CHAPTER 2

FETAL GROWTH PERFORMANCE OF THE REGION[†]

2.1. **Introduction**

Determination of the fetal growth curve in human species is difficult because precise measurements of fetal weight during intra-uterine period, used in clinical practice are based on data obtained from live born babies of different gestational ages. Various studies on intra-uterine growth revealed, considerable differences in the fetal growth during the last tri-mester of pregnancy [1-3]. The question comes what are the factors which are affecting the fetal growth. Is it the maternal nutritional status, oxygen supply to the fetus, height and weight of the mothers, genetic factors or something else or in combination ?

There are various observations made by various authors and it is found that fetus rarely fully express its genetically determined potentiality for growth [4]. Thus the growth curve would not reflect optimum fetal growth. In addition optimal birth weight associated with lowest perinatal mortality seems to vary considerably from one ethnic group to other, from one population to other and even within the same ethnic group between different socio-economic groups [5-8].

Though wide range of values showed difficulties in interpreting birth weight statistics, when the level of perinatal mortality for every birth weight class is not known, it is impossible to know whether the mean fetal growth is normal i.e. the difference between optimal birth weight and mean birth weight is in the usual range or there is the real problem of fetal growth retardation in a population.

Works from India on mean birth weight showed wide fluctuations in different parts of the country and also from the similar study of Western mothers [1,9]. But almost in every study it has been shown that the regular and rapid growth during 2nd trimester of intra-uterine life is followed by slight faltering which becomes more pronounced just before birth [10]. This faltering is attributed to various factors by various authors, like differences in populations, methodologies, nutritional status of the mother, placental

[†] This is based on the publication [Modelling, Measurement and Control, C, AMSE Press, France, vol.47, no.2, 1995, 23-44] of the author.

blood flow and / or some unknown factors in mothers, in the absence of which the growth curve would have been a straight line.

Widdowson [11] suggested that the placental blood flow might be the regulator factor of fetal growth. Since plasma concentration of nutrients does not vary markedly between the species, whereas placental blood flows are very different. This hypothesis is supported by the allometric relationship between maternal and fetal growth. When comparing species of different sizes, the relationship between physiological variables and body weight is not necessarily linear [12,13]. The best example is basal metabolic rate, which is much lower per unit of body weight in larger species. Some variables, such as energy reserves or muscular mass, are related to body weight, whereas others, such as blood flows, are related to body surface area; others, such as blood pressure, are independent of physical size. These study suggests that fetal growth is regulated by an unknown factor related to body-surface area. This blood flow regulates the oxygen availability of the fetus as well.

However, when there is maternal fasting [14,15] mother is hypoglycemic. Since glucose crosses the placenta by a faciliated diffusion mechanism, this results in fetal hypoglycemia. Fetal insulin production is depressed. Thus there is a reduction of fetal metabolism and growth. Hard muscular work would also affect intra-uterine growth [16]. It results in increased sympathetic nervous activity which likely to provoke a reduced placental blood flow [17].

This study of intra uterine growth of fetus was conducted amongst poor socio-economic mothers of the region and comparisons have been made with (i) higher socio-economic mothers of the same region; and (ii) few Western studies. This study concentrates on the classical clinical way of data collection i.e., data of live born babies of different gestational ages.

2.2. **Materials and Methods**

The present study comprise of 858 of new born babies selected from the deliveries of poor socio-economic mothers conducted at North Bengal Medical College and Hospital during the year 1992 and 1169 babies born of higher socio-economic mothers delivered in one eminent Nursing Home in the same area. Those mothers were excluded from the study having the diseases known to affect normal foetal growth (e.g. diabetes mellitus, chronic hypertension) and / or having multiple gestation (e.g. twins). The weekly interval was centered on the week (e.g. 40 week interval 39.50 - 40.49 weeks).

2.3. **Smoothing of Data**

In the following tables we have shown the actual means and SDs for various growth parameters as well as smoothed means using polynomials in age. That is a polynomial of the form

$$Y = a+bx+cx^2 +dx^3 +.....+kx^n$$

was fitted to the estimated mean values, where Y denotes the estimated mean values of different growth parameters and x the specified ages. Necessary computations were done using orthogonal polynomials. Using analysis of variance technique, goodness of fit of the polynomial of each degree was made through testing for additional information in the orthogonal polynomials of higher degree. A typical equation may be represented as follows :

$$Y \text{ (Birth weight for babies)} = 1.733 + 0.348x - 0.022x^2$$

2.4. **Observations**

2.4.1. Birth weight

Average birth weight

i) Lower socio-economic group = 2.66 kg.
ii) Higher socio-economic group = 3.08 kg.

2.4.2. Incidence of low birth weight

i) Lower socio-economic group = 47.15%
ii) Higher socio-economic group = 11.71%

2.4.3. Incidence of pre-term delivery

i) Lower socio-economic group = 15.75%
ii) Higher socio-economic group = 3.84%

2.5. **Intra-uterine growth of fetus**

The pool data for all the new born babies were distributed by the birth weight according to socio-economic status at various gestational ages at weekly interval (table 2(A)).

2.5.1. A comparison between lower and higher socio-economic mothers of North-Bengal region.

Table 2(A)

Intra-uterine growth of fetus

GESTATIONAL AGE (wks)	No. of Obs.	LSEG Birth Weight (kg)		No. of Obs.	HSEG Birth Weight (kg)	
		ACTUAL MEAN & SD	SMOOTH MEAN		ACTUAL MEAN & SD	SMOOTH MEAN
34	29	1.90 ± 0.42	1.89	16	2.16 ± 0.44	2.05
35	40	2.12 ± 0.30	2.16	15	2.25 ± 0.51	2.34
36	58	2.43 ± 0.37	2.36	45	2.43 ± 0.49	2.57
37	100	2.49 ± 0.43	2.50	98	2.83 ± 0.44	2.77
38	151	2.53 ± 0.38	2.58	219	2.91 ± 0.50	2.92
39	170	2.65 ± 0.35	2.63	300	3.13 ± 1.50	3.02
40	169	2.66 ± 0.36	2.65	300	3.10 ± 0.47	3.08
41	94	2.67 ± 0.39	2.67	143	3.11 ± 0.52	3.10
42	47	2.68 ± 0.36	2.69	33	2.96 ± 0.44	3.07

2.5.2. Birth weight (kg) of lower and higher socio-economic group of North-Bengal region and its comparison with Western studies.

Table 2(B)

GESTATIONAL AGE(wks)	NORTH BENGAL REGION		BALTIMORE [3]	MONTREAL [18]	PORTLAND [19]	BRITAIN [20]
	LSEG	HSEG				
32			1.75	1.72	1.88	1.87
33			1.95	1.90	2.15	2.01
34	1.89	2.05	2.17	2.11	2.34	2.20
35	2.16	2.34	2.39	2.34	2.51	2.41
36	2.36	2.57	2.61	2.58	2.74	2.68
37	2.50	2.77	2.83	2.86	2.98	2.89
38	2.58	2.92	3.05	3.13	3.18	3.07
39	2.63	3.02	3.21	3.36	3.33	3.22
40	2.65	3.08	3.28	3.48	3.46	3.36
41	2.67	3.10	3.35	3.56	3.56	3.45
42	2.69	3.07	3.40	3.53	3.63	3.51

Observations on the incidence of lower birth weight suggests that the incidence varies significantly according to the socio-economic status. The average birth weight of a full term baby is high in higher socio-economic status but the difference from the Western after 40 weeks of menstrual age studies were about 300-400 gms. However, in poor mothers the average birth weight was 2.66 kg. with very high incidence of low birth weight.

