International Center for Research on Women
1717 Massachusetts Avenue NW, Suite 302
Washington, DC 20036

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Early Nutrition and Physical and Mental Development in Mexican Rural Adolescent Females

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by

Adolfo Chávez
Celia Martínez
Beatriz Soberanes
Luciano Domínguez
Abelardo Avila

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Authors' Affiliations

Adolfo Chávez
Celia Martínez
Beatriz Soberanes
Luciano Domínguez
Abelardo Avila

Division of Community Nutrition
"Salvador Zubiran" National Institute of Nutrition
Mexico, D.F.

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For more information, please contact:

Publications Department
International Center for Research on Women
1717 Massachusetts Avenue NW, Suite 302
Washington, DC 20036
Tel: (202) 797-0007
Fax: (202) 797-0020
Email: icrw@igc.apc.org

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Executive Summary

This report presents longitudinal data on the effects of nutritional supplementation in childhood on the physical, mental and behavioral development of 72 adolescent males and females in Tezonteopán, a poor rural village in Mexico. Using a quasi-experimental design, the investigators, starting in 1968, offered nutritional supplementation to a group of pregnant women and to the children born to these women, from birth up to age 10. These children constituted the intervention group. The other half the sample was a control group of children, chosen to have similar characteristics to those in the intervention group, that received no supplementation. Results showing the effects of supplementation and gender differences on adolescent maturation and development are plotted graphically over time, starting with age 12 up to age 18, for most tests.

Supplementation had a positive long-term impact on the physical and mental growth of both boys and girls. Supplemented adolescent girls were taller and heavier than non-supplemented girls, had more subcutaneous fat, and showed more physical ability in most physical ability tests. Supplemented girls, however, also had early age at menarche, so that they matured sooner, both physically and mentally, while non-supplemented girls matured more slowly over a longer period of time.

Overall, boys performed significantly better than girls in both physical and mental ability tests. Supplementation improved boys' mental performance significantly more than it improved girls' mental performance. While mental ages were overall substantially lower than chronological ages, supplemented boys had 2 1/2 years higher mental age than girls, and non-supplemented boys still had 1 1/2 years higher mental age than girls. Supplemented girls showed little increase in mental age after age 15, and so sustained a much smaller improvement over non-supplemented girls by the end of adolescence. The investigators postulate that girls' mental stunting may be the result of a "social ceiling" effect that inhibits the

mental progress of adolescents in general beyond a certain age, and of adolescent girls in particular, because of cultural restrictions that affect girls more than boys in traditional communities and because of their lack of access to schooling.

1. Introduction: Moderate Malnutrition

A different type of malnutrition has become increasingly widespread in Latin America during the second half of this century. The more serious, acute forms that cause death in children have decreased steadily, whereas moderate forms, which probably should be called chronic and which impair the physical and mental development of the general population, have increased. Moderate or chronic malnutrition is actually a consequence or "scar" of more serious forms of malnutrition suffered earlier in life, particularly between the ages of 8 and 20 months. These forms do not cause death but leave in their wake a "vulnerable survivor," a human being with particular deficiencies.

The common denominator of nutritional problems is a deficient and monotonous diet based on cereals or root crops. Cross-sectional studies of the nutritional status of poor communities have showed that only a few children had signs of serious malnutrition or obvious manifestations of deficiencies and that the large majority appeared to tolerate malnutrition acceptably well. In a number of studies published in the 1960s, researchers noted that, although the children of these societies did not suffer from clearly defined symptoms of malnutrition, they grew poorly.

This report presents the most recent data of a 23-year longitudinal observation study conducted among the children of a poor and malnourished village in Mexico, Tezonteopán. By analyzing the consequences of early malnutrition from school age through adolescence and up to the onset of adult life, the study describes the "natural history" of chronic malnutrition. The National Institute of Nutrition in Mexico remarked, as early as the 1950s, on the existence of "chronic" forms of malnutrition with largely functional manifestations, both of a general nature, including apathy, lethargy and wasting, as well as manifestations in some specific organs and systems. A number of articles were published on the hematological (anemia), endocrinological (a number of different hormonal changes), gastroenterological (diarrhea), and other manifestations of chronic malnutrition (1).

This research project was designed to determine the long-term impact of moderate malnutrition on physical, mental and behavioral development. The study used a quasi-experimental design that included the observation of two groups over time: malnourished children and children in the same ecological and social conditions who were better nourished (i.e., received additional food) during at least the first 10 years of their lives. The study was designed in the form of an intervention, in order to control for variables not relevant to nutrition.

Half of the children studied were given food supplements from birth to 10 years of age and the mothers received supplements during pregnancy. The other half of the children and their mothers received no supplementation. This design was used to provide information on a debate that had already emerged in 1967 (when the study was designed) on whether people in poor areas who are smaller perform worse on a number of different mental tests, and exhibit different behavioral traits relative to people in wealthier areas. If true, a second question is whether this is due predominantly to physiological, genetic, environmental or cultural determinants.

There were several reasons to think that it would be best to study a small number of cases, but with precision. The first was the need to conduct the study within the family units themselves, by living with the families for at least three consecutive days every 2 months in order to measure the amount of breast milk consumed by an infant as well as to observe the child's behavior during the survey. This task could not be accomplished by having a large number of research observers that would change over time because the families would not accept them. The second reason was ethical. Nutrition was to be improved for a number of children, while other children were to be observed within their natural environment where they would consume the usual nutritionally deficient village diet. Accordingly, these children would probably become malnourished, as children in these villages often do. This small village group was only part of some one and one-half million children who would be born in Mexico that year who would experience the same problems.

The research group felt that the study design, in which half the children would receive no food supplements, was justified from an ethical standpoint. They were studying an age-old problem, not only of Mexico, but common to most poor countries, and it was felt that the knowledge generated would be useful in motivating decision makers to invest more resources in strengthening nutritional programs and in finding solutions to malnutrition.

