Chapter V

DIETARY INTAKE AND ADOLESCENT GROWTH

5.1 Dietary intake and growth

Nutrition is one of the major environmental factors required for proper physical growth. The fact was strongly brought out by the changes in body size of Japanese children over the years. The secular trend in height was actually reversed during the war period. But once the quality of food was improved, there was substantial increase in body weight and heights of the Japanese children. The age at maximum increment in height was considerably earlier for post war period i.e. in 1963 (12.5 years) than during the war period i.e. in 1948 (14.5 years). Hence the better dietary intake seems to be associated with better physical growth during adolescence. (Frisch R., Revelle R,1969).

The influence of nutrition on growth during adolescence was investigated with the help of data on mean weights for different age groups and per capita calorie supplies estimates (United States Department of Agriculture) for seven Latin American countries and seven Asian countries in the same paper. They found that the mean age of maximum increment in growth in weight (MIGW) for adolescent boys from countries with higher per capita calorie supply (> 2300 K cal) was 13.0 ± 0.10 years where as that of boys from countries with lower per capita calorie supply (< 2300 Kcal) was 15.5 ± 0.33 years. Correlation coefficient between mean age of MIGW and calorie supply was found to be -0.85 for boys. Thus the above observations suggest strong influence of nutrition on adolescent growth spurt.

When the correlation coefficient between body measurements and calorie intake for various age groups were calculated, it was observed that increase in calorie intake led to increase in average weight, height and arm circumference of children and adolescents. (Hassan H, Ahmed K, 1984). The calorie intake in this study was obtained by intrafamily food distribution survey. The correlation coefficients between weights and calorie intake were 0.63, 0.37, 0.32 and 0.45 for the age groups 1 - 3 , 4 - 6 , 7 - 9 and 10 - 19 year old boys. The similar correlations for height and calorie intake were given as 0.57,0.25, 0.30 and 0.47 for the above age groups respectively. Thus such a correlation was observed to be greater in younger age groups and decreasd thereafter.

Black Alison et. al. (1976) have also reported similar observation. He measured dietary intake of 140 preschoolers for five days by weighment method and found that correlation coefficient between weight and energy intake were 0.48, 0.41 and 0.25 for ages 8 months, 20 months and 3 years respectively. Thus there was an indication that at the time of rapid growth in infancy, the correlation was maximum and as age increases,i.e. with decrease in growth rate the correlation between intake and weight decreased.

Evaluation of supplementary feeding programmes also brings out similar phenomenon. Thus the gain in weight observed for supplemented children was significant during preschool age (C.Gopalan et.al., 1973) but not significant in case of older children i.e. school age children (C.R.Soman,1982; D.K.Agarwal et.al.1987).

Whether the correlation between intake and body measurements further continues to decrease during adolescence or it undergoes change altogehter has not been investigated in earlier studies. In fact with rapid changes in weight and increased nutritional demands as reported by nutritionists, it is likely that correlation between intake and weight could be significant around onset of spurt.

Adolescents, in a way, have remained a neglected group as designing and implementing supplementary feeding programmes for this group has been rarely done. However, it might be because relation between nutrition and growth during adolescence has not been adequately studied. Though it has been reported that deteriorated nutritional status delays growth spurt, there is no documented evidence that increased dietary intake during adolescnece leads to higher increments in weight, height etc. The investigation of relationship between nutrition and growth during adolescence becomes complicated as variability in body measurements is very high.

Initially the average calorie intake and protein intake are computed for the broad age groups and are compared in the following section.

5.1.1 Comparison of average dietary intake with the recommended intake.

Body needs energy to perform various functions such as maintaining body temperature, various metabolic processes, for physical activity and for growth. Many physical and physiological changes occur during adolescence, which place a great demand on their nutritional requirements. The nutritional requirements during this period are thus relatively higher than those for during early school age or adulthood (B.S.Narsinga Rao, 1985).

The average calorie intake for each round and for all the rounds combined were computed for the broad age group categories. (Table 5.1). This was mainly done to differentiate the children in various stages of growth namely before spurt (accelerating phase, age group < 12.5 years), during spurt (age between 12.5 to 13.5 years) and after spurt (decelerating phase, age >= 13.5 years). These age groups were based on age at PHV (13.07 years, PB1 estimate) for the MSE group. Similar grouping was done for LSE for comparison purposes. The average calorie intakes were compared for different age groups within a given socio-economic class, between the two socio-economic classes and then with the recommended calorie allowance (WHO,1985). The boys who were present in all rounds of diet as well as anthropometric surveys were considered for this analysis.