Now from the velocity curve, we can make out that both in higher and lower socio-economic group, the weight velocity of the fetus starts decreasing around after 35 weeks. In poorer mothers, the rate of fall is more stiff than the well off mothers in whom the rate of fall is gradual. When we compare with growth velocity curves of babies born of Western mothers, this rate of fall in the weight velocity started around 37-38 weeks.

Growth acceleration / retardation can be defined as rate of change of growth velocity per unit time. When it is +ve, it is growth acceleration; and when it is -ve, it is growth retardation.

Velocity charts and velocity growth curves show that the rate of increase in velocity is not uniform throughout the gestation and this acceleration and retardation i.e. change of velocity are different at different gestational ages. But when compared between lower socio-economic and higher socio-economic mothers there is some growth acceleration at 39 weeks amongst poor mothers which is not true for higher socio-economic mothers or any Western studies. In the higher socio-economic group the acceleration and retardation score is almost uniform from 37-42 weeks.

Growth trend is defined as mode of change of acceleration or retardation with respect to per unit gestation time.

Growth index can be defined as rate of change of weight acceleration or retardation per week. Growth trend is the quality of growth index.

From the Bar diagram of growth index (fig.2.3), we find that the fetus of poorer mothers suffer from growth shock at 35 weeks which is very marked from other studies (both Western and higher socio-economic group of the region). So, we may conclude that at around 35 weeks, these mothers should be taken under care.

The growth trend for different slops of growth acceleration were made for the target groups (LSEG, HSEG, Baltimore, Montreal, Portland, Britain). The -ve trends were found in cases of lower socio-economic group of India, Baltimore and Britain. Lower socio-economic group shows the maximum -ve trend and Britain being the minimum (table 2(F)).

When we looked for the +ve trend on growth acceleration, the maximum +ve trend was found for the fetus of mothers belonging to higher socio-economic group of the region. Thus we may conclude that the variations on growth trend is maximum for the fetus of Indian mothers of higher socio-economic status compared to the mothers of poor socio-economic status (table 2(F)).

2.5.3. Intra-uterine growth pattern of fetus of Indian and Western mothers

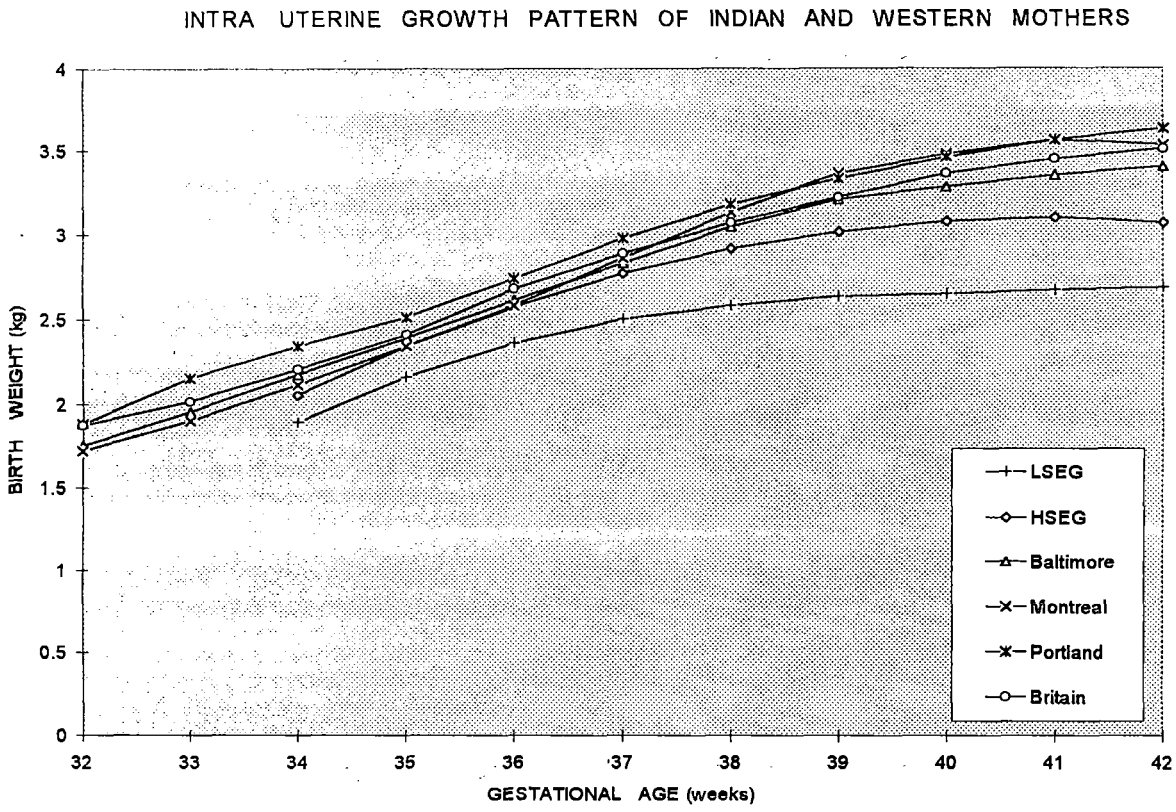

Fig. 2.1

2.6. **The growth velocity charts**

2.6.1. Weight velocity of LSEG

Table 2C(I)

