291	37.8	91	0.3	9
> 4,000	16/25	64	47	0	53

Factors affecting the accuracy of Johnsons formula

The accuracy of Johnsons formula was affected significantly not only by birth weight, but also by gestational age and Symphysis fundal height while maternal age , ethnicity, marital status, occupational status, level of education ,area of residence, BMI, gravidity, membrane status, station, cervical dilatation and sex of the neonate did not affect the accuracy.

Table 7.Sociodemographic and obstetric factors affecting the accuracy of Johnson's formula among pregnant mothers who gave birth in JUSH, May-August 2014.

Variable	N	Accuracy of Johnson's formula (%)	p-value
Age (years)			.45
<21	78	42.3	
21– 25	114	37.7	
26 – 30	109	33.9	
31-35	24	4.2	
36-40	8	37.5	
>40	1	0	
Ethnicity			.94
Oromo	247	41	
Amhara	40	37.5	
Gurage	16	43.8	
Dawro.	10	0	
Yem	7	28.6	
Tigrie	5	20	
Others	9	11.1	
Marital status			0.43
Married	311	39	
Divorced	10	50.8	
Single	8	3.2	
Widowed	5	40	
Level of education			.67
Cannot read and write	88	49.5	
Read and write only	63	28.9	
Grade 1-4	24	42.7	
Grade 5-10	86	33	
Grade11-12	35	26.1	
University/college	39	31	
Occupation			.72
House wife	182	38.4	
Civil servant	59	22.1	
merchant	39	41	
Farmer	33	34	
Daily labourer	9	37.5	
NGO	6	20	
student	6	0	
Residence			.7
Jimma	212	23	
Out of Jimma	112	30	
BMI(kg/m2)			.46
<18.5	50	33.3	
18.5- 24.9	220	39.3	
25-29.9	58	35.7	
30-34.9	4	14.3	
35-39.9	–	–	
≥40	1	100	

Gravidity Primigravida Multigravida	 166 168	 39.2 36.3	.92
Gestational age <37 37-41[+6] ≥42	 **44** **255** **35**	 **9.1** **38.4** **65.7**	**.03**
Symphysis Fundal height(cm) 25_28 29-37 ≥38	 6 251 77	 0 39.8 27	.000
station - 3 -2 -1 0 +1 +2 +3	 43 86 94 65 31 12 3	 34.9 43 41.5 29.2 41.9 25 33.3	.21
Membranes Ruptured Intact	 234 100	 **40.6** **31**	**.34**
Cervical dilatation 0 1 2 3 4 5 6 7 8 9 10	 **14** **14** **48** **55** **68** **33** **34** **7** **19** **5** **37**	 **35.7** **35.7** **39.6** **27.3** **51.5** **42.4** **32.4** **42.9** **42.1** **0** **32.4**	**.16**

Derivation study

Gestational age,SFH,neonatal sex, membrane status and BMI are significantly associated with fetal weight. Maternal age, ethnicity, occupational status, level of education, religion, area of residence, gravidity and station of the presenting part are not associated with birth weight.

Multivariable linear regression of all maternal sociodemographic and obstetric factors as independent variables and birth weight as dependent variable would give us the following linear equations that:

From table 7. Gestational age , SFH, neonatal sex, and membrane status are significantly associated with fetal weight. The derived linear equation for prediction of fetal weight based on these birth weight predictive variables is:

Equation 1. EFW(gm) = -3159+101(Gestatinal Age)+58(SFH in cm)+100(Sex of neonate)-156(membrane status) (1=male: 0=female) (1=intact, 0=ruptured membrane) : ($R = 0.78$, p-value ≤ 0.05). (Table 7)

Excluding insignificant socio demograhic variables and considering only possible obstetric variables affecting prediction of fetal weight, BMI in addition to gestational age , SFH, neonatal sex, and membrane status are significantly associated with fetal weight with the following linear equation with out affecting the regression coefficient R : (R=.78 Vs .77).

