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Development of Weight Gain Chart for Pregnant Southern Sudanese Mothers in Juba City University of Bahri - Khartoum, Sudan

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Abstract: ***Assessment of pregnant mothers using weight gain chart is rare in Sudan. The aims of the study were to design a new reference weight gain chart of pregnant women using the body mass index and weeks of gestation, to compare to Mardones and Roso chart. Study design it is a cross-sectional and longitudinal health facility- based study, carried out in Juba city. The participants were Sudanese pregnant mothers who belong to the local tribes, during their second or third trimester. Methods anthropometric measurements (height, weight) were used. Result The new reference weight gain chart based on BMI and week of gestation showed that the upper limit below the proposed Rosso and Mardones considered as normal curve for the studied groups. Nevertheless the chart shows an obvious increase in weight gain according to the two successive measurements of mothers' body mass index. We concluded that the optimal BMI suited the southern Sudanese mothers found to be 23.37±3.52 relative to the best outcome during second trimester and 23.55±3.59kg/m2 during third trimester. However the designed chart might be suitable and good predictable for weight gain during pregnancy and consequently pregnancy outcome***

Keywords: Weight Gain Chart, Weight Gain, Body Mass Index, Pregnant Mothers, Birth Weight

1. Background

Lack of precise and detailed data concerning nutritional status assessment during pregnancy using body mass index as an indicator are very rare in Sudan particularly in Southern Sudan [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.], therefore this study aimed to establish cut-off points for body mass index and to use it as an indicator for weight gain during pregnancy and compared to weight gain chart developed by Rosso and Mardones chart for nutritional status assessment. It also aimed to implement the use of this chart for quick assessment among pregnant mothers to identify mothers who are at risk of delivering small babies (low birth weight) [12], for targeting nutritional interventions aimed at preventing low or high birth weights. The RM chart defines categories of maternal nutritional status in early gestation based on weight/height, expressed either as percentage of standard weight (PSW) or body mass index (BMI), and desirable gestational weight gains for each of these categories. Yasmin Neggers and Robert L. Goldenberg [13] suggested that a low pregnancy body mass index is one of strongest predictors of adverse pregnancy outcomes such as preterm birth and fetal growth retardation, In developing countries, where deficiencies of multiple micronutrients and macronutrients are common, some evidence indicates that increasing micronutrient intakes, either by supplementation or by increased consumption of micronutrient-rich foods, is associated with significant increase in birth size and a reduction of IUGR in women with a low prepregnancy BMI. It is plausible that in these undernourished women both low prepregnancy BMI and a low plasma volume may be associated with poor micronutrient status. This combination may thus result in a decreased transfer of nutrients from mother to fetus and may have an adverse effect on fetal growth. They concluded that well-designed randomized controlled trials in high-risk women with low pre-pregnancy BMI, preferably in developing countries (where multiple micronutrient deficiencies are common) to evaluate the role of micronutrients related to poor pregnancy outcomes.[14] Calvo, and colleagues 2009 created reference charts for weight gain and body mass index (BMI) in pregnancy derived from longitudinal data obtained in a representative sample of the Argentinean population. Their results pointed out that the mean weight gain at 38 weeks of gestation was 11.9 ± 4.4 kg. There were no differences in total weight gain between women who enter pregnancy with low, normal or overweight; only those women with a pre-pregnancy BMI in the range of obesity showed a significantly lower weight gain (10.2 ± 4.8 kg). They Concluded that BMI for gestational age chart, based on women who delivered normal birth weight infants and processed with modern statistical methods, represents an improvement in pre-natal care monitoring. The risk of preterm birth, low birth weight and small for gestational age (SGA) were all associated with pre-pregnancy weight and gestational weight gain [15, 16, 17, 18.].The increased amounts of maternal weight gain might improve fetal growth and therefore improve fetal health [19]. Weight gain during pregnancy has been shown to be a critical indicator of pregnancy outcome. Inadequate weight gain during pregnancy is an important cause of low birth weight [20, 21, 22]

In this study we designed new model chart to be applicable and suit the assessment of pregnancy outcome among the women in South region of Sudan Based on Mardones, F., Rosso, P. weight gain chart. The chart established desirable body mass index in relation to weeks of gestation and

2. Design and Setting

Three hundred pregnant southern women in their second and third trimesters participated in this study after their consent.