AGE IN WEEK	KG/WEEK
33.5	0.09
34.5	0.27
35.5	0.20
36.5	0.14
37.5	0.08
38.5	0.05
39.5	0.02
40.5	0.02
41.5	0.02

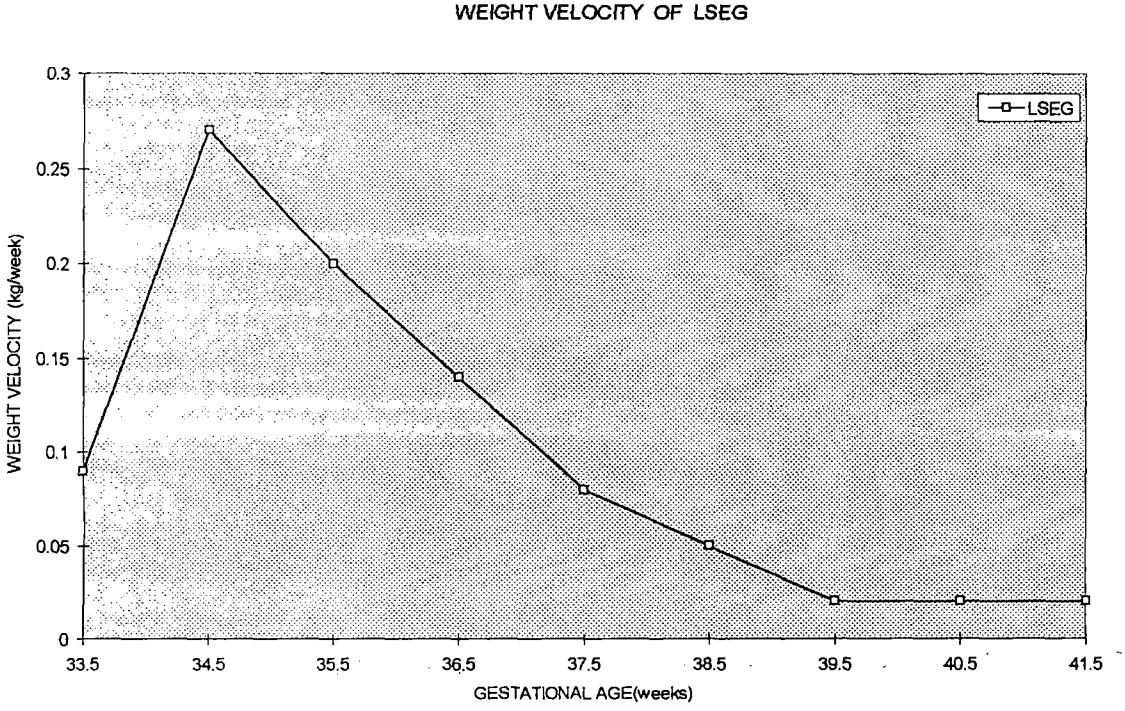

Fig. 2.1(a)

2.6.2. Weight velocity of HSEG

Table 2C(II)

AGE IN WEEK	KG/WEEK
33.5	0.05
34.5	0.29
35.5	0.23
36.5	0.20
37.5	0.15
38.5	0.10
39.5	0.06
40.5	0.02
41.5	- 0.03

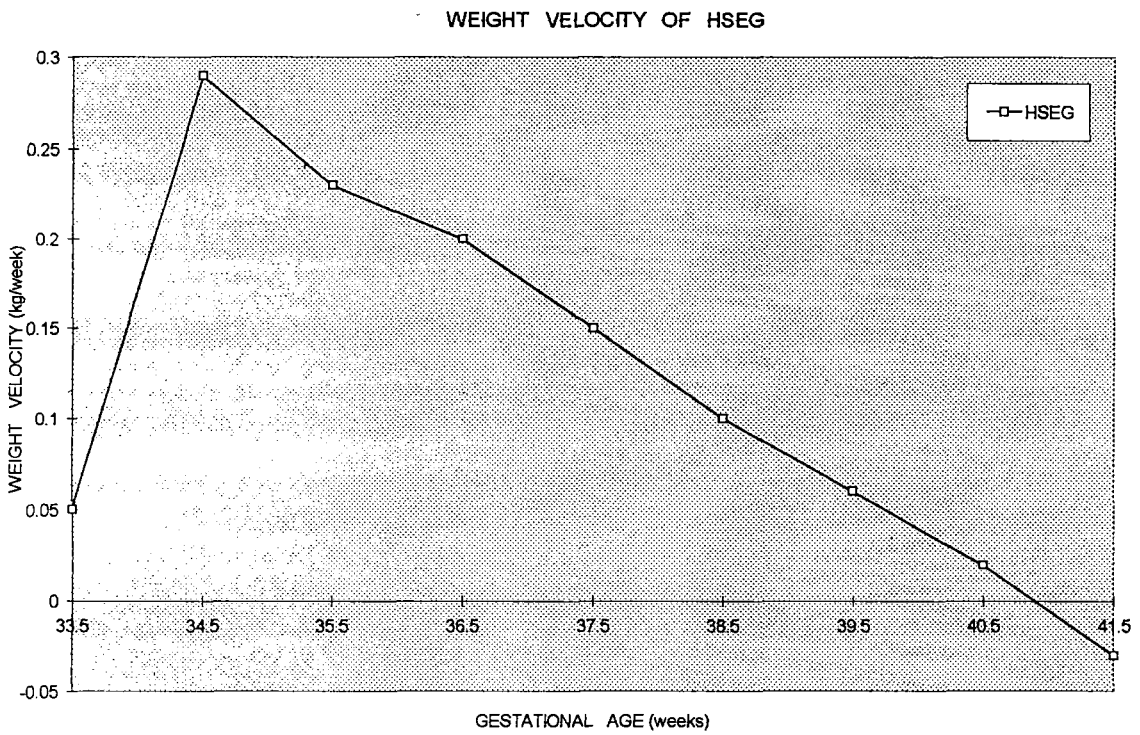

Fig. 2.1(b)

2.6.3 . Weight velocity of Baltimore

Table 2C(III)

AGE IN WEEK	KG/WEEK
31.5	0.05
32.5	0.02
33.5	0.22
34.5	0.22
35.5	0.22
36.5	0.22
37.5	0.22
38.5	0.16
39.5	0.07
40.5	0.07
41.5	0.05

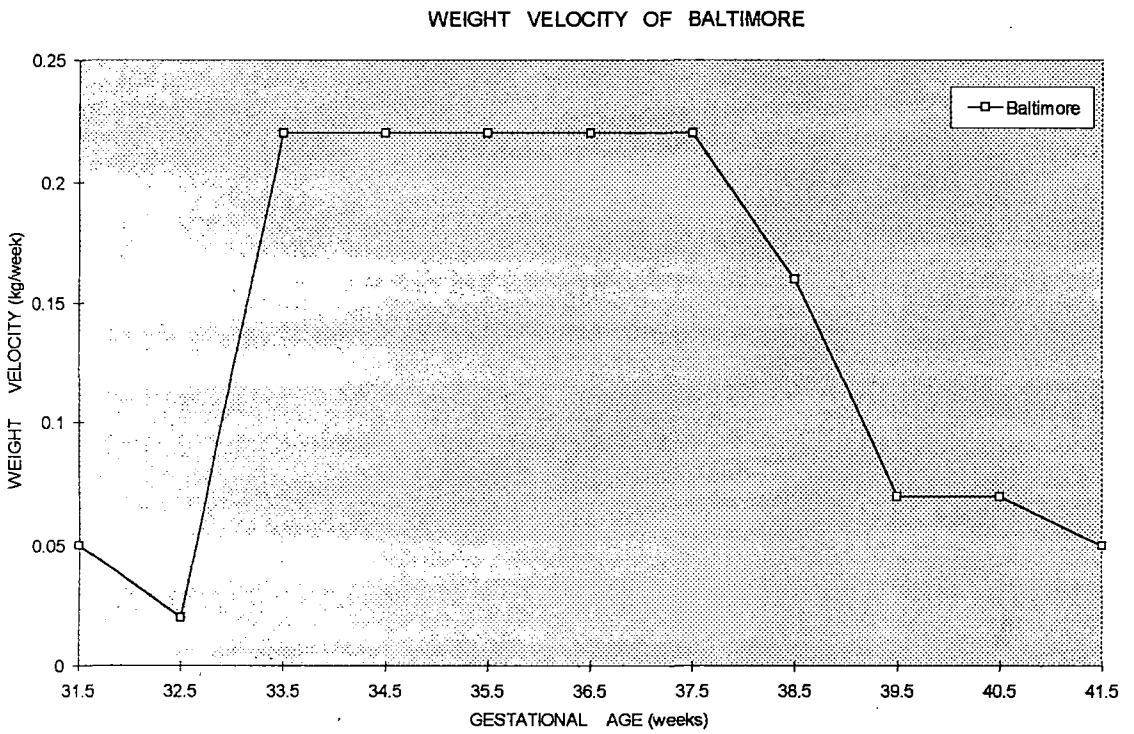

Fig. 2.1(c)