Equation 2. EFW(gm)= -3O79+99(Gestatinal Age)+56(SFH)+96(Sex of neonate)+11(BMI) -152(Membrane status) (1=male: 0=female),(1=intact, 0=ruptured membrane) : ($R = 0.77$, p-value ≤ 0.05). (Table 8)

But since sex of the neonate cannot be determined before birth we can have another equation with out significant effect on regression coefficient:

Equation 3. EFW=-3206+100(Gestatinal Age)+58(SFH)+11(BMI) -158(Membrane status) ($R = 0.77$, p-value ≤ 0.05). (Table 9)

When the gestational age is unknown the derived equation is:

Equation4. EFW= -533+ 100(SFH) +190(membrane status) : (R= .65, p-value ≤ 0.05). (Table 10)

But inspection of the scatter plot in Figure 1 shows that the line is nearly linear between SFH of 30cm and 43cm but this linear relationship is lost at the extremes. Considering the linear relationship at this two points only we can have a derivation formula based on for a linear equation y= y0(Y intercept)+slope of the graph(x). From the graph the mean actual birth weight at SFH measurement of 30cm is 2600gm, that is y0 (Y intercept). Slope is calculated by taking the values at 2 points on the linear graph as (Y2-Y1)/X2-X1. From inspection of the graph the actual birth weight at SFH value of 43 cm is 4100gm and at 30cm is 2600gm. So slope = (4100-2600) / (43-30)=115. Therefore the derived equation between these points is:

Equation 5.   EFW(gm)= 2600 + 115(SFH (cm)- 30).

Figure 1. Scatter plot of actual birth weight and SFH among pregnant mothers who gave birth in JUSH, augest 2014.

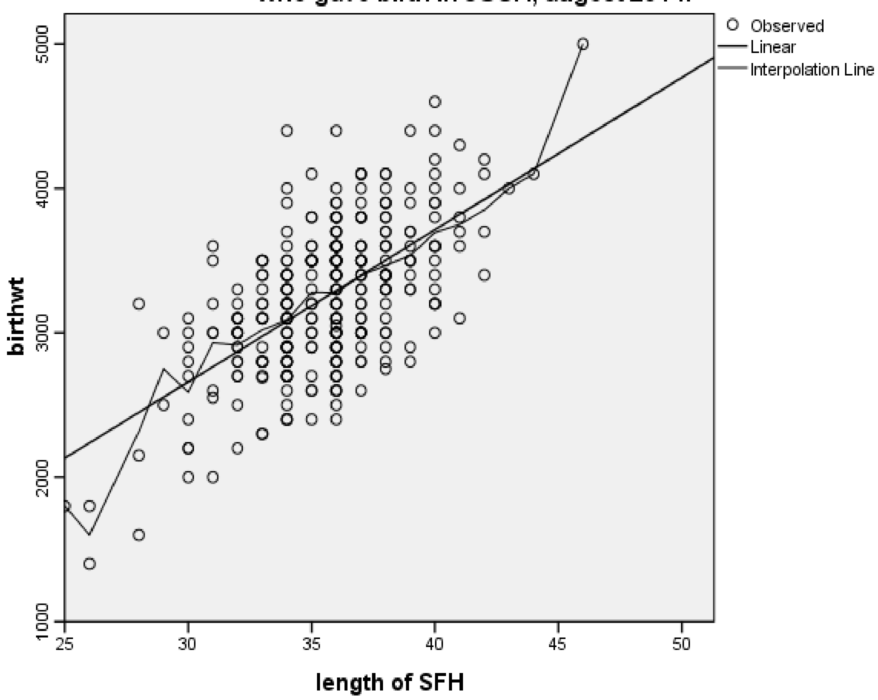


Table 8. Multivariable analysis of factors associated with infant birth weight among pregnant mothers who gave birth in JUSH, May-August 2014. (Dependent variable: neonatal weight)