It may safely be said that several of the social objectives of the project were achieved. In 1973, just a few months following submission of the first report, the government of Mexico launched a large-scale program. It focused on teaching mothers how to improve children's nourishment by beginning mixed feeding at age 3 months and using foods that were available in the home but that had been ground and boiled (2). Large numbers of rural women were trained and equipped with educational materials to deliver this message to two million poor families. This was the greatest single effort resulting from the Tezonteopân research. Together with other a smaller scale but also controlled studies, it contributed to a significant reduction in the severity of malnutrition and offered useful information for the promotion of primary health care (3).

However, the economic and agricultural crisis which has plagued the country since 1982 has significantly reduced applied nutrition activities, especially those that use the techniques derived from the Tezonteopân study. This reduction has occurred despite the fact that, following Alma Ata in 1978 and the world summit on children in 1990, several countries, including Mexico, committed themselves to promoting primary health.

Celia Martinez, the resident researcher, conducted the studies on breast-feeding behavior and several other subjects between 1968 and 1973. She continues working in the village 24 years later, undertaking the studies involving adolescence and early adulthood, sometimes with very little in the way of resources and support. It is largely to her that we owe the accumulation of knowledge that has been provided by this research effort.

1. To compare the latest results with regard to the physical, mental and social development of the group of supplemented children compared with the non-supplemented children, in order to determine the "ultimate impact" of moderate malnutrition in children in developing countries, and to estimate the extent to which such malnutrition can be corrected with improved feeding.

2. By comparing differences between the sexes, to determine whether the consequences generated by moderate early malnutrition are more serious in females than in males. This second objective is especially important in the current phase of the project.

2. Design and Implementation of the Longitudinal Intervention Study

The study was planned in the form of an intervention. One group of mother-child units received supplemental food in an attempt to ensure that they attained adequate nutritional intake despite adverse conditions in the village. The other served as a control group; they received no benefits from the intervention and continued to be nourished by their families according to local custom. Observation of children in the nonintervention group provided information regarding how natural conditions led to a situation of moderate malnutrition and resulting developmental changes (4). The design was a case study and not a representative epidemiological survey. Breastmilk consumption by children was measured to assess whether the problem of moderate malnutrition was related to insufficient breast-feeding (5).

It was also felt that the primary consequences of malnutrition would be in the area of child behavior. Very little was known about this area, and studying it would also require considerable dedication (6). Since these studies could only be conducted by direct observation in the individual homes, it would not be possible to observe a large sample of mother-child pairs. According to a sample size defined calculation using the data available at that point, 40 children (20 pairs) were defined for the study.

No plans were made to study the two groups simultaneously since people of the village could have questioned why some children received supplements while others did not. Accordingly, during the first year of work, all currently pregnant mothers were studied; once their children were born, they formed the non-supplemented group. During the second and third years, diet supplementation was initiated for all pregnant women. When their children were born, they formed the supplemented group. They were paired with the non-supplemented children on the basis of physical and socioeconomic characteristics, making it possible to achieve a considerable degree of similarity between the groups from birth. It should be remembered that the non-supplemented children were two or more years older than the supplemented children.

Field work began in February 1968 and, following a period of doing general studies of the community and of developing rapport with the families, project personnel proceeded to monitor all pregnant women in the village.

In the first calendar year, 41 mother-child units were included. They were not supplemented. That is, the program did not provide them with food, nor did the research staff intervene, except in emergency situations. These children grew up with only the customary support provided by the culture and the resources of their families. They had a prolonged period of breastfeeding, with a late and gentle supplementary feeding within an environment of contamination and, accordingly, infection. These non-supplemented children had low birth weights, and in their third month their growth rate began to decrease. Two children became critically malnourished, were withdrawn from the study, and treated. A substitute was found for one of them, but not for the other. Another died under circumstances which made treatment difficult, and three left the village. Thus 36 mother-child pairs of the original 41 were left.

The following year, researchers began to observe a second group of women which had the same social and physical characteristics. Women were identified as being pregnant when they missed a menstrual period. They were immediately given a food and micronutrient supplement. This was a fruit-based milk shake of full powdered milk that, when given twice a day, would provide the 400 calories that they required daily according to recommendations. Strict experimental control was exercised and the group actually did consume a daily supplement of 325 calories. Emphasis was placed on those micronutrients that were insufficient in the village diet (iron, vitamins A and C, niacin and riboflavin). Later, during lactation the women received the milk shake three times a day.

When the children of these mothers were born, they were paired according to physical and social characteristics with the non-supplemented group until there were 36 mother-child units. This process of identification and pairing took almost 3 years.

It was planned that at the first sign of any deficiency in the children of the supplemented mothers, program-sponsored supplementation of the children would begin. The signs appeared quite consistently at about 12 weeks. First, a bottle of milk (from full powdered milk) was administered at night. When the child increased breastfeeding frequency again, he or she was given pureed fruits and vegetables from jars. (It was easier to quantify and handle such food in jars.) Subsequently, the child was nourished on an entirely "ad lib" basis by providing milk and a number of different types of purees, but with the insistence that the mother continue to breastfeed.

At age 4 years, supplementation was switched to a meat or cheese sandwich with a glass of milk twice a day. When the children began to attend school, a certain amount of irregularity in consumption of the supplement occurred because, although the school allowed the children to leave to get the supplement, they frequently did not do so, preferring instead to play. However, in the afternoon they always went to get the supplement. At age 10, supplementation was suspended.

Throughout the study, considerable effort was made to ensure that the difference between the groups was only one of food supplementation. Hence, a number of steps were taken to control the time of contact with project personnel, the number of visits, and any actions that could be considered an additional intervention or stimulus.

Several parameters pertaining to nutrition and child development were studied longitudinally. As of the date of this report, the non-supplemented children are approximately 22 years old, i.e. they have completed their maturation, whereas the supplemented children are between 17 and 20 years old. This range of age in the supplemented group occurred because the pairing and paperwork took almost 3 years. For the sake of complete comparison, only data up to 18 years of age were analyzed for this report.

3. A Marginal Village: Its Situation and its Problems

In 1968, when the study was initiated, Tezonteopán had a total of 1,495 inhabitants, most of them young. It was geographically isolated, since it was located nine kilometers from a paved highway with little access to transportation, and 2½ hours from Mexico City by car (7). The village was founded in 1884 by 18 families fleeing from a neighboring *hacienda* who settled on 200 hectares of non-irrigated land. In the agrarian land distribution of 1938, they were given an additional 552 hectares of equal quality which since that time has been their only cropland. They grow corn, beans, and squash for consumption, and peanuts as their only commercial crop.