Data collected from three places, the main hospital (Juba Teaching Hospital) and two other health centers around the area (Kattwor and Kuwait). The main residents in Juba city included in the study were Bari, Morrow, Mundy, Kakwa, kuku, Phogolou, Dinka, Avukya, Lutokwa, Mundari, Baka, Luquara, Loloboh, Yanquara, Nueir, Asholi, Azandi. Infant birth weights were obtained from only 257 in which 14 of the deliveries were twins. Twins' birth weights were excluded from the calculations of birth weight, consequently only 243 infant weights included in the final data analysis.The results of this longitudinal as well as cross sectional study were presented in tables and charts using SPSS.

3. The Site of the study

Brief viewpoints
Central Equatorial is the largest state in the south region of Sudan with an area of 22,956 km square. The White Nile flows through the state and known before as Baher El Jabal state. Central Equatorial, the name given on 2005 in the first Interim Legislative Assembly, divided into four counties Terkeka in the north, Juba in the center, Yei in the southeast and Kajokji in the south.The subjects who were eligible to participate in the study were pregnant women in their second or third trimester, between ages 11-42 residing in Juba city for more than five years

Height .and weight measurements
Heights of the mothers were taking during the time of data. Two measurements of weight have been recorded. Previous weight from the health record including weeks of gestation was observed. The second weight measurements have been taken during the interview by the researcher. Weeks of gestation have been registered at the time of interview.

Body mass index was calculated using the following formula: BMI= Weight (kg)/Height (m2).

Two measurements of weights were registered during the field work. The first BMI were calculated from weight recorded in the hospital or the health centers. The second BMI were calculated from weight that had been taken by the researcher during the field work/ height. Then the two measurements where analyzed. Body mass index was calculated to give general idea about the degree of fat, low energy intake or wasting .

Body mass index for each woman was compared to Francisco Mardones and Pedro Rosso weight gain chart 1997 (RM chart). The estimated values for the second trimester were; under weight women body mass index is about <23.1 kg/m2. Normal body mass index range between 23.1-25.3 kg/m2, over weight > 25.3. The estimated values for the third trimester were; under weight<25.5 kg/m2 normal weight 25.5-27.8 kg/m2 and over weight>28 kg/m2. The researcher used the two different body mass indices and compared with the normal range proposed by Mardones and Rosso .

Weight gains were estimated by using two measurements of weight. The first weight was taken from the previous health records. The other weight was taken by the researcher during the time of interview. Weight gain was calculated by subtracting the second maternal weight from the first maternal recorded weight. Weeks of gestation were registered in the questionnaire sheet .
Estimation of Weight Gain/month= Weight taken by the researcher - Weight recorded in the health report

Birth weight: were collected through out six months period, started in October 2007 until April 2008. Weight of the infant single or twins were registered. Complications were identified. Only about 257 birth weights were submitted, from which 17 (5.7%) were twins' deliveries. Data was lost from the other 13.3% due to the different reasons. The total sample of only 243 was included in the final result analysis.

4. Results

Results presented in tables and graphs

Table 1: Maternal Height and Maternal WeightMeasurements of Pregnant Mothers in Juba city

Anthropometric measurements	No	%	Mean	SD
Maternal height				
Less Than 148 cm*	3	3.3	162.59	7.5
148 cm More Than	297	96.7		
Maternal weight				
<45 kg	3	3.3	62.11	10.53
≥45 kg	297	96.7		

Table 1 describes the different anthropometric measurements. The majority (96.7%) of pregnant mothers' heights were found to be more than 148 cm with a mean of 162.59±7.50 cm. the weight mean 62.11±10.53kg.