It was observed that the calorie intakes of boys in preadolescent stage (<12.5 years of age) and post adolescent stage (>=13.5 years) differed significantly for MSE class. Thus the average calorie intake seemed to increase as growth advances. As against this, average calorie intake remained similar for all age groups for LSE. The average intakes when compared between MSE and LSE did not vary significantly.

Table 5.1 : Mean ± SD calorie intake.

Age group (year)	n	Mean ± SD calorie intake (Kcal)					
		Round 1	Round 2	Round 3	Round 4	All rounds combined	Recommended dietary Allowance (Kcal)
MSE							
< 12.5	20	1820 ± 471	1747 ± 391	1775 ± 504	-	1781 ± 459 (a)	2275 (g)
12.5-13.5	10	2222 ± 649	2105 ± 464	2028 ± 581	-	2118 ± 571 (b)	2375 (h)
13.5-14.5	11	2293 ± 559	2310 ± 606	2339 ± 727	-	2314 ± 631 (c)	2645 (i)
LSE							
< 12.5	9	2144 ± 431	1876 ± 492	2145 ± 497	1731 ± 354	1974 ± 475 (d)	2275 (j)
12.5-13.5	24	2197 ± 455	1951 ± 488	2135 ± 452	1735 ± 429	2004 ± 488 (e)	2375 (k)
13.5-14.5	11	2398 ± 657	2028 ± 522	2203 ± 514	2083 ± 428	2178 ± 547 (f)	2645 (l)

Table 5.1A : Comparisons of Average Calorie Intake

Between socio-economic classes		Within socio-economic class		With recommended allowance	
	t value		t value		t value
		MSE			
(a) Vs (d)	1.27 NS	(a) Vs (b)	2.34 *	(a) Vs (g)	4.18 **
(b) Vs (e)	1.02 NS	(a) Vs (c)	3.89 **	(b) Vs (h)	1.77 NS
(c) Vs (f)	0.79 NS	(b) Vs (c)	1.17 NS	(c) Vs (i)	2.39 *
		LSE			
		(b) Vs (e)	0.32 NS	(d) Vs (j)	1.97 NS
		(d) Vs (f)	1.47 NS	(e) Vs (k)	3.96 **
		(e) Vs (f)	1.19 NS	(f) Vs (l)	3.37 **

The intakes of children during preadolescent as well as postadolescent stage were significantly less than the recommended dietary allowance. The only age group which had calorie intakes similar to recommendations was the during spurt (i.e. 12.5 to 13.5 year age group) for MSE. However in case of LSE the calorie intake was similar to the recommended allowance only upto the age of 12.5 years. Afterwards the intake was significantly less than the recommendations.

Protein is an important nutrient, as it is essential not only for providing essential amino acids, but also the nitrogen which is required for synthesis of body proteins and enzymes etc. Average protein intake of boys included in the diet survey are presented in Table 5.2. It was observed that 10 to 12% of the total calorie intake could be obtained from proteins in the diet. It has been reported that the most satisfactory human diets provide 10 to 15 % of energy in the form of protein. As such the diets of the study population can be regarded as satisfactory in respect of protein intake.

In addition to the quantity of protein in the diet another important aspect of protein is quality. It can be estimated by utilising the index 'net dietary protein energy ratio'. Considering that NPUop for mixed indian diet has