Almost all of the families are poor, each having only 2 or 3 hectares of land, and production is scarcely sufficient to enable them to pay the debts they incur each year with store owners to finance their consumption and production expenses and, on occasion, their expenses for extraordinary events (such as baptisms and other *fiestas*, medical care, etc.). In 1968, most homes were single-room shacks built of sticks or adobe, sometimes with a separate kitchen. Their standard of living and hygiene level were quite low: there was no electricity, drinking water or any other public service. Their income at the outset of the program was estimated to be one dollar per family per day.

Their birth rate and mortality rate were quite high. Around 1966, prior to the initiation of the program, the average annual birth rate was 58.8/1,000, which explains the extremely young population, whereas the general mortality rate was 18.5/1,000. Together, these rates generated a considerable population growth. The infant mortality rate was 126/1,000 live births and the preschool age mortality rate was 16.9/1,000 of population. The changes in these statistics over the period the program was in effect are shown in the following table.

Community Demographic Statistics

(average of 5 years around the reference year)

Demographic Data	1966	1972	1978	1984	1990
Total Population	1355	1779	2195	2577	2918
Birth Rate	58.8	50.4	45.1	40.0	33.2
General Mortality Rate	18.5	12.5	9.6	9.7	6.9
Population Growth Rate	38.3	40.3	35.5	30.3	26.3
Preschool Mortality Rate	16.9	7.5	11.9	6.3	2.6
Infant Mortality Rate	126.0	108.1	76.7	77.7	61.9

Fertility was low because menarche occurred late, beginning at age 15.5 years, and menopause occurred early, at age 40.5 years (8). Inter-birth intervals were quite long (about 27 months between one child and the next) due to the fact that breastfeeding lasted for 30 months or more and postpartum amenorrhea was prolonged (about 13.5 months). Fecundity was quite high and the women did not use family planning methods during the 25 years of their reproductive lives. Hence, they had an average of nine children, of whom five would survive to school age.

The diets did not vary much. Corn provided two-thirds of dietary energy. Beans, sugar (in coffee or tea), occasionally pasta or bread, garden vegetables and, on rare occasions, meat (no more than once a week) provided the remaining one-third. Feeding patterns were very consistent among infants. Breastmilk was given as the only food for 8 to 10 months. Subsequently, the child was given small amounts of corn porridge (*atole*), broth and tortilla, gradually and with considerable gentleness, in order that the child would slowly attempt to dissolve food in his or her mouth.

Since the purpose of the National Institute of Nutrition staff was to implement the research project, which included a minimum of interventions, plans were limited to providing basic health care and supporting the community in other areas based on their specific requests. Nevertheless, as a result of the presence of the researchers and especially as a result of the fact that during this period the government promoted the development of rural areas and encouraged social mobility, significant change took place in the village. Initially such change was slow. It was not until the third year of the project that the village requested assistance in obtaining electricity and not until the fifth year that it requested assistance in getting piped water. Following this, however, the desire for change increased and around 1980 the village began to plan and requested assistance in implementing a number of additional projects, among them economic development projects that included irrigation pumps, new cash crops such as tomatoes, machinery for hulling peanuts, and trucks for transporting them. In all of these endeavors, the Institute provided support to the villagers in their dealings with the appropriate authorities.

This process of change was interrupted by the economic crisis of 1982, which left village residents with nothing but worries, as manifested in a sharp increase in the level of emigration, especially among young men. In 1982, the first *campesinos* left to work in a neighboring community and now, 10 years later, some 150 villagers, including women, work in the United States, as far away as Alaska, and Canada.

The social and economic improvement in the village, especially after 1975, changed a number of things, but curiously did not change many basic elements. For example, in the 1990s, practically all families have television sets and even VCRs, though they continue to sleep on the floor on a straw mat (*petate*). Although they have modified the construction of their houses, to brick and cement, the appearance of the houses is similar, with no windows and the same household contamination. Although there is now a water tap inside the house, they use it to fill containers, and although income has increased, villagers' diets have not changed much. The changes in infant feeding patterns, however, have been more pronounced, likely because residents have seen the improved growth of the children who received food supplements under the program. They now provide more food earlier and make an effort to obtain milk in order to supplement breastfeeding.

Despite the economic crisis that has affected the country for the past 10 years, the community continues to try to increase production, but they now also seek resources from other sources, especially wages sent home from young people who emigrate for several years. The recent trend toward emigrating from the village has been the most significant change. It is the one that is helping them to survive and even improve their status. Although it is true that there is less financing available and that prices for agricultural products have decreased, the community is less isolated and seeks the necessary resources. And, although the change in their standard of living seems hardly perceptible, it has been enough to produce some improvements in feeding and health practices toward young children. However, it has not been sufficient to promote the physical and mental development of the survivors. The improvements have reduced infant mortality, leaving many undernourished children surviving.

4. Material and Methods

The sample for this part of the study involves 72 youths, half females and half males, all of whom have reached their 18th birthday. The study design chose food supplementation as the main independent variable. Extra food was provided to pregnant women and children between the ages of 3 months and 10 years. Physical, mental and social development of the children were the dependent variables. The quasi-experimental design matched the two groups in as many variables as can be controlled in a natural setting, and the experimental variable of extra food was introduced so that its effect on one group could be longitudinally observed in comparison with the other. The difference between the groups was almost exclusively the consequence of the improved nutrition.

The factor that most threatened to confound the results of the study was that food supplementation affected the supplemented group not only on the basis of its nutrients, i.e., more calories and proteins of additional food, but also as a social stimulus, and its consumption changed both maternal and family attitudes. Perhaps most important was that the child with the improved diet modified his or her physical activity, physical development and behavior. All of this changed the child's microenvironment, and therefore, the environment's response to the child as well. For example, the better nourished child was more active and smiled more. Her father held her more than is the custom, and everyone interacted more with this very responsive child. The child received more stimulation, which in turn encouraged her nutritional status.