Table 2: Classification of the estimated body mass index according to trimesters

Anthropometric measurements	*No*	*%*	*Mean-BMI*	*SD*
Body Mass Index (kg/m^2) for 2nd trimester 12-25 weeks				
Underweight<23.1	79	62.2	23.37	3.52
Normal 23.1-25.3	24	18.9		
Over weight >25.3	24	18.9		
Body Mass Index (kg/m^2) for 3rd trimester 26-37-40 weeks				
Underweight<25.5	135	78	23.55	3.64
Normal 25.5-27.8	22	12.7		
Over weight >27.8	16	9.2		

*****The above estimated body mass index were calculated from Francisco Mardones and Pedro Rosso weight gain chart for pregnant women 1991 (RM chart).

Table (2) shows the distribution of body mass index according to trimesters. The estimated values for the second trimester were; under weight women body mass index (BMI <23.1 kg/m^2) about 62.2%, normal body mass index (23.1-25.3 kg/m^2) 18.9%, 18.9 % were over weight (BMI > 25.3 kg/m^2), the mean body mass index during second trimester was 23.37±3.52 kg/m^2. The estimated values during the third trimester were: 78 % underweight (BMI <25.5 kg/m^2), 12.7 % of mothers were found to have body mass index within the normal estimated range (BMI 25.5-27.8 kg/m^2) and 9.2 % were found to be over weight (BMI >28 kg/m^2). The mean BMI during third trimester was 23.55±3.64 kg/m^2.

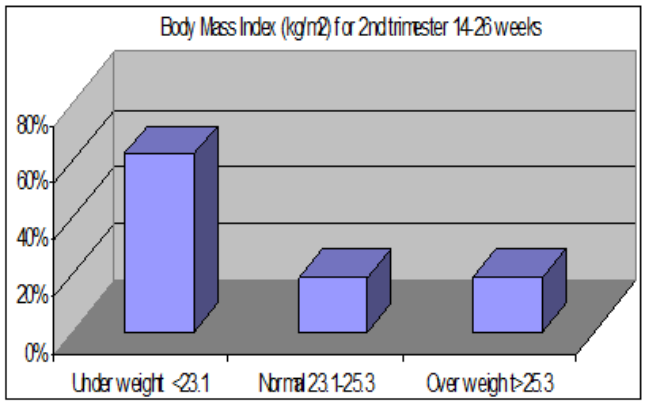

Figure 1: shows distribution of underweight, normal weight and overweight mothers according to the estimated body mass index during the second trimester**.**

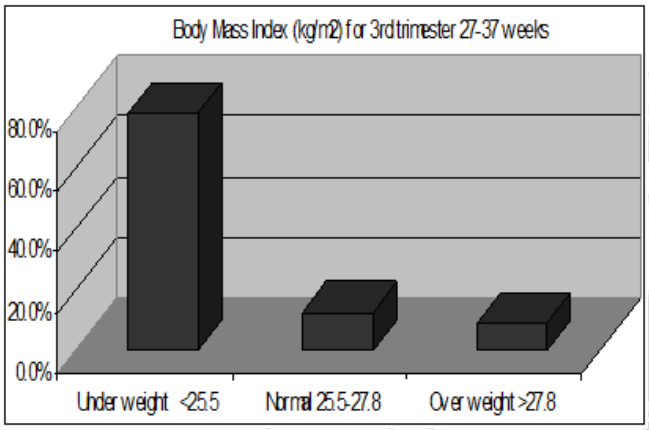

Figure 2: describes the distribution of Body mass index during third trimester.

Table 3: Maternal Weight Gain/month

Level	*No*	*%*	*Mean ± SD*
Less Than 1.50 kg*	111	37%	
1.50 kg* and more	189	63%	1.63±0.48kg/month

*WHO recommended weight gain/month

Mean weight gain among this group 1.63±0.48 kg/month. More than 1/3 of mothers gained less than the recommended value by the WHO 1995

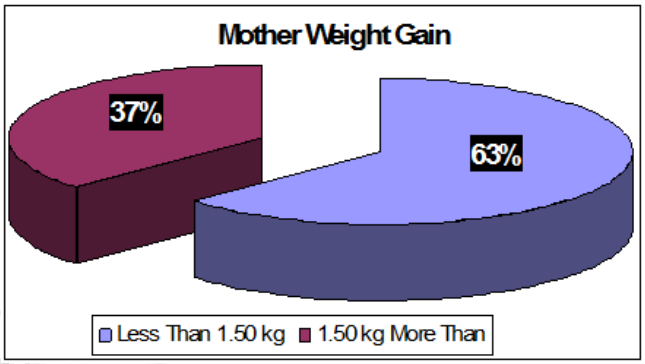

Figure 3: indicated mother weight gain

A new weight gain chart for pregnant mothers based on Mardones and Rosso estimation

