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Original Research Article

Development of new localised formula basis for birthweight estimation: single variable and single constant coefficient based clinical formula

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ABSTRACT

Introduction: The OBGY professionals' primary goal is the well - being of fetal and mother. And, to achieve this, accurate fetal weight assessment is of prime importance. The prevalent fetal weight assessment formulas are of western origin and developed several decades ago, and hence its applicability throughout the world is always under debate.
Methods: Present study of analytical formula basis development was carried out at the OBGY Department of a semi-urban cum rural tertiary care hospital, Dhiraj Hospital, SBKS MRC, at Gujarat. The study was undertaken over total of 50 pregnant women at full term pregnancy, till delivery. The actual localised birthweight data of these cases were collected and analysed, to derive a new formula basis and named as 'SHF as singular kinematic' (SSK). Same is verified, validated and compared using prevalent Johnson's formula, for its significance, accuracy / error and positive predictive value. The Microsoft office, excel was used for the calculations and analysis and for graphs.
Results: The new linear formula basis for birthweight estimation is BW(e-ssk)=(SFH-5.8)/8.588, is developed and got validated for its accuracy and predictive value. In comparison to prevalent clinical method Johnson and Toshach formula (JT), it was derived that new SSK formula has identical p value and higher PPV. Also, weighted average PPV % of the study using new SSK formula has resulted higher than, that of PPV % of Similar studies using prevalent formula.
Conclusion: This study concludes that for clinical birthweight estimation, for pregnancy at term, using the newly derived formula basis "SFH as Singular Kinematic–SSK", provides better accuracy for birthweight estimation over prevalent formula, while simultaneously solving the purpose of easy to learn and easy to use method for all concerned, even including non-medical persons and expecting mothers, at their own with basic training.

Keywords: Fetal weight estimation, Birthweight estimations, Clinical methods for fetal weight estimation, Symphysial fetal height, Pregnancy

INTRODUCTION

The body weight of a newborn baby measured at the time of birth is defined as birthweight.[1] The birthweight is the prime indicator of Maternal and fetal health. The percentage of low-birth-weight babies has undergone a change overlast few decades. There was a decrease in US from 7.9% (1970) to 6.8% (1980), then a slight increase to 8.3% (2006), to the current levels of 8.2% (2016) and 8.6 % (2022).[2,3] The data from three groups across Asia, the US, and Europe, found that 7% of women were underweight and 38% were overweight and obese at the time of pregnancy. Women with more overweight were at higher risk of having obese babies and requiring a caesarean birth and delivery complication. Women who went into a pregnancy with underweight and who didn't put on recommended weight had an 8% risk of having an underweight baby, and an 8% risk of a premature birth.[4]

The low birthweight is estimated to 28% of total births for India, for 2024.[5] As estimated by the Sample Registration System (SRS) Report of Registrar General of India (RGI), the maternal mortality rate, (MMR) has decreased from 8.1 in 2015-17 to 7.3 in 2016-18 for India.[6] The state of Gujarat has even lower MMR of 5.1, and though Indian MMR is rated "Low', still almost double than the average of 2.4 'Very Low' for top 25 countries with lowest MMR.[7] Even Indian infant mortality rate (IMR), has reduced from 37 per 1000 live births in 2015 to 30 per 1,000 live births in 2019, still it is rated "High' in global reference.[8] Although, Gujarat IMR is lower at 25, than that of Indian IMR. Low birth weight as well as high birth weight is the root cause for cases with infectious diseases in infants, IMR, MMR and later date health concerns in their adulthood.[9] Various studies have observed with different level of accuracy, to establish relation between birth weight and later-life conditions, like diabetes, obesity, fast foods, lack of physical exercise etc.[10] That's why the early knowledge of the weight of the foetus in utero, with good accuracy is of prime importance for the obstetrician to decide whether to deliver or not to deliver and to decide on how to deliver, the mode and place of delivery etc to optimize the fetomaternal outcome.