2.6.4 Weight velocity of Portland

Table 2C(IV)

AGE IN WEEK	KG/WEEK
31.5	0.08
32.5	0.27
33.5	0.19
34.5	0.17
35.5	0.23
36.5	0.23
37.5	0.20
38.5	0.15
39.5	0.12
40.5	0.10
41.5	0.07

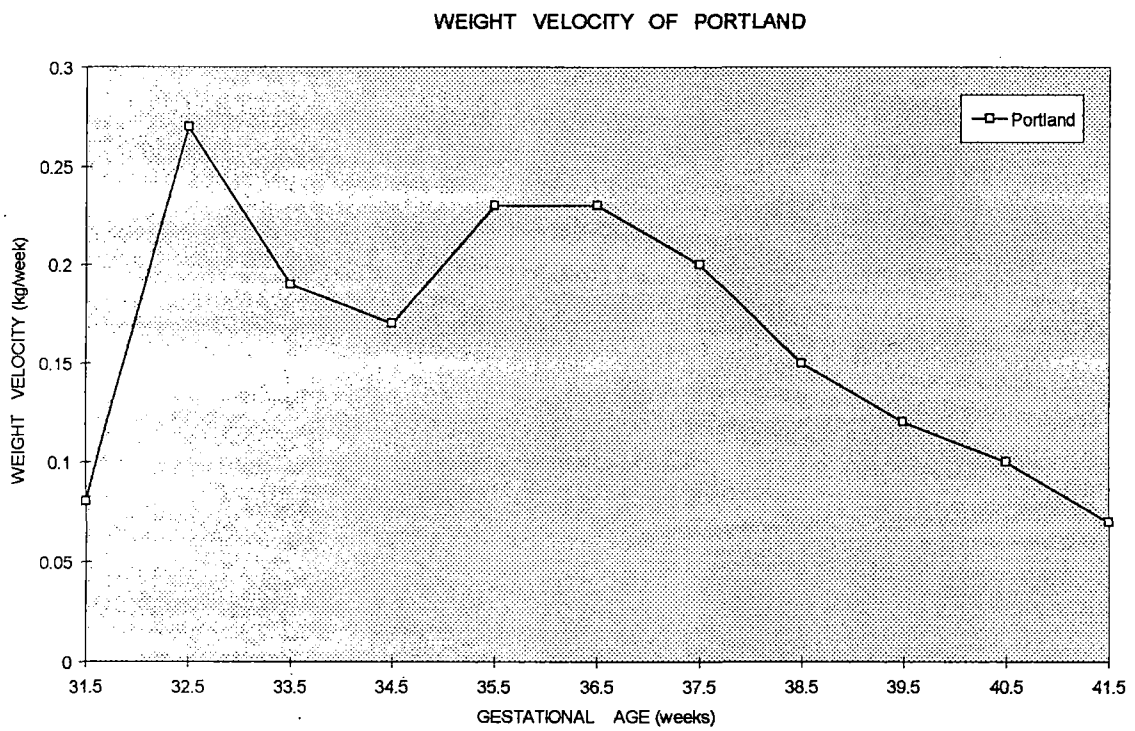

Fig. 2.1(d)

2.6.5. Weight velocity of Montreal

Table 2C(V)

AGE IN WEEK	KG/WEEK
31.5	0.02
32.5	0.18
33.5	0.21
34.5	0.23
35.5	0.24
36.5	0.27
37.5	0.27
38.5	0.23
39.5	0.12
40.5	0.08
41.5	- 0.03

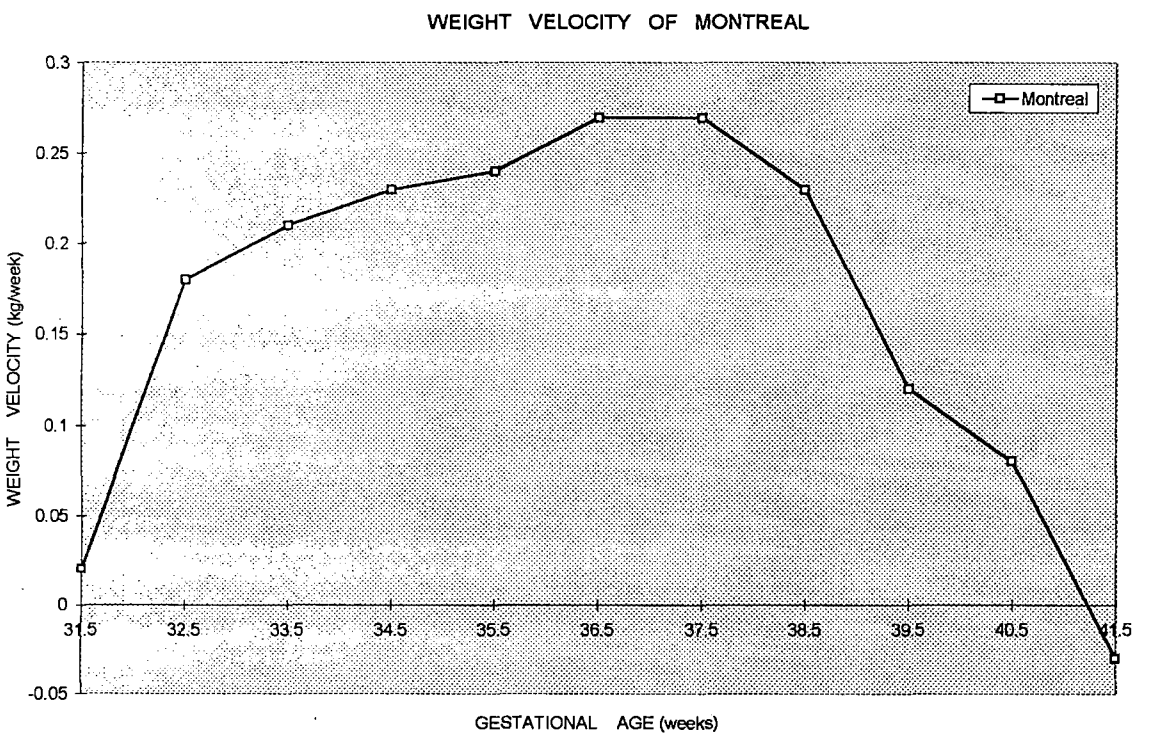

Fig. 2.1(e)

2.6.6. Weight velocity of Britain

Table 2C(VI)