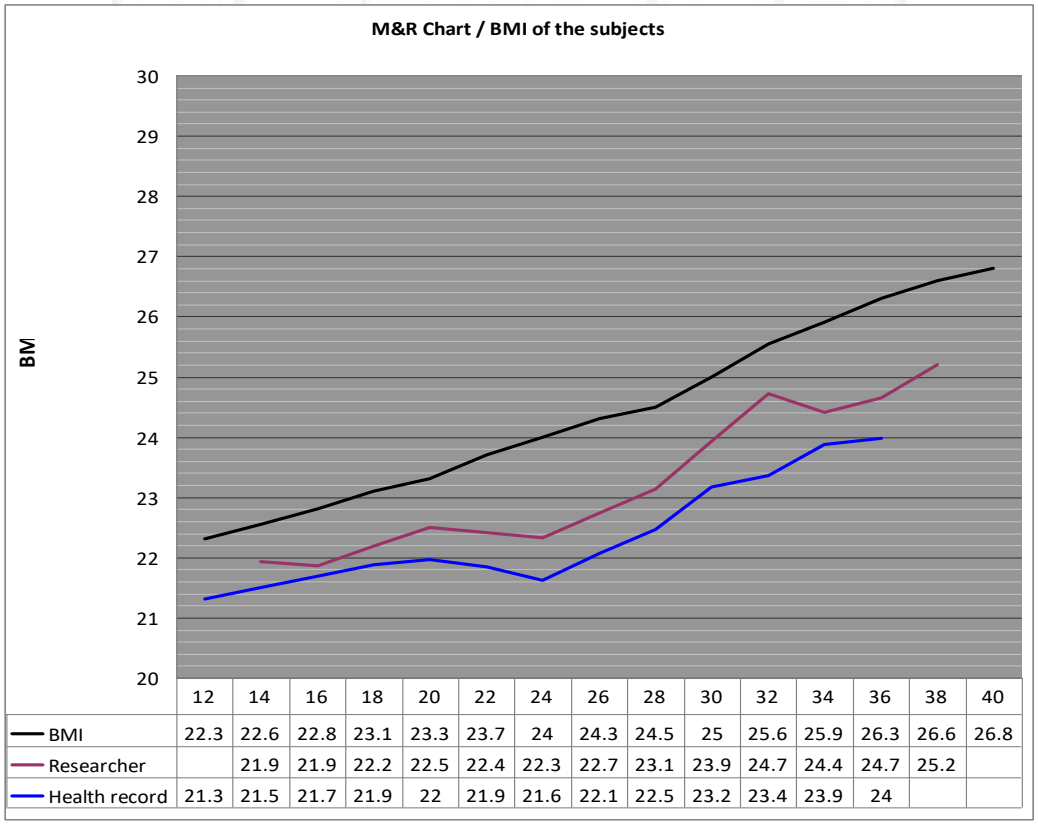

Figure 4: Describes weight gain among pregnant mothers based on BMI and weeks of gestation compared to Mardones and Rosso estimation.

Black line describes the estimated Rosso and Mardones 1997 curve of normality. The red line describes weight measures during the study by the researcher while the blue line describes weight of mother in the previous month according to the health center records

The Rosso and Mardones chart was used as guide lines for weight gain among the target group. All the mothers were below the proposed Rosso and Mardones normal curve. The two dips of the curve at weeks 20 and 32 were duplicated by both measurements observed at Jubapregnantmothers. On the other hand the chart shows an obvious increase in weight gain according to the two successive measurement of mother body mass index.