Table 5.2 : Mean ± SD protein intake

Age group (year)	n	Mean protein intake ± SD (9) Round 1	Round 2	Round 3	Round 4	For 4 rounds combined	% calories from proteins	Net dieta protein energy ra
	MSE							
< 12.5	20	49.42 ± 12.56	46.98 ± 10.39	44.92 ± 11.93	-	47.11 ± 11.81 (a)	10.58	6.88
12.5-13.5	10	59.26 ± 16.16	54.19 ± 11.26	50.77 ± 14.45	-	54.74 ± 14.53 (b)	10.34	6.72
13.5-14.5	11	63.98 ± 15.86	62.22 ± 15.92	59.52 ± 17.78	-	61.91 ± 16.64 (c)	10.70	6.96
	LSE							
< 12.5	9	63.15 ± 13.22	54.78 ± 14.29	59.88 ± 12.40	50.24±10.77	57.01 ± 13.65 (d)	11.55	7.51
12.5-13.5	24	61.84 ± 13.47	56.85 ± 13.23	58.32 ± 12.84	49.59±12.71	56.65 ± 13.81 (e)	11.31	7.35
13.5-14.5	11	65.38 ± 13.58	56.54 ± 14.84	59.62 ± 14.15	60.53±12.08	60.52 ± 14.06 (f)	11.11	7.22

Table 5.2A : Comparisons of Average Protein Intake

Between socio-economic classes	t value	Within socio-economic class	t value
		MSE	
(a) Vs (d)	1.99 NS	(a) Vs (b)	1.55 NS
(b) Vs (e)	0.36 NS	(a) Vs (c)	2.88 **
(c) Vs (f)	0.21 NS	(b) Vs (c)	1.05 NS
		LSE	
		(b) Vs (e)	0.07 NS
		(d) Vs (f)	0.57 NS
		(e) Vs (f)	0.77 NS

been suggested 65, the index showed values between 6 and 8, which are well above dietary protein energy ratio for maintenance. (i.e. 5% NDP cal).

Average protein intakes in case of children for MSE increased significantly with advancing growth but did not change much in case of children from LSE class.

5.1.2 Correlation between average dietary intake and annual height increments :

In order to examine the relation between dietary intake and growth, simple correlation coefficients between average calorie intake (and also average protein intake) and annual increments in height were computed initially. The coefficients were computed for height increments and not for 'size attained' as height increments are of special significance especially during adolescence. The computations here are done for broad age group categories as done previously. (Table 5.3).

It was observed that for MSE class, the correlation coefficient between intake and growth velocity was significant, only before the age of 12.5 years. This age group roughly coincides with the age at take off of

Table 5.3 : Correlation coefficient between average intake and annual height increments.

Age group (Year)	n	Average calorie intake (Kcal)	Average annual height increments cm/yr.	Correlation coefficient between av.cal.intake and annual ht.increment	Average protein intake (g)	Corr.coeff. bet av. protein intake and annual height increment
MSE						
< 12.5	20	1781	5.3	0.45*	47.11	0.48*
12.5-13.5	10	2118	7.4	0.38(NS)	54.74	0.43(NS)
13.5-14.5	11	2314	6.5	0.36(NS)	61.91	-0.53(NS)
LSE						
< 12.5	9	1974	6.7	-0.18(NS)	57.01	-0.05(NS)
12.5-13.5	24	2004	6.1	0.34(NS)	56.64	0.27(NS)
13.5-14.5	11	2178	6.8	0.72*	60.51	0.47(NS)

adolescent growth spurt. Thus during this period the better calorie intake was associated with higher height increments. Beyond the age of 12.5 years, no relation between intake and growth could be found. Influence of better nutrition is therefore seen only before the onset of spurt or at take-off.

Such correlation coefficient when calculated for LSE group was significant for the age group 13.5 to 14.5 years, which was again the period prior to attainment of PHV. (Age at PHV for LSE = 14.82 years, PB1 estimate). Thus during this particular period higher calorie intake was associated with higher annual height increments.

The correlation coefficients between average protein intake and annual height increments was significant for the age group < 12.5 years for MSE class. Thus the better protein intake was also associated with better growth during this period. As against this, protein intake was not associated with increments in any of the age group for LSE children. This may, however, mean that protein in case of LSE children might have been utilised for energy purposes.

The important implications of these findings are from the point of view of nutrition intervention programmes. It thus means that if programmes are appropriately targeted for the children in prepubertal stage even for the short period such as one year, the benefits could be seen in terms of higher increments assuring better growth during adolescence.

5.1.3 Multiple Regressions :

Sophisticated technique of multiple regression was further employed to examine the various factors responsible for causing variations in annual height increments. `Annual height increment' was considered as dependent variable where as age (years), nutritional status (in anthropometric indices) and dietary intake (in terms of calories, proteins, calories per kg., proteins per kg.) were considered as independent variables. Such an analysis was done for the age group in each socio-economic class which showed significant correlation between dietary intake and annual height increments i.e. prepubertal stage.