Variable	**B**	**Sign.**
(Constant)	-3159.2	.00
Age	-.61	.61
Religion		
Muslim	5	.45
Orthodox	46.2	.49
Protestant	13.1	.88
Catholic‡		
Ethnicity		
Oromo	-78.38	.56
Amhara	-69.49	.63
Gurage	38.47	.81
Dawro	-4.73	.98
Others(Tigre,Wolayita, yem)‡		
Marrital status	69.17	.58
Education		
Read & write	-16.4	.32
Grade 1-4	41.8	.564
Grade 5-10	-22.4	.763
Grade11-12	-33.9	.576
University	-141.2	.55
Cannot read & write‡		
Occupation		
Housewife	-2.0	.972
Gov employ	-10.2	.894
Merchant	73.7	.355
others(student, daily labourer)‡		
Area of residence	-26.3	.55
Gravida	34.8	.44
BMI of pt	10.8	.07
Length of SFH	58.	.00
Station		
-3	224.0	.27
-2	197.0	.32
-1	203.2	.30
0	171.2	.39
+1	192.5	.34
+2	200.8	.36
+3‡		
Gestational age in week	101	.00
Sex of neonate	99.7	.02
Membrane status	-155.8	.001

EFW(gm) = -3159+101(Gestatinal Age in week)+58(SFH in cm)+100(Sex of neonate)-156(membrane status) (1=male: 0=female) (1=intact, 0=ruptured membrane) : ($R = 0.78$, p-value ≤ 0.05) R=.78, Statistical significance at P≤0.05: B= Regression coefficient

‡=reference variable

Table 9. Multivariable regression analysis of possible obstetric factors associated with infant birth weight among pregnant mothers who gave birth in JUSH, May-August 2014. (Dependent variable: infant birth weight weight)

Variable	B	Sign.
(Constant)	-3079.4	.000
Gestational Age in week	98.9	.000
Length of SFH	56.0	.000
Membrane	-152.8	.000
sex	86.3	.023
BMI	11.4	.028
Gravida	46.2	.213
Station		
-3	199.1	.319
-2	211.3	.280
-1	189.0	.332
0	210.1	.286
+1	176.7	.378
+2	213.2	.320
+3‡		

EFW(gm)= -3O79+99(Gestatinal Age)+56(SFH)+96(Sex of neonate)+11(BMI) -152(Membrane status) (1=male: 0=female),(1=intact, 0=ruptured membrane) : (R = 0.77, p-value ≤ 0.05).
R= .77, Statistical significance at P≤0.05
B= Regression coefficient
‡=reference variable

Table 10. Multivariable regression analysis of possible obstetric factors other than neonatal sex associated with infant birth weight among pregnant mothers who gave birth in JUSH, May-August 2014. (Dependent variable: infant birth weight weight)

Variable	**B**	**Sign.**
(Constant)	-3206.8	.000
Gestational Age in week	100.6	.000
Length of SFH	57.7	.000
Membrane	-157.5	.000
BMI	11.2	.030
Gravida	45.3	.223
Station		
-3	248.9	.213
-2	271.0	.165
-1	245.7	.207
0	272.3	.165
+1	230.1	.251
+2	276.1	.197
+3‡		

EFW=-3206+100(Gestatinal Age)+58(SFH)+11(BMI) -158(Membrane status) ($R = 0.77$, p-value ≤ 0.05).
R= .77, Statistical significance at $P \leq 0.05$
B= Regression coefficient
‡=reference variable

Table 11. Multivariable regression analysis of possible obstetric factors other than neonatal sex associated with infant birth weight and with unknown gestational age among pregnant mothers who gave birth in JUSH, May-August 2014. (Dependent variable: infant birth weight weight)

Variable	**B**	**Sign.**
(Constant)	-533.4	.13
Length of SFH	100.7	.000
Membrane	-189.9	.000
BMI	7.7	.2
Gravida	31.5	.4
Station		
-3	14.5	.9
-2	98.2	.6
-1	81.6	.7
0	48.5	.8
+1	42.8	.8
+2	83.7	.7
+3‡		

EFW= -533+ 100(SFH) +190(membrane status) : (R= .65, p-value $\leq$ 0.05).