AGE IN WEEK	KG/WEEK
31.5	0.07
32.5	0.14
33.5	0.19
34.5	0.21
35.5	0.27
36.5	0.31
37.5	0.18
38.5	0.15
39.5	0.14
40.5	0.09
41.5	0.06

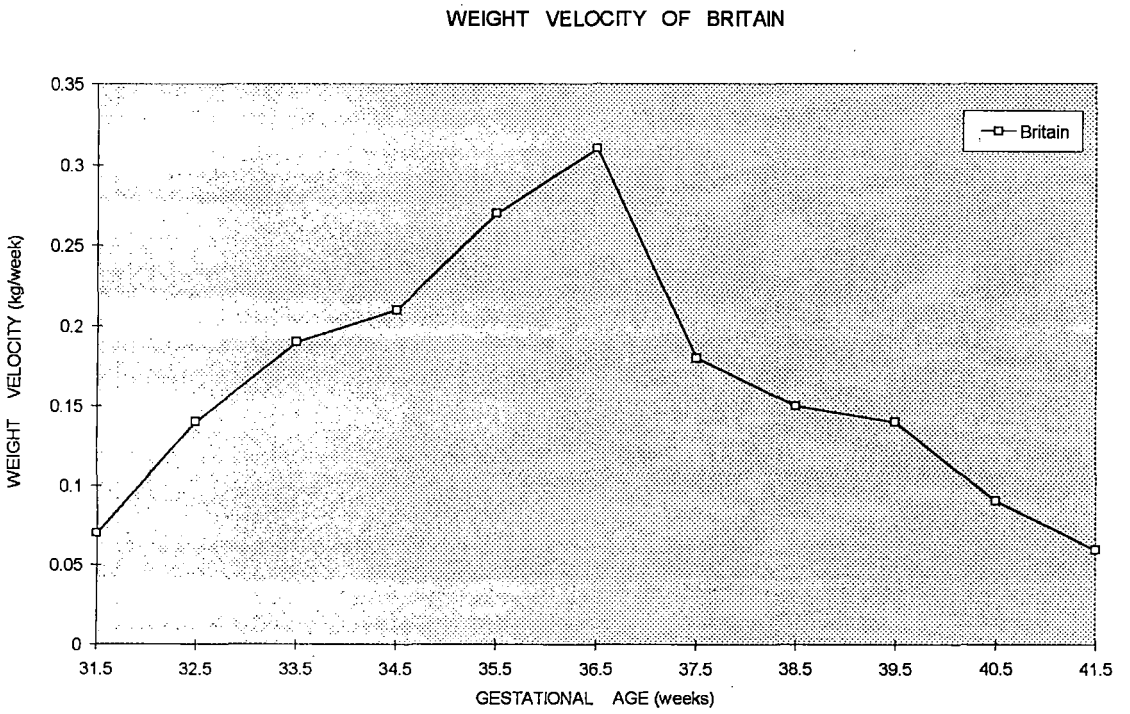

Fig. 2.1(f)

2.7. Rate of change of weight velocity per week. ('+' growth acceleration, '-' growth retardation)

2.7.1. Rate of change of weight velocity per week of LSEG

Table 2D(I)

AGE IN WEEK	WT. ACCL/RETARD
34	0.18
35	0.18
36	- 0.07
37	- 0.06
38	- 0.06
39	0.03
40	- 0.03
41	± 0.00
42	± 0.00

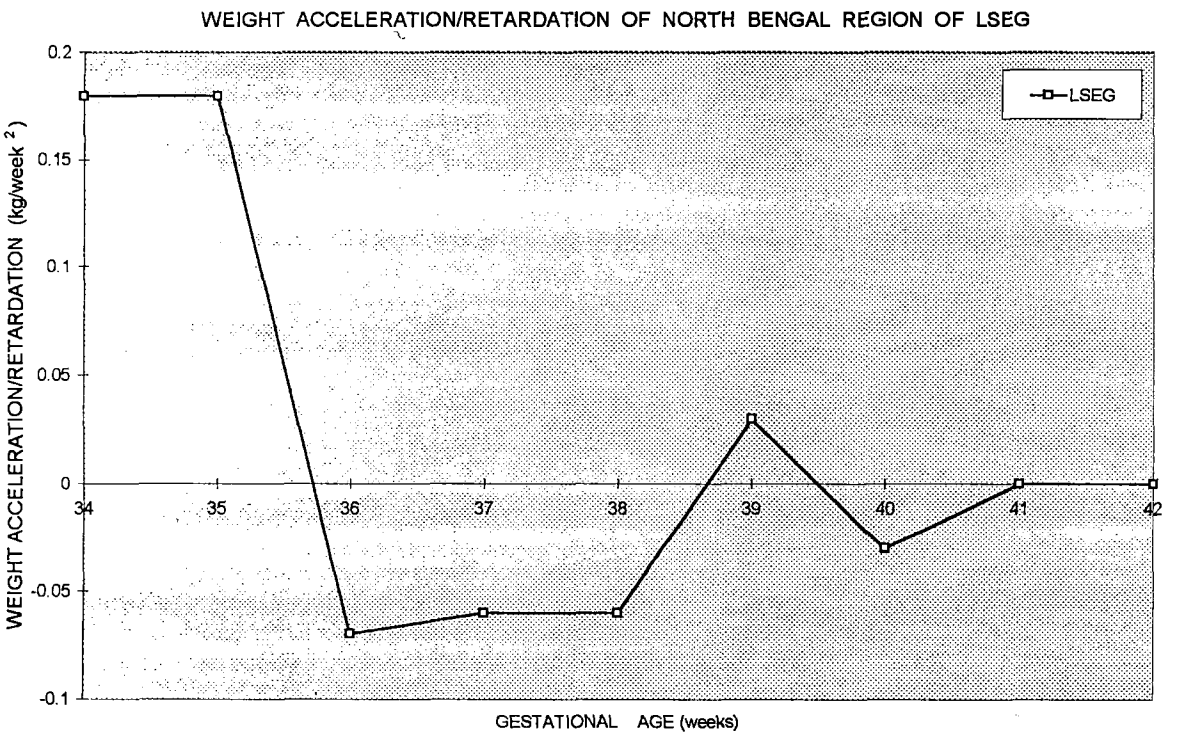

Fig. 2.2(a)

2.7.2. Rate of change of weight velocity per week of HSEG

Table 2D(II)