Thus in all 12 different combinations of three independent variables led to 12 multiple regressions e.g.

$$y = \alpha + \beta 1 \text{ (AGE)} + \beta 2 \text{ (WFA)} + \beta 3 \text{ (AVGCAL)} + \epsilon \quad \text{--(1)}$$

$$y = \alpha + \beta 1 \text{ (AGE)} + \beta 2 \text{ (WFA)} + \beta 3 \text{ (AVGCPB)} + \epsilon \quad \text{--(2)}$$

$$y = \alpha + \beta 1 \text{ (AGE)} + \beta 2 \text{ (WFA)} + \beta 3 \text{ (AVGPRO)} + \epsilon \quad \text{--(3)}$$

$$y = \alpha + \beta 1 \text{ (AGE)} + \beta 2 \text{ (WFA)} + \beta 3 \text{ (AVGPPB)} + \epsilon \quad \text{--(4)}$$

Where α = regression constant

$\beta 1$, $\beta 2$, $\beta 3$ = partial regression coefficients

ϵ = error term $\epsilon \sim N(o, \sigma^2)$

AGE = Age in years in the beginning of study period.

WFA = Weight for age in the beginning of study period.

AVGCAL = Average calorie intake (Kcal).

AVGCPB = Average calorie intake per kg body weight (Kcal/Kg).

AVGPRO = Average protein intake (gm).

AVGPPB = Average protein intake per kg body weight

Similarly using height for age and weight for height as indices of nutritional status led to eight more sets of computations (Table 5.4).

In case of LSE it was observed that the factor 'AGE' i.e. the age of the individual in the beginning of the study period was not significant in any of these computations. Hence the multiple regression analysis, in this particular class was restricted to two independent variables namely nutritional status and dietary intake only.

It was observed that R^2 i.e. percent of variation in height increments as explained by the independent factors such as nutritional status and dietary intake ranged from 24% to 84%. The maximum R^2 was observed for the independent

Table 5.4 : Multiple regression analysis for LSE class.
Y = annual height increment (cm/yr)
= dependent variable

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
1) Weight for age	-4.74724	-0.07401	0.034451	0.6985**
Average calorie intake		0.007528**	0.001963	
2) Weight for age	-12.1251	0.078873	0.069433	0.5448*
Average calorie intake per kg.		0.224682*	0.084678	
3) Weight for age	2.376733	-0.09104	0.046754	0.472079
Average protein intake		0.171747	0.07704	
4) Weight for age	-4.67038	5.922447	2.951812	0.429592
Average protein intake per kg.		0.022135	0.065084	
5) Height for age	9.096664	-0.24266*	0.060319	0.842703**
Average calorie intake		0.009032**	0.001479	

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
6) Height for age	-8.15861	0.053533	0.131261	0.482095
Average calorie intake per kg.		0.1653*	0.068888	
7) Height for age	18.58582	-0.28317*	0.103844	0.5967*
Average protein intake		0.228957*	0.073632	
8) Height for age	0.247139	-0.02178	0.123369	0.42359
Average protein intake per kg.		5.042127	2.414357	
9) Weight for age	-16.5213	0.064779	0.068308	0.572542*
Average calorie intake		0.008131*	0.002488	
10) Weight for age	-10.2213	0.075626	0.073004	0.533856*
Average calorie intake per kg.		0.171969*	0.056924	

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
11) Weight for height	1.997765	0.034788	0.09086	0.235894
Average protein intake		0.149768	0.09572	
12) Weight for height	-12.8511	0.098288	0.077949	0.517282
Average protein intake per kg.		6.622784*	2.266466	

variables height for age and average calorie intake. The partial regression coefficients for height for age was negative and that for average calorie intake was positive and highly significant. Thus it is indicated that children having low height for age status (or stunted) were showing higher increments during this period. While boys having good height for age status had lower increments in this age group, as these boys probably are early maturers and as such, had higher increments in height before the age of 13.5 years. The positive and significant partial regression coefficients of average calorie intake revealed that the boys consuming more calories were showing greater annual height increments.

Out of three indices of nutritional status, the increments were more significantly affected by height for age status of an individual in LSE class. This observation confirms the finding in earlier chapter on Growth Modelling. It was observed that, the growth of adolescent boys was more affected by poor height for age status than by poor weight for age status.