R= .65, Statistical significance at $P \leq 0.05$
B= Regression coefficient
‡=reference variable

Table 12. The mean birth weight and SFH by BMI, sex, and status of membrane of mothers who gave birth in JUSH, May-August 2014.

Variable	N	Mean Birth weight	Mean SFH
BMI			
<18.5	51	3035.10	34.45
18.5- 24.9	219	3268.72	35.54
25-29.9	56	3300.89	36.20
30-34.9	7	3457.14	38.57
?40	1	5000.00	46.00
Total	334	3247.57	35.58
sex of neonate			
Male	198	3343.18	35.97
Female	136	3108.38	35.01
Total	334	3247.57	35.58
Status of membrane			
Ruptured	234	3316.20	35.68
intact	100	3087.00	35.34
Total	334	3247.57	35.58

Discussion

This study validated Johnson’s formula. The formula provided intra partum prediction of birth weight in singleton live vertex presentations to within 10% of the birth weight in 37.7% of estimations. This value is very low when compared with to a similar validation study done Thailand and Brazil which have confirmed that Johnson’s formula correctly predicts actual birth weight from 61 to 72 %.(15-17) While a similar study done in Ethiopia by Belete, and Gaym reported 38% accuracy .21This difference in the level of accuracy can be explained by shape difference between Ethiopian pregnant women and Thailand and Brazilian populations. The accuracy of Johnsons formula was affected significantly by birth weight, gestational age and Symphysis fundal height while maternal age , ethnicity, marital status, occupational status, level of education ,area of residence, BMI, gravidity, membrane status, station, cervical dilatation and sex of the neonate did not affect the accuracy. The accuracy in LBW, normal birth weight and macrosomic infants is 0 %, 37% and 64% respectively . Similarly the accuracy was significantly reduced as gestational age and Symphysis fundal height decreases. Over all Johnson’s formula over estimated in eighty eight percent of the cases .While it tends to overestimate in all LBW infants ,and in ninety one percent of normal birth weight infants, in fifty three percent of macrosomic infants it tends to under estimate. The accuracy at gestational age less than 37 completed weeks, 37 weeks up to 41^{+6} completed weeks, and greater than 42 weeks is 9%, 38% , 65% respectively. Therefore Johnson’s formula accurately predicts birth weight in macrosomic babies or at gestational age > 42 weeks.

This very low accuracy of Johnson’s 's formula to predict the birth weight can indicate that maternal sociodemographic and obstetric factors in addition to Symphysis fundal height may affect the fetal weight estimation. Based on this assumption multivariable regression was done taking actual birth weight as dependent variable. Maternal age , ethnicity, marital status, occupational status, level of education ,area of residence, and gravidity, and station do not have significant association with the birth weight. While gestational age at birth , SFH value , BMI and status of the membrane are significantly associated with birth weight (r=0.78). When compared to other similar studies our study has strong correlation than a similar study done in South Africa , India and Thailand (r=0.56)9-12 This might be because theydid not do a multivariant regression analysis of the different maternal sociodemographic and obstetric factors associated with birth weight.

On multivariate regression analysis gestational age at birth , SFH value , status of membrane and neonatal sex are significantly associated with birth weight and we have derived different alternative formulas according to the known or measurable variables of each individual mother. For example although fetal sex is significantly associated with birth weight we cannot determine sex of the neonate before delivery. Therefore we can use the formula which does not consider sex of the neonate among the variables which are used to predict birth weight (Table 9). Additionally if the gestational age is unknown we will use the regression formula of table 10. But different literatures have shown that sociodemographic variables did not affect the prediction of fetal weight at birth. In our study excluding maternal sociodemographic variables resulted in significant association between birth weight and gestational age , SFH, sex of neonate, status of the membrane and BMI without affecting the regression coefficient, BMI was not significantly associated when insignificant maternal sociodemographic variables are considered, but when they are excluded it becomes significantly associated. Gestational age and SFH are the most strongly associated obstetric variables with birth weight. Depending on the clinical circumstance we can use the following formula:

Equation 1. EFW(gm) = -3159+101(Gestatinal Age in week)+58(SFH in cm)+100(Sex of neonate)-156(membrane status) (1=male: 0=female) (1=intact, 0=ruptured membrane) : (R = 0.78, p-value $\leq$ 0.05). (Table 7)

Excluding insignificant socio demograhic variables and considering only possible obstetric variables affecting prediction of fetal weight, BMI in addition to gestational age , SFH, neonatal sex, and membrane status are significantly associated with fetal weight.(R=.78 Vs .77)

Equation 2. EFW(gm) = -3O79+99(Gestatinal Age)+56(SFH)+96(Sex of neonate)+11(BMI) -152(Membrane status) (1=male: 0=female),(1=intact, 0=ruptured membrane) : (R = 0.77, p-value $\leq$ 0.05). (Table 8)

But since sex of the neonate cannot be determined before birth we can have another equation wiyh out significant effect on regression coefficient:

Equation 3. EFW= -3206+100(Gestatinal Age)+58(SFH)+11(BMI) -158(Membrane status) (R = 0.77, p-value $\leq$ 0.05). (Table 9)

When the gestational age is unknown the derived equation is:

Equation4. EFW= -533+ 100(SFH) -190(membrane status) : (R= .65, p-value $\leq$ 0.05). (Table 10)

Equation 5. EFW(gm)= 2600 + 115(SFH (cm)- 30).

Table 13. Summary of results of different studies done on accuracy of Johnsons formula.

Reference	Gestational age	Sample size	Overall A ccuracy		<2500gm			2500-4000gm			>4000gm		
						Accuracy			Accuracy			Accuracy	
			N	%	N	n	%	N	n	%	N	n	%
Kumari 2010, India	Term	500	355	71	132		55	365	317	87	3	0	0
Amrita ,2004 India	Term	200	82	41	NOT AVAILABLE								
Nareelux ,India	28-42	126	45	35	6	1	17	117	42	36	3	2	67
Altenfelder,Brazil	term	132	80	61									
Watchree,Thailand	34-42	400	284	71	13	2	15	378	275	72	9	9	100
Belete 2008		320	122	38									
This study	28-46	334	126	37	18	0	0	291	110	37.8	25	16	64

Conclusion

Johnson's formula was found to be inaccurate in this study particularly in LBW babies. But in macrosomic babies it is considered accurate although the small sample size in this group precludes a firm conclusion. The formula inaccurately predicts birth weight in preterms and at terms between gestational age thirty seven and fourty one weeks and six days. But is accurate at gestational age greater than 42 completed weeks despite small sample size in this group. Birth weight is strongly correlated with SFH which can be transformed by a simple clinical formula where: Weight in Gm= 2600 + 115(SFH(cm)- 30) for estimation of fetal weight between Symphysis fundal height of 30 and 43 cm. The accuracy also decreases with the level of the Symphysis fundal height value.

Recommendation

Johnson's formula should not be used for our community. This is because birth weight is associated with maternal sociodemographic and obstetric factors in addition to SFH, and engagement and any derived formula can be utilized only for that specific community. Based on this we recommend using the formula: Estimated fetal weight (gm)= 2600 + 115(SFH(cm)- 30) between SFH of 30 and 43 cm which is derived based on the our maternal sociodemographic and obstetric factors .

The following alternative formulas can be used based on the availability of the independent variable of an individual patient. But they have to be simplified to the nearest hundred so that they can be easily remembered by nurses and midwifes working in the rular area of the country.

1. EFW(gm) = -3159+101(Gestatinal Age in week)+58(SFH)+100(Sex of neonate)-156 (membrane status) (1=male: 0=female) (1=intact, 0=ruptured membrane) : (R = 0.78)

2. EFW(gm) = -3O79+99(Gestatinal Age)+56(SFH)+96(Sex of neonate)+11(BMI) -152 (Membrane status): (R = 0.77))

3. EFW(gm) = -3206+100(Gestatinal Age)+58(SFH)+11(BMI) -158(Membrane status) (R = 0.77)

4. EFW(gm) = -533+ 100(SFH) -190(membrane status) : (R= .65)

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