This project studied the effects of childhood food supplementation on the following five parameters during adolescence:

1. **Physical growth**. Weight, height, sitting height, thoracic and arm circumference, and subscapular skinfolds were measured every 6 months through age 21 in non-supplemented children and through age 18 in supplemented children.

2. **Physical performance.** Standardized tests included speed and resistance races, throwing and kicking a ball, and performance of deep knee bends, push-ups and sit-ups (9). These tests were also administered every 6 months through age 21 in non-supplemented and through age 18 in supplemented children.

3. **Intelligence quotient and mental age.** The Terman-Merrill test was administered in early adolescence and the Raven test for adults in late adolescence (10).

4. **Blood lipids.** Since one group had received full powdered milk during infancy and the other breastmilk only, blood was taken from both groups to see whether there were any differences between them in terms of cholesterol and low- and high-density lipoproteins.

5. **Behavior.** Tests were given of "learned incapacity" and "dependence-independence." "Learned incapacity" is the way in which the subjects "project" or attribute responsibility or blame to others -- their parents, girlfriends or boyfriends, luck or God -- rather than take responsibility themselves for many aspects of their lives. An attempt was also made to measure the "dependence-independence" system of rural adolescents and, in particular, to compare differences between the sexes (11).

Data Analysis

Means and standard deviations for both anthropometry and mental and physical tests for both groups and both sexes have been plotted on longitudinal graphs beginning at age 12. Analyses at earlier ages had already shown broad and consistent differences among these groups over time.

Data on physical growth during puberty (the growth spurt) were analyzed by using menarcheal age rather than chronological age. To illustrate growth relative to menarche, a new variable for girls was created: "menarcheal age." This variable equaled 0 when menarche occurred, regardless of chronological age. One year before menarche, a girl's menarcheal age equaled -1; one year after menarche, it equaled +1. If the girl experienced a growth spurt, height (and probably weight) was expected to increase most rapidly just before menarche. The statistical analysis included comparisons of supplemented with non-supplemented groups by using t-tests and 2-by-2 tables among both boys and girls.

girls. Graphs of the results, including standard deviations, were plotted over time. (A more complex analysis of the earlier childhood data are contained in a doctoral thesis (12)).

5. Early Supplementation and the Attained Anthropometry of Adolescent Females

Results are reported in this section according to chronological age. The data are analyzed further in Chapter 7, looking at changes in: 1) between ages 12 and 18, and 2) according to menarcheal age.

Attained Anthropometry

The primary data are contained in Graphs 1 through 5, which illustrate three major results.

1. There were differences that consistently favored the supplemented adolescent girls compared to the non-supplemented girls. They were taller and heavier and had more subcutaneous fat. This difference was maintained through age 18, at which point the groups can be considered adults.

2. There was a partial late recovery in the non-supplemented girls. This phenomenon is analyzed in detail below. With regard to height, the most marked recovery occurred between ages 13 and 15, after which the height gains of the two groups were parallel, at a difference of 7 to 8 centimeters at 18 years.

   The final heights were 1.46 m ± 4.6 cm for the non-supplemented females and 1.54 m ± 6.2 cm for supplemented females. This difference may be important given what is known about the relationship between the mother's height and the birth size of her child. The numbers varied around a controversial but likely "critical height for maternity" between 1.45 and 1.5 m.

3. Non-supplemented girls tended not to accumulate as much fat in late adolescence as supplemented girls. This was shown clearly with regard to weight, body mass index and subcutaneous fat. Non-supplemented girls increased only 5 kg in weight after age 15.5, their body mass index (BMI) increased very little, and they experienced almost no increase in arm circumference or subscapular skinfold. This would appear to be disadvantageous to fetal nutrition since there are data that demonstrate a relationship between the accumulation of fat in adolescence and the birth weight of her infant. (Adolescent girls do not wish to gain weight, but it is between the ages of 15 and 18 that such weight gain is extremely important for a good birth outcome if the first pregnancy is between these ages.)

Physical Ability

In almost all of the physical tests, it was quite clear that the supplemented adolescent girls were stronger and more physically able. However, there were differences between the tests that are worthy of comment:

1. Some of the tests - walking 700 yards (Graph 6), kicking a ball, (Graph 7) and doing deep knee bends (Graph 8) are the result of the contractive capacity of the leg muscles, particularly the quadriceps. The results of these tests were consistent: the better nourished girls performed better, but only by a small margin and to a degree that did not vary with age.

2. There were several other tests, especially those involving strength, such as sit-ups and push-ups (Graphs 9 and 10), in which the groups were similar between the ages of 12 and 15 but in which the difference subsequently became considerable as the supplemented girls greatly increased their ability. This is one example of a delayed effect of early supplementation.

3. In the case of throwing a ball with the hand (Graph 11), which could correspond to speed of muscle contraction, the greatest difference was between ages 13 and 16, as the supplemented girls increased their ability at age 13 whereas the non-supplemented girls did so at age 15. These differences are probably related to their different ages at menarche. When menarcheal age is controlled, the better nourished girls performed better, but by a smaller margin (Graph 76).

4. The time required to run 50 yards increased with age, particularly among the supplemented girls after about age 13 and one year after menarche (Graphs 12 and 75).

Mental Ability

The results on mental ability are of special significance. Mental ability varied with age of menarche, and those results are presented in Chapter 7. Only two points are made here regarding results according to chronological age.

1. The effect of early supplementation of females was both less clear and less obvious in the area of mental development (Graphs 13 and 14) than in the other dependent variables. Results were less clear because of the large standard deviations among the observations, largely the result of many low scores in both groups, and because the average differences, especially after age 16, were equivalent to only 0.5 year of mental age, i.e., less that five I.Q. points.

2. Both supplemented and non-supplemented groups remained at very low levels, many with mental ages of 11-12 years (I.Q.= 70 although they were 17-22 years old). Supplemented females scored slightly above this low level, whereas non-supplemented females scored somewhat below.

6. The Impact of Early Supplementation on Females Compared with Males

Investigating any differential impact of early supplementation is of interest because it allows us to hypothesize on the possible effect of environment on physiological changes. Although the boys and girls were from the same village and their socioeconomic level was the same, and although their houses, degree of contamination, school and other factors were identical, there were a number of differences between the two sexes in stimuli, attention and relationships with parents and community. Within the village, adolescent boys enjoyed much greater freedom, independence and opportunities for expression and social interaction than the girls. So although boys and girls lived in the same environment the boys had greater opportunity and ability to make use of that environment.