Out of the four indicators of dietary intakes considered here the indicator 'average calorie intake' as well as 'average calorie intake per kg body weight' showed positive and significant association with all the multiple regressions which considered them as one of the independent factors.

The importance of average protein intake (also average protein intake per kg body weight) was brought out only in the presence of height for age as an another independent variable.

Thus the importance of better dietary intake in terms of calories or proteins was well brought out for the age group before the age at PHV. (age at PHV for LSE = 14.82 years, PB1 estimate).

Similar analysis was done for MSE class for the boys in the prepubertal stage, (Table 5.5) which showed highest values for simple correlations.

Table 5.5 : Multiple regression analysis for MSE class.
Y = annual height increment (cm/yr)
= dependent variable

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
1) Age	-6.98555	0.522948	0.31657	0.41*
Wt for age		0.066512	0.034622	
Av. calorie intake		0.000912	0.001153	
2) Age	-8.59628	0.666328*	0.300752	0.3885*
Wt for age		0.079827	0.036897	
Av. claorie intake		0.010299	0.036444	
3) Age	-6.87169	0.491707	0.315019	0.41904
Wt for age		0.064631	0.034358	
Av. Prot. intake per kg.		1.674321	1.431364	
4) Age	-40.6972	0.74808	0.27715	0.48628
Ht for age		0.36842	0.124412	
Av. Prot. intake per kg.		1.6743321	1.431364	

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
5) Age	-30.1246	0.412888	0.273546	0.539175
Ht for age		0.292797	0.096222	
Av. calorie intake		0.00177	0.000965	
6) Age	-38.7299	0.735553	0.282057	0.474102
Ht for age		0.354426	0.125031	
Av. calorie intake		0.036573	0.037177	
7) Age	-30.0458	0.380004	0.27155	0.556321
Ht for age		0.292195	0.094385	
Av. Protein intake		0.074064	0.036524	
8) Age	-9.37401	0.680644	0.298238	0.393204
Wt for age		0.082653	0.037068	
Av. Protein intake		0.627556	1.416746	
9) Age	-1.89999	0.420307	0.356899	
Wt for Ht		-0.00419	0.050273	
Av. Calorie intake		0.001684	0.00139	0.272805
10) Age	-1.57974	0.575078	0.335349	0.223623
Wt for Ht		0.024036	0.045339	
Av. Calorie intake		-0.02235	0.037164	

Independent variable	Regression constant	Partial regression coefficient	Standard error	R^2
11) Age	-1.64567	0.379766	0.356716	
Wt for Ht		-0.00709	0.049265	
Av. Protein intake		0.072987	0.052553	
12) Age	-1.9323	0.588453	0.33509	0.217985
Wt for Ht		0.023815	0.04558	
Av. Protein intake		-0.71378	1.445628	

It was observed that the factor height for age was significantly and positively associated with the annual height increments. Age was also responsible in causing the variations in annual height increments. This was true only for boys from MSE class and not for those from LSE class. The p value for the partial regression coefficients for average calorie or protein intake was in the range 0.05 to 0.1 indicating marginal significance. However intakes were significantly correlated with annual height increments when considered individually.

Thus the multiple regression brought out the fact that relation between dietary intake and height increments was significant only for preadolescent stage, suggesting the importance of nutrition and intake at take off. Secondly the multiple regressions showed highest value of R^2 for both the classes when height for age was considered as another independent variable along with dietary intake in the multiple regression equation. The coefficient for height for age was negative in case of LSE children while that for MSE class it was positive. The suggestion is that children from LSE class indicate a mixture of early and late maturers giving rise to negative coefficient and in general brings out importance of achieving height status at prepubertal stage in the context of adolescent growth that would be attained in the later phase. The overall magnitude of R^2 was observed to be much higher in case of boys from LSE class (84%) than for MSE class (55%). The possibility is that the effect of intake in LSE class could be seen easily if given the intervention, while in case of MSE children it appears that the variability in intake is likely to be higher reducing the relationship between intake and height increment (R^2=55 %). It is therefore necessary to further analyse the variations in dietary intake of adolescent boys.

