METABOLIC PATTERNS OF CALORIES AND PROTEINS OF POST ADOLESCENT WOMEN STUDENTS RESIDING IN A HOSTEL

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INTRODUCTION

Gradients in quantity and quality of diet are associated with parallel gradients in rate of growth, adult stature, physical performance, mental ability and resistence to disease (Montague, 1957., Macy, 1951). Dietary patterns have special significance, when the body is subject to the nutritional stress which augmented nutritive requirements, that accompany the physiological activities of growth (Mitchell, 1964).

The extent of growth spurt of the adolescent depends upon the adequacy of the supply of nutrients as stated by FAO (1963). It is an established fact that decrease in the expected rate of growth is the consequence of nutritional failure, especially of the inadequacy of proteins and calories, (Mitchell, 1962., Dreizen *et al.*, 1951., Gyorgy, 1960., Dreizen *et al.*, 1962., Mitchell, 1964., Mitchell and Santo, 1963., Tanner, 1952., Howe and Schiller, 1952). Studies conducted at Stuttgart, Germany support the theory that even a small nutritional limitation in adolescence may result in a retardation of growth greater than in children of other age groups. (Howe and Schiller, 1952). This is evidenced by the retarded heights and lowered gain in weights of the Japanese children during periods of nutritional stress of the two world wars, (School Health Committee of Education, Japan, 1961). Similarly Indian adolescents depending largely on plant proteins with little if any of animal protein foods tend to be short and small built in stature, (ICMR, 1951., 1966).

As there are obviously wide variations even among the normal adolescents, it is often difficult to decide, whether a particular adolescent is growing as well as he or she should. The accretions of the chemical units like nitrogen and calcium, determined by the metabolic balance procedures have been used as a measure of growth and development. So the metabolic patterns during growth and development have been studied in comparison with the nutrient intakes of adolescents, (Macy and Kelly, 1957., Bricker and Smith, 1951).

In evaluating a dietary pattern, the final test is, whether the food intake supply the chemical needs of the body. In this connection, metabolic balance methods of determining assimilation and retention of nutrients are of great use. The amount and proportions of nutrients retained by the body will depend on age, dietary intake, nutritional status, and physical activity of the individual (Macy and Kelly, 1957).

Most of the studies on the relationship of diet and growth and nutritional status of adolescents have been carried out in economically affluent countries. (Mack et al., 1942., Chaloners, 1952., Hard et al., 1953., ~~Darby, 1953.,~~ Warnick et al., 1955., Lanty, 1958., Hard et al., 1958., and Hodges and Krehl, 1965). The diets tested in these studies were normally generous as compared with those eaten by millions of youth in the less developed countries.

Consequently, there is little information on the so called 'minimum requirements' of adolescents. How this minimum requirements could be defined, apart from the amount that is sufficient to prevent manifestation of deficiency diseases is a problem. Many reports suggest that very generous intake of several nutrients do confer special advantages on the health and well being of a person, (Pathak, 1958., Plough and Bridgeforth, 1962). Minimum requirements of many nutrients have been determined with acceptable degrees of validity although further definition is needed of the pre-existing states of health and nutrition for which those minimum requirements are applicable.

College students in India fall in the post adolescent age group, between 15 and 20 years as defined by Nageswara Rao (1966). Studies conducted in several hostels in India, revealed that the diets consumed by the students were inadequate in calories, proteins, calcium, iron, thiamine, riboflavin, niacin and vitamin C, (Banerjee et al., 1953., Banerjee, 1953., Sarkar and Sarkar , 1953). The above studies were confined to restricted areas and limited number of students belonging to the North and Eastern parts of India. An elaborate study conducted by Nageswara Rao (1966) covering 194 teaching institutions all over India showed that, the majority of the diets eaten by college students, consisted of excessive amounts of cereals and were low in protective foods. They failed to meet the accepted standards of nutritional requirements as proposed by (ICMR, 1968).

The caloric and protein intakes, recommended for adolescents, can only be approximations. Hansen (1959) estimated 50 calories/kg/day as the requirement for those above 15 years of age. According to ICMR (1966), the caloric requirement of the age group (16 to 19 years) is 2100 calories for girls and that of protein is 2 gms/kg of body weight for both boys and girls.

Scoular (1946) reported the food intake of 106 college women, in the United States of America, by calculation and and analysis of food. On an average, they consumed 2446 calories and 94g of proteins per day. On the other hand, Banarjee et al., (1963) reported the daily consumption of calories and protein by six adolescent young college women of Rajasthan to be 1438 calories, and 43g of protein. Thus there seems to be a wide variation in the caloric and protein intake, between the western countries and India. The implications of such a restricted intake on the nutritional status of the college students needs to be studied more critically.

The present study is an attempt towards this problem. Women College students in the post adolescent age group (between 13 to 19 years) served as subjects for this study. They were residing in the College hostel. They consumed the usual college hostel diets and no attempt was made to change their dietary patterns. The weights of the cooked foods consumed by the students were recorded. From this data the caloric and protein intakes of the subjects were calculated using the food composition tables compiled by Aykroyd et al., (1963) and also checked by direct analysis of the food samples for calories and nitrogen. The total urinary nitrogen and creatinine were determined, for a 24 hour collection for three consecutive days. Further fecal calories and nitrogen were also determined on similar 24 hours sample for three consecutive days.

The heights and weights of the selected subjects were recorded once in a fortnight for a period of eight months, to find out any variations in weight and growth in these post adolescent college students. Basal metabolic rates were also determined. Thus the design of the study helped to

a) Compare two methods of studying dietary intake, by calculation from weighment of the cooked foods actually consumed by the students and by direct analysis of the food preparation or diets.

b) Correlate the dietary intake with the metabolic pattern of the subjects, as determined by the fecal calories, and the urinary and fecal nitrogen and creatinine excretion.

c) Record the heights and weights on every fortnight over a period of eight months for these subjects and

d) Assess the pattern of energy expenditure by factorial method by determination of the Basal Metabolic Rate and keeping a timed record of all the activities of the subjects daily for seven consecutive days.

II REVIEW OF LITERATURE

The importance of nutrition to health and growth had been stressed by many workers (Mitchell, 1952., Eppright et al., 1956). The literature is replete with examples of the ill effects caused by gross dietary deficiencies. Minimum requirements of many nutrients have been determined with acceptable degrees of validity. While deficiency diseases like scurvy and pellagra have become a rarity, our attention is directed more towards the significance of varying levels of nutrients above minimal needs. Attempts to establish "optimal" level of intake have been hampered due to the wide range of individual variations and by the incomplete understanding of factors involved in these variations. Eventually, the maximal and minimal levels of the nutrient requirements compatible with health, need to be determined. Again the variation among individuals in absorption and utilisation of nutrients need to be understood better.

The available literature reports on the relationship of diet to growth and nutritional status of adolescents which had been carried out in the economically affluent countries (Macy, 1951., Warnick et al., 1955., Hard et al., 1958., Hard and Esselbough, 1956., Lantz and Wood, 1958.,) and usually the diets tested were generous as compared with those eaten by millions of children in less developed countries.

Age of Menarche and its Relation to Growth Spurt

The adolescent period will be considered here as embracing the span beginning with the appearance of secondary sexual characters and terminating with the cessation of skeletal growth. The metabolic changes correlate with physiological rather than chronological age (Johnston, 1957).

Since one of the outstanding characteristics of the adolescent is growth, a brief discussion of their normal variations in growth of adolescents seems appropriate. While the pattern of growth and development in all normal children is similar, there is considerable individual variations especially in the chronological age at which the adolescent spurt of growth occurs and in its magnitude (Weinbach, 1941., Tuxford, 1942., Jones, 1947., Reynold and Wines, 1948., Tanner, 1952., and Martin, 1953).

During the early school years from six to twelve in boys and girls, the gain in weights and heights are approximately of the same pattern ranging from five to six kilograms in weight, and 2.2 cm. in height (Mushan, 1947., Tanner, 1952., Gray, 1941., Chaudhuri et al., 1966). Within a year of the appearance of the first menstrual period or more frequently before it, the girls show a sharp spurt of growth in terms of both height and weight (Baldwin, 1921., Jones, 1947., Chaudhuri et al., 1963). As the age of menarche may vary approximately from 10 years to 17 years in normal girls according to Gould and Gould, (1932) Popenoe (1928), Engel and Shelesnyak, (1934) and Simmons and Greulich (1943) there is considerable variation in the age at which, the growth spurt occurs. As a general rule, the earlier the menarche, the greater the spurt of growth (ICMR, 1955., and Kelly and Redfield, 1941). Thus it is clear that memarche is a period where maximum growth spurt occurs. At this critical period, nutritional requirements of the adolescents should be met, if optimum growth is expected.

Engelmann (1902), Shuttleworth (1937) and Mayer (1940) reported that between the years 1933 and 1940, the mean age at menarche of American girls averaged 13.0 to 13.5 years. Simmons and Greulich reported the age of menarche to be 12.6 in 1943. Roderuck (1953) reported the mean age at menarche of Iowa girls to be 12.75 years. Hence, the average age at menarche in the United States does appear to have decreased gradually during the past 30 years approaching perhaps a minimal value. On the other hand, Madhavan (1965) reported the age at menarche of South Indian girls to be 14 years. This age has not been changed from the earlier reports on the age of menarche of Indian girls by Peters and Shrikande (1957).

Several workers have demonstrated that the rate of growth of adolescents has been adversely affected by protein limitation and increased by protein supplementation (Mitchell, 1962). Mitchell (1964) observed that some races may not have realised their full potential in stature, because of limitations of proteins for generations. Mitchell (1964) and Dreizen *et al.*, (1961) feel that a protein limitation of marginal nature may affect the growth of the cartilage cells in the bone matrix and thus retard the rate of formation of new bone. In countries where the quality and quantity of protein are inadequate, the stature of whole groups of people, may be affected (Dreizen and Stone, 1962). For example, in our country major sections of population who depend largely on plant proteins, with little if any of animal protein foods, tend to be short in stature (ICMR, 1961, 1966).

DIETARY CALORIES

Factors affecting the caloric requirements

Four variable factors which affect the caloric requirements of individuals were ~~determined~~ listed by FAO (1957).

They were

(a) Physical activity

(b) Body size and composition

(c) Age

and (d) Climatic environment

The degree of physical activity was the most important factor in determining the caloric requirements of the individual (Boger[t], 1960., Taylor *et al.*, 1956). A large share of the cost of physical activity was directly related to body weight (McHenry and Beaton, 1963., and Taylor *et al.*, 1956).

That the total energy requirements varied according to body size was the observations of Crampton and Lloyd (1959).

Bogert (1960) considered the energy expenditure as the sum of the three components:

a) resting energy expenditure (B.M.R.)

b) energy expenditure related to the ingestion of food.

and c) energy expenditure involved in physical activity.

Age influences the caloric requirements (Bogert, 1960). The effect of aging on energy requirements was operated in three ways through (a) the normal decline in physical activities (b) the fall in Basal Metabolic Rate (B.M.R.) and (c) changes in the efficiency with which muscular movements are carriet out. FAO (1957) pointed out another factor that human beings in a hot climate ate less food than those in a cold climate.

Caloric allowances for post adolescent women

The caloric intake recommended for adolescents can only be approximate (Heinz, 1959). Hasen (1959) had estimated caloric allowance of 50 calories in terms of kg. of body weight. FAO (1957) reported the caloric requirement of the post adolescent of 16 to 19 years to be 2400 k.calories per day. On the other hand according to the ICMR (1966) the energy requirements of the post adolescent girl was 2100

k. calories per day.

In the Indian recommendations of 1944 and the earlier American recommendations no allowance was made for differences in sex of adolescent children. The Committee on nutrition of the British Medical Association in the United Kingdom had recommended different scales for boys and girls from the age of 11 years on wards (British Medical Association, 1950). The British figures of 2600 calories for the post adolescent girls were based on records of food consumption as ascertained in various surveys. In U.S.A. the recommended allowances of 3200 calories was based on the admitted fact that adolescent ~~girls~~ boys were more active and engage in more energetic games than the latter. If this was true for U.S.A. and U.K. the question deserved closer examination in India where adolescent girls were in general much less active than their male counterparts. Patwardhan (1960) argued that the adolescent girls of the age 16 to 18 in India are much less active than their male counterparts and hence the recommended allowances for calories was only 2100 per day, while in U.S.A. and U.K. and FAO allowances for the same age group are higher. During the period-s of rapid growth, Macy (1942) found that the caloric equivalent of the actual weight gain was a very small fraction of the increased caloric intake by the adolescent and the reason for this was not clear.

That consideration of protein requirements is inseparable from total caloric intake was pointed out by Cathcart

(1928) and Powers (1925). The excellent review of Wait and Roberts (1933), Wang, Wang et al., (1936) of the literature on the adolescent requirement of protein and calories are available in the paper, support the view that the optimal intake of protein for the adolescent should constitute 12.6 per cent of an adequate caloric intake.

Banerjee et al. (1959) reported the caloric intakes of 12 adolescent students of Bikaner Medical College Rajasthan to be 1438 calories/day. Srivatsa and Puri (1932) reported that the caloric consumption of women students of the Lady Irwin College to be 2443/day.

Using the Bomb-calorimeter Davis and Scoular (1957) reported the daily energy value of the diets consumed by young college women in Scotland to be 2103 calories. Scoular (1943) reported the food intake of 106 college women living in the United States by calculation and by analysis of food and found that they consumed 2446 calories/day. Robinson and Scoular (1957) reported a daily consumption of 2042 calories by the residents of a women's college. Odland et al. (1955) reported the daily caloric intake of 418 Montana students to be 2050.

Thus the caloric consumption of adolescents appear to have wide variations. In general, the caloric intakes of the Indian adolescents are smaller than their counter parts in other countries. Such an observation correlates with the smaller statures of our adolescent girls as compared to the western standards.

Basal Metabolic rates

The resting energy expenditure is represented as a first approximation by the basal metabolism not taking into account the external temperature to which the individual is exposed (Davidson and Passmore, 1966). Adjustment to a suboptimal intake of calories and protein is regularly made by fall in basal metabolism (Johnston, 1938). This together with its implications was long since pointed out by Benedict et al., (1919). With a view to find normal standards of basal metabolism for men and women in South India data were collected on 78 medical college students in Madras, whose ages ranged between 18 to 25 years on an average. The basal metabolic rate of the students was 31.1 calories/sq.m/hour (Krishnan and Vareed, 1932). Niyogi et al., (1940) reported a study conducted on the basal metabolism of 52 women, between the ages 18 and 35 years. The BMR of women was 32.05 calories/sq.m/hour.

Mason and Benedict (1931) found 31.3 calories /sq.m/ hour for 21 years old women in Madras. The BMR of 10 college women as reported by Pittman et al., (1943) was 31.96 calories/hour/sq.meter of the body surface. Kleiber (1947) and Coons (1931) reported sharp increase in the BMR before the menarche with a decreases after it. Seider (1938) noted the BMR was higher in prepuberty than in post puberty for girls.

Banerjee (1962) reported that the BMR expressed ~~in~~ in terms of unit body surface area of the Indians was lower than the western standards. However, Patwardhan (1960) viewed BMR of Indians as only apparent and not real. The lower BMR of Indians workout to be the same as for the westerners if the body cell mass or lean body mass was taken as the biometric unit of expression.

Fecal loss of Calories

Data regarding the fecal loss of calories in human subjects consuming different diets are scanty. A knowledge of the extent of fecal loss of calories is helpful in working out the energy requirements of different groups of population (Ramanamurthy and Belavady, 1966). The practice at present is to provide an additional 10 per cent allowance of over the caloric requirements which is expected to cover all the physiological factors involved in digestion and absorption of food.

The availability of dietary calories depends on the efficiency of absorption of food. Studies carried out by McCance and Walshan (1948) and McCance and Glaser (1948) revealed that caloric losses ranged as much as 9.6 to 15 per cent of intake when the diet was based mainly on whole wheat bread.