Table 4: Live birth weights (distribution of birth weight)

Birth Weight (k)	**No**	**%**	**Mean**	**SD**
Less than 2.50 kg	**93**	**38.3**		
2.50 – 3.99 kg	**145**	**59.7**		
More than 3.99 kg	**5**	**2.0**		
Total live birth	**243**	**81%**	**2.89**	**.496**

Up to 59.7% of mothers delivered babies weighing 2.5-3.99 kg. And 38.3% gave birth to babies weighing less than 2.5 (low birth weight). Up to 2 % delivered babies weighing more than 3.99 kg. Over weight babies were noted. The mean birth weight was 2.89±.496 kg (table 5).

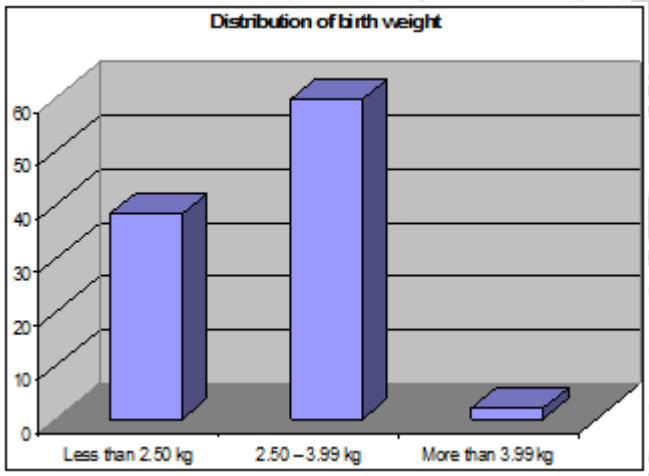

Table 5: Correlations between infant weight and anthropometric indices.

Anthropometric Measurements	birth weight	
	R	**P_value**
Maternal Height	.205	.001
Weight of Mother	.382	.000

*Correlation Significant in 0.05 level
** High Correlation Significant in 0.01 level

Table (5) shows strong positive correlation between infant birth weight and maternal height (r=.205, p<0.01) maternal weight (r=.382, p<0.01),

Table 6: Distribution of birth weight according to different body mass index's values that proposed by the researcher

Anthropometric measurement	No	%	Mean birth weight +SD
Body Mass Index (kg/m^2) for 2nd trimester 12-25 weeks			
Underweight<23.1	79	62.2	2.76±.51
Normal 23.1-25.3	24	18.9	2.85±.48
Over weigh t>25.3	24	18.9	3.11±.53
Body Mass Index (kg/m^2) for 3rd trimester 26-37 weeks			
Underweight<25.5	135	78	2.88±.49
Normal 25.5-27.8	22	12.7	3.08±.57
Over weight >27.8	16	9.2	3.06±.57

Table 6 describes mean birth weight according to different trimesters. Second trimester for under weight mothers (BMI<23.1kg/m^2) the mean birth weight was 2.76±.51kg, normal BMI the mean birth weight was 2.85±.48 kg, obese mother mean birth weight was 3.11±.53 kg.

During third trimester among under weight mothers mean birth weight was 2.88±.49 kg, with normal body mass index the mean birth weight was3.08±.57 and with over weight mothers' birth weight was 3.06±.57kg. The above result indicates that there was an increase in birth weight during third trimester and this increase have relation with mother body mass index.

Table 7: Distribution of the estimated body Mass Index in relation to birth weights.

Variables		Infant Weight				pvalue
2nd trimester (14-26weeks)		<2.5 kg		>2.50 kg		
Body Mass Index (kg/m^2) (Wight/height square)		**No**	**%**	**No**	**%**	**0.004**
Under weight	<23.1	27	45	33	55	
Normal	23.1-25.3	8	42.1	11	57.9	
Over weight	>25.3	4	21.1	15	78.9	
Variables		Infant Weight				P
3rd trimester (27-37 weeks)		<2.5 kg		>2.50 kg		
Body Mass Index (kg/m^2) (Wight/height square)		**No**	**%**	**No**	**%**	
Under weight	<25.5	44	38.9	69	61.1	
Normal	25.5-27.8	5	29.4	12	70.6	
Over weight	>27.8	5	33.3	10	66.7	**0.104**

Chi square test showed a significant association between the estimated body mass index during the second trimester with birth weight (p<.004), but the association was not detected during the third trimester. Up to 21.1 % belong to mothers BMIs more than 25.3 kg/m^2. No significant association was observed during the third trimester (8).