5.2 Variations in dietary intake

Adolescence is characterised by very rapid changes in physical dimensions. Consequently, the changes in the dietary intake are also expected to take place during adolescence. However in the absence of longitudinal studies reported in literature for investigating changes in body measurements as well as changes in dietary intakes, very little information could be traced regarding variations in intakes of boys during adolescence. Our study offers an opportunity to address the issue of variability for several reasons. Firstly the same cohort was observed three times over a period of a year. Further as the intakes are measured during 'weigh as you eat method' the accuracy in the measurement of intake was reasonably high, thus allowing estimation of between and within variations in intakes. The technique of Analysis of variance (ANOVA) was used for this purpose.

Initially the simple one way ANOVA (random effect model) was carried out seperately for each round to obtain the estimates of between (σ_b^2) and within (σ_W^2) individual variations in dietary intakes.

The mathematical expression is given by

$Yij = \mu + Ai + \epsilon ij$

$i = 1,2 ---- a$ (a = number of boys)

$j = 1,2 ---- n$ (n = number of days in each round of diet survey = 6)

$\epsilon ij = N(0,\sigma^2)$

Yij = Calorie intake of i^{th} individual on the j^{th} day.

μ = Overall mean calorie intake

Ai = difference between intake of i^{th} boy and overall mean.

ϵij = error term.

Table 5.6 now gives the ANOVA for the two classes for calorie intake of adolescent boys who were present in three rounds of dief survey. The estimates $\hat{\sigma}_b^2$ and $\hat{\sigma}_\omega^2$ were obtained by solving the expression.

$$M.S.(between) = 6\,\hat{\sigma}_b^2 + \hat{\sigma}_\omega^2$$

$$M.S.(within) = \hat{\sigma}_\omega^2$$

Following points are evident from Table 5.6. For the MSE class, within individual variations contribute substantially to the total variation and is almost of the same order as that of between individual variation in dietary intake. Further not only the variability in body measurements but also the variability in dietary intakes within individual seemed to be increased during adolescence.

Table 5.6 : Analysis of variance (One way) for Calorie intake

Source	df	Round 1 MS	(%)	Round 2 MS	(%)	Round 3 MS	(%)
MSE							
Between Subject	56	1581648.20	234903.77 (58%)	993787.37	142977.75 (51%)	1284889.02	181362.17 (48%)
Within subject	285	172225.56	172225.56 (42%)	135920.88	135920.88 (49%)	196716.02	196716.02 (52%)
Standard deviation (σ_w)			415.0007		368.6745		443.53
Mean intake (Kcal)			2145		2010		2044
C.V. %			19.35		18.34		21.70
LSE							
Between subject	71	485628.44	39353.49 (14%)	594704.48	63974.13 (23%)	413137.24	36085.11 (16%)
Within subjects	360	249507.49	249507.49 (86%)	210859.67	210859.67 (77%)	196626.56	196626.56 (84%)
Standard deviation (σW)			499.5072		459.1946		443.4259
Mean intake (Kcal)			2236		1964		2139
C.V. %			22.34		23.38		20.73

In case of LSE class, within individual variability in dietary intake was even higher than those in case of MSE boys. The reasons for this observation are further investigated in the subsequent analysis.

As diet survey was carried out in different seasons of the year, part of the variation could be due to seasonal variations. It has been also reported that after eliminating the effect of exogenous variables considerable within variation remains (Rao,1987, Widdowson 1961). In order to examine these aspects of within variability, hierarchal model of ANOVA are necessary. The intakes are therefore analysed using this technique.

The mathematical expression for hierachal model is given by

$$Yijk = \mu + Ai + Bij + \epsilon ijk$$

i = 1,2 --- a (a = number of boys)

j = 1,2 --- b (b = number of periods or rounds = 3)

K = 1,2 --- n (n = number of days within each period = 6)

$Ai = N(0, \sigma_A^2)$ $Bij = N(0, \sigma_B^2)$ $\epsilon ijk = N(0, \sigma^2)$

Ai, Bij, ϵ ijk are assumed to be independent.

The estimates of three sources of variations can be obtained by solving following sets of equations.