Generally speaking, there were large differences between the sexes, in both the supplemented and non-supplemented groups. Males were 15 to 17 centimeters taller, and they performed much better on the physical tests and, especially, on the mental tests.

Graphs 15 through 28 show that boys experienced deficits from early moderate malnutrition that were very similar to those seen in girls, though there were a few significant differences.

1. The effects of early malnutrition on boys were very similar to those on girls with respect to anthropometric changes (Graphs 15 through 19). Non-supplemented boys recovered in height somewhat during adolescence. From being 13 centimeters shorter at age 12, they were only 7.7 centimeters shorter at age 18. At age 12 there had been both nutritional differences and hormonal differences as a result of their different age of maturation. With regard to weight, the situation was the opposite, the main difference being that supplemented boys increased in weight per centimeter of height beginning at age 14, but particularly from age 16 on. This was not the result of an increase in muscular mass, as the difference in arm circumference was not particularly significant and it did not change. Instead, it was the result of an increase in subcutaneous fat, which was evident in supplemented males after age 16.

2. In strength and muscular dexterity, supplemented boys showed the same increased ability with regard to non-supplemented boys that was previously

mentioned for girls, except that in boys the effect of hormonal changes was less observable, for example in the ball throw (Graphs 20 and through 26).

In supplemented boys there was an increase in strength, especially in the larger muscles such as the abdominals, beginning at about age 15. In all other tests, results for supplemented boys parallelled those for non-supplemented boys, with very few differences.

3. Boys differed considerably from girls on the mental tests. The tests were standardized for both sexes and schooling was quite similar for both groups. What was not equal is what has already been mentioned as regards the opportunities they received from their families and communities for moving about and expressing themselves.

The shapes of the mental development graphs for girls (Graphs 13 and 14) and boys (Graphs 27 and 28) were similar, except the following differences.

1. Boys attained higher mental ages than girls -- 1½ years in non-supplemented boys and 2½ years in supplemented boys.

2. The difference between supplemented and non-supplemented subjects was greater in boys. This might indicate that early supplementation is more favorable to boys than it is to girls. This phenomenon could be an environmental effect to the extent that the community conditions a "ceiling" with regard to the mental progress of both sexes, but particularly to that of girls.

3. Girls showed little increase in mental age after 15 years, whereas all boys, whether supplemented or non-supplemented, continued to increase. The possibility that the community establishes such a "ceiling" with regard to the mental development of adolescents, especially girls, is very real and is due in part to the dearth of resources in the village, including culture and schooling. Culture tends to greatly restrict expression among adolescents, for example, custom dictates that they should not offer their opinions, propose innovations, or suggest that things be done differently. For this reason, it is possible that at age 15 a "ceiling" is imposed upon them that prevents any further mental progress. The best that they can do is to achieve the "maximum" level prevailing in the village.

7. Changes During Adolescence (12-18 years) and According to Menarcheal Age

A number of different graphs illustrate the primary changes that the girls went through during puberty. Several items of interest were discovered with regard to their growth and physical and mental maturation.

1. **Height** (Graphs 29 through 31). After age 12 non-supplemented, girls grow much more than supplemented girls, by almost 4 centimeters (Graph 29). This difference was greater than that observed in boys, where growth was greatest after age 16 (Graph 30).

   If height is graphed according to age of menarche (Graph 32), the phenomenon is reversed. Supplemented girls grew more and over a longer period of time than the non-supplemented girls (8.5 cm. vs 6.7 cm.) following menarche (Graph 31). The growth process began at a much earlier age. Among supplemented girls, menarche occurred at age 12 years and 8 months, whereas among non-supplemented girls it occurred at age 14 years and 2 months, a difference that is significant at a level of 0.001.

2. **Weight** (Graphs 33 through 36). There were no big differences in the increases recorded by supplemented and non-supplemented girls after age 12 (Graph 33). This was also true for boys (Graph 34). But after adjusting for age at menarche, there was a very noticeable late increase in those that were supplemented (Graph 35). This is especially obvious in Graph 36 in which it can be seen that 3 years after menarche, non-supplemented girls no longer gained weight, whereas supplemented girls continued to gain.

3. **Body mass index** (Graphs 37 through 40). After age 12, supplemented girls had greater weight gains for their height than non-supplemented girls (Graph 37). Similarly, from 2 years after menarche, supplemented girls tended to have much greater weight gains for their height than did non-supplemented girls (Graph 39). Increases in body mass index were much clearer in boys, especially among those between ages 16 and 18 (Graph 38).

4. **Fat mass** (Graphs 41 through 48). After age 12 the biggest difference between boys and girls was that after age 14 the supplemented girls greatly increased their fatty tissue. In this respect, the differences between the supplemented and the non-supplemented groups were few and occurred late. However, after adjusting for age at menarche, one year following menarche, the supplemented girls quickly increased their subcutaneous fat and the non-supplemented girls did not. This is important with regard to future childbearing.

5. **Muscular strength** (sit-ups and push-ups) (Graphs 49 through 56). The differences between supplemented and non-supplemented girls were marked. The increase shown by supplemented girls began 1.5 years following menarche in the case of sit-ups (Graph 53) and 2 years for push-ups (Graph 54).

6. **Leg strength** (Graphs 57 through 68). The results for supplemented and non-supplemented girls were quite similar. Three of the tests used -- doing deep knee bends, walking 700 yards, and kicking a ball -- relate primarily to the strength of the quadriceps. In these three tests, the differences between supplemented and non-supplemented girls, both following age 12 (Graphs 57 through 59) as well as following menarche (Graphs 63 through 65), were quite small. There was also no difference between supplemented and non-supplemented men following age 12 (Graphs 60 through 62).