Table 8: Relationship between infant birth weight and mother weight gain

Variables	Infant weight				P value
	<2.5kg		>2.5kg		
Weight gain*	No	%	No	%	
<1.5kg	42	53.8	36	46.1	.001
≥1.5kg	51	30.9	114	69.1	

*WHO recommendation for developing countries

As shown in table 9 more than (53.8 %) of mothers who gained less than WHO recommendation delivered babies weighing less than 2.5kg. less than third 1/3 (30.9%) who

gained weight with the WHO recommendations delivered low birth weight babes. Significant association ($p<0.001$) was noticed between weight gain and infant birth weight.

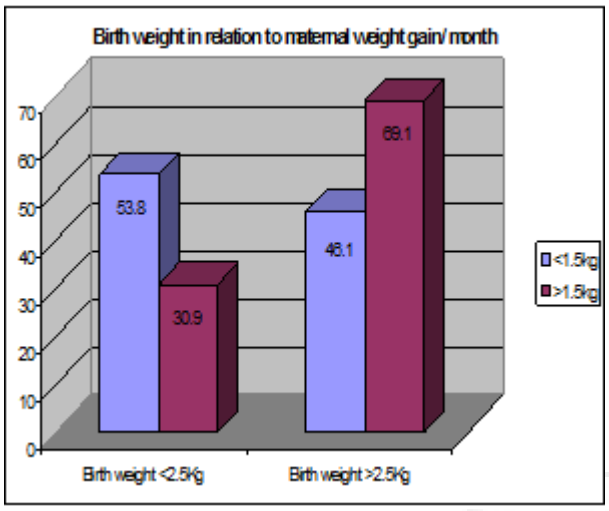

Figure 6: Shows the distribution of live birth weight and maternal weight gain.

5. Discussion

Maternal weight gain

In this study, based on two successive prenatal weight measurements, we found that the mean weight gain/month is around 1.63±.48 kg/month,which is little above the proposed WHO weight gain (1.5kg/month). In about 37% of mothers the weight gain was less than 1.5kg/month while 63% had more than 1.5kg/month. Most increase in weight usually occurs during second and third trimesters.[23]Jansen et al, (1980) found that average weight gain during the second 1/2 of the pregnancy was 1.9 kg in rural Machakos, Kenya, and 1.6 kg in urban women which is similar to our result. This might indicates that in developing countries the gain in weight among pregnant women is approximately not exceeding 2kg/month as in developed countries.

[24]WHO (1996) indicated that total weight gain during pregnancy, is the most commonly used maternal anthropometric indicator and that weight gain is strongly related to risk of low birth weight (LBW) and small for gestational age (SGA). They suggested that in developing countries gains of 1.5 kg/month during the last two trimesters are consistent with good pregnancy outcomes, while in developed countries gains of about 2.0 kg/month produce the same outcomes relative to adequate birth weight.[25]Butte (2005) suggested that weight gain during pregnancy was correlated significantly with gains in total body water, total body potassium, protein, fat-free mass, and fat mass. They concluded that gestational weight gain is needed to optimize birth weight and minimize maternal postpartum fat retention..

Body mass index

Due to the lack of pre-pregnancy body mass index for this group this study measured weight and height during pregnancy (2^{nd} or 3^{rd} trimesters) to calculate BMI during second and third trimester using Mardones and Rosso weight gain chart as guide lines for weight gain. According to these estimates, 62.2% of the sample can be considered as underweight, only 18.8% had a normal BMI and 18.8% were overweight. The study also shows that about 12% of the mothers were within normal BMI during their third trimester while the majority (78%) can be considered as underweight and that only 9.2% were overweight. The mean body mass index during second trimester was calculated and found to be 23.37±3.52 kg/m^2, and during third trimester it was 23.55±3.64 kg/m^2. According to the result it is evident that the prevalence of undernourished mothers is very high and attention should be focused on practical steps during the antenatal period. There is a strong relationship between pre-pregnancy BMI and weight gain during pregnancy. Women with a low pre-pregnancy BMI are likely to gain more weight compared to women with a high pre-pregnancy BMI [26], provided that they receive adequate nutrition during pregnancy.