Different methods of estimating fetal weight had been developed and have been extensively used in different parts of the world, in search of the best method. Broadly these are classified as clinical methods, risk factor assessment, maternal self-estimation, obstetric ultrasonography. Some of the most popular amongst these are clinical methods based on the formulas established to estimate birthweight and are prevalent throughout the world and even in India. However, there exist controversies around, as to which method/formula is most useful and widely applicable for predicting fetal weight. Let us briefly understand the logic behind it. Logically, all methods are developed in western world. To be more specific, let us understand history of Johnson and Tosch formula, which was developed in 1954, almost seven decades before from now. It was developed following average birth weight during that timeline and that too for average European birthweight of those years, as mentioned earlier, this is at the level of 3.5 kg.[11] Obviously, if one need to apply this formula on Ethiopian pregnant mothers on one hand and pregnant mothers from Nauru, on other hand, would outcome result be equally accurate in estimation. Even average Asian birthweight is ranging between 3.0-3.25.

So, obviously formula devised based on average birth weight of 3.5 kg, by Europeans, will end up resulting to estimation errors to the tune of 250 to 500 gm.[12,13] Over and above that, there are several other factors related to diverse ethnicity, variation in per capita income, food habits and lifestyle, penetration of processed or fast-food products and simultaneously depleting in nutrient value of food intake has undergone vast changes, over last several decades for the world population in general and more severely in certain regions. And, these changes are not adequately reflecting to resultant output of these prevalent formulas. (e.g. Obesity has tripled worldwide since 1975 from 13%, to 39% at present). Therefore, there is a need to develop a new formula basis to accurately predict birthweight, focusing on the database of localised-regional actual birthweight records, to achieve the best outcome while simultaneously incorporating in-built indirect and passive correction of all regional parameters of differentiation related to diversified ethnicity, economic conditions of the population mass, BMI, genetics, food habits and lifestyle etc. Thus, making it more accurate and relevant to reflect inherent aspects of localised regional population.

The goal of this research study is to develop tailor-made, localised-regional formula basis, to estimate birthweight, which in turn, by default inherently incorporate in-built indirect passive correction of all regional mass parameters related to diversified ethnicity, economic conditions of the population mass, BMI, genetics, food habits and lifestyle etc. making it more relevant and accurate, in context of a typical regional population visiting nearby tertiary care hospital for the purpose of delivering a child. An additionally, also making it easy to learn and easy to use method, even for maternal self-assessment of birthweight with a single measurement, using household device-a measuring tape, following the basic training.

METHODS

The study was conducted at Department of Obstetrics Gynaecology, Dhiraj Hospital, SBKS MRC, from 1st January 2024 to 30th July 2024. The approval from the SBKS Ethical Committee was obtained. It was a comparative type of study covering 50 pregnant women at term, (i.e.,>37 weeks of gestation or at labour), who delivered at the hospital.

Inclusion criteria

All the cases of pregnant women admitted for confinement in antenatal ward at term, at Dhiraj Hospital, provided they are pregnant with single foetus, in vertex presentation form.

Exclusion criteria

The cases of pregnant women with, an of following conditions like, 'Multiple Gestation' or 'Malpresentation' or 'Poly-or oligohydramnios' or 'intrauterine growth retardation (IUGR)' or 'fibroids' or "adnexal mass' or 'intrauterine fetal death (IUFD) or congenital anomalies are excluded from the study. All the cases, which qualified under inclusion criteria, their demographic details, clinical history, abdominal and pelvic examination related information were collected and collated in a structured form in excel worksheet. Further, station identification was done and recorded, along with symphysis fundal height (SFH) measurement, prior to delivery. On delivery, for each and every qualified case, actual birthweight is

measured and recorded, as BW(a). To establish relationship between SFH thus collected with Actual birth weight BW(a), these data were plotted graphically against X-axis and Y-axis, and then trend line of all these case data points, were taken as a basis to develop the new formula for birth weight estimation. As SHF is used as an only singular kinematic for this formula, we named new formula as "SHF as singular kinematic (SSK)", as regional representative formula, which will by default passively or indirectly address all the local socio-economical, genetical, lifestyle etc. related factors, as actual birth weights of new-borns, of actual mothers from the same region/locality, and same were taken as a basis for the developing this new formula. Applying a straight-line arithmetic equation Y=m×X+C, on the trend line, value of m (slope of the trendline) and value of C (Y-axis intercept), were estimated from the graph using respective scales of X axis and Y-axis. And later, using this newly developed formula basis of SSK was applied, using SHF data collected for all these case on one one hand, whereas on other hand, Johnson-Toshach formula for birthweight was also applied using station position and SFH as two variable factors, for the cases under this study. To validate and compare SSK formula for birthweight estimation BW(e-ssk), vis-à-vis birthweight estimations BW(e-jt), by Johnson and Toshach (JT) formula for the purpose, their resultant output data of birth weights are compared graphically, with each other, first. And later, both estimations were compared with that of actual birth weight data. Finally, analysis about significance, errors and positive predictive values for SSK and JT methods for birthweight estimation, was carried out. The outcome results are summarised and discussed in subsequent sections.