AGE IN WEEK	WT. ACCL/RETARD
34	0.10
35	0.24
36	-0.06
37	-0.03
38	-0.05
39	-0.05
40	-0.04
41	-0.04
42	-0.05

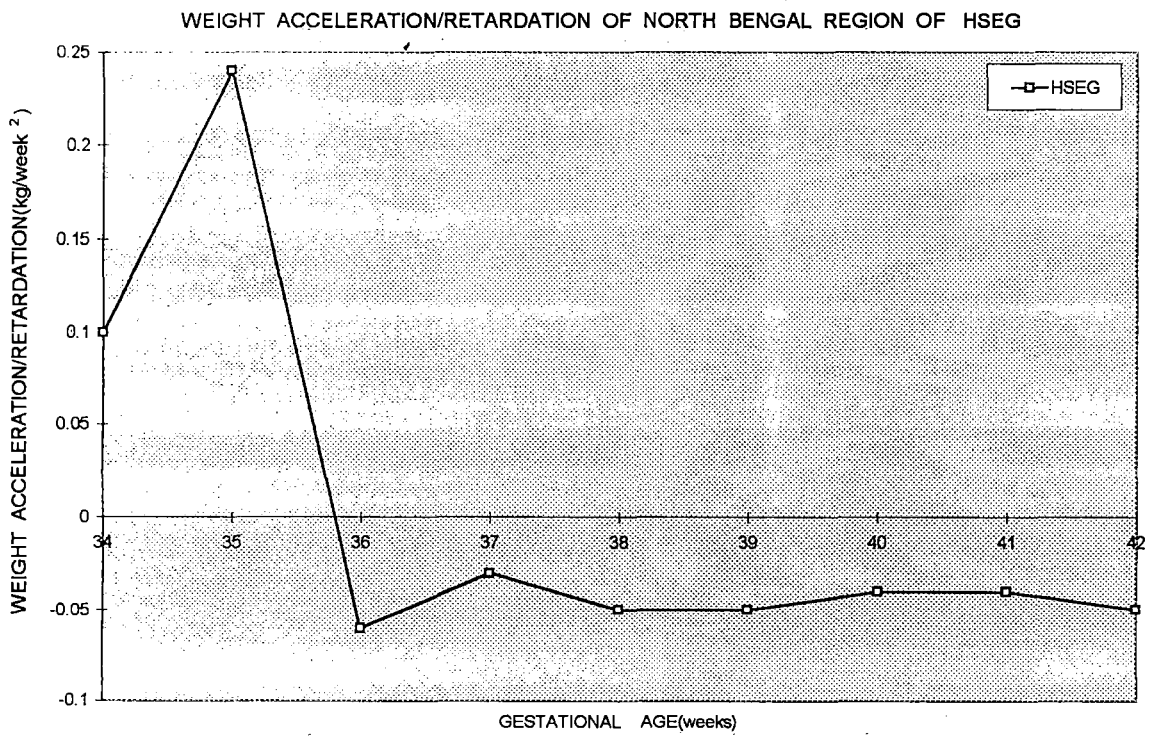

Fig. 2.2(b)

2.7.3. Rate of change of weight velocity per week of Baltimore

Table 2D(III)

AGE IN WEEK	WT ACCL/RETARD
32	0.10
33	0.15
34	0.02
35	± 0.00
36	± 0.00
37	± 0.00
38	± 0.00
39	- 0.06
40	- 0.09
41	± 0.00
42	- 0.02

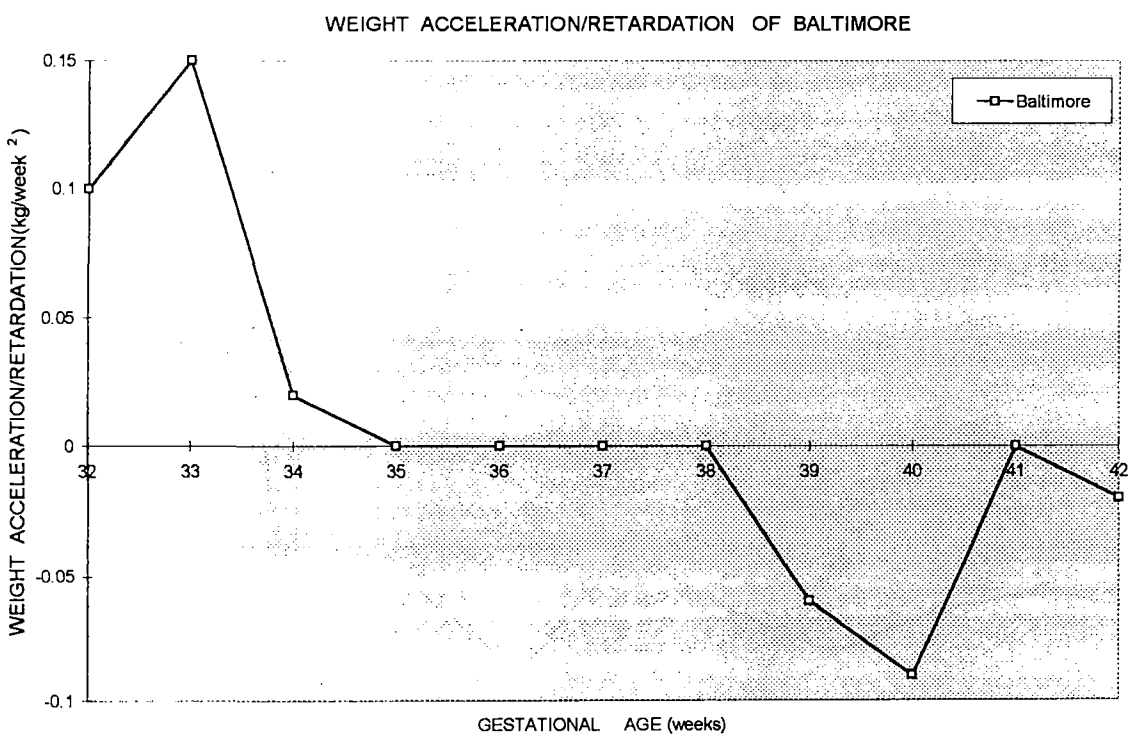

Fig. 2.2(c)

2.7.4. Rate of change of weight velocity per week of Portland

Table 2D(IV)

AGE IN WEEK	WT. ACCL/RETARD
32	0.16
33	0.19
34	-0.08
35	-0.02
36	-0.06
37	±0.0
38	-0.03
39	-0.05
40	-0.03
41	-0.02
42	-0.03