7. **Speed of muscle contraction** (running time and ball throw)(Graphs 69 through 76). The test involving running fast was the only test in which the malnourished girls performed better. For both supplemented and non-supplemented girls, the time required to run 50 yards increased, i.e. they all performed worse as they get older. But the non-supplemented girls increased their time less, i.e. they performed better compared to the supplemented girls. The increase for the non-supplemented group was less than for the supplemented group after age 12 (Graph 69) and especially after menarche (Graph 73). Since this test requires a "fast start", perhaps the greater weight of the supplemented girls caused them to be slower.

   In the test involving the distance that they could throw a ball, both supplemented and non-supplemented girls improved with age. The influence of menarche was clear. Because of it, the supplemented girls were first to increase their distance after age 12 although the non-supplemented girls did so subsequently. By age 18, both groups threw a ball a similar distance.

   Supplemented boys clearly increased their running time after age 12, i.e., they become slower, whereas non-supplemented boys maintained their times. The distance for throwing a ball, in contrast, was almost equal for both groups.

8. **Mental tests** (Graphs 77 and 87). There was a considerable degree of levelling off in the progress of both supplemented and non-supplemented girls. Between the ages of 12 and 16, that 45-month period when girls should exhibit maximum progress, they increased only 25 months in mental age, half of that expected. Between the ages of 16 and 18, when progress should be slight, they managed to catch up somewhat. Mental age

continued to increase. When analyzed according to increases after age 12 there was no significant difference between the increases of the supplemented and the non-supplemented girls.

The lack of progress especially among supplemented girls was particularly clear with the intelligence quotient (I.Q.), obtained by dividing mental age by chronological age (Graph 78). At age 12, supplemented girls had attained a level considerably higher than non-supplemented girls but, perhaps as a result of their early menarche, their development did not continue when adjusted for age at menarche (Graph 82). Progress after menarche was similar for both groups.

Graph 82 shows a very interesting phenomenon: non-supplemented girls experienced a late upturn in their intelligence quotient beginning 2 years after menarche. An increase at this time was not expected. There are two possible reasons for the increase. First, the non-supplemented girls matured over a longer period of time. Second, the non-supplemented girls, who had lagged very far behind, experienced delayed progress in attaining the "ceiling" established by the community.

Graph 84 shows that 4 years following menarche, non-supplemented girls almost caught up with supplemented girls and recovered what they had lost prior to menarche. This is probably closely related to the above-mentioned "low ceiling" imposed on the mental development of rural girls.

8. Gender Difference and Supplementation

The Terman-Merrill test used in this study is standardized up to a mental age of 16 years and since most of the cases did not exceed this mental age, we continued to use it up to a chronological age of 18. It was found that all groups, and especially those who were not supplemented, continued to progress in their performance on the tests. This could mean, on one hand, that in this type of population group, especially among the malnourished, a phenomenon exists by which changes continue to occur following age 16 or, on the other hand, that an effect occurs as a result of learning conditions or effort put forth as a consequence of repeated exposure to the same tests. To control for this learning effect of repeated exposures, we also applied a different ability test, the Raven test, which is for adults and therefore also controls for the effect of age.

With regard to the interpretation of the results of the Raven test, it must be borne in mind that the youngsters who were supplemented were between 2 and 4 years younger than those not supplemented and that when the test was administered, 30 percent of the supplemented males were not truly adults as they were between 16.5 and 18 years old. If it had been possible to administer the test again after they were 18 years, the differences as a result of supplementation might have been even greater. The following table presents the gender differences.

Difference in the Raven Test by Sex

(Average Scores from Two Applications to Supplemented and Non-supplemented Individuals)

Group	Sex		Significance of the Difference
	Female	Male	
Non-supplemented	28.5 ± 8.2	33.0 ± 11.1	0.1
Supplemented	31.5 ± 12.2	41.6 ± 11.2	0.03
Total	30.1 ± 10.5	38.0 ± 11.7	0.01

The results of the Raven test replicate the phenomenon described above for the Terman-Merrill test:

1. As a group, females obtained much lower results, with a significance of 0.01, than men.

2. Supplemented females performed only marginally better on the tests than those who were not supplemented. The difference was less than 5 points and was not significant. This is probably due to the fact that supplemented females ceased to show gains from age 15 on.

3. Supplementation was more favorable to males, as those who received it obtained considerably better scores than those who did not.

A statistical model was developed to analyze other gender differences related to whether the subjects were supplemented or not. The objective was to determine which aspects of adolescent life showed most benefit from early supplementation. As a basic criterion, each parameter was measured every six months between ages 14 and 18, and the differences between the sexes were analyzed. The most significant results were the following:

1. **Anthropometry.** The body mass index increased more with supplementation in males than in females, if one compares supplemented to non-supplemented subjects. In contrast, among non-supplemented subjects, the change in BMI was greater in females. Accordingly, from the

standpoint of fat accumulation, early supplementation was less beneficial to females.

2. **Physical tests.** It was very significant that supplementation caused more changes in males, especially with regard to strength. Non-supplemented females ran better than supplemented females, whereas non-supplemented males were limited in many of the tests.

3. **Mental tests.** Malnutrition affected the mental ability of adolescent females to a much greater degree than males (non-supplemented females had lower mental scores than males). Furthermore, supplementation was more beneficial to men (the improvement of supplemented over non-supplemented males was greater than the improvement of supplemented over non-supplemented females). These were the most important aspects of the analysis.

An instrument to assess "personality or character" variables related to learned incapacity did not generate the expected results. This test was constructed and standardized for urban areas, where adolescents are more active, expressive and independent than those in rural areas. The rural test scores obtained were quite low, regardless of supplementation status or gender. The nutrition and gender variables are, however, related to aspects associated with behavior control systems. The sexes were significantly different in their relations with their parents and their characteristics involving personal appearance. Supplemented adolescent girls were better able to manage their relationships with their parents and were less controlled by them than non-supplemented girls. With regard to personal appearance, the supplemented males took greater care with their dress and neatness than the non-supplemented males or either group of females.

Perhaps the primary difference attributable to supplementation was that non-supplemented females were psychologically more tied to their families. They attributed to their parents almost all responsibility for their behavior and took their views into account in all decision-making, whereas supplemented females made more of their own decisions. The results suggest that supplementation helped them to partially counteract learned incapacity from cultural factors that were so influential in "weighing down" individual development among village adolescents.