Ramanamurthy and Belavady (1966) reported a study conducted on the facal loss of calories of Indian males whose age ranged between 30 to 40 years. The loss of calories in the fecal ranged from 3.9 to 8.7 per cent of the intake. The subjects on the high calories group lost more calories in the faces which amounted to 8.6 per cent of the intake, while those on the low caloric diet lost 7.7 per cent of calories.

In view of the fact that the fibre content of the Indian cereal diets is high, the fecal loss of calories is bound to be a factor which will influence the caloric allowances.

Energy expenditure pattern

The energy cost of muscular or physical activity is the body's second largest caloric expenditure next to basal energy cost. Under ordinary conditions about one fourth of the total energy expenditure is on physical activities. However in the case of a very active person this might equal or exceed that of the basal metabolism (Heaton and McHenry, 1964).

An individual's energy expenditure for a specific physical activity for a period of work involves three factors namely the energy cost of the activity, the time spent in the pursuit of the activity and the body size of the individual.

Many thousands of measurements of the caloric costs of various types of physical activity had been made and expressed as either k.cals/kg. of body weight per hour or per square meter of the body surface (Taylor and McLeod, 1949., Widdowson et al., 1954). Passmore and Durnin (1955) had compiled energy expenditure data from British and German surveys as well as from data that have appeared in the literature over the past 50 years. These extensive compilications include 38 tables of energy expenditure of individuals, subject to many many kinds of activities such as walking, climbing etc. Those expenditure were expressed in terms of k.calories per minute.

For calculating the daily energy expenditure pattern the time spent in actual performance of a specific activity should be measured as accurately as possible. In the preparation of energy expenditure chart, this factor is sometimes over estimated because of the actual time spent in the activity itself is not a continuous but rather intermittent (Konishi, 1965).

Body size is another important consideration in the determination of energy costs of physical activity. Linear relationship between energy expenditure and body weight had been reported (Hutson et al., 1965). Thus a larger person expends more energy than a smaller one in performing a given activity because a larger mass of body is involved. (Hutson et al., 1965).

__Energy cost of activities for Indian post adolescent women__

In the activities normally carried out by the Indian women college students Banerjee (1962) found large individual variations due to age, sex, height, weight and body surface area. They found the college students had a total caloric expenditure of 1503 k.calories. So they recommended a diet furnishing these calories for the above groups of students doing sedentary work. Patwardhan (1958) determined the energy cost of several activities of laboratory workers and textile mill labourers and listed his results under (a) energy cost of essential activities and (b) energy costs of light, moderate and heavy work.

Almost all the activities carried out by the college students fell in the very light group. As a conclusion of his studies Patwardhan (1958) proposed that the caloric expenditure of college girls were 1600 k.calories. The FAO/WHO expert committee (1962) suggested that in estimating energy requirements the effect of body size could be better used rather than body weight. No simple procedure had been derived for estimating caloric allowances. The stress conditions produced by the hot and humid environments was reported to influence to a great extent the weight of cell mass, cell solid or lean body mass and thus the oxygen consumption. It will therefore be seen that for the expression of BMR in a tropical country like India, it is advantageous to use either the weight of the body cell solids or cell mass as a reference standard, in preference to the surface area of the body. So for all practical purposes a simple unit of expression on cell solids or cell mass like the height-weight or skinfold measurements should be evolved (Patwardhan, 1958).

DIETARY PROTEIN

Factors affecting the Protein Requirements

The protein requirement of an individual is made up of two components, (a) a basal amount below which it is believed that normal health and growth cannot be achieved and (b) an additional amount to provide for the stresses including minor infections to which everyone is exposed (FAO, 1965). When estimates are being made of the protein allowances for population or groups, a further allowance must be made for individual variability.

The adequacy of protein in the diet is determined not only by the quantity of protein ingested but also by its quality which in turn depends on the essential amino acid composition (Patwardhan and Phansalkar, 1950).

The size of the individual is an important factor in determining the protein requirement (Peckos, 1953). The total amount of protein needed for tissue up keep is naturally dependent upon the amount of active tissue in the body and for this reason the protein requirement is reckoned per unit of body weight (Bogert, 1950). Regardless of sex, a person of small body weight would need less and one of larger than average weight would need more than the standard allowance. Hence the daily protein allowance is best calculated as (McHenry(1957) recommends for each individual according to his body weight.

Childhood is a factor that comes into play when extra-protein was needed for building new tissues in growth (FAO,1966). Rapidly growing young children might need two to four times as much protein/unit of body weight, as adults do, to provide for protein storage in new tissues (Bogert, 1960).

Under Arctic conditions the calorie requirements increases. On an ordinary diet, increased calorie intake is accompanied by an increase in the intake of protein (Mitchell and Bernard, 1954). Cold induces a stress situation and leads to increased nitrogen excretion (Krause,1966). To replace this loss, the requirement for dietary protein would be temporarily raised. The protein needs of heavy workers were much greater than those of sedantary workers (Peyton, 1957., McHenry and Beaton, 1963).

The effects of protein intake on resistance to infection and that of infection on nitrogen metabolism have been reviewed by Scrimshaw (1963). Johnston (1957) reported that girls who had developed the habit of eating meals relatively low in protein were much more likely to develop active tuberculosis around the age of puberty than were well nourished individuals who had been similarly exposed. In addition, in longitudinal balance studies he found that negative nitrogen balances during the treatment of their diseases were usually followed by an extension of the lung lesions. On the other hand, nitrogen retention,eventhough there was no increase in body weight, was associated with healing of the lesions and probably indicated previous depletion.

The inter-relationships between pathological states and protein requirements has been stressed by Mitchell and Bernard (1954) and Chaney (1954).

Factors such as anxiety and pain may markedly increase the nitrogen excretion of an individual (Scrimshaw, 1963). Anxiety about personal problems and physical pain such as headache have all been shown to have a reduced nitrogen balance despite adequate protein intake (FAO, 1965). Under these circumstances, nitrogen excretion has been observed to be increased by as much as one third for several days continuously (Ohlson, 1958). Physiological factors have been found to be responsible for the poor absorption of amino acids (FAO, 1965).

<u>Protein requirements of post adolescent woman</u>

The FAO Committee on protein requirements (1957) had prescribed as 0.8 gm./kilogram of body weight, that is at more than twice the level it recommended for adults, as the requirements of protein for girls in the post adolescent girls of the age group from 16 to 19 years.

In 1965 the FAO Expert Committee did not consider this very large difference in protein requirements between adolescents and adults to be justified, since the factorial approach takes account of the pre-pubertal increase in growth rate (FAO, 1965). The recommended dietary allowances in the United States (NRC, 1964) provide 1.6 gm/kilogram of body weight. The Canadian Council on Nutrition (1964) recommended for all adolescents in the age group of 15 to 21 years 1.6 gm/kg of body weight. The Nutrition Committee of the National Health and Medical Research Council of Australia (1954) reported the minimum requirement of protein to be 75 grams. The ICMR (1965) recommends a dietary allowance of 2.0 gms/kilogram of body weight, for the post adolescent age group, which is rather generous when compared to the allowances set up in other countries.

Calorie protein ratio

A reduction in nitrogen retention in the presence of markedly restricted calorie intake has been reported in man and animals (Sibald et al., 1956., Bosshardt et al., 1948., Calloway and Spector, 1955., Forbes and Yohe, 1955., Schwimmer and McGavak, 1948).

Johnston (1961) reported that when normal adolescent children were fed 15 per cent of their calories as protein, positive nitrogen balances were obtained consistently. The NRC of U.S.A. (1964) recommends the provision of 10 per cent of the calories through proteins for girls of 13 to 19 years age. Johnston (1961) found that adolescents fed 20 per cent of their calories as protein usually complained of nausea, abdominal discomfort and sometimes vomiting and excreted excessive amounts of nitrogen in the urine thereby proving that 15 per cent protein calories would be the optimal level.

The British Medical Association Committee on Nutrition (1950) recommended that 14 per cent of the calories be taken in the form of protein by adolescents. Reporting on the eating habits of British adolescent girls from 16 to 19 years Robertson (1968) and Widdowson (1939) found that they consumed 12.5 per cent of calories as protein.

The ICMR recommended allowances (Aykroyd et al., 1966) for protein is not expressed in terms of percentage of calorie allowances. This aspect of the protein calorie relationships for the Indian adolescent group needs much more critical appraisal.

Nitrogen retention studies

The Nitrogen retention of 18 college women in U.S.A. between the ages 19 and 32 years was studied by Wharton et al. (1953). Three types of diets were given to them - the diet I consisted of 1 gm. of protein / kgm of body weight, the diet II contained 130 to 170 mg. of nitrogen and the diet III contained 1.12 gms. of protein / kgm of body weight. It was proved that, the retention of nitrogen in the above studies was 7.75 mg/kgm 14.18 mg/kg and 31.95 mg/kg of body weight respectively. The nitrogen metabolism of

14 college women was reported by Leverton and Gram (1949). When no animal protein was included in the diet, the average daily excretion of nitrogen was 9.02 g. as compared with 8.33 g. when only the vegetable protein was consumed. Johnston and McMillan (1952) reported that the mean nitrogen retention of six young women on an intake of 70 gm. of protein/day ~~and~~ to be 0.84 gms/day. Leverton and Rhodes (1949) studied the nitrogen retention of 17 college women. Their protein intake ranged from 60 to 105 gm/day, and the daily nitrogen retention was between 0.31 gm. and 2.[illegible]4 gm.

Many studies had been conducted on the nitrogen balance of post-adolescent college students in Western countries. But not many such reports are available on the metabolic patterns of women college students in India.

<u>Obligatory nitrogen loss in feces</u>

An obligatory loss of nitrogen in feces (endogenous or metabolic fecal nitrogen excretion) occus in subjects, receiving a protein free diet (Mitchell and Best, 1954 and FAO, 1965). This was largely derived from digestible juices and secretions, elaborated in the wall of the alimentary tract. When protein was added to the diet, some escaped absorption and increased the fecal nitrogen output (White *et al.*, 1959., and Bell *et al.*, 1961). In the adult, the excretion on a protein free diet was about 1.0 g. N/day, i.e., 10.20 mg.N/kg. body weight (~~Martin and Robinson, 1922.~~, FAO, 1965).

when a protein free diet was continued for a long time, the loss in the feces unlike that in the urine, apparantly did not progressively decrease (FAO, 1965).

Obligatory nitrogen loss in the urine

Of the three routes of obligatory loss of nitrogen, urine, feces and skin, the urine is quantitatively the most important (FAO, 1965). The body is capable of adjusting its urinary nitrogen output to balance a wide range of intakes (Albanese, 1963). However, below a certain critical level of intake, this adjustment does not take place and the body suffers, a continuing loss of nitrogen (Patwardhan et al., 1949., Sherman, 1952). The output of nitrogen does not in fact attain a constant level (Phansalkar and Patwardhan, 1954., Patwardhan, 1930) but falls continuously as the body becomes depleted of protein (FAO, 1965).

On the other hand Pasricha (1965) did nitrogen balance in adult Indian women and found that the urinary nitrogen excretion generally decreased rapidly after the low protein diet was instituted and stabilized in three or four days.

Errors in balance studies

Since nearly all experimental data on protein and amino acid requirements of man as well as information on the nutritive value of dietary protein, have been obtained by nitrogen balance techniques, it is particularly pertinent to describe certain limitations of this method.

Since the same food the subject eats can not be analysed, this must be done on a duplicate sample. As emphasised by Wallace et al., (1948) it is likely that the intake would be over estimated since small losses on utensils and small amounts of uneaten portions of food are likely to be included in the analysed sample. The excretion would tend to be underestimated since there are numerous opportunities for incomplete collection. These errors are not likely to be random. Even a 2 per cent over or under estimation of the intake or excretion of nitrogen might change the retention value by 178 per cent. Fur ther more the determination of a small value of nitrogen retention, by the difference between two large values of intake and excretion is inherently inaccurate (Snedecor, 1956). The error is thus expected to be larger when the balance study is done with a diet high in protein (Beaton and McHenry, 1964).

In the past, nitrogen losses included only the urine and fecal excretions although nitrogen losses were observed in sweat, hair or nail. Eventhough information on the dermal nitrogen losses has been published prior to 1950 (Mitchell and Hamilton, 1949), the Food and Agriculture Organisation of the United Nations publication (1957) did not mention the possibility of increased protein allowances under conditions that produce profuse sweating. These nitrogen losses ranging even as high as 130 mg/100 ml of sweat (Mitchell and Edman, 1962) might be of consequence in evaluating protein requirements especially of individuals consuming low protein intakes in hot humid or hot dry areas.

A third factor which might influence the results and which might make interpretation difficult is that information is seldom available on body composition. Balance studies are usually carried out for rather short periods and shifts in body composition or the distribution of the nitrogen in various tissues may possibly occur. Thus short-term experiments under experimental conditions might be only gross indications of long term effect.

Creatinine Excretion

The biochemical measures of protein nutrition may refer to either the relative adequacy of protein intake or the extent of protein depletion (Karambelkar et al., 1962). Arroyave (1960., 1963) pointed out that the maintenance of skeletal musculature is compatible only with adequate protein intake. Racitegu ~~Mentigy~~ (1962) points out that 78 per cent of the creatinine is in the smeletal muscle, and since it has been demonstrated that muscle creatinine is the precursor of urinary creatinine, the excreation of creatinine could serve as an index of muscularè mass. Scrimashaw et al., (1966) reported that, with a constant diet, urinary creatinine excretion reflects the change in lean body mass. However changes in urninary creatinine excretion following stress have been reported by Schottstadt et al., (1956).

Since urinary excretion of creatinine is determined principally by lean body mass, the number of milligrams of creatinine excreated in 24 hours, per kilogram of body weight, that is, the "creatinine co-efficient" has been used as an index of relative amount of muscle mass of the individual. Folin (1905) found that as the protein intake was increased, the percentage of urea nitrogen becomes greater percentage in the total nitrogen creatinine ratio in urine and may prove to be a useful index of protein intake (Kerambelkar *et al.*, 1952).

III EXPERIMENTAL PROCEDURE

This study was undertaken to assess the metabolic patterns with reference to protein and calories of six selected post adolescent college students who were consuming a vegetarian diet in the hostel. The intake of calories and proteins were assessed by calculation and by direct analysis of the samples. It was also aimed to compare the accuracy of computing these intakes with the aid of the food composition tables (Aykroyd, 1966) by comparing with analysed values. The daily fecal loss of calories, and urinary and fecal nitrogen losses were determined. Urinary creatinine excretions were also determined. Heights and weights of these post-adolescent subjects were recorded for over a period of eight months in order to assess the trends in their growth during the experimental period. Fluctuations in body weights alone would be used as an index of the caloric balance between the intake and expenditure. The Basal Metabolic Rate of these subjects were determined. And time record of the physical activities of the subjects were analysed to correlate with their energy expenditure.

Selection of subjects

Seventeen to nineteen year old college students studying in Sri Avinashilingam Home Science College and residing in the hostel situated in the college campus were selected for the study, after acquiring their consent and cooperation. They were clinically examined for normal state of health. They were free from intestinal parasites and had no known food allergies.

Determination of food intake

As the aim of the study was to find out the metabolic patterns of calories and proteins of post adolescent girls in their normal diets, no restrictions or modifications in the hostel diet were introduced. Throughout the experimental period of eight months the menu given in Appendix I was followed. Thus 30 subjects were selected for the study of food intake including the six subjects whose metabolic patterns were determined later on.

The cooked foods actually consumed by the subjects were weighed in order to determine the food and nutrient intake of the individuals. This method was selected because weighment is the most accurate and precise one than any other methods like the recall, food list, questionnaire and interview methods and is independent of memory (Chalmers, 1952, FAO, 1953). At every meal for three consecutive days before the subjects came to the table each item of the cooked foods were weighed to a nearest gram on a Chaus scales placed in a separate set of dishes. The subjects were requested to eat adlibitum out of the weighed out foods placed on the table. The left over foods in the utensils and the plate wastes were weighed for each food item. The weights of the cooked food actually consumed by the subjects was thus calculated from the differences in the weights of the foods in the table before and after meals. Thus the daily consumption of the cooked foods by the subjects were recorded. The food intake determinations as per the above procedure were repeated after a period of three months to find out whether there were any changes during the course of the experiment on the caloric and protein intakes by the subjects.