RESULTS

Demographic distribution of the cases included in this research study, are collated and presented in the figure 1 below, in terms of age group distribution, education levels, domicile, employment status and gravida status, as their relative percentage.

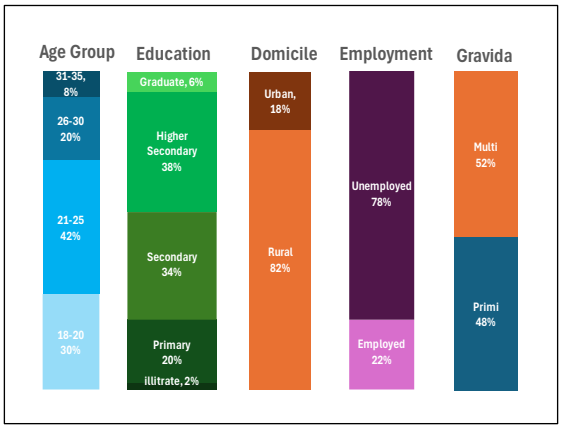

Figure 1: Demographic distribution of the case profiles.

Majority of the "actual birthweights-BW(a)", of the research study belonged to the average birth weight category of 2.0 kg to 2.5 kg, then followed by 2.5 kg to 3.0 kg. To establish relationship with BW(a) and SFH, the data points collected during this study are plotted for its graphical corelation, and same is exhibited as figure 2 below.

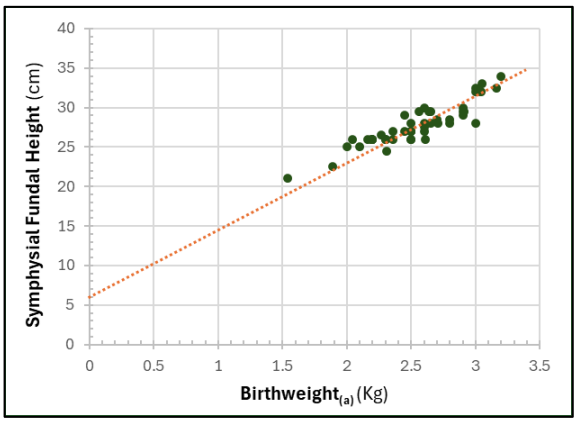

Figure 2: BW(a) vs measured SFH, with origin (x,y) as (0,0).

On evaluating trendline of figure 2, following the straight-line equation, Y = m×X+C, the Y axis intercept C can be considered as 5.8 and slope (m) worked out as follows, m = (35-5.8)/3.40) = 8.588. Thus, newly derived equation for Birthweight estimation BW(e-psk) can be worked out as follows.

$$Y = m \times X + C$$

Therefore, X=(Y-C)/m.

By putting value for m and C and placing correct nomenclatures for X and Y, above equation can be re-written as follows. SSK (SHF as singular kinematic) formula basis: BW(e-ssk)=(SFH–5.8)/8.588. Using, this SSK formula, "Birth Weight estimation by SSK formula basis-BW(e-ssk)" was made for all the cases of this study and plotted versus BW(a) as figure 3.

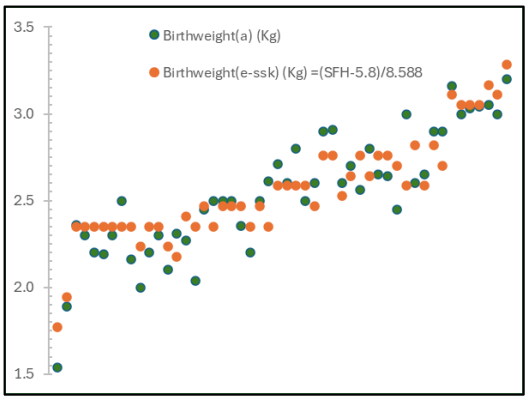

Figure 3: BW(a) vs estimated birthweight BW (e-ssk).