9. Blood Lipids

Studies of blood lipids in supplemented and non-supplemented subjects were conducted to investigate whether the consumption of milk (the supplement) in infancy among supplemented children would cause higher levels of total cholesterol and low density lipoproteins (LDL). The results show that the situation was the reverse. The supplemented subjects tended to have lower total cholesterol and LDL, although the differences were not statistically significant (Graphs 85 through 88).

There has been an important change in the basic eating habits in the village in recent years in addition to the milk supplement in infancy. When the groups were selected, the village diet consisted primarily of corn meal tortillas and beans, with young children being given breast milk, corn porridge (*atole*) and bean broth, which were inadequate to maintain good nutritional status. Over the past ten years, the village has become integrated with the national market on a commercial scale. Village residents frequently leave the village to work and shop, and trucks visit the village with merchandise for sale, especially low-quality industrial products (bread, pastry, fried foods, soft drinks, mayonnaise, etc). The changes in food consumption over the past ten years have exposed adolescents and young children over 10 years of age, whether previously supplemented or not, to a diet containing more animal fat than previously. They now consume pork lard for cooking, large amounts of pork rinds and considerable amounts of soft drinks, pastry, and fried foods.

One possible interpretation of the results of the blood tests is that the consumption of cow's milk at an early age, in the moderate or appropriate amounts in which it was administered during the supplementation process, does not cause cholesterol levels to increase later in life or with greater frequency than in non-supplemented people. Rather, the reverse may be true. The consumption of cow's milk might build adaptive mechanisms that later help them to better tolerate fat.

In conclusion, we might state the hypothesis, which should be tested in another research project, that from the standpoint of metabolism it might be undesirable not to ingest milk or food containing fat during early childhood, and to consume them only later during adolescence. Later first consumption may actually make people more susceptible to high cholesterol and arteriosclerosis.

Unfortunately, the number of cases studied in this cohort of young people is insufficient to test this hypothesis. It is likewise insufficient for further investigation of certain other observations made by the field researchers. For example, it was observed that obesity was more likely to occur in children who were not supplemented, i.e. who were moderately malnourished in early childhood. It was also observed that non-supplemented adolescents, who were shorter, consumed a lot of high fat food in their early youth, which contributed to the fact that many more among them were becoming overweight than among the supplemented individuals. Could this also be one of the mechanisms related to the high frequency of diabetes found in the Mexican population?

10. Conclusions

The data clearly show that early malnutrition in childhood has a major impact on late development during adolescence and on the final physical features of rural adults.

Girls who were not nourished with food of good quality between the ages of 3 months and 10 years and who did not consume sufficient amounts of energy and other nutrients failed to subsequently achieve adequate nutritional, mental and physical status important for them as individuals and as childbearers. Thus, for example, most non-supplemented females failed to attain a height of 1.50 meters and to accumulate an appropriate reserve of fat, factors known to be important in providing protection during childbearing. They also failed to attain an intelligence quotient of 70.

Better nutrition in childhood helped the supplemented girls attain satisfactory status up until menarche, but subsequently the non-supplemented girls almost caught up with them in various respects. This was the result of two factors. First, earlier menarche of supplemented girls reduced development time, so they matured sooner both physically and mentally, whereas non-supplemented girls matured more slowly and over a longer period of time. Second, there probably exists a culturally imposed social "ceiling" affecting female development that greatly restricts their progress, particularly during adolescence.

After age 12, non-supplemented girls grew more in height than the supplemented girls. Both groups of females seemed to grow less after 16.5 years. At age 12, there was a difference of about 14 cm between the two groups of females; by age 18, the difference was only about 5 cm. Thus, by age 18 the non-supplemented girls had gained back about one-third of the gap in height that existed at age 12 between them and the supplemented girls.

Similarly for boys after age 12, the non-supplemented grew more in height than the supplemented. All of them, however, continued to grow rapidly after 16 years. At age 12, there was a difference of about 13 cm between the two groups of males; by age 18, the difference was only about 7 cm. Thus, by age 18, the non-supplemented boys had gained back about half of the gap in height that existed at age 12 between them and the supplemented boys.

Some effects of early supplementation were manifested during adolescence, for example, the accumulation of fat 1 or 2 years following menarche. This can be explained by the hypothesis that early consumption of foods rich in fat, such as milk, promotes greater cellularity in fatty tissue in children and that accordingly it became more likely that fat would accumulate at the end of the growth period.

There were readily observable anthropometric differences between supplemented and non-supplemented females that unfortunately were not measured and accordingly not documented in this research project. Females supplemented in infancy attained not only greater height and a better distribution of fat but also longer legs, a larger waist, and a better upright position. This was due to the fact that their hips had become broader and more horizontally oriented. These morphological differences can be important to childbearing, both for better growth of the fetus and for fewer problems during childbirth.

Differences related to supplementation were clear in certain aspects of physical ability, such as the ability to do sit-ups. This was not true, however, with regard to leg strength and speed. There was no difference in leg strength between supplemented and non-supplemented adolescents, and speed was greater for non-supplemented females than supplemented ones.

More important were differences in intellectual development. There were documented differences, as shown in the graphs, as well as undocumented differences, which should be the subject of further research. In the Terman-Merrill tests, it was discovered that the differences in early adolescence tended to disappear by late adolescence. The tests in which poorly nourished subjects exhibited the greatest degree of failure were those involving language, attention and memory. Poor results in these same areas had also been noted during the second and third years of life.

Non-supplemented females also had more "learned incapacity," exhibiting a greater tendency than supplemented females to attribute their current and future circumstances to others rather than self -- their parents and "superior" forces, such as God or luck. This learned incapacity reflects a restrictive culture. Supplemented females attributed more responsibility to themselves than non-supplemented females, but still attributed much to external forces.

Improvement in IQ scores seems to be a long-term benefit of supplementation in early childhood. For both boys and girls, the supplemented adolescents had higher IQ scores than the non-supplemented at the beginning and end of adolescence (ages 12 and 18). The pattern of change in IQ scores during adolescence, however, is different for boys and girls. Supplemented girls did not experience an increase in IQ scores, whereas all boys and non-supplemented girls did. The pattern in girls was most striking by menarcheal age. Non-supplemented girls gained 3 IQ points after menarche whereas supplemented girls lost 2 points.