In order to compare the raw food equivalents of the cooked foods the quantities of the raw ingredients that were used for 100 g. of the cooked foods were determined by weighment and calculated. From the data, using the food consumption tables of Aykroyd et al., (1966) the caloric and protein consumption of the subjects were computed.

Analysis of the food sample for calories and protein

One tenth of each of the items of the cooked foods actually consumed by the subjects were weighed and collected as a representative sample for analysis in a jar. This sample was homogenised in 1 N.Hydrochloric acid and made upto 250 ml. and stored in a refrigerator. The same night or the next day morning triplicate samples of 5 ml. of the homogenised food were taken for protein estimation by the Macro Kjeldahl method (A.O.A.C.1960). Hundred ml. of the homogenised food was dried to constant weight at 80°C for 24 hours and one gram of this sample was used for caloric estimation in a Bomb calorimeter (Wilson et al., 1960)

Collection of urine and fecal samples and the analysis made on them.

The 24 hours voidings of urine and faces were collected (6 a.m. to 6 a.m.) for three consecutive days per subject. Ten ml of toluene was added as a preservative in the urine sample and stored in a refrigerator. Nitrogen and creatinine estimations were done either on the same evening or the next day morning within 10 hours after the collection time. Triplicates of five ml. of the urine samples and two grams of the fecal samples were used for nitrogen estimation (A.O.A.C., 1960). The experiment was done on the 24 hours urine and fecal samples for three consecutive days for each subject.

Five grams of the feces were weighed and dried to constant weight at 80° C, and powdered and about one gram of the dried feces was used for determining its caloric content in a bomb calorimeter. (Wilson et al.,1960).

One ml of the 24 hour urine sample was used for creatinine estimation by the Jafee method (Kleiner and Dotti, 1962). Creatinine estimation was done invariably within two hours after the collections.

Assessment of basal energy requirements

The basal metabolic rate of the subjects were determined using the Benedict Roth apparatus (Wilson et al., 1960). The subjects were requested to keep a time record of all their daily activities for seven consecutive days by the factorial method using the Tables given by Banerjee (1962).

Recording of heights and weights

The heights and weights of the subjects were recorded at every fortnight for a period of eight months in order to assess growth if it had occured, during this period. Fluctuations in body weight was, used as an index of caloric balance. Heights and weights of the subjects were taken as follows.

The subjects were asked to stand erect, barefoot with heals and scapulae in contact with wall. The head was so held that the line of sight was horizontal. By keeping a scale in contact with the scalp heights were recorded to the nearest centimeter.

The subjects stood barefooted on the plateform of a weighing machine. The weight was recorded correct to 0.1 kg. No corrections were made for the weights of the clothing worn by them.

Statistical analysis

The difference between two indices were tested by using 't' test:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_{\bar{x}_1 - \bar{x}_2}}$$

Among the resultant 't' values with N - 1 degrees of freedom, using the 't' tables only those with a probability of 0.05 to 0.01 or less were considered to be significant.

The regression equations were calculated between the nitrogen retention and nitrogen intake. When both were expressed on the basis of body weight, surface area, and basal calories. In each case the correlation coefficient was also calculated. The details of these calculations are given in Appendix XII.

IV RESULTS AND DISCUSSION

The present study was undertaken to assess the metabolic patterns with reference to calories and protein of six post adolescent students who were residing in a hostel. No attempt was made to change the hostel diet. The dietary intake of calories and protein were assessed by calculation from weight of the cooked foods actually consumed by the subjects and by direct analysis of the samples. It was also aimed to compare the accuracy of computing these intakes with the aid of the food composition tables of Aykroyd et al. (1966) by comparing with the analysed values. Heights and weights of these post adolescent subjects were recorded on every fortnight for over a period of eight months, in order to assess their growth if any had occured during the above period. On the other hand fluctuations in body weights alone would be used as an index of the caloric balance. To find out any fluctuations in the caloric and protein intake of the subjects the weighment of food intake and analysis were repeated for the six subjects after a three month period.

Daily fecal loss of calories, urinary and fecal nitrogen losses, creatinine excretion, and basal metabolic rate of these subjects were determined for three consecutive days. A time record of all the daily activities of these students for seven consecutive days were maintained ~~kept~~ to calculate the caloric expenditure of the subjects by the factorial method. The number of subjects for whom the above data were collected are presented in Table I.

TABLE I

PARTICULARS ABOUT THE TRIPLICATE MEASUREMENTS OF THE POST ADOLESCENT WOMEN STUDENTS AND THEIR NUMBERS

S.No.	Measurements	Number of subjects
1.	Fortnightly height and weight records for eight months ..	30
2.	Calorie and protein intake (by weighment of cooked food and calculation and by analysis) ..	30
3.	Fecal calories ..	6
4.	Urinary nitrogen ..	6
5.	Fecal nitrogen ..	6
6.	Urinary creatinine for 24 hours ..	6
7.	Basal metabolic rate ..	6
8.	Time record of the daily activities	6

Heights and weights

The age, heights and weights of the subjects are reported in Table II along with the age of menarche. The individual values are given in Appendix II.

TABLE II

AGE, H[EIGHT], WEIGHT AND AGE OF MENARCHE OF THE POST ADOLESCENT WOMEN STUDENTS STUDIED

No. of subjects	Age at the beginning of the study	Age of menarche	Number of years since menarche	Height cm	Weight in Kg. Initial 1	Means of the three fortnightly measurements 2	3	4	Final 5	't' value Initial wt Vs Final wt
30	18.6	13.7	5.1	152.3 ± 0.87	41.4 ± 0.19	41.7	42.0	40.3	41.5 ± 0.75	0.5904
6	18.2	13.6	4.8	153.6 ± 3.58	40.0 ± 1.17	40.3	40.2	40.1	49.4 ± 1.41	0.3568

The subjects were 17 to 19 years of age and hence belonged to the post adolescent age group as per the definition of Wang *et al.* (1936) and Johnston (1958).

The heights of the 30 subjects which were recorded every fortnight showed absolutely no changes except in two cases where the subjects had increased by 0.5 cms. Hence the means of the initial heights alone are reported in Table III. The adolescent growth spurt occurs before and around menarche which was around an average of 14 years for our subjects (Table II) since it was three or four years since their menarche they might have already stopped growing in terms of increases in heights. The periodical height records which did not show any increase correlated with the above reasoning.

The mean heights and weights of our subjects were 152.8 ± 0.33 cms. and 41.4 ± 0.19 kg. Clarke (1968) reported mean heights and weights on 183 medical college students in Ludhiana and Vellore to be 155.7 cms. and 49.0 kg. Bhalekar and Phadnis (1936) reported the mean heights and weights of 18 year old women college students to be 152.4 cm and 43.6 kg which is very close to the mean heights of our subjects. Very few studies had been reported in India for heights and weights of the post adolescent age group. Banerjee (1961., 1962) reported the heights and weights of 19 to 20 year old girls of Rajasthan to be 156.3 cm. and 43.0 kg. Table III give the mean heights and weights of the post adolescent students of the present study compared with other published reports in India.

TABLE III

MEAN AGE, HEIGHT AND WEIGHT OF INDIAN WOMEN STUDENTS AS PER REPORTS IN THE LITERATURE COMPARED WITH THE PRESENT STUDY

Number of Students	Reference	Place of measurement.	Age (yrs)	Height (cm)	Weight (kg)
30	This Report	Coimbatore	18.6	152.8	41.4
183	Clarke (1966)	Ludhiana and Vellore	20.8	155.7	49.0
27	Satoskar *et al* (1961)	Bombay	20.00	157.3	47.3
18	Banerjee (1961, 1962)	Rajasthan	19.9	156.6	43.0
9	Banerjee and Sen (1958)	Calcutta	20.2	156.2	49.5

Compared with these data (Table III) our subjects seemed to be equally tall but weighed less.

The discussion elsewhere on the marginal caloric intake and expenditure of the subjects also correlated with the above finding of our study. The body weights of the subjects were recorded every fortnight and their means did not differ significantly.

A comparison at the beginning and at the end of the study did not show any significant change in the body weights of the subjects. Such a maintenance of body weights with insignificant fluctuations by the post adolescent girls whose heights were constant may be considered as a reflection of the caloric balance between intake and expenditure. No attempt was made to explore their body composition. The fact that all of them were in high positive nitrogen balance while weight changes did not occur indicated that they may be accumulating lean body mass at the expense of adipose tissue. Hence different methods should be used to evaluate caloric requirements when marked changes in body composition were observed (Hutson, et al., 1965).

Food intake

As could be seen from Table IV the calculated mean consumption of food groups by thirty of the post adolescent subjects (Appendix IV) were below the recommended allowances for balanced diet of ICMR (Aykroyd et al., 1966).

TABLE IV

MEAN CONSUMPTION OF FOOD GROUPS BY THE POST ADOLESCENT WOMEN STUDENTS COMPARED WITH THE RECOMMENDED ALLOWANCES (AYKROYD *et al.*, 1966) FOR A BALANCED DIET

S.No.	Food stuffs	Mean of actual intake for 30 students g.	Mean for 6 students g.	Recommended Allowance (ICMR, 1963) g.
1.	Cereals	336	323	400
2.	Pulses	53	51	85
3.	Leafy vegetables	9	10	114
4.	Roots and Tubers	42	47	35
5.	Other vegetables	39	31	85
6.	Fruits	87	75	85
7.	Milk and milk products.	370	252	284
8.	Sugar	24	24	57
9.	Oil	18	22	57

The mean quantity of cereals consumed by the subjects was 336 g. which was less than the recommended allowances of 400 g. This was reflected in the lower caloric and protein intakes of the subjects (Table V) and is discussed elsewhere. The cereals mainly consumed were rice and wheat. Ragi was consumed once a week as ragi malt or puttu.

TABLE V

MEAN SUPPLY OF CALORIES AND PROTEIN FROM THE FOOD GROUPS CONSUMED BY THE POST ADOLESCENT WOMEN STUDENTS

Food groups	Quantity g	K.Calories	Protein g
Cereals	336	1166	30.6
Pulses	53	187	11.8
Leafy vegetables	9	3	0.3
Roots and Tubers	42	30	0.5
Other vegetables	39	9	0.5
Fruits	87	100	0.9
Milk and milk products	267	181	8.5
Sugar	24	96	-
Oil	18	162	-
Total		1934	53.2

Fifty three g. ofp pulses were consumed against a recommended allowance of 85 g. The daily consumption of pulses by the students were smaller than what has been reported for most other areas in India as found in the Dietary Atlas of India (ICMR, 1984). Among the pulses consumed, 53 per cent was red gram and 35 and 12 per cents were bengal gram and green gram. The protein content of the diet was mainly constituted by the cereals and pulses. Considerable quantity of protein was contributed from milk, which met the recommended allowances of the balanced diet of ICMR (1981). It may be pertinent here to point out that the milk intake data was recorded for the actual individual consumption per day taking care to detect the quantity of water added in the form of coffee, tea etc. The higher quantities of milk consumption reported here was unusual.for a hostel diet in India. Nageswara Rao (1965) surveyed 332 diet schedules in the 194 educational institutions in South India and found 70 per cent of the total number of diets did not provide even 285 g. of milk.

Yellow and green vegetables were eaten in small quantities. But carrots and tomatoes were used in salads. Leafy vegetables, roots and tubers were also consumed in very small quantities. The consumption of fruits was nearly fulfilling the recommended allowances, which again was unusual for a hostel diet. Nageswara Rao (1965) reported that more than half the number of hostel diet schedules did not contain fruits. The fuits mainly consumed by the subjects were bananas and only 25 per cent were of the citrus variety. Hence recommended allowances of vitamin A and C through fruits may not be fully met in the hostel diet consumed by the subjects.

TABLE VI

CALCULATED AND ANALYSED CALORIC AND PROTEIN INTAKES OF THE POST ADOLESCENT STUDENTS STUDIED

S.No.	K.Calories		Protein g.	
	Calculated	Analysed	Calculated	Analysed
1.	2284	2184	54.2	52.6
2.	2162	2070	56.0	55.7
3.	1583	1416	39.7	36.7
4.	1970	1879	43.2	48.9
5.	1751	1673	51.6	50.9
6.	1841	1693	46.4	50.8
7.	1837	1377	48.5	50.6
8.	1609	1565	43.8	42.7
9.	2216	2048	54.4	55.3
10.	1904	1800	45.9	47.9
11.	1760	1562	51.2	44.3
12.	2214	2136	54.2	54.3
13.	1906	1837	50.7	52.9
14.	1852	1753	44.0	44.5
15.	1899	1788	49.1	44.7
16.	1785	1707	47.7	45.1
17.	1957	1746	52.3	50.1
18.	1859	1753	52.1	53.2
19.	1685	1641	45.0	44.0
20.	2270	1975	49.1	49.8
21.	1801	1757	48.5	47.6
22.	1827	1773	45.3	43.6
23.	1709	1639	44.0	44.3
24.	1763	1706	48.0	47.5
25.	1681	1648	42.4	43.3
26.	1735	1744	44.5	43.2
27.	1786	1848	44.4	41.7
28.	1983	2000	43.2	43.8
29.	1793	1764	55.9	57.3
30.	1959	1811	46.2	44.6
Mean	1872± 23	1787± 31	48.3± 0.79	47.6± 1.22

Caloric intake

The mean calculated and analysed values of the caloric intake by the subjects are presented in Table XI. The mean analysed value of caloric intake by the post adolescent subjects was 1787± 31 K.calories (Table VI). These values are smaller than the 2100 K.Calories which is the recommended allowance of the ICMR (Aykroyd et al., 1966) for the 16 to 18 year old girls. Cereals supplied the bulk of the calories.

The caloric allowances for Indian girls of the age group 16 to 21 years was lowered in 1957 revision, since the activities of the adolescent girls in India are much lower than their male counterparts. The physical activities of our present subjects were still lower as shown by the activity records of the students for seven consecutive days (Appendix VI). None of the six students participated in strenuous games during the period of study. The pattern of the caloric expenditure of the subjects calculated by the factorial method gave a total expenditure of 1987 K.Calories per day (Table XIV).

Banerjee (1962) reported that the energy expenditure of college students in Calcutta was only 1503 K.calories per day. Banerjee et al., (1963) reported the energy consumption of post adolescent women students of Rajasthan as 1438 K.calories.

The western standards gave an average of 2000 to 2400 K.calories per day for 16 to 18 year old post adolescent girls (Young and Pitcher, 1950., Eppright et al., 1954., Holt and Fays, 1921). Thus there seems to be a wide variation in the caloric intake of post adolescent girls in western countries and India. The implications of such a marginal intake on the nutritional status of the college students needs to be studied critically.

Adolescent age group (16 to 19 years) has been considered as a separate age group in the assignment of energy allowances. The caloric requirement of adolescents are 2400 for girls (FAO, 1957). As in the case of adult population, tables of adjustments for body wei-ght had been developed by FAO (1966) for calculating the daily caloric requirements. Thus for a body weight of 40 kg. the caloric requirements of girls (16 to 20 years) is 1896 calories which seems to be nearer to the caloric intake of the subjects in the present study.

The caloric intake of the students in the present study expressed as per unit body weight was 43 k.cal/kg. of body weight FAO (1959) recommended an allowance of 46.7 cal/kg. thus showing that the caloric intakes of the subjects in the present study were lower than that of FAO (1959), even when expressed in terms of unit body weight.

Protein intake

The protein intake of the post adolescent students was 46.9 ± 3.05 g. (Table IV) or 1.3 Kg/kg body weight, which was devided mainly from cereals, milk and pulses.

Thus the amino acid pattern would have been met the requirement of the subjects since the proteins were from a wide variety on sources (Patwardhan, 1960).