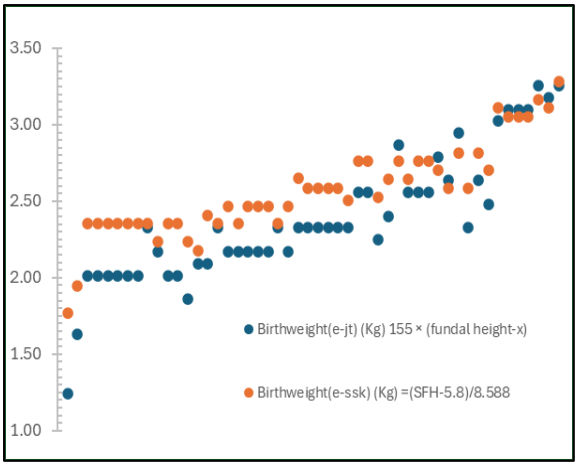

Figure 4: Relative validation of BW(e-ssk) w.r.t. BW (e-jt).

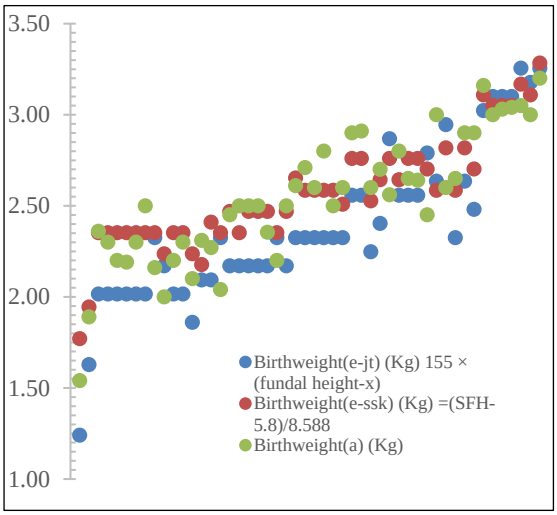

Figure 5: Actual birthweight BW(a) vs. Estimated Birthweights BW(e-ssk) and BW(e-jt).

The figure 3 above establishes clear corelation with of new SSK formula for birth weight estimation with that of actual Birthweight and provides reasonable accurate estimates of actual birthweight, in most of the cases.

Table 1: Popular and prevalent formulas for fetal weight estimation.

Johnson and Toshach formula	Fetal weight×(gm)=155 (SFH–where X=11 at plus (+) station=12 at zero (0) station=13 at minus(-) station
Dare's formula	fetal weight (gm)=SHF×AG, Where AG=abdominal grith
Dawn's formula	fetal weight (gm)=LDU×(TDU/2)^2×1.44, LTD=longitudinal dimeter of uterus, TDU=transverse diameter of uterus

With an objective of validation of the new SSK formula, it was prudent to use existing prevalent formula as validation basis. Following the case data points collected during this study for SFH and station position, birthweights are estimated for all the cases individually. And to further validate the outcome of BW(e-ssk), "estimation of birthweight using the formula of Johnson and Toshach BW(e-jt)" was carried out for all the cases. And both the findings are plotted on the same scale on same axis, to validation corelation between both these estimates, as figure 4.

DISCUSSION

At the outset, the results of estimated birthweight thus derived from from newly developed SSK formula for birth weight estimation, BW(e-ssk) and the results obtained by using Johnson-Toshach formula for birth weight estimation, BW(e-jt), are collated and compared graphically with that of actual birth weight. Figure 5 clearly establish the fact that newly derived SSK formula for birthweight estimation shows lower margin of errors, and in almost all cases BW(e-ssk) datapoints, being in closest proximity with that of BW(a) data points than that of datapoints of estimates made by BW (e-jt), thus revealing the conclusion that BW(e-ssk) estimates are more accurate than that of BW(e-jt). This graphically derived conclusion is further endorsed by estimating mean error (in kg as well as in %), p value and positive predictive values for both birth weight estimation methods and are summarised in table 2.