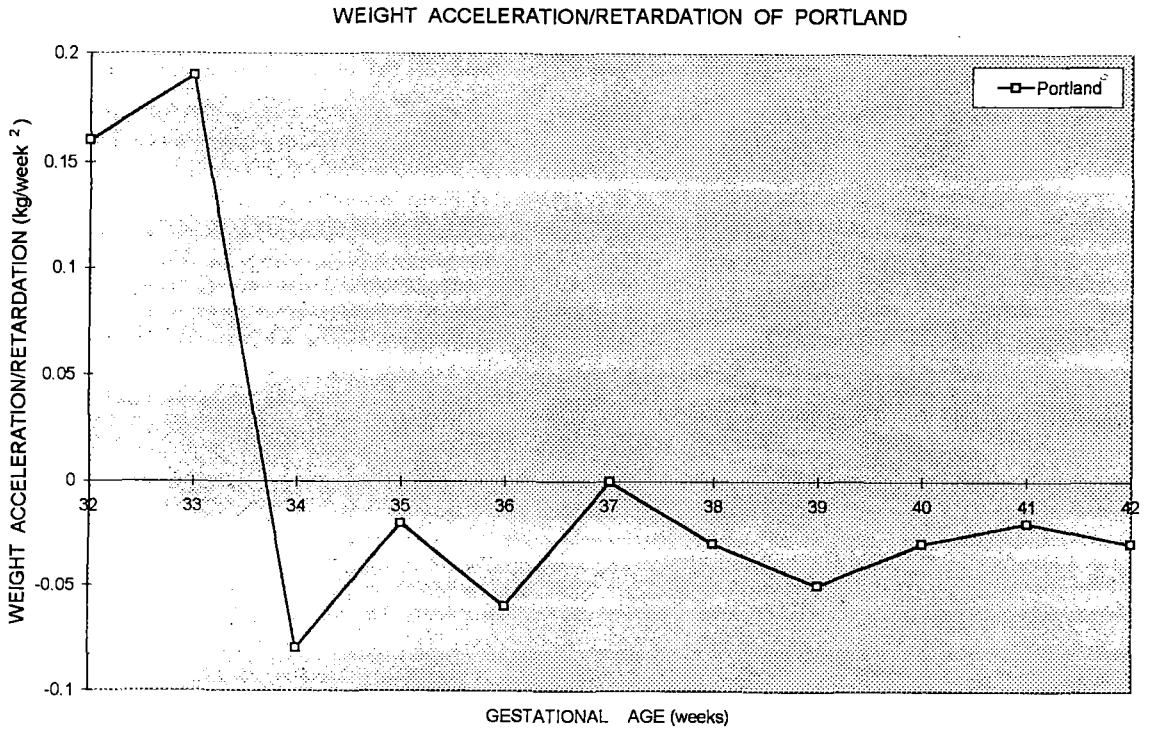

Fig. 2.2(d)

2.7.5. Rate of change of weight velocity per week of Montreal

Table 2D(V)

AGE IN WEEK	WT. ACCL/RETARD
32	0.04
33	0.16
34	0.03
35	0.02
36	0.01
37	0.03
38	±0.00
39	-0.04
40	-0.11
41	-0.04
42	-0.11

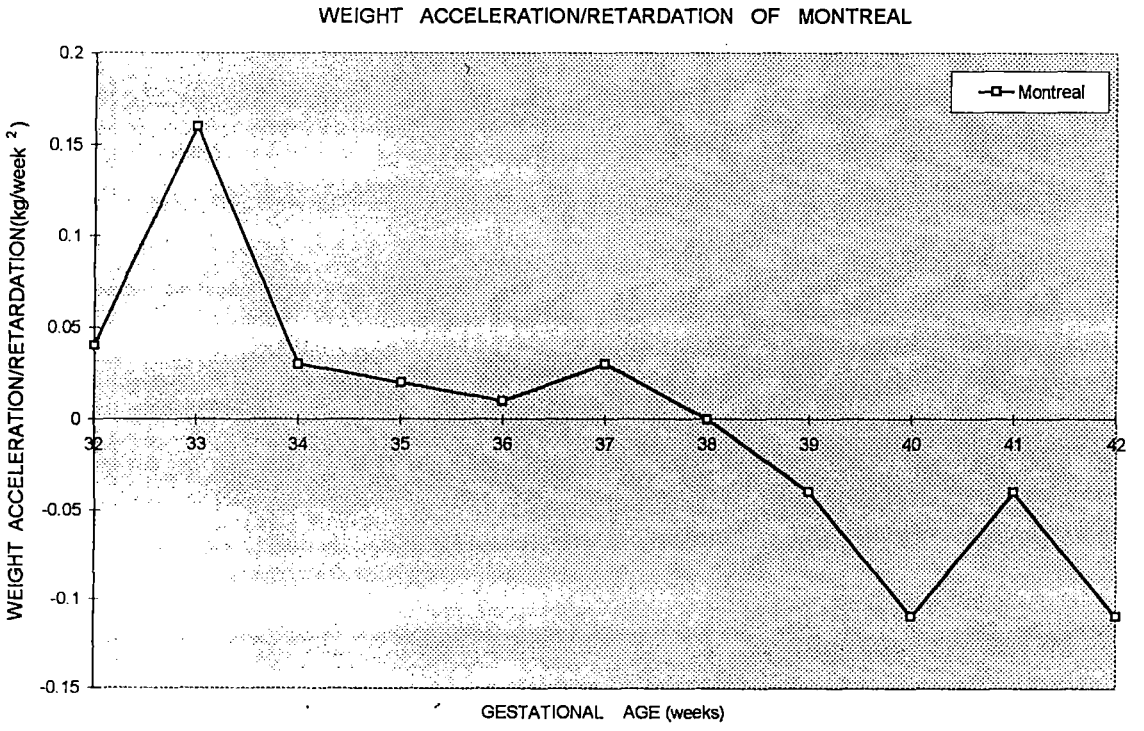

Fig. 2.2(e)

2.7.6. Rate of change of weight velocity per week of Britain

Table 2D(VI)

AGE IN WEEK	WT ACCL/RETARD
32	0.14
33	0.07
34	0.05
35	0.02
36	0.06
37	0.04
38	-0.13
39	-0.03
40	-0.01
41	-0.05
42	-0.03

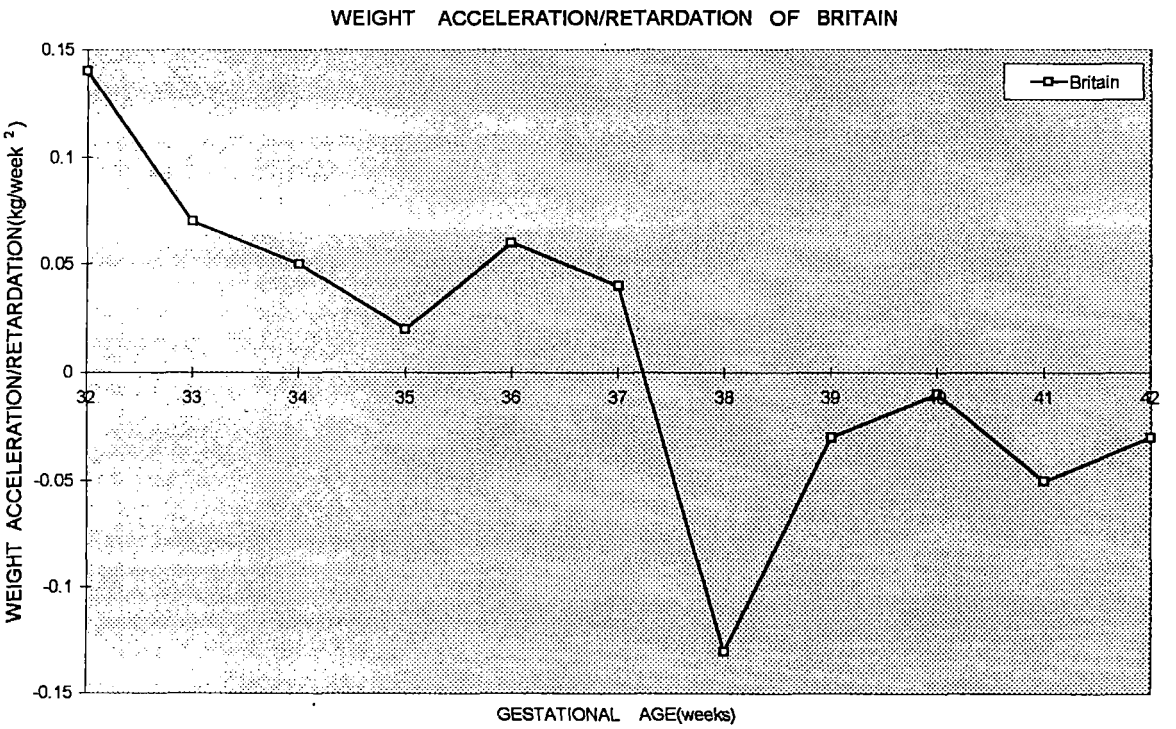

Fig. 2.2(f)