The protein intake recommended for this age group by the ICMR is (2.0 g/kg body weight) 83 grams for a girl of body weight 41.5 kg. Thus the subjects were meeting only around 51 per cent of the recommended allowances of the ICMR.

But the FAO (1957) "safe practical allowances" for the post adolescent girls of 16 to 19 years old is 41 g. for a dietary protein score of 81 and 58 g. for a protein score of 52. Thus the protein intake by the subjects of the present study seemed to meet this requirements as per "safe practical allowances" of FAO (1957).

The mean daily protein intake obtained from the dietary surveys carried out in India were 43 g. for the post adolescent women (ICMR, 1964). Scoular (1946) reported the protein intake of 106 college women in United States and found that they consumed 94 g. of protein per day. On the other hand Banerjee et al., (1963) reported the daily consumption of protein of 6 adolescent young college women in Rajasthan to be 43 g. Thus the protein intake of the subject of this study was similar to the values reported in India but much lower than those of western reports.

Individual and periodical variations in calories and protein intakes among the subjects.

Table VII gives the caloric and protein intake of the six students at the beginning of the study and after a period of three months. The individual data are given in Appendices IV and V. This data was collected in order to find out whether there are any periodical variations in caloric and protein intake by the subjects.

TABLE VII

MEAN CALORIC INTAKE OF SIX POST ADOLESCENT STUDENTS AT THE BEGINNING OF THE STUDY AND AFTER A PERIOD OF THREE MONTHS

	At the beginning				After three months			
	I day	II day	III day	Mean	I day	II day	III day	Mean
K.calories	1963	1905	1928	1932 ± 97.7	1737	1854	1690	1759 ± 270.4
Protein (g)	49.9	50.4	47.8	49.3 ± 2.40	42.1	47.7	43.4	44.4 ± 1.87

Calculated daily caloric intake ranged from a value as low as 1425 to 2580 K.calories and protein intakes ranged from 42.1g. to 50.4g. there by showing that there were wide individual variations. The mean daily caloric intakes had particularly high standard errors, while the protein intakes had a comparatively smaller standard error. No statistical analysis on daily variations of intakes of calories or proteins could be done for individual subjects since data on food intake was collected only for three consecutive days.

In order to check whether there were any periodical fluctuations in caloric and protein intake by the groups of post adolescent girls, the dietary intake was studied at the beginning and repeated for the same six girls after a period of three months. The mean values for calories and proteins were 1936 ± 98 and 1757 ± 270 Kilocalories and 49.3 ± 2.4 g. and 44.4 ± 1.87g respectively. The 't' values between these two sets of means were not significant, because of the wide individual variations leading to large standard errors for the means.

Thus eventhough the caloric and protein intakes were not significantly different during the two periods, the mean values of caloric and protein intakes had a decreasing trend after a period of 3 months.

Calculated and analysed values for the caloric and protein content of the foods consumed by the subject.

The cooked foods actually consumed by the subjects were weighed in order to determine the caloric intake of the individuals. By weighments the quantities of the raw ingredients that went into 100 g. of cooked foods were calculated. From this data using the food composition Tables of Aykroyd *et al.* (1963) the calorie and protein intake were calculated and the mean values are reported in Table VIII

TABLE VII

MEAN CALORIC AND PROTEIN INTAKE OF THE POST ADOLESCENT WOMEN STUDENTS

	K. Calories				Protein (g)			
Number of subjects	By Calculations	By Analysis	Difference	't' Calculated vs Analysed	By Calculations	By Analysis	Difference	't' Calculated vs Analysed
30	1872 ± 23	1787 ± 31	85	2.196*	48.3±0.79	47.6±1.22	0.7	0.340
6	1719 ± 20	1960 ± 26	29	0.219	49.9±3.44	46.9±3.05	3.0	0.463

* Significant at five per cent level

Cooked food samples were also analysed in a bomb calorimeter for calories. Nitrogen content was determined by macro Kjeldahl method. The individual data are given in Appendix VI and VII.

The mean of the computed values of daily caloric intake was 1872 ± 23 K.calories and the analysed mean value was 1787 ± 31. Thus the computed values of the caloric intake had a positive significant error of nearly 85 K. calories.

It appears that if the weight of cooked foods actually consumed by the individuals were determined calculated caloric values are very near to that of analysed values obtained by using a bomb calorimeter.

The means of the calculated and analysed protein intake values were 48.3 ± 0.79 g. an 47.6 ± 1.28 g. which were not significantly different from each other. Although accuracy in metabolic balance studies can be achieved only by laboratory analysis of the diet, published tables (Aykroyd et al., 1966) offer a close estimate of dietary proteins and caloric values than reported before as per the results of our study.

Protein calories of the six most adolescent women students

The ratio of calories to protein is one of the most important problems. If the caloric needs are not met by the diets, the efficiency of protein utilization is reduced.

Hence the protein intake is expressed as percentage of calorie intake in this section. The calories and protein values presented here are the means of the triplicate analysis of the cooked food sample actually consumed by the subjects. The mean daily intake of calories, protein and percentage of protein calories of the six post adolescent women are presented in Table ~~VIII~~ IX.

TABLE ~~VIII~~ IX.

MEAN DAILY ANALYSED VALUES FOR CALORIES, PROTEIN AND PERCENTAGE OF PROTEIN CALORIES OF THE POST ADOLESCENT WOMEN STUDENTS

S.No.	Daily intake of K.calories	Daily intake of protein g.	Percentage of protein calories
1.	1850	56.0	12.1
2.	1754	52.5	11.9
3.	1734	36.6	8.8
4.	1777	43.0	9.6
5.	1489	49.6	13.3
6.	1537	44.0	11.4
Mean	1690 ± 59.9	45.9±3.05	11.1 ± 0.66

The mean percentage of protein calories of the post adolescent women students of the present study was 11.1 ± 0.66.

TABLE ~~VIII~~ X̄.

COMPARISON OF THE MEAN INTAKE OF CALORIES AND THE PERCENTAGE OF PROTEIN CALORIES OF THE POST ADOLESCENT WOMEN STUDENTS

Reference	Age 16 to 18 years	
	Total Dietary intake K.calories	Percentage of protein calories
National Research Council (1964)	2400	12.5
Indian Council of Medical Research (1968)	2100	8.6 Computed from total protein allowance
Canada (1954)	2385	8.8
Young and Pitcher (Idaho) (1950)	1976	13.0
FAO (1965)	1910	11.0
Eppright, Sidwell and Swanson (1954)	2552	11.7
Holt and Fales (1921)	3057	14.3
As per the present study	1690 ± 59.9	11.1 ± 0.66

Table ~~VIII~~ X̄. gives the comparison of the percentage of protein calories supplied in the present study with other available reports.

Johnston (1961) reported that when normal adolescents were fed 15 per cent of their calories as protein consistently positive nitrogen balances were obtained. The United States Recommended allowances provide about 10 per cent for boys and girls of 13 to 19 years of age. Johnston (1961) found that adolescents fed 20 per cent of their calories as protein usually complained of nausea, abdominal discomfort and sometimes vomiting and excreted excessive amounts of nitrogen in the urine. The British Medical Association Committee on Nutrition (1950) recommended for all adolescents that 14 per cent of the calories be taken in the form of protein. Widdowson's report (1957) cited by Beaton and McHenry (1966) on the eating habits of some 400 British adolescent children in 1935-1939 showed that they usually ate between 11.5 and 11.9 per cent of their calories as protein except for the girls from 16 to 19 years whose average was 12.5 per cent. Thus the present data for the protein calories of 11.1 per cent seems to be similar to the observation of Widdowson (1939) where as the other western standards report a ratio of 15 per cent. The ICMR (Aykroyd et al., 1966) did not recommend any value for this important protein calorie ratio.

<u>Fecal loss of calories</u>

The mean daily fecal loss of calories are presented in the Table XI.

TABLE XX.

THE DAILY FECAL LOSS OF CALORIES BY THE SIX POST ADOLESCENT WOMAN STUDENTS

S.No.	Daily intake calories	Fecal loss of calories	Fecal loss as percentage of intake
1.	1850	242	13.0
2.	1754	138	7.8
3.	1734	175	10.1
4.	1777	159	8.3
5.	1438	101	9.1
6.	1537	110	7.4
Mean	1690 ± 59.9	154.1 ± 20.4	9.3 ± 1.18

The fecal loss of calories varied from 13.0 to 7.4 per cent of the caloric intake. The daily diet contained a crude fibre continent of 5 g. Studies carried out by Mccance and Walsham (1948) revealed that caloric losses ranged from 9.6 to 15 per cent of intake derived from whole meal bread or oat meal. Ramanamurthy and Malavady (1966) reported a fecal loss of 3.9 to 9.2 per cent of the intake in Indian adult males. No attempt was made in the present study to correlate the dietary fat intake and fecal fat losses. The subjects of the present study did not suffer from any gross defect in absorption that might have interested with the results. It would appear from our results an allowance of 8 to 10 per cent had to be made in proposing the calorie requirement of population groups for loss occuring in feces.

<u>Nitrogen Balance</u>

Nitrogen balance as well as values for creatinine excretion for the six post adolescent women students of age 17 to 20 years are given in Table XII. All the subjects were in positive balance with an intake ranging from 6.21 g. to 8.82 g. of nitrogen. They were accumulating nearly 1.06 g. to 3.56 g of nitrogen daily in their body with a mean value of 2.36 ± 0.78.

TABLE XII.

NITROGEN BALANCE DATA FOR THE SIX POST ADOLESCENT WOMEN STUDENTS

S.No.	Nitrogen intake g.	Daily urinary excretion of g. nitrogen.	Daily faecal excretion g.	Balance g.	24 hour creatinine excretion g.	Body weight kg.	Creatinine co efficient
1.	8.82	5.36	1.09	+2.37	0.778	38.0	20.4
2.	8.45	5.53	1.21	+2.71	0.846	41.5	20.4
3.	6.85	2.63	2.00	+2.20	0.716	36.0	19.9
4.	7.67	3.00	1.11	+3.56	1.048	43.0	24.4
5.	7.06	2.73	2.08	+2.24	0.754	37.5	20.1
6.	6.21	3.93	1.22	+1.06	0.908	40.3	22.5
Mean	7.50 ± 0.41	3.86 ± 0.24	1.41 ± 0.18	2.36 ± 0.78	0.84 ± 0.17	39.41 ± 1.415	21.8 ± 2.12

Wang *et al.*, (1933) determined nitrogen balance on eight normal girls and found that they retained 1.4 g. of nitrogen per day during the post menarcheal period, when their intakes of protein constituted 15 per cent of the total calories. Phansalkar and Patwardhan (1930) reported that at a minimum protein intake of 40 to 45 g from mixed vegetable source resulted in nitrogen equillibrium of an Indian male. They observed than an intake of 3.5 to 4.6 g from cereals and pulses per square metre body surface or 5 g. per kg. body weight was sufficient to maintain nitrogen equillibrium. The results of Pasricha *et al.*, (1955) showed that for adult Indian women 0.31 g. per kg. of the body weight resulted in nitrogen equillibrium. Their subjects were in positive balance for about 4 g of daily nitrogen intake.

Considering the above figures reported in the literature it is not surprising that the adolescent students were in a trong positive nitrogen balance at a daily intake of 7.5 ± 0.41 g of nitrogen.

Fecal nitrogen

Fecal nitrogen exceted on an average with different levels of protein intake by the subjects was within a narrow range of 1.09 to 1.22 g. per day. Apparently there was no correleation between fecal nitrogen values found by Plansalkar and Patwardhan (1958) for male Indian adults on marginal protein intakes. The fecal excretion of the subject of the present study seems to be similar to those reported by Pasricha et al., (1965) for adult Indian women who were ill nourished with low protein intakes. Reports from other countries (Bricker et al., 1949., and Hegsted et al., 1946) mentioned still lower figures for fecal nitrogen on similar intake on diets containing mainly vegetable protein. ~~It is likely that.~~

Creatinine excretion

The daily creatinine excretion is presented in Table XII. Creatinine excretion was fairly constant for the different subjects of this study on different levels of protein intake. The creatinine excretion for 24 hours ranged from 0.716 mg. to 1.048 mg. The creatinine coefficient varied from 19.9 to 24.4. According to Hunter (1928) the creatinine coefficients were from 20 to 26 for males and 14 to 22 for females. Hodges and Lewis (1923) considered the differences in muscular development was the reason for differences in creatinine coefficients between males and females. They reported that moderately corpulent persons eliminate daily 20 mg. of creatinine per kg. of body weight, while lean ones yield 25 mg. per kg. Pasricha et al. (1965) reported creatinine coefficient of 16 to 20 adult Indian Women subjects, whereas the mean creatinine coefficient of the six post adolescent girls was 21.8 ± 2.12.

Basal metabolic rate

The basal metabolic rate of the subjects were determined for three days each and the values are presented in the Table XIII. Body surface area was calculated using the tables of Banerjee (1962).

TABLE XIII

THE BASAL METABOLIC RATE OF THE SIX POST ADOLESCENT WOMEN STUDENTS

	Age at the beginning of the study years.	Height Cm.	Weight kg	Body surface area M^2	Basal Metabolic Rate Cal/Hr/M^2 DAYS I	II	Rate III	Mean
1.	18.25	143	38.0	1.37	35.5	38.9	30.4	35.0
2.	18.55	160	41.5	1.55	35.6	30.7	29.0	31.8
3.	18.95	151	36.5	1.40	35.5	35.3	32.1	34.3
4.	19.05	145	41.0	1.42	33.8	35.7	32.1	33.9
5.	17.05	165	42.5	1.61	32.3	37.2	36.3	35.3
6.	17.05	158	40.5	1.53	37.2	30.4	34.0	33.9
Mean	18.22	153.6 ± 3.58	40.0 ± 1.17	1.48 ± 0.05	34.9 ± 0.68	34.7 ± 1.41	32.3 ± 1.32	34.3 ± 0.84

The mean BMR value for the subjects who are in the post adolescent age group were 34.2 $\pm$ 0.84 K.cal/hr/m^2. In the department of Physiology Presidency College, basal metabolic rate was determined for 17 students of age 18 to 20. The basal metabolic rate was 32.25 $\pm$ 0.51 which is similar to the mean values of the present study. The deviation from the Mayo foundation standard is 12.2 per cent. Banerjee (1962) was of the opinion that BMR of Indians is lower than western standards when the body surface area is used as a unit for its expression. This lower basal metabolic rate of the Indians is however only apparent and not real. Basal metabolic rate of the Indians should be the same as that of the people of the west, if the cell mass, cell solid or lea body is taken as the biometric unit of expression of BMR (Patwardhan, 1930). An attempt was also made to calculate the energy expenditure of the present subjects by noting down the activities for seven consecutive days.

Calculated energy requirements of the post adolescent-women college students studied.

Table XIV gives the total energy expenditure of the six subjects calculated by the factorical method (Patwardan, 1980). The energy expenditure for the activities were computed using the Tables for average energy cost of different activities of college students given by Banerjee, (1980). The mean time spent for each activity by each subject per day are given in Appendix VIII.

TABLE XIV

TOTAL CALORIFIC EXPENDITURE PER DAY OF THE SIX POST ADOLESCENT WOMEN STUDENTS

Activities	Subjects						
	1	2	3	4	5.	6	
Basal calories	840	763	823	814	847	814	
Lying rest	6	29	37	41	8	33	
Sitting rest	255	211	214	224	207	233	
Standing rest	30	48	33	22	57	36	
Sitting study	362	308	372	318	327	316	
Sitting house-hold work	289	255	265	199	235	197	
Standing labo-ratory work.	85	87	-	87	99	94	
Walking	102	102	108	117	117	73	
Ascending stairs	55	56	48	51	55	91	
Descending stairs	36	41	42	31	45	60	
Total caloric expenditure	2060	1920	1942	1904	2027	1946	Mean 1967

Table XVI gives the mean caloric consumption of the six subjects. A comparison with the caloric intake (Table) showed that the food the students consume did not satisfy the requirements for calories. But the initial and final weights of the students did not change greatly (Table 't' test). The reason for these differences are not known.