Mean square (between individuals) = $\hat{\sigma}_d^2 + 6\hat{\sigma}_p^2 + 18\hat{\sigma}_b^2$

Mean square (between periods, within individuals) = $\hat{\sigma}_d^2 + 6\hat{\sigma}_p^2$

Mean square (between days, within periods, within boys) = $\hat{\sigma}_d^2$

Where $\hat{\sigma}_d^2$ = estimate of variability in calorie intake between days.

$\hat{\sigma}_b^2$ = estimate of variability in calorie intake between individuals.

$\hat{\sigma}_p^2$ = estimate of variability in calorie intake between periods.

$\hat{\sigma}_w^2$ can be obtained by ($\hat{\sigma}_p^2 + \hat{\sigma}_d^2$)

The hierarchal ANOVA alongwith ANOVA for weekly mean calorie intake for MSE and LSE class are presented in Table 5.7. It was observed that, for MSE class, standard deviation (SD) for weekly mean (273) was lower that the SD obtained from analysis of daily intakes (410). However, the reduction is not in the proportion, if it is assumed that the daily intakes are random. This is because, if we assume that the daily intakes are random then SD in weekly means is expected to reduce in the proportion 1/P (P = number of days over which mean is taken = 6). However SD obtained in case of weekly means in much higher (273) than in case daily intakes are random (167).

Table 5.7: Hierarchal analysis of variance (calorie intake)

Source	df	Daily calorie intake		Weekly means	
		MS	Estimate of Variance (%)	MS	Estimate of (Variance (%)
MSE					
Between individuals	56	3013221.83	142648.98 (40%)	502203.51	142648.93 (66%)
Within periods with individuals	114	445540.26	46208.80 (13%)	74256.72	74256.72 (34%)
Between days,within periods, within individuals	855	168287.49	168287.49 (47%)		
Standard deviation(6W)			410.2286		272.5009
Mean calorie intake (Kcal)			2067		2067
C.V. %			19.85		13.19

Contd..

Source	df	Daily calorie intake		Weekly means	
		MS	Estimate of Variance (%)	MS	Estimate of (Variance (%)
LSE					
Between individuals	71	923413.41	29361.83 (11%)	153902.24	29361.83(31%)
Between periods, within individuals	144	394900.54	29317.11 (11%)	65816.76	65816.76 (69
Between days,within periods ,within individuals	1080	218997.90	218997.90 (78%)	-	-
Standard deviation(6W)			467.9721		256.5478
Mean calorie intake (Kcal)			2213		2213
C.V. %			22.15		12.14

Daily dietary intake thus appears to be non random in nature.

This was also true for LSE class.

Thus even after averaging calorie intake over a period, variation between weeks remains large. Similar finding has been reported by Rao (1987).

This within variation is likely to be affected by changes in wieght during adolescence and as such ANOVA are done for calorie intake per Kg body weight and are presented in Table 5.8. It was observed that the coefficients of variations did not decrease substantially.

Thus the within individual variations remain significantly larger during adolescence even after averaging the intakes on weekly basis as well as after expressing on per Kg basis, suggesting that within the wide range of intra individual variation intakes are poorly correlated with weights.

In order to examine which component of within variability reflects change during adolescence, hierarchal models are further employed for different age groups representing different phases of growth. The age groups are similar as reported in section 5.1.

Table 5.8 Hierarchal Analysis of Variance (Calorie intake/kg body weight)

Source		Daily calorie intake/kg		Weekly means/kg	
	df	MS	Estimate of Variance (%)	MS	Estimate of (Variance (%)
MSE					
Between individuals	56	2092.86	91.64 (32.47%)	3448.82	91.65 (55.37
Between periods within individuals	114	443.28	50.54 (17.91%)	73.87	73.87 (44.63
Between days, within periods, within individuals	855	140.06	140.06 (49.63%)	-	-
Standard deviation(6W)			11.8345		8.5948
Mean intake(Kcal/kg)			60.4988		60.4988
c.v. %			19.50		14.21

Contd.