2.8. **Growth Trend**

2.8.1. Weight acceleration / retardation per week of lower and higher socio-economic group of North-Bengal Region and its comparison with Western values

Table 2(E)

WEEKS	MONTREAL	BRITAIN	BALTIMORE	PORTLAND	INDIA	
					LSEG	HSEG
34	- 0.03	- 0.01	- 0.02	0.06	± 0.00	0.14
35	0.04	- 0.01	± 0.00	- 0.04	- 0.25	- 0.03
36	- 0.02	0.02	± 0.00	0.06	0.01	0.03
37	- 0.17	- 0.03	± 0.00	- 0.03	± 0.00	- 0.02
38	0.10	- 0.04	- 0.06	- 0.02	- 0.09	± 0.00
39	0.02	- 0.07	- 0.03	0.02	- 0.06	0.01
40	- 0.04	0.07	0.02	0.01	- 0.03	± 0.00
41	0.02	- 0.07	- 0.02	- 0.01	± 0.00	- 0.01

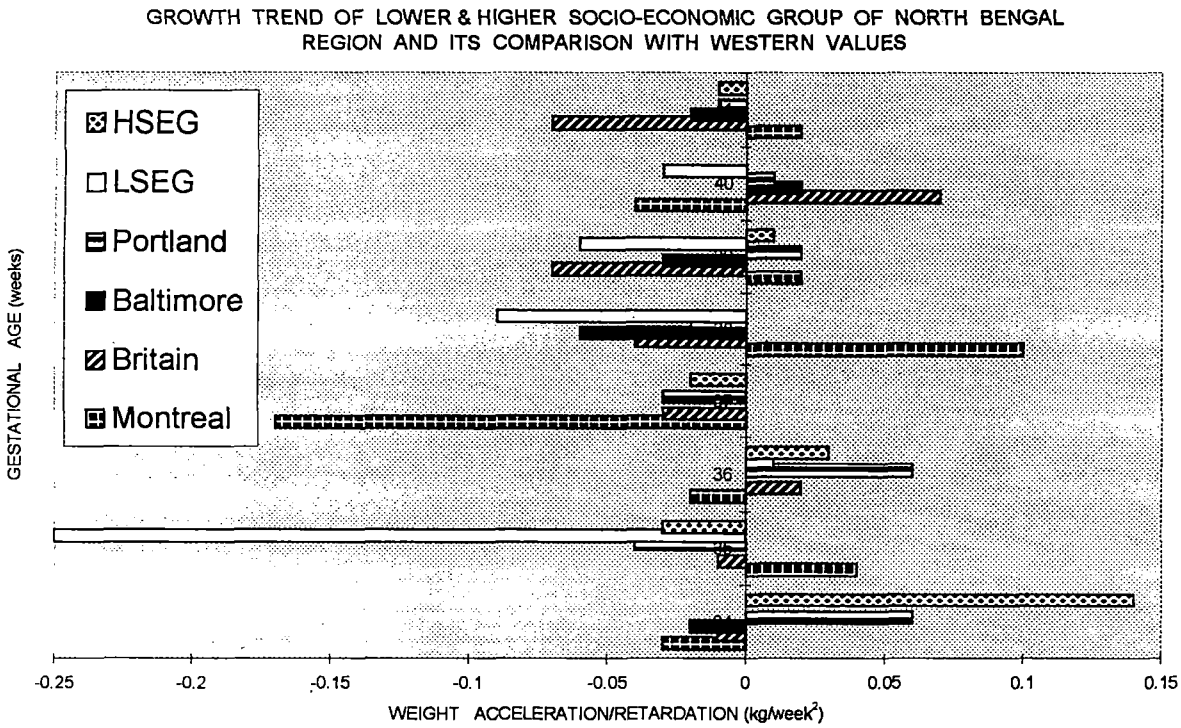

Fig. 2.3

2.9. **Growth Impact**

Table 2(F)

SL. NO.	TARGET GROUP	TREND	AVERAGE	IMPACT				VARIATION	SAMPLE STANDARD DEVIATION
				-VE	MAX	+VE	MAX		
				Week	Value	Week	Value		
1.	Montreal	+	0.01	37	0.17	39 41	0.02	0.19	0.074
2.	Britain	-	0.07	39 41	0.07	40	0.07	0.14	0.044
3.	Baltimore	-	0.11	38	0.06	40	0.02	0.08	0.023
4.	Portland	+	0.05	35	0.04	34	0.06	0.10	0.036
5.	L SEG	-	0.42	35	0.25	36	0.01	0.26	0.031
6.	HSEG	+	0.12	35	0.03	34	0.14	0.17	0.050

Deviation of readings are 0.074, 0.044, 0.023, 0.036, 0.031 and 0.050 from the calculated arithmetic average during the gestation period.

2.10. **Conclusions**

From these studies we may conclude that in Indian mothers besides nutritional factors there are certainly other factors as well, which are affecting the fetal growth. In nutritionally deprived mothers the growth of the fetus are affected very early much before 34 weeks of gestation.

In well to do mothers there is no question of nutritional deprivation as these mothers were educated, rich, came for regular check up in Nursing Home and accepted the doctor's advice regarding their diet and took sufficient rest. In them till 37 weeks of gestation, the fetus was growing well, similar to the Western mothers; the deviation of intra-uterine growth curve from Western mothers started after 37 weeks. Though the birth weight at 40 weeks was much better than low socio-economic status, it is fairly less than Western studies. Thus it can be inferred that in higher socio-economic group of India, it is not only the nutritional factor but some other factors which are operating. It is perhaps the same factor which are responsible for faltering of the intra-uterine growth curve studied elsewhere. It is thought by the researchers that placental blood circulation, thus in turn the oxygen supply to the fetus, is responsible for this growth faltering. Further, at per the experts, it is the surface area of the mother which is an important factor regulating the placental blood circulation. We know that the Indian mothers are smaller in size than Western ladies and this might be one of the responsible factors for the poor growth performance found in lower socio-economic group of India at 35 weeks. This is very significant and can be taken at negative growth

shock. When studied for higher socio-economic group here also we could find that at 35 weeks of gestation there is -ve impact on growth velocity but this is markedly less than the lower socio-economic group. Whereas for some Western studies, the maximum -ve impact are different for different studies. However, it is revealed from this study that fetal growth performance demands a regular monitoring especially for lower socio-economic mothers. This should certainly assist in good and safe outcome of a fetus.

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