These might be due to the inherent errors in the assessment of energy requirements by the use of the factorial method. There was a difficulty in describing accurately the type of activity performed and in measuring the length of time spent in various activities, the unavailability of energy data on various types of activities and the difficulty in assessing accurately the intensity of an activity.

Thus our data on the calculated caloric expenditure of the post adolescent college students might not have been accurate estimates of the actual pattern.

Minimum nitrogen requirement for nitrogen equillibrium

Minimum nitrogen intake for nitrogen balance was calculated from the nitrogen balance data of the subjects. To do this the pooled nitrogen intake values were first plotted against nitrogen balance, expressing both values on the basis of body weight, surface area and basal calories.

The regression equations and correlation co-efficients obtained when the intake and balance were expressed on the basis of body weight, surface area and basal colories are given in Table XV.

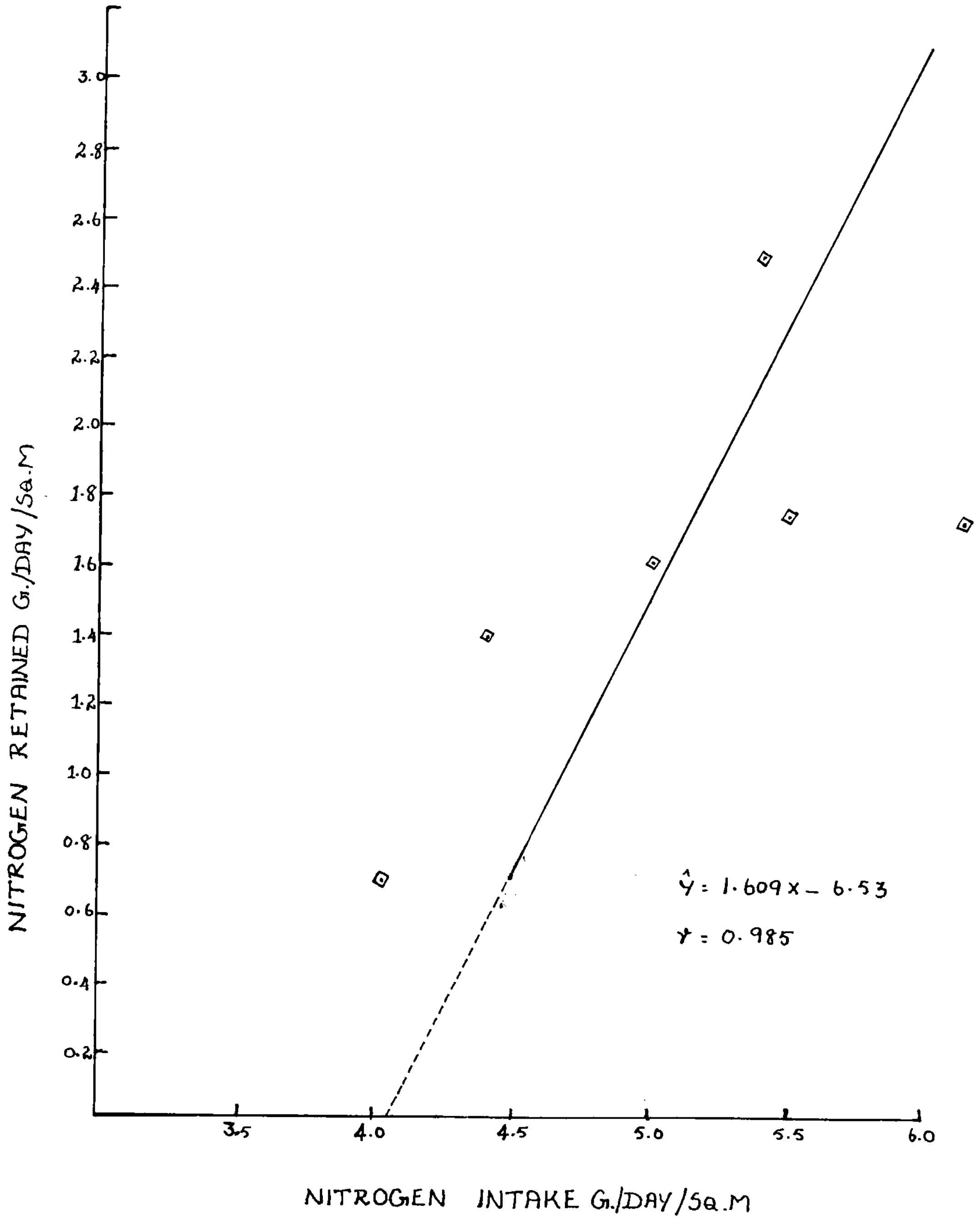
NITROGEN RETAINED G./DAY/SQ.M
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
3.5
4.0
4.5
5.0
5.5
6.0
$\hat{Y} = 1.609x - 6.53$
$r = 0.985$
NITROGEN INTAKE G./DAY/SQ.M

TABLE XV

REGRESSION OF EQUATIONS AND CORRELATION COEFFICIENTS

Unit	Regression line	r
mg./N/kg.body weight	$\hat{y}$ = -24.01 +0.444x	0.5322
g.N/M^2 body surface area	$\hat{y}$ = - 6.53 +1.609x	0.9850
g.N/1000 basal calories	$\hat{y}$ = 0.315+0.407x	0.5714

When nitrogen intake and retention were expressed on the basis of body surface the correlation was highest (r = 0.9850). The plot of nitrogen intake expressed on the surface area basis is given in Figure I.

From the regression equations in Table nitrogen intake for nitrogen equillibrium was calculated. This calculation of minimum nitrogen requirement was on the assumption that a straight line relationship would hold good upto the point of nitrogen equillibrium eventhough none of the subjects were in negative equillibrium. It was found that 3.86g. of nitrogen per square meter body surface area per day was necessary for maintaining nitrogen equillibrium. Considering other equations minimum nitrogen intake for nitrogen equillibrium was found to be 2 mg. per basal calorie and 54.08 mg. per kg. body weight.

Our figures 3.86 g. N as minimum requirement in terms of body surface area were higher than that of 3.55 or 2.71 g. N/m^2 body surface area by Phansalkar and Patwardhan

(1956) and Pasricha et al. (1965) for adult Indian males and females respectively.

The minimum nitrogen intake for nitrogen equillibrium obtained in this study are lower than those reported from the United States. Hegsted et al., (1946) found a value of 2.88 g. nitrogen per square meter per day for nitrogen equillibrium in their subjects on all vegetarian diets (Table XVI)

TABLE XVI

MINIMUM NITROGEN REQUIREMENT AS ESTIMATED BY THE PRESENT STUDY IN COMPARISON WITH SIMILAR VALUES REPORTED IN THE LITERATURE

Unit	Reference	Minimum requirement estimated value	Age of the subjects
g.N/m^2 body surface	This report	3.86	17-19 (Women)
	Hegsted et al.(1946)	2.88 2.73	Adults (men)
	Phansalkar and Patwardhan (1956)	3.55	Adults (Men)
	Pasricha et al. (1965)	2.71	Adults(women)
mg.N/kg.body weight	This report	54.08	17-19(Women)
	Pasricha et al.(1965)	81.70	Adults(Women)
mg.N/Basal calories	This report	2.00	17-19(women)
	Bricker et al. (1945)	2.80-4.80	College women
	Pasricha et al.(1965)	3.31	Adult women

Our results are more closer to those of Bricker and coworkers (1943, 1945) who found values of 2.8 mg. to 4.8 mg. nitrogen per basal Calorie for young women on different types of diets.

Minimum protein requirement in normal Indian post adolescent women could be computed from the above figure provided allowance is made for sweat and integumental losses of nitrogen. Exact figures for these are not available for Indians. In an average allowance of 0.77 g. nitrogen per square meter as suggested by Bricker et al., (1951), for such losses is used the protein requirement would be 28.94 g. per square meter per day. Daily minimum requirement of the protein of the type employed in this study would be 42.33 g. per day. These proteins however refer to the type of protein employed in this study (84 per cent from vegetable origin and 16 per cent from milk. Such protein mixtures are fairly representative of Indian dietaries.

Further it should be emphasized that the above figures were determined under the condition in which the requirements for other nutrients such as vitamins and minerals were not adequately met. Minimum protein requirement in normal Indian post adolescent women could be computed from the above figure.

The essential amino acid composition of the diets used in this study (Table XVII) providing a daily protein content of 47.6 g. was well above the minimum requirement for women determined by Leverton et al., (1959).

TABLE XVII

CALCULATED DAILY AMINO ACID INTAKE OF POST ADOLESCENT WOMEN

Amino Acid	Calculated daily amino acid intake of post adolescent women.	Minimum requirement of women (Leverton et al.,1959)
	mg./day	mg./day
Lysine	2383	500
Tryptophan	398	160
Phenylalanine	2446	220
Cystine	510	550
Methionine	716	
Threonine	1436	310
Leucine	3620	620
Isoleucine	2003	450
Valine	1230	650

Even the limiting amono acids methionime and tryptophan were much above the requirements.

V SUMMARY AND CONCLUSIONS

The study was undertaken to assess the metabolic patterns of post adolescent women of 17 to 19 years old and consuming a college hostel diet, with reference to calories and proteins.

Heights and weights of the post adolescent subjects were recorded on every fotnight for a period of eight months to assess growth if any had occured during the above period. Fluctuations in body weight was used as an index of caloric balance.

The dietary intake of protein and calories were assessed by calculation from the weight of cooked foods actually consumed by the 30 subjects and by direct analysis of the samples. It was also aimed to compare the calculated values with that of analysed values.

To find out any fluctuations in the caloric and protein intake of the subjects the weighment of food intake was repeated for the six subjects after a three month period.

For studying metabolic patterns of calories and proteins, daily fecal losses of calories, urinary and fecal loss of nitrogen, and urinary creatinine were determined for three consecutive days. Triplicate measurements of basal metabolic rate and time records of the activities of these students for seven consecutive days were obtained to calculate their daily energy expenditure by the factorial method.

The mean heights and weights of the 30 students were 152.8 ± 0.87 cms. and 41.4 ± 0.19 kg. respectively. The post adolescent women college students of the present study were equally tall but lower in body weights when compared with other Indian reports. The height and weight records of the 30 students showed no significant differences during the experimental period of 8 months there by showing that there was no growth in terms of increase in heights or weights in these subjects. These 17 to 19 years old girls have had their menarche 4 or 5 years before and have had already passed their growth spurt period. The insignificant fluctuations in weight during the experimental period might indicate that the subject were in caloric balance.

Except in milk and fruits none of the other food groups consumed daily by the subjects met the recommended allowances for a balanced diet according ICMR (Aykroyd *et al.*, 1966).

Neither the calorie intake of 1787 ± 31 k.calorie nor the protein intake of 47.6 ± 1.22g of the subjects met the recommended allowances of the ICMR (Aykroyd *et al.*, 1966). No significant periodical differences in the caloric and protein intakes were observed.

Calculated value of the protein and calories from the weighment data using the Food Composition Tables of Aykroyd et al., (1966) offered a close estimate of the analysed values especially for protein.

The fecal loss of calories was on an average 9 per cent of the total calories.

During the three days of metabolic study, all the subjects were in positive nitrogen balance ranging from 1.06 g to 3.56 g. when their nitrogen intakes ranged from 6.21 to 8.44 g. The daily fecal nitrogen values had a narrow range of 1.09 to 2.08 g of N and were independent of the nitrogen intakes. Daily urinary nitrogen ranged from 2.33 g. to 5.53 g. Deriving 11.1 per cent of the total calories from protein the six post adolescent women were found to be in a positive nitrogen balance for the three days of study.

The BMR of the subjects were on an average 34.3 ± 0.34 K.calories/Hr/M^2 of body surface which is similar to other reports from India, but were 11.2 per cent lower than the Mayo Foundation standards. The apparently lower BMR rates might have been equal to western standards, had the calculations been based on cell mass, Cell solid or lean body mass rather than the body surface areas as the unit of expression for BMR.

A calculation of the daily caloric expenditure from the BMR and cost of energy for various daily activities showed an average estimated output of 1987 K.calories. Thus the mean intake of 1957 calories did not satisfy their estimated requirement for calories. Probable calorie balance was depicted by constant body weight having unsignificant fluctuations. The discrepancy in the estimated calorie expenditure might be due to the factorial method, like the difficulty in describing accurately the type of activity performed, and in measuring the length of time actually spent in various activities.

The daily creatinine excretion for the subject were fairly constant and had a mean value of 842 ± 173 mg. per 24 hours on different levels of protein intake. Mean creatinine coefficient of 21.3 ± 2.12 showed that the subjects were moderately corpulant.

From the data on nitrogen metabolism, regression equations were calculated between nitrogen intake and excretion, when values were expressed as the basis of body surface, body weight and basal calories. When values were expressed on the basis of body surface area the correlation coefficient increased to a very high value of 0.9850. From the regression equation the nitrogen intake for nitrogen equilibrium was calculated. It was found out that 3.86 g N/m^2 body surface area per day or a total daily requirement of 42.83 g per day was necessary for maintaining nitrogen equilibrium in post adolescent college women consuming a hostel diet.

Thus data on the normal metabolic patterns of calories and proteins of post adolescent women students who were residing in a college hostel were presented. Such studies involving a larger number of subjects might lead to better understanding of minimum requirements of calories and proteins.

BIBLIOGRAPHY

Albanese, A.A.
1963 Newer Methods of Nutritional Biochemistry. New York and London, Academic press.

Arroyave, G.
1960 Biochemical evaluation in nutritional status in man. Fifth International Congress of Nutrition, 9650 Wisconsin Avenue, Washington, 14, D.C., U.S.A.

Arroyave, G.
1963 Estimation of body protein deficit, in protein malnourished population by creatinine measurements. Symbosium on Protein Nutrition and Metabolism, Special Publication No.4, University of Illinois College of Agricultural Experiment Station, Illinois.

Association of Official Agricultural Chemists 9th edition
1960 Official and Tentative Methods of Analysis 9th edition Association of Official Agricultural Chemists, Washington, D.C.

Aykroyd, W.R., Gopalan, C., and Balasubramanian, S.C.
1966 The Nutritive Value of Indian Foods and the Planning of satisfactory diets. Special Report Series No.42., Indian Council of Medical Research, New Delhi.

Baldwin, B.T.
1921 The physical growth of children from birth to maturity. University of Iowa studies in Child Welfare 1. Iowa City, Iowa

Banerjee, B.
1953 Nutritional level of students and nurses of Assam Medical College during the winter Season, 1950-51. Journal of Applied Physiology 5., 432.

Banerjee, S.
1962 Studies in energy metablosm, Special Report Series No.43., Indian Council of Medical Research, New Delhi.

Banerjee, S., Barua, ., and Ghosh, A.
1961 Energy metabolism in College girls. Journal of applied Physiology 16., 164.

Banerjee, S., and Biswas, D.K.
1957 Studies on the nutritional status of students of the EDEN Hindu Hostel attached to Presidency College, Calcutta. Indian Journal of Medical Research, 45., 411

Banerjee, S. and Mahindra, S.K.
1962 Energy intake and expenditure of college women.
Journal of Applied Physiology 17., 971.

Banerjee, S., Mahindra, S.K., and Bandyopadhyay, A.
1963 The food intake of adolescent college girls of Rajasthan.
Indian Journal of Medical Research 51., 494

Banerjee, S. and Sen, R.
1958 Body compositionof Indians and its relation to basal metabolic rate.
Journal of Applied Physiology 12., 29.

Beaton, G.H. and McHenry, E.W.
1964 Nutrition A Comprehensive Treatise 1. New York London, Academic Press.

Bell, G.H., Davidson, J.N., and Scarborough, H.
1961 Text book of Physiology and Biochemistry 5th edition. Edinburgh and London, E and S Livingstone Ltd.