It is prudent to note here from the table 2 that, although p-values are more or less identical in nature, for all birthweight categories for BW(e-ssk) and BW (e-jt), the positive predictive values for all categories for BW (e-ssk) are higher than that of BW(e-jt). And, obviously, so do the weighted average PPV (WAPPV) for WB (e-ssk) provides nearly 13.6 % higher predictive value than that of WAPPV of BW (e-jt). Hence, it is getting further endorsed that, the birth weight estimates BW (e-ssk) are relatively more accurate to that of BW (e-jt), as per our study. Table 3 summarises the comparison of PPV as concluded by different studies undertaken for Johnson Toshach's formula for birth weight estimation (including that of our study), with that of newly derived SSK formula for birthweight estimation.

It is prudent to note here from table 3 that, when we compare positive prediction values (PPV%) of birthweight estimation done in our study using Johnson Toshach formula BW(e-jt), with that of PPV% values derived by different studies undertaken by Amritha et al, Tiwari et al, Torloni et al, PPV% outcome of all these four studies is more or less same, ranging from 57% to 78 %. Whereas PPV % value for the birth weight estimation done by using newly developed SSK (SHF as Singular Kinematic) formula BW(e-ssk) is significantly higher at 91.3 % than those resultant PPV% of all the above four studies using Johnson Toshach's formula.[14-16]

Table 2: Summary of standard error, mean error, p value and PPV for BW(e-ssk) and BW(e-jt).

Birthweight summary as estimated by, "SHF as singular kinematic (SSK)" formula basis								
Categories BW (kg)	$BW_{(e\text{-}ssk)}$ in (kg)			Mean error		P value	PPV	WA PPV
	Mean	SD±	Std error	(kg)	(%)	(<)	(%)	
< 2.00	1.86	0.12	0.09	0.14	0.09	-	-	91.1 %
2.01 to 2.50	2.37	0.08	0.05	0.14	0.06	0.05	91.3	
2.51 to 3.00	2.68	0.09	0.06	0.12	0.05	0.05	90.9	
>3.01	3.12	0.09	0.05	0.04	0.01	0.05		
Birthweight Summary as estimated by "Johnson and Toshach (JT)" formula								
Categories BW (kg)	$BW_{(e\text{-}ssk)}$ in (kg)			Mean error		P value	PPV	WA PPV
	Mean	SD±	Std error	(kg)	(%)	(<)	(%)	
< 2.00	1.43	0.27	0.23	0.28	0.17	-	-	77.5 %
2.01 to 2.50	2.16	0.14	0.10	0.27	0.11	0.05	77.8	
2.51 to 3.00	2.58	0.19	0.12	0.30	0.11	0.05	76.9	
>3.01	3.12	0.07	0.04	0.03	0.01	0.05	-	

Table 3: PPV (%) of different studies for JT formula w.r.t SSK formula of our study.

Various studies for JT formula	PPV (%)	PPV of our study by $BW_{(e\text{-}ssk)}$
Amritha et al14	63.50	91.3 %
Tiwari et al	78.00	
Torloni et al15	57.00	
Our study* BW	77.49	

The sample size of this research study is small, though case profile distribution in terms of Birth weight category and domicile is apparently, quite representative. However, a much larger sample size, for each individual birth weight category, will enhance overall accuracy and that of within birth category, considerably further.

That's why outcome of this study is claimed as "Formula Basis", and not the formula or method of birthweight estimation.

CONCLUSION

This newly developed, "SFH as Singular Kinematic (SSK) formula basis" for birthweight estimation, solve the purpose of primary estimates of birthweight, and provides similar or slightly better results over prevalent clinical method of prediction of fetal weight. This simpler method using single measurable obstetric parameter, requiring minimal manpower training and just taking SFH measurement with a simple household device-measuring tape.

We hope that the conclusions of this study will add up to the further evidence provided by earlier investigators that clinical methods are equally reliable, cheap and easier to teach, easy to use and can go a long way in aiding decision-making process in resource poor regions of developing and underdeveloped nations, without compromising on the end goal of fetal and maternal well-being.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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