Birth weight findings

The mean birth weight is found to be 2.89±0.49 kg among pregnant mothers in Juba city (two hundred and forty three live births). The mean birth weight was lower than that found in the two previous studies carried out in Omdurman city Sudan reported a mean birth weight of 3.02±0.49 kg for both genders [1]and 3.2±.48 kg [27]. Another study in Bengalee found that the birth weight was 2.59±0.371 kg. Among boys, mean birth weight was 2.65±0.362 kg, while among girls it was 2.51±0.367 kg [28] Bisai et al 2006).[29] Martorell and González-Cossío (2007) suggested that LBW is strongly associated with infant mortality, especially among neonate. There is some indication that it is also related to preschool mortality rates (1-4 years). Using <2.5 kg in full-term infant as cut off points for low birth weight we concluded that, the prevalence of low birth weight (LBW) is very high among the pregnant mothers in this study (38.3%). Effort should be directed towards improving the health and nutritional status of this and similar groups of mothers as part of national policies.

6. Pregnancy Outcome Evaluation

BMI in relation to pregnancy outcome

This study showed a significant association between the estimated body mass index during the second trimester with birth weight ($p<.004$), but the association was not detected during the third trimester. Women with a higher BMI have more fat and lean tissueand that there was an increase in birth weight during third trimester and these increases have a relation with the body mass index. An increase in body mass index during second trimester is associated with increased birth weight.

Weight gain in relation to birth weight

[21]Abrams &Selvin, (1995) proposed that maternal weight gain in the first and second trimesters may be stronger determinants of newborn size than weight gain in the third trimester pregnancy. Adequate nutrition but lower energy intakes may lead to this situation. This is because fat deposit takes place during second trimester while fat loss may occur during third trimester during the growth of the fetus with increased energy demand for the mothers' metabolism.

In our study we found strong significant association between birth weight and maternal weight gain $p<.001$ (1.63±0.48

kg/month) (table 9). TheRosso and Mardones weight gain chart (RM) was used to define categories of maternal nutritional status based on BMI kg/cm^2 and weeks of gestation. All mothers were below the proposed Rosso and Mardones normal weight gain curve but there was an increase in weight gain according to the two successive measurements of mother's body mass index. There is no cutoff point for assessing nutritional status and weight gain among pregnant mothers in Sudan so the use of weight gain chart might be very useful if implemented by health professionals in health care centers.

Other study [30] suggested that the best predictor of birth weight as a continuous variable was maternal weight at the first visit, each 1 kg increase in weight at registration being associated with an increase in birth weight of about 260 g.[31] Paxton et al (1999) indicated that maternal weight and body water at term were significantly associated with infant birth weight, but maternal body fat at term was not. They also suggested that in well-nourished women delivering at term, maternal body fat near term does not contribute significantly to infant birth weight, but maternal body water does. This is probably related to maternal protein stores. Maternal fat by itself does not indicate adequate nutrition for foetal growth

7. Conclusions

The optimal BMI cut of point that suggested by the researchers for southern Sudanese mothers found to be around23.1-25.3 relative to the best outcome (2.85±.48 kg birth weight) during the second trimester and 25.5-27.8BMI(birth weight 3.08±.57lg) during third trimester. Thenew chart is designed according to those new suggested body mass index.

The weight gain chart for pregnant women, developed by the researcher is analysed and compare to Rosso and Mardones (RM chart, 1997) [21] to be implemented in health care system for targeting nutritional interventions aimed at preventing low birth weights among southern Sudanese mothers. The chart based on weight/height, expressed body mass index (BMI). All mothers were found to be below the proposed Rosso and Mardones normal curve.The two dips of the curve at weeks 20 and 32 were duplicated by both measurements observed. On the other hand the chart shows an obvious increase in weight gain according to the two successive measurement of mother body mass index. The chart providesgraphical presentation of maternal nutritional status as a tool for quick assessments and help to draw the attention of health care providers to women who need special advice and support.

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