Benerjee, V., Rao, P.S.S., Klonitz, C.E., Rao., B.R.H., Begum, A., and Dumm, M.S.
1960 Nutrition and health survey of school children
Indian Journal of Pediatrics 28, 213.

Benedict, F.G., Miles, W.R., Roth, P., and Smith, H.M.
1919 Human vitality and efficiency under prolonged restricted diet.
Carnegie Institute, Washington Publication No.280.

Bhalekar, K. and Phadnis, L.
1966 Standard Height-Weight Survey.
The Indian Journal of Home Science 1., 26.

Bosshardt, D.K., Paul, W., Dorothy, K., Barnes, R.H.
1948 Caloric restriction and protein metabolism in the growing mouse.
Journal of Nutrition 36., 773.

Boas, F.
1933 Studies in growth.
Human Biology 5., 429.

Boynton, B.
1936 The physical growth of girls, A study of rythum of physical growth from anthropometric measurements of girls from birth to 18 years.
University of Iowa Studies in Child Welfare 12.

Bogert, L.J.
1960 Nutrition and Physical fitness 7th edition, Philadelphia and London.
W.B. Saunders Company.

British Medical Association
1950 Report of the Committee on nutrition.
British Medical Association house, London.

Bricker, M., Mitchell, H.H., Kinsman, G.M.
1945 The protein requirement of adult human subjects in terms of the protein contained in individual foods and foods combination.
Journal of Nutrition 30., 269.

Bricker, M.L., Shively, R.F., Smith, J.M., Mitchell, H.H., and Hamilton, T.S.
1949 The protein requirements of college women on high cereal diets with observations on the adequacy of short balance periods.
Journal of Nutrition 37., 163.

Bricker, M.L. and Smith, J.M.
1951 A study of the endogenous nitrogen output of college women with particular reference to the use of creatinine output in the calculation of the biological values of the protein of egg and sunflower seed flour.
Journal of Nutrition 44., 553.

Calloway, D.H. and Spector, H.
1955 Nitrogen utilisation during caloric restriction. II. The effect of Variation in nitrogen intake.
Journal of Nutrition 56., 545.

Cathcart, E.P.
1922 Influence of fat and carbohydrate on the nitrogen distribution in the urine.
Biochemical Journal 16., 247.

Chalmers, F.W.
1952 Nutritional status of West Virginia University students, West Virginia University, Agricultural Experiment Station, Bulletin No.352.

Chalmers, F.W.
1952 The dietary record-how many and which days.
Journal of American Dietetic Association28., 1146.

Chaudhuri, S., Ghosh, J. and Tapaswi, P.
1966 Anthropometric, Haematological and bio-chemical study of Indian School Children of two communities in Calcutta.
Indian Journal of Pediatrics 3., 349.

Canadian Council on Nutrition
1964 Dietary standard for Canada.
Canadian Bulletin of Nutrition 6., 1.

Chaney, M.S.

Chaney, M.S.
1964 Nutrition 6th Edition, United States of America, Houghton Mifflin Company.

Clarke, M.F.
1966 The relation of weight to stature in young Indian women. Studies at two Medical college. Indian Journal of Medical Research 54., 389.

Coons, C.M.,
1931 Basal metabolism in relation to nutritional status. American Journal of Physiology 98, 698.

Crampton, E.W. and Lloyd, L.E.
1959 Fundamentals of Nutrition, San Francisco and London, W.H.Freeman and Company.

Davis, A.N. and Scoular, F.T.
1957 The energy value of self selected diets consumed by young college women. Journal of Nutrition 61., 289.

Davidson, S. and Passmore, R.
1966 Human Nutrition and Dietetics, Edinburgh and London, E and S Livingstone Ltd.

Lakshayani, R., Ramana Murthy, P.S.V., and Srikantia, S.G.
1962 Body composition and basal metabolism of normal Indian women. Indian Journal of Medical Research 50., 800.

~~Darby, W.J.~~
~~1956 A study of the dietary background and nutritive of the Navajo Indian Children 30.~~

Donelson, E.G., Nelson, P.M., Ohlson, M.A., Pittman, M.S., Leverton, R.M., McKay, H., Kinsman, G.M., Armstrong, W., and Reynolds, M.S.
1945 Nutritional status of midwestern college women. Journal of American Dietetic Association 21., 145.

Dreizen, S. and Stone, R.E.
1962 Human nutrition and growth failure. Post-graduate Medicine 32., 381.

Dreizen, S., Stone, R.E., and Spies, T.D.
1961 The influence of chronic undernutrition on the bone growth in children. Post-graduate Medicine 29., 182.

Engel, E.T. and Shelesnyak, M.C.
1934 First menstruation and subsequent menstrual cycles of pubertal girls, Human Biology 6., 431.

Engelmann, G.J.
1902 Age at first menstruation on the North American Continent. New York Medical Journal 75., 221.

Eppright, E.S., Sidwell, V.D., and Swansen, P.P.
1954 Nutrient value of the diet of Iowa School children. Journal of Nutrition 54., 371.

Eppright, E.S., Cooms, I., and Jebe, E.
1953 Very heavy and obese school children in Iowa. Journal of Home Economics 43., 133.

Folin, O.
1905 Laws governing the chemical composition of urine. American Journal of Physiology 3., 66.

Food and Agriculture Organisation
1957a Caloric Requirements.
FAO Nutritional studies, No.15, Food and Agricultural Organisation of he United Nations, Rome Italy.

Food and Agriculture Organisation.
1957b Protein Requirements.
FAO Nutritional studies, No.16, Rome, Italy.

Food and Agriculture Organisation
1963 Malnutrition and Disease-A Major problem of the Human Race.
Freedom From Hunger Campaign, Special report number 12., Food and Agriculture Organisation of the United Nation, Geneva.

Food and Agriculture Organisation
1957 Protein Requirements.
Report of the FAO Committee, No.16.
Food and Agriculture Organisation of the United Nations, Rome, Italy.

Food and Agriculture Organisation
1965 Protein Requirements, Report of a Joint FAO/WHO Expert Group., FAO Nutrition Meetings Report Series No.37, Food and Agriculture Organisation of the United Nations, Rome, Italy.

Food and Agriculture Organisation
1963 Six billions to Feed. No.4. Food and Agriculture Organisation of the United Nations, Rome.

FAO/WHO
1962 Joint FAO/WHO Expert Committee on Nutrition Sixth report. WHO Technical Report Series No.245

Food and Nutrition Board
1964 Recommended Dietary Allowances, Revised, 1964.
National Research Council Publication, 1146.
National Academy of Science.

Forbes, R.M. and Yohe, M.
1955 Effect of energy intake on the biological value of protein fed to rats.
Journal of Nutrition 55., 499.

Gould, H.N. and Gould, M.R.
1932 Age at first menstruation in mothers and daughters.
Journal of American Medical Association 98., 1349.

Gray, H.
1941 Individual growth rates from birth to maturity for fifteen physical traits.
Human Biology, 13., 306.

Greulich, W.W.
1951 The growth and developmental status of Germanian school children in 1947.
American Journal of Physical Anthropometry 9., 55.

Gyorgy, P.
1960 The late effects of early nutrition.
American Journal of Clinical Nutrition 8., 344.

Hansen, A.E.
1959 Nutritional Requirements.
Text Book of Pediatrics 7th edition, Philadelphia, W.B.Saunder's Company.

Hard, M.M. and Esselbough, N.C.
1956 Nutritional status of selected adolescent children.
American Journal of Clinical Nutrition 4., 231.

Hard, M.M., Esselbough,NC., and Donald, E.A.
1958 Nutritional status of selected adolescent children.
American Journal of Clinical Nutrition 6., 401.

Heinz.,H.J.
1959 The Heinz Handbook of Nutrition London New York Toranto.

Hodges, R.E. and Krehl, W.A.
1965 Nutritional status of teenagers in Iowa.
The American Journal of Clinical Nutrition 2., 200.

Hegsted, D.M., Tsongas, A.G., Abbott, D.B., and Stare, F.J.
1946 Protein requirements of adults.
Journal of Laboratory and Clinical Medicine 31, 261.

Howe, P.E. and Schiller, M.
1952 Growth response of the school child to changes in the diet and environmental factors.
Journal of Applied Physiology 5, 51.

Hodgson, P. and Lewis, H.B.
1928 Cited by Albanese, A.A., 1959, Protein and Amino Acid Nutrition, New York, London, Academic Press.

Holt, L.E., and Fales, H.L.
1921 Food requirements of children, II.Protein requirement, American Journal of Diseases children, 22., 371.

Hunter, A.
1928 Creatine and Creatinine.
Longman's green, New York.

Hutson, E.M., Cohen, N.L., Kunkel, N.D., Steinkamp, R.C., Rourke, M.H., and Walsh, H.E.
1965 Measurement of body fat and related factors in normal adults.
Journal of American Dietetic Association, 47., 179.

Indian Council of Medical Research
1964 Diet Atlas of India, Special report series No.48
Indian Council of Medical Research, Nutrition Research Laboratories, Hydrabad.7.

Indian Council ofMedical Research
1961 Review of Nutrition Surveys carried out in India.
Indian Council of Medical Research,
Special Report Series No.36

Indian Council of Medical Research
1966 Annual Report for the period 1st October 1964 to 30th September 1965.
The Nutrition Research Laboratories, Hyderabad.

Johnston, J.A.
1957 Protein requirements of adolescents.
Annals of The New York Academy of Sciences 69, Wilmington, Del.
E.T.du pant de Nemours and Company, Inc.

Johnston, J.A.
1961 Meeting Protein Needs
National Academy of Sciences,
National Research Council Publication 843., 319.

Johnston, J.A.
1936 Relation of basal metabolism to dietary intake.
American Journal of Diseases Children 51., 1039

Johnston, F.A. and Mcmillar, T.J.
1952 The amount of nitrogen retaind by six young women on an intake of approximately 70 grams of protein a day.
Journal of Nutrition 47., 425.

Jones, H.E.
1947 The sexual maturing of girls as related to growth in strength.
Research Quarterly 18., 135.

Karambelkar, P.V., Patwardhan, V.N., and Sreenivasan, A.
1952 Studies in protein metabolism.
Creatinine excretion in urine in relation to sources of dietary protein.
Indian Journal of Medical Research 40., 89.

Kelly, H.J. and Redfield., J.E.
1941 Physical growth from birth to maturity.
Review of Educational Research 11., 573.

Kleiber, M.
1947 Body size and metabolic rate.
Physiological Reviews 27., 511.

Kanishi, F.
1965 Food energy equivalents of various activities.
Journal of American Dietetic Association 46., 186.

Kleiner, I.S. and Dotti, L.B.
1962 Laboratory Instructions in Biochemistry Sixth edition
Saint Louis
The C.V.Mosby Company.

Krause, M.V.
1966 Food Nutrition and Diet Therapy, 4th Edition.
Philadelphia and London
W.B.Sounder's Company.

Krishnan, B.T. and Vareed, C.
1932 Basal Metabolism of young college students, men and women in Madras,
Indian Journal of Medical Research 19., 831.

Krishnan, B.G.
1939 Caloric requirements of South Indian Children
Indian Council of Medical Research 26., 531.

Lantz, E.L. and Wood, P.
1958 Nutrition of new mexian spanish american and angle adolescents.
Journal of American Dietetic Associntion 34., 145.

Leitch, I. and Bayne, A.W.
1960 Recent change in the height and weight of adolescents.
Nutrition Abstracts and Reviews 30., 1173.

Leverton, R.M. and Gram, M.R.
1949 Nutrition excretion of women related to the distribution of animal proteins in daily meals,
Journal of Nutrition 39., 57.

Leverton, R.M. Rhodas, M.N.
1949 Nitrogen calcium, phosphorous and basal energy metabolism of obese college women during weight reduction.
Journal of of American Dietetic Association 25.,1012.

Mack, P.B., Smith, J.M., Logan, C.M., Brien, A.T., Stewart, A.H. and Doods, P.
1942 Mass studies in Human nutrition--Nutritional status of children in a college community.
Journal of American dietetic Association 18., 39.

Macy, I.G.
1942 Nutrition and Chemical growth in a college community.
Journal of American Dietetic Association 18., 39.

Macy, I.G.
1951 Nutrition and Chemical growth in childhood.
Charles C.Thomas, Spring field, Illinois 1.

Macy, I.G.
1957 Chemical Anthropology.
A New Approach to growth in children.
The University of Chicago Press, Chicago.

Madhavan, S.
1965 Age at Menarche of South Indian girls belonging to the states of Madras and Kerala.
Indian Journal of Medical Research 53., 669.

Martin, E.A.
1953 Robert's Nutrition work with children,
Chicago and London.
The University of Chicago Press.

Mason, E.D. and Benedict, F.G.
1931 Basal metobolism rate of college students.
Indian Journal of Medical Research 19., 75.

McCance, R.A., and Glaseh E.M.
1948 The energy absorption of oat meal and digestibility and absorption of calories, proteins, purines, and fat, and calcium of the whole meal wheat bread.
British Journal of Nutrition 2., 26.

McCance., R.A. and Walshan, J.M.
1948 The digestibility and absorption of calories, proteins purines, and fast, and calcium of the whole meal wheat bread,
British Journal of Nutrition 2., 26.

McHenry, E.W.
1957 Basic Nutrition ~~Montreal~~,
J.B.Lippincott company, Philadelphia, montreal.

McHenry E.W. and Beaton, G.H.
1963 Basic Nutrition Revised edition.
J.B.Lippincott Company, Philadelphia, montreal.

Mitchell, H.S.
1964 Protein limitation and human growth.
Journal of American Dietetic Association 44., 166.

Mitchell, H.S.
1962 Nutrition in relation to stature.
Journal of American Dietetic association 40., 521.

Mitchell, K. and Bernard, R.C.
1954 Food in health and disease 5th edition.
Philadelphia, F.A.Davis Company.

Mitchell, H.H. and Berg, A.H.
1964 The determination of metabolic fecal nitrogen
Journal of Nutrition 52., 483

Mitchell, H.H. and Edman, M.
1962 Nutritional significance of dermal losses of nutrients in man, particularly of nitrogen and minerals.
American Journal of Clinical Nutrition 10, 163.

Mitchell, H.H. and Hamilton, T.S.
1949 The dermal excretion under controlled environmental condition of nitrogen and minerals in human subjects with particular reference to calcium and iron.
Journal of Biological chemistry 178, 345.

Mitchell, H.S. and Santo, S.
1963 A study of children, in Hokkaido orphanages, heights, weights and dietary patterns.
Journal of Faculty of Agriculture 52., 483.

Montague, M.F.
1957 Nature, nurture and Nutrition.
American Journal of clinical Nutrition 5., 237.

Munro, A.
1955 A five year study of the daily food consumption of South African University students.
British Journal of Nutrition 10., 1.

Musham, H.V.
1947 Height and weight. Correlation in growth.
Human Biology 19., 280.

Nageswara Rao, G.
1953 A survey of diets in residential hostels in India.
Indian Journal of Medical Research 54., 475.

National Research Council.
1952 Recommended dietary allowances--revised, A report of the food and Nutrition Board, Publication 589
National Research Council Publication 302,
Washington, D.C.

Niyogi, S.P., Patwardhan, V.N., Power, F.L., and Sirest, M.V.
1940 Studies on basal metabolism in Bombay.
Part II. Basal Metabolism of Boys.
Indian Journal of Medical Research 28., 345.

Odland, L.M. Page, L., and Guild, L.M.
1955 Nutrient intakes and food habits of Montana students,
Journal of American Dietetic association 31., 1134.

Ohlsen, M.A.
1958 Discussion. Protein requirements of adolescents
Annals of New York academy of sciences 69., 913.

Osmond, A. and Wilson, W.
1952 Tables of Composition of Australian Foods.
Special Report Series No.2.,
Australian Institute of Anatomy, Canberra.

Passmore, R. and Durin, J.V.G.A.
1955 Human energy expenditure.
Physiologial reviews 35., 801.