Source	df	Daily calorie intake/kg MS	Daily calorie intake/kg Estimate of Variance (%)	Weekly means/kg MS	Weekly means/kg Estimate of (Variance (%)
<u>LSE</u>					
Betwween individual	71	1909.74	81.08 (25.41)	318.33	81.20 (52.0
Between periods within individuals	194	450.26	42.46 (13.31)	74.74	74.74 (47.9
Between days,within periods within individuals	1080	195.51	195.51 (61.28)	-	-
Standard deviation(6W)			13.9825		8.6452
Mean intake (Kcal/kg)			61.9406		61.94
C.V. %			22.57		13.96

The daily calorie intakes per kg body weight were considered while carrying out this ANOVA. As mentioned earlier, the hierarchal model was useful for estimating variance between individuals (σ_b^2), variance between periods within individuals (σ_p^2) and variance between days, within periods, within individuals (σ_d^2). These estimates were obtained for two phases i.e. For first 6 months i.e. Phase I (round 2 and round 3) and for next six months i.e. Phase II (round 2 and round 3).

It was observed that (Table 5.9) for LSE class that variations in intake between periods (σ_p^2) expressed as percent of total variation shown considerable increase from 11.13 for Phase I to 22.89 for Phase II, for the age groups 14.5 to 15.5 yr, the age group in which maximum height increment was observed.

In case of MSE class, similar observation was recorded.

Thus the σ_p^2 , a component of within individual variability relects change in response to process of adolescent growth.

The technique of analysis of the variance was helpful in bringing out the nature and extent of variation in dietary intake of adolescent boys from two socio-economic

Table 5.9 : Hierarchal analysis of variance for two phases. (calorie intake/ kg body weight).

Age group (Year)	Source of variation		d.f.	Phase I MSE	Phase I Estimate(%)	Phase II Mss	Phase II Estimate(%)
			MSE				
<12.5	Bet.boys	(1)	23	1380.97	77.17(29.67)	1162.72	74.05(31.42)
	Bet.Periods within boys	(2)	24	454.98	54.41(20.92)	274.08	22.49 (9.54)
	Bet.days,within periods within boys.	(3)	240	128.55	128.55(49.42)	139.16	139.16(59.04)
12.5	Bet.boys		9	1674.19	73.31(20.87)	1832.22	118.47(372)
to	Bet.Periods within boys		10	794.51	103.32(29.47)	410.53	42.10(13.22)
13.5	Bet.days,within periods within boys.		100	174.58	174.58(49.71)	157.93	157.93(49.58)
13.5	Bet.boys		13	1072.50	67.16(31.79)	1306.18	73.69(27.32)
to	Bet.Periods within boys		14	266.62	24.51(11.60)	421.84	45.17(16.75)
14.5	Bet.days,within periods within boys.		140	119.56	119.56(56.6)	150.84	150.84(55.93)

Contd...

Age group (Year)	Source of variation	d.f.	Phase I MSE	Phase I Estimate(%)	Phase II Mss	Phase II Estimate(%)
<12.5	Bet.boys	LSE 13	869.32	14.29(4.53)	1280.94	79.11(24.63)
	Bet.Periods within boys	14	697.90	790.42(25.20)	331.66	17.91(5.57)
	Bet.days,within periods within boys	140	221.39	221.39(70.26)	224.22	224.22(69.80)
12.5	Bet.boys	27	1094.99	38.59(12.36)	755.39	44.54(18.94)
to	Bet.Periods within boys	28	631.95	71.69(22.97)	220.94	6.06(2.58)
13.5	Bet.days,within periods within boys.	280	201.80	201.80(64.66)	184.57	184.57(78.48)
13.5	Bet.boys	18	1740.93	94.69(22.48)	1496.80	107.29(40.89)
to	Bet.Periods within boys	19	607.71	56.22(13.35)	209.38	10.86(4.14)
14.5	Bet.days,within periods within boys.	190	270.37	270.37(64.18)	144.23	144.23(54.97)
14.5	Bet.boys	6	941.04	54.57(25.06)	286.89	2.46(2.03)
to	Bet.Periods within boys	7	286.16	24.60(11.30)	257.40	27.74(22.89)
15.5	Bet.days,within periods within boys.	70	138.57	138.57(63.64)	90.98	90.98(75.08)

classes namely, LSE and MSE. It was observed that not only the variability in body measurements, but also the variability in dietary intake within an individual also increases during adolescence. It remained significantly higher even after averaging them for one period of six days as well as on expressing them in terms of per kg basis. The component i.e. variance between periods reflected increase as the adolescent growth advanced. This within individual variation has been viewed as a reflection of response of an individual to the environment (Sukhatme P.V., 1982) and highlights the biological individuality.