Patel, T.V., Thakor, V.H., Howman, T.J., Mehta, D.G., and Contractor, A.A.
1955 Report on the veneral diseases and Nutritional deficiency diseases surveys conducted in Dangs, District, Gujarat State (1960--1962).
Indian Council of Medical Research
Special report series No.52
Indian Council of Medical Research, New Delhi.

Pathak, C.L.
1958 Nutritional adoption to low dietary intake of calories, proteins, vitamins and minerals.
American Journal of Clinical Nutrition 6., 151.

Patwardhan, V.N.
1950 Calorie requirements-Indian Council of Medical Research, Special Report seri s No.35., 27.

Patwardhan, V.N. and Jagannathan, S.N.
1962 A review of Nutrition Studies in India (1951--56). Indian Council of Medical Research Special report series No.37. Indian Council of Medical Research, New Delhi.

Patwardhan, V.N., Mukundam, R., RamanaSastri, B.V., and Tulpule, P.G.
1947 Studies in protein metabolism., The influence of dietary protein on the urinary nitrogen excretion. Indian Journal of Medical Research 37., 327.

Patwardhan, V.N. and Phansalker, S.V.
1960 Protein requirements. Indian Council of Medical Research, Special Report Series No135., 21.

Peters, H. and Shrikande, S.M.
1957 Age at menarche in Indian women. Fertility and Sterility 8., 355.

Peckos, I.S. and Bridge-Forth, A.B.
1953 Caloric intake in relation to physique in children-Science 117., 631.

Peyton, A.B.
1957 Practical Nutrition, J.B. Lippincott Company Philadelphia Montreal.

Phansalkar, S.V. and Patwardhan, V.N.
1954 Partition of urinary nitrogen in Indian adults Relation between urea nitrogen and total nitrogen. Indian Journal of Medical Research 42., 333.

Phansalkar, S.V. and Patwardhan, V.N.
1956 Utilization of animal and vegetable proteins. Nitrogen balances at marginal protein intakes and he determinationof minimum protein requirements for maintenance in young Indian men. Indian Journal of Medical Research 44., 1.

Pittman, M.S., Baxter, V., Stokely, E.D., Ohlson., M.A., Serman, J., Donelson, E.G.Patton., M.B., and Himwich, W.A.
1948 The variations in the basal metabolism of midwestern college women. Journal of American Dietetics Association 22., 307.

Plough, I.C. and Bridgeforth, A.B.
1960 Relations of clinical and dietary findings in nutrition surveys. Public Health Report 75., 133

Popenoe, P.
1928 Inheritance of age of onset of menstruation
Eugenical News 13., 101.

Powers, G.F.
1925 Comparison and interpretation on caloric basis of milk mixtures used in infant feeding.
American Journal of Diseases of children 30., 453.

Ramanamurthy, P.S.V., and Baluvady, B.
1966 Fecal loss of calories on Indian diets.
Indian Journal of Medical Research 54., 1087.

Rao, S.K. and Tasker, A.D.
1954 Nutrition and haemoglobin surveys in children in Nilgiris District.
Indian Journal of Medical Research 42., 55.

Reategu, F.E.
1962 Creatinine excretion and body composion.
American Journal of Clinical Nutrition 10., 128.

British Medical Association
1950 Report of the Committee on Nutrition
British Medical Association House, London.

Reynolds, E.L. and Wines, J.V.
1948 Individual differences with physical changes associated with adolescence in girls.
American Journal of Diseases of children 75., 329.

Robertson, E.C.
1966 The Nutrition of Children and adolescents
Nutrition a comprehensive treatise 3
New York, London Academic Press.

Robinson, M. and Secular, F.I.
1957 Calorie value of food served in a women's residence hall.
Journal of American Dietetic Association33., 1270.

Roderuck, C.E.
1963 Nutrition and growth of Iowa school girls.
American Journal of Clinical nutrition 13., 173.

Sarkar, A.K. and Sarkar, M.
1953 Dietary survey of a nurses hostel in West Bengal
Journal of Indian Medical Association 22., 415.

Satoskar, R., Kulkarni, B.S., and Rege, D.V.
1961 Serum proteins, cholesterol, vitamin B12 and folic acid in lacto vegetarians and non-vegetarians.
Indian Journal of Medical Research 49., 387.

School Health Committee
1961 School Health Statistical Report.
Ministry of Education, Tokyo, Japan.

Schottstadt, W.W., Grace, W.J., and Wolff, H.G.
1956 Variations in excretion of endogenous creatinine.
Journal of Psychosomatic Research 1., 292.

Schwimmer, D. and McGavack, T.H.
1948 Some newer aspects of protein metabolism.
New York State Journal of Medicine 48., 1707.

Scoular, F. and Lilian, B.
1946 The food intake of college women.
Journal of American Dietetic Association 22., 401.

Scrimshaw, N.S.
1963 Factors influencing protein requirements.
Harvey Lecture 58.

Scrimshaw, N.S., Habicht, J.P., Piche, M.L., Cholakos, B.
and Arroyave, G.
1966 Protein metabolism of young men during University
examinations.
American Journal of Clinical Nutrition 18., 321.

Seidden, J.M.
1958 Age changes in basal metabolism.
The Adolescent
Holt, Rinehart and Winston, Inc., New York.

Sherman, H.C.
1952 Chemistry of Food and Nutrition - 8th edition -
The MacMillan Company, New York.

Shuttleworth, F.K.
1937 Sexual maturation and the physical growth of
girls age six to nineteen.
Monographs of the Society for Research in Child
Development 2.

Sibbald, I.R., Berg., R.I., and Howland, J.P.
Digestible energy in relationto food intake
and nitrogen retention in the weanling rat,
Journal of Pediatrics 22., 518.

Snedecor, G.W.
1956 Statistical methods,
5th edition, Ames, Iowa.
Iowa State College

Srivatsa, M. and Puri, B.
1962 Some nutritional findings among Lady Irwon College
Students.
Indian Journal of Medical Research 50., 810.

Stearns, G., Newman, K.S.J., McKinley, J.B. and Jeans, P.C.
The Protein requirements of children from one to ten years of age.
Annals of New York Academy of Sciences 39., 857.

Swaminathan, M., Joseph, A., Narayana Rao, M., Chandramani, S.V., Subramaniam, L., and Indira, K.
1950 Balanced Diets and Nutritive Value of Common Recipes.
Central Food Technologial Research Institute, Mysore.

Tanner, J.M.
1952 The assessment of growth and development in children. Achieves of disease in childhood 27., 10.

Taylor, C.M. and Macleod, G.
1949 Roses Laboratory Hand Book For Dietetics 5th edition.
The Macmillan Company, New York.

Taylor, C.M., Macleod, G., and Rose, M.S.
1956 Foundations of Nutrition 5th edition.
The Macmillan Company, New York

Tuxford, A.W.
1942 Indices of Physical Development,
Journal of Hygiene 42., 549.

Young, C.M. and Pilcher, H.L.
1950 Nutritional Status Survey, Groton Township, New York
Journal of American Dietetic Association 26., 776

Wait, B. and Roberts, L.J.
1933 Studies on food requirements of adolescent girls, protein intake of well nourished girls ten to sixteen years of age.
Journal of American Dietetic Association 8, 403.

Wallace, W.M., Weil, W.B., and Talor
1958 Cited by Beaten G.H. and McHenry, E.W.
Nutrition A Comprehensive Treatise
New York and London
Academic Press

Wang, C.C., Hodgen, J. and Wing, M.
1936 Metabolism of adolescent girls.
II. Fat and protein metabolism
American Journal of Diseases of Children 51., 1083.

Warnick, K.P., Bring, S.V., and Woods, E.
1955 Nutritional status of adolescent Idaho children.
Journal of American Dietetic Association 31.,435

Weinbach, A.P.
1941 Human growth curve from birth to puberty.
Growth 5., 235.

Wharton, M.A., Tyrreti, D., and Patton, M.B.
1953 Amino acid intake and nitrogen balance of college women.
Journal of American Dietetic Association 29., 573.

White, A., Handler, P., Smith, E.L. and Stetten, D.W.
1959 Principles of Biochemistry 2nd edition.
London McGraw Hill Book Company, Inc.

Widdowson, E.M.
1939 Cited by
Beaton, G.H. and McHenry, E.W. 1966
Nutrition A comprehensive Treatise 3
New York and London
Academic Press.

Widdowson, E.M.
1957 Cited by
Beaton, G.E.(1966) and McHenry, E.W.
Nutrition A comprehensive Treatise 3
New York and London Academic Press

Widdowson, E.M., Edholm, O.G., and McCance, R.A.
1954 Cited by
Beaton, G.H. and McHenry, E.W. 1964
Nutrition A Comprehensive Treatise 1
New York London Academic Press

Wilson, E.D., Fisher, K.H. and Fiqua, M.E.
1960 Principles of Nutrition
John w ley and sons Inc. New York London

APPENDIX

APPENDIX I

A WEEKLY MENU OF THE DIETS OF THE POST ADOLESCENT WOMEN HOSTEL STUDENTS

Days	Early morning 6.30 a.m.	Breakfast	Lunch	Evening Tea	Dinner
Monday	Coffee or Milk	Wheat Uppuma Coconut Chutney Banana	Rice Drumstick Sambar Greens Porial Rasam Curds	Banana Coffee or Milk	Bonda or Vadai Milk
Tuesday	Coffee or Milk	Iddli Tomato Chutney Banana	Vegetable Rice Rice Carrot Pachadi Curds	Puffed rice and Ground nuts Coffee or Milk	Rice Beans Porial Pumpkin Kulumbu Milk
Wednesday	Coffee or Milk	Chappathi Potato Curry Banana	Rice Brinjal Sambar Yam Porial Curds	Green gram Sundal Coffee or Milk	Lime rice Curds rice Cabbage Porial Milk
Thursday	Coffee or Milk	Iddli Tomato Sambar Banana	Rice Radish Sambar Greens Kootu Curds	Banana Coffee or Milk	Tomato rice Snake gourd Kootu Curds Milk
Friday	Coffee or Milk	Chappathi Dhal curry Banana	Rice Ladiesfinger Sambar Cluster beans Porial Curds	Puffed Rice and Ground nuts Coffee or Milk	Coconut rice Rice Beans Porial Curds Milk
Saturday	Coffee or Milk	Beaten rice Uppuma or Ragi puttu Coconut Chutney Banana	Rice Drumstick Sambar Pumpkin Porial Curds	Peas sundal Coffee or Milk	Tamarind rice Cauliflower Porial Curds
Sunday	Coffee or Milk	Iddli Coconut Chutney Banana	Rice Mour Kulumbu Snake gourd Porial Rasam Curds	Bajji or Potato Bonda Coffee or Milk	Rice Onion Kulumbu Ladies finger Porial Curds Milk

APPENDIX II

AGE AT THE BEGINNING OF THE STUDY, AGE OF MENARCHE, YEARS SINCE MENARCHE, AVERAGE HEIGHTS AND MEAN FORT NIGHTLY BODY WEIGHT MEASUREMENTS OF THE POST ADOLESCENT WOMEN STUDENTS

S.No.	Age at the beginning of the study Years Months	Age of menarche Years Months	Years since menarche Years Months	Heights cm	Body weight in Kg (mean of the fortnightly measurements) Initial 1	2	3	4	Final 5
1.	18 . 3	12 . 8	5 . 8	143	38.0	38.0	38.3	38.0	38.0
2.	18 . 4	14 . 1	4 . 3	160	41.5	42.0	42.0	42.3	41.5
3.	18 . 9	14 . 3	4 . 5	151	36.5	36.5	36.3	35.8	36.0
4.	19 . 1	14 . 3	4 . 9	145	41.0	41.5	40.8	40.8	37.5
5.	17 . 1	13 . 4	4 . 9	165	42.5	43.0	43.3	43.3	43.0
6.	17 . 8	12 . 7	5 . 1	158	40.5	40.5	40.5	40.8	40.3
7.	18 . 3	12 . 7	4 . 7	151	47.0	48.0	48.5	48.0	49.0
8.	17 . 2	14 . 3	2 . 0	163	44.5	44.5	45.0	43.5	44.0
9.	18 . 0	12 . 8	5 . 4	153	38.0	38.0	38.5	38.5	38.0
10.	19 . 7	12 . 5	7 . 2	144	46.5	47.0	46.5	45.5	45.5
11.	19 . 0	12 . 5	6 . 7	156	43.0	43.5	43.0	42.5	42.0
12.	19 . 3	13 . 1	6 . 2	155	47.0	48.0	50.0	50.0	49.0
13.	18 . 7	13 . 66	5 . 1	157	40.0	40.5	40.5	40.3	41.0

Contd.........

Appendix II Continued.

S.No.	Age at the beginning of the study Years	Months	Age of menorche Years	Months	Years since monarche Years	Months	Body Heights cm	Body weight in Kg (mean of the fortnightly measurements) Initial 1	2	3	4	Final 5
14.	18	1	12	9	5	4	152	7 39.0	37.0	37.3	37.3	36.3
15.	17	1	14	1	3	0	150	38.5	38.5	38.5	38.0	37.5
16.	18	9	12	6	6	3	154	42.5	45.0	45.0	44.0	45.5
17.	18	5	14	4	4	1	156	45.0	45.0	41.5	41.8	41.5
18.	18	3	13	2	5	1	144	40.0	40.5	40.5	40.5	41.0
19.	19	0	14	7	4	5	156	39.0	41.0	42.0	42.0	40.3
20.	19	7	13	1	6	6	150	45.5	45.5	45.0	45.0	44.5
21.	19	5	14	4	5	1	148	40.0	40.5	40.8	40.5	41.0
22.	19	3	14	2	5	1	157	50.0	50.0	50.0	50.0	49.8
23.	18	8	14	5	4	3	156	43.0	43.0	43.3	42.3	42.3
24.	18	2	14	5	5	7	154	37.0	37.0	36.0	36.5	37.0
25.	18	6	13	5	5	1	149	42.5	42.0	41.0	41.0	41.5
26.	19	1	13	8	5	5	148	43.0	43.5	44.5	44.5	44.5
27.	19	7	14	7	5	0	150	41.0	39.0	42.0	41.6	42.3
28.	18	3	13	2	5	1	154	41.5	41.5	41.5	41.5	41.5
29.	19	5	13	8	5	9	148	35.5	35.5	36.5	36.0	36.0
30.	18	1	12	9	5	4	152	39.5	40.5	40.3	40.2	39.8
Mean	18	8	13	7	5	1	152.8 ± 0.87	41.4 ± 0.19	41.7	42.0	40.3	41.5 ± 0.75

Note: The first six serial numbers represent the subjects whose metabolic patterns were studied.

APPENDIX III

MEAN CONSUMPTION OF FOOD GROUPS BY THE POST ADOLESCENT WOMEN STUDENTS

			Food Groups g.						
No.	Cereals	Pulses	Leafy Vegetables	Roots & Tubers	Other Vegetables	Fruits	Milk & Products	Sugar	Oil
1.	238	40.2	8.6	62.5	14.2	107	328	31	24.6
2.	309	49.6	56.8	13.4	31.4	164	288	23	13.6
3.	362	74.3	3.9	29.0	20.1	43	224	21	19.6
4.	331	49.6	9.1	37.7	38.4	34	218	18	29.0
5.	320	68.6	1.7	60.6	42.7	60	245	26	25.9
6.	378	34.7	1.6	40.1	42.5	80	259	22	26.5
7.	373	36.0	5.1	55.2	34.6	106	289	40	13.0
8.	325	80.2	7.1	59.7	21.2	140	231	37	14.6
9.	320	44.2	11.1	24.3	108.5	96	259	23	15.3
10.	373	47.8	7.6	65.3	18.1	136	257	19	24.5
11.	366	82.5	7.3	22.8	13.1	122	260	22	15.9
12.	339	30.6	7.5	32.7	27.1	57	253	40	15.2
13.	350	38.7	9.6	35.6	26.7	83	293	24	19.5
14.	372	70.7	1.4	115.0	28.3	220	242	33	22.0
15.	343	64.2	3.8	54.2	30.9	68	248	29	13.2
16.	314	62.5	1.5	27.3	71.1	55	298	18	26.9
17.	329	42.0	1.9	25.6	107.8	72	229	21	16.5
18.	274	22.6	30.0	43.0	10.8	66	248	20	18.7
19.	418	82.0	6.9	33.0	34.3	112	318	28	19.0
20.	423	34.7	6.1	97.0	55.0	114	329	20	15.0
21.	341	57.2	3.0	10.9	35.8	56	389	28	22.0
22.	322	83.0	6.3	46.2	14.8	130	250	22	13.0
23.	285	35.0	3.2	30.1	23.6	54	328	24	18.6
24.	354	38.2	15.0	16.9	66.4	94	231	17	19.9
25.	302	30.1	16.9	39.5	76.3	45	285	20	17.4
26.	338	34.9	9.9	19.6	59.8	55	242	18	18.6
27.	323	96.0	12.4	8.5	12.0	52	277	13	11.8
28.	291	25.1	13.0	56.3	65.3	47	252	20	22.2
29.	369	45.3	11.0	57.0	26.7	86	282	21	17.4
30.	344	23.6	19.7	55.0	12.5	99	266	28	8.5
Mean	336	53.1	9.2	42.4	39.0	87	269	24.0	18.2

Note: First six serial numbers represent the subjects whose metabolic patterns were studied.

APPENDIX IV

CALORIC INTAKE OF SIX POST ADOLESCENT WOMEN STUDENTS AT THE BEGINNING OF THE STUDY AND AFTER A PERIOD OF THREE MONTHS

	Beginning				After three months			
S_s No.	I Day	II Day	III Day	Mean	I Day	II Day	III Day	Mean
1.	2291	2021	2540	2284	1742	2262	1942	1982
2.	2348	2064	2074	2162	1973	1933	1328	1744
3.	1425	1624	1701	1583	1768	1766	1343	1625
4.	2118	1837	1956	1970	1543	1634	2022	1733
5.	1810	1864	1579	1751	1742	1694	1828	1732
6.	1826	2022	1677	1842	1659	1819	1682	1720
Mean	1963	1905	1928	1932 ± 97.7	1737	1854	1690	1759 ± 270.4

APPENDIX V

PROTEIN INTAKE OF SIX POST ADOLESCENT WOMEN STUDENTS AT THE BEGINNING OF THE STUDY AND AFTER A PERIOD OF THREE MONTHS

	Begining				After three months			
S.No.	I Day	II Day	III Day	Mean	I Day	II Day	III Day	Mean
1.	58.5	56.4	53.9	54.2	48.2	56.5	50.9	51.8
2.	53.6	59.1	55.4	56.0	42.1	55.8	39.5	45.8
3.	41.8	37.3	40.2	39.8	42.3	44.7	39.3	42.1
4.	44.3	48.5	50.8	48.2	38.5	45.1	40.3	40.1
5.	55.0	54.8	45.2	51.7	36.0	44.5	46.8	42.4
6.	46.4	51.8	41.0	46.4	45.4	39.6	43.6	42.9
Mean	49.9	50.4	47.8	49.3 ± 2.40	42.1	47.7	43.4	44.4 ± 1.87

APPENDIX VI

CALCULATED AND ANALYSED VALUES OF CALORIC INTAKE OF THE 30 POST ADOLESCENT WOMEN STUDENTS

	Calculated				Analysed			
S.No.	I Day	II Day	III Day	Mean	I Day	II Day	III Day	Mean
1.	2251	2021	2580	2284	2190	2094	2269	2184
2.	2348	2064	2074	2162	2117	2029	2065	2070
3.	1425	1624	1701	1583	1351	1404	1491	1415
4.	2118	1837	1956	1970	1973	1917	1747	1879
5.	1810	1864	1579	1751	1846	1661	1512	1673
6.	1826	2022	1677	1842	1780	1857	1444	1693
7.	1837	1521	1561	1637	1941	1546	1545	1677
8.	1665	1585	1577	1609	1698	1575	1422	1565
9.	2153	2623	1874	2216	1905	2373	1868	2048
10.	1938	1817	1959	1904	2018	1717	1665	1800
11.	1784	1679	1817	1760	1611	1546	1529	1562
12.	2119	2375	2148	2214	2337	2124	2037	2166
13.	2055	2141	1522	1906	1972	1953	1587	1837
14.	2047	2236	1275	1852	1930	1963	1381	1758
15.	2163	1996	1540	1899	2049	1861	1454	1788
16.	1502	1910	1843	1785	1488	1813	1820	1707
17.	1660	2338	1875	1957	1602	1911	1725	1746

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Appendix VI. Continued.

	Calculated				Analysed			
S.No.	I Day	II Day	III Day	Mean	I Day	II Day	III Day	Mean
18.	1719	1834	2026	1859	1661	1729	1869	1753
19.	1906	1504	1647	1685	1792	1529	1603	1641
20.	1910	2507	2393	2270	1882	2067	1976	1975
21.	1669	1901	1835	1801	1727	1869	1675	1757
22.	1724	1768	1991	1827	1739	1705	1875	1773
23.	1784	1619	1724	1709	1850	1518	1549	1639
24.	1948	1725	1616	1763	2088	1518	1512	1706
25.	1490	1889	1666	1681	1565	1843	1536	1648
26.	1884	1912	1409	1735	1833	1844	1556	1744
27.	1771	1750	1837	1786	1649	1661	2114	1808
28.	2065	2025	1861	1983	2292	1890	1818	2000
29.	1955	1736	1689	1793	1811	1654	1827	1764
30.	1760	1851	2266	1959	1793	1820	1820	1811
Mean	1874	1922	1821	1872 ± 22.5	1850	1800	1710	1787 ± 30.8

Note: First six serial numbers represent the subjects whose metabolic patterns were studied.

APPENDIX VII

CALCULATED AND ANALYSED VALUES OF PROTEIN INTAKE OF THE 30 POST ADOLESCENT WOMEN STUDENTS

	Calculated				Analysed			
S.No.	I Day	II Day	III Day	Mean	I Day	II Day	III Day	Mean
1.	58.5	50.4	53.9	54.3	55.2	51.9	50.7	52.6
2.	53.6	59.1	55.4	56.0	56.5	53.7	56.9	55.7
3.	41.8	37.3	40.2	39.8	37.4	36.4	36.3	36.7
4.	44.3	49.5	50.8	48.2	45.8	51.9	49.0	48.9
5.	55.0	54.8	45.2	51.7	56.0	52.4	44.3	50.9
6.	46.4	51.8	41.0	46.4	53.1	49.6	49.7	50.8
7.	52.7	45.4	47.4	48.5	61.4	46.4	44.0	50.6
8.	43.1	47.9	40.4	43.8	41.7	47.3	39.1	42.7
9.	48.8	60.3	54.1	54.4	49.1	64.5	52.3	55.3
10.	46.0	46.1	54.6	48.9	48.1	42.7	52.9	47.9
11.	51.9	44.6	57.1	51.2	53.8	36.3	42.8	44.3
12.	52.3	56.6	53.7	54.2	53.0	57.1	52.8	54.3
13.	61.8	54.0	36.3	50.7	67.1	49.0	42.6	52.9
14.	53.4	44.6	34.0	44.0	58.9	40.1	34.5	44.5
15.	55.2	56.8	35.3	49.1	56.1	45.6	32.4	44.7
16.	39.1	55.0	49.0	47.7	37.1	50.0	48.2	45.1

Contd......

Appendix VII. Continued.

S.No.	Calculated I Day	Calculated II Day	Calculated III Day	Calculated Mean	Analysed I Day	Analysed II Day	Analysed III Day	Analysed Mean
17.	45.2	51.7	60.0	52.3	42.3	49.1	58.9	50.1
18.	49.5	55.9	50.9	52.1	48.5	58.4	52.7	53.2
19.	41.0	49.4	44.6	45.0	41.2	49.0	41.8	44.0
20.	52.5	49.2	45.6	49.1	49.1	46.5	53.8	49.8
21.	48.6	45.2	51.7	48.5	49.9	44.7	48.2	47.6
22.	49.9	42.0	44.0	45.3	46.1	41.8	42.9	43.6
23.	41.0	43.2	47.8	44.0	41.2	40.7	51.0	44.3
24.	56.2	46.5	43.3	48.0	54.0	46.4	42.0	47.5
25.	48.4	42.9	38.9	43.4	47.4	42.7	39.8	43.3
26.	54.1	38.5	40.9	44.5	44.1	47.8	37.7	43.2
27.	40.8	43.0	48.6	44.4	38.7	41.4	45.1	41.7
28.	45.7	38.6	45.7	43.2	42.7	38.6	50.1	43.8
29.	57.9	56.8	56.0	56.9	59.0	54.9	58.0	57.3
30.	43.6	50.0	45.0	46.2	44.2	49.5	40.1	44.6
Total	1476.3	1467.9	1405.4	1451.5	1475.7	1436.4	1390.7	1428.9
Mean	49.2	48.9	46.8	48.3	49.2	47.5	46.3	47.6

Note: First six serial numbers represent the subjects whose metabolic patterns were studied.

APPENDIX VIII

AVERAGE DAILY ACTIVITIES OF THE SIX POST ADOLESCENT WOMEN STUDENT CALCULATED FROM A SEVEN DAY ACTIVITY RECORD IN HOURS AND MINUTES

S.No.	Lying rest	Sitting rest	Standing rest	Sitting study	Sitting house hold work	Standing laboratory work	Walking	Ascending stairs	Descending stairs	Sleep
1.	0.07	4.56	0.31	6.26	2.11	1.09	0.35	0.15	0.15	7.35
2.	0.35	4.05	0.50	5.40	2.00	1.10	0.35	0.18	0.17	8.30
3.	0.45	4.08	0.35	6.50	2.00	-	0.57	0.13	0.18	8.54
4.	0.50	4.20	0.25	5.50	1.30	1.10	0.10	0.14	0.13	8.50
5.	0.10	4.00	1.00	6.01	2.00	1.20	0.40	0.15	0.19	8.15
6.	0.40	4.30	0.38	5.47	1.29	1.16	0.26	0.25	0.25	8.25

APPENDIX IX

VOLUME OF URINE AND WEIGHT OF FECES VOIDED PER DAY BY EACH SUBJECT IN THE METABOLIC STUDY

S.No.	Volume of urine in milliliters			Weight of feces in grams		
	I Day	II Day	III Day	I Day	II Day	III Day
1.	300	390	790	138	78	48
2.	700	680	750	158	110	149
3.	780	830	500	116	84	148
4.	850	600	500	135	240	88
5.	550	750	800	125	88	48
6.	300	750	650	98	136	140

APPENDIX X

CALCULATIONS FOR STANDARD ERROR

The sample standard error is symbolised by $S_{\bar{x}}$ and it is equal to $\frac{S}{\sqrt{N}}$ where S is standard deviation of the mean, n is the the number of observations. Standard error was calculated as follows:-

$$\text{Standard error} = S_{\bar{x}} = \frac{S}{\sqrt{N}}$$

$$S = \sqrt{\frac{\Sigma x_i^2 - (\Sigma x_i)^2/n}{(n-1)}}$$

For example

S.No.	xi	xi^2
1.	143	20449
2.	160	25600
3.	151	22801
4.	145	21025
5.	165	27225
6.	158	24964
Total	922	142064

where $n = 6$

$$\bar{x} = \frac{\Sigma xi}{n} = \frac{922}{6}$$

$$= 153.6$$

$$(\Sigma xi)^2 = 850084$$

$$\Sigma xi^2 = 142064$$

Using the above formula

$$S^2 = \frac{142064 - \frac{850084}{6}}{(6-1)} = \frac{142064 - 141680}{5}$$

$$S^2 = 76.8$$

$$S = 8.77$$

$$S_{\bar{x}} = \frac{8.77}{2.449} = 3.581$$

Bases on this calculation other standard errors were calculated.

APPENDIX XI

Tests of Hypotheses concerning the Means of Two Populations:

Suppose we have two samples, one from each of two populations. We might wish to know whether the means of the two populations are equal. We will denote the two populations means by $\mu 1$ and $\mu 2$ and the two population variances by $\sigma 1^2$ and $\sigma 2^2$. To compare μ_1 and μ_2, we take a sample of N observations from the first population, a sample of N_2 observations from the second popuation; and compute the respective means $\bar{x}_1$ and $\bar{x}_2$. They to test the hypothesis that $\mu 1 - \mu 2 = 0$, we use the statistic $\bar{x}_1 - \bar{x}_2$ and reject the hypothesis if this difference is significantly far from zero:

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\ _1 - \ _2)}{S_{\bar{x} - \bar{x}_2}}$$

which becomes with $\mu 1 - \mu 2 = 0$

$$t = \frac{\bar{x} - \bar{x}_2}{S_{\bar{x} - \bar{x}_2}}$$

For example

S.No.	Group I	Group II
1.	38.0	38.0
2.	41.5	41.5
3.	36.0	36.5
4.	37.5	41.00
5.	43.0	42.5
6.	40.3	40.5
Total	236.3	240.0

/continued...

Appendix XI - Continued

$$\bar{x}_1 - \bar{x}_2 = 40.0 - 39.4 = 0.6$$

$$S_{\bar{x}_1 - \bar{x}_2} = \frac{S_1^2 + S_2^2}{2} = \frac{5.20+11.78}{2} = \frac{16.98}{2} = 8.49 = S^2$$

$$S_{\bar{x}}^2 = \frac{S^2}{n} = \frac{8.49}{6} = 1.415$$

$$S_{\bar{x} - \bar{x}}^2 = 2 S_{\bar{x}}^2 = 1.415 \times 2 = 2.830$$

Substituting the difference between the group means, along with its standard deviation,

$$\sqrt{2.83} = 1.682$$

$$t = \frac{0.6}{1.682} = 0.3568$$

Among the resultant 't' values with n-= degrees of freedom, using the 't' tables only, those with a probability of 0.05 to 0.01 or less were considered to be significant.

Based on the example given other 't' values were calculated.

APPENDIX XII

In the simple linear regression situation it is postulated that the relationship between the Yi and Xi is of the form:

$$Y_i = \alpha + \beta X_i + e_i$$

where the intercept α and the slope β are unknown parameters and the e_i are random variates from a universe with u = 0 and variance σ^2. There is, in the regression context, a very important distinction between Y and X. The variate X is regarded as being measured without "error", i.e., its standard deviation is zero. In fact, the Yi need have no parent distribution in the statistical sense.

The regression equations between N. retention and N intake used in the study were computed in the manner shown below:

$N = 6$

$Sx^2 = (222)^2 + (204)^2 + (187)^2 + (187)^2 + (136)^2 + (153)^2 = 211803$

$Sx = 222 + 204 + 187 + 187 + 166 + 153 = 1119$

$Sy^2 = (32)^2 + (35)^2 + (60)^2 + (89)^2 + (54)^2 + (26)^2 = 356$

$SY = 32 + 35 + 30 + 89 + 54 + 26 = 356$

$SXY = (222) \times 62 + 204 \times 35 + 187 \times 30 + 187 \times 39 + 136 \times 54 + 153 \times 26$

$= 37832$

$Cx = (1119)^2 / 6$

$Cy = (356)^2 / 6$

$Cxy = 1119 \times 356 / 6 = \frac{398200}{6} = 66366$

/Continued...

Appendix XII - continued.

Sx_1^2 = 211803 - 208500 = 3303

Syi^2 = 23182 - 21123 = 2059

Sxiyi = 37832 - 36366 = 1466

Mx = 187

My = 59

b = $Sxiyi/Sxi^2$ = 1466/3303 = 0.4439

a = my - b = 59 - (0.4439x187) = -24.01

$\hat{Y}i$ = - 24.01 + 0.4439xi

Correlation coefficient:

Correlation coefficient was estimated by

$$r = SxiYi \sqrt{(Sxi^2 (syi^2)}$$

The correlation coefficient was used as a measure of the degree of association between X and Y.