One explanation may lie within a larger pattern of girls having much lower IQ scores than boys (71 vs. 82). The community may have a lower "ceiling" for girls, and supplemented girls may have already reached or exceeded the ceiling by the beginning of adolescence. In addition, the tests might favor the males in many ways. For example, the females were less interested in the tests and became nervous while taking them, whereas males used "trial and error" methods more extensively.

There is a low social ceiling for both sexes, but particularly for girls. They have nothing to read, they are apathetic, they feel there is little reason to think, synthesize or analyze. The boys talk more with the adults, and express some opinions. The girls take care of the young children and do the domestic work. Also, non-supplemented females were less emotional and less participative, and they had a considerable degree of passiveness.

One topic deserving particular mention is the difference observed between males and females. The results from the earlier analyses of this study showed that it is quite possible that females are more malnourished than males. However, it also showed that girls were better able to survive, perhaps because girls were able to grow with 20 percent less energy than boys (13). This difference is characteristic of all primates and explains why in all species equal numbers of each sex are born, yet groups of surviving adults have only one male for every two or three females.

The oft-mentioned cultural factor — that boys enjoy more protection than girls — was neither documented nor observed in the early age groups. There is no doubt that preferences are given to boys, but such preferences do not translate into discriminatory practices. The same is true during adolescence, but at this age there are cultural practices that are definitely discriminatory against adolescent girls.

In general, malnutrition caused more physical, mental and social "weakness" in females than in males. This "weakness" made females more likely to be deprived of social and family rights and even to be shunted aside, mistreated and even beaten by males, as is customary in the community (14).

In both sexes, but more so among females, the malnourished group exhibited a considerable degree of passiveness and low levels of emotion. Indeed, whether love or passion actually existed among the non-supplemented group was the subject of many discussions. There was no model of physical beauty or perhaps even of intellectual ability or behavior that was preferred. The most accepted value for purposes of matrimony was "that he or she be hardworking" or be able to contribute financially.

All of the above-mentioned traits regarding the character and behavior of malnourished *campesinos* require further research, especially regarding their security, independence, and responsibility, not only in and of themselves but also regarding differences between the sexes and the impact that nutrition during childhood or adolescence might have on those traits.

Analyses of data conducted with regard to menarche show the considerable importance that nutrition has for development and to menarcheal age. Females who are malnourished in infancy grow and develop for a longer period of time prior to reaching menarche, which helps them to recover a portion of their earlier loss.

In the post-menarche stage, supplemented females experienced better and faster growth and development in many aspects, whereas non-supplemented females grew and developed more slowly, although for a longer period of time, often recovering much of what they had lost.

Following development, at age 18, both groups of women unfortunately still had deficiencies. Supplemented women, as a result of their early menarche and social limitations, failed to reach an acceptable level of physical, mental and social development, and non-supplemented women, although they did experience a considerable recovery, failed to reach the level attained by the supplemented group.

In conclusion, non-supplemented rural females showed considerable physical, mental and social weakness that not only affected them individually but will also affect them in future childbearing. Malnutrition is the vehicle for passing on short stature, low fat reserves, limited functional capacity, and particularly intellectual, behavioral and social limitations.

It is highly probable that improved nutrition for girls during the crucial years of early development would ensure the nutritional status of adolescents. Supplementation in infancy definitely helps, since it helps females to overcome certain minimum physical and functional limitations, but it is also quite possible that nutritional support is required during adolescence as well. The potential effect of such support should be investigated.

The weakness in physiological, behavioral and social traits of the females in the study population is quite similar to that observed in other developing countries and surely carries into their adulthood, affecting as well their dependence and lack of social rights. A solid nutrition and primary health program that promotes not only infant survival, which is increasingly attained, but also improved development, can surely aid in breaking the vicious cycle of malnutrition in the community.

The study demonstrated that the improved early nutritional status of girls can aid them in overcoming the physiological and social limitations that put them at risk during childbearing and that contribute to the vicious cycle of malnutrition in the community. A solid nutrition program for girls and women would help prevent malnutrition at its source by preventing that aspect of malnutrition that is dependent on the mother. This occurs during the initial months of human development: intrauterine development and birth weight, early breast-feeding and breast-feeding from 3 to 8 months, which should provide the child with the growth and reserves required to traverse the "valley of death" between 8 and 20 months. This study has shown that maternal malnutrition can be partially prevented by improved nutrition for girls during childhood.

References

1. Zubirán S. Principales manifestaciones clínicas de la desnutrición en nuestro medio. Rev. Inv. Clín. Mex. Vol. 6:157, 1954.

2. Muñoz de Chávez M. y Chávez A. Evaluación de un programa de educatión masiva para mejorar la alimentación infantil rural. Rev. Inv. Clín. Mex. Vol. 38, Suppl. "La Nutrición en México 1980-1985," pag. 153, 1986.

3. Chávez A., Avila A., Bermejo S., Roldán J.A. and Madrigal H. The food and nutrition of Mexico: A report of the 1960-1990 tendencies on food consumption, nutrition status and applied program. ICC-ICN technical report on the world food situation, Geneva Feb. 1992.

4. Chávez A. y Martínez C. Nutrición y desarrollo infantil. Nueva Editorial Interamericana, México, 1979.

5. Martínez C. and Chávez A. Nutrition and development of children from poor rural areas I. Consumption of mothers' milk by infants. Nutr. Rep. Intern. 4:139, 1971.

6. Chávez A., Martínez C. and Yashine T. Nutrition, behavioral development and mother-child interaction in young rural children. Fed. Proc. 34:1574, 1975.

7. Chávez A. and Martínez C. Growing up in a developing community. INCAP-UNU Publ. 1982.

8. Chávez A. and Martínez C. Nutrition and development of infants from poor rural areas III. Maternal nutrition and its consequences on fertility. Nutr.Rep.Intern. 7: 1, 1973.

9. Huenemann R.L. et al. Teen agers: Activities and attitudes towards activity J. Am. Diet Asoc. 51:433, 1967.

10. Chávez A. and Martínez C. Nutrition and development of children from poor rural areas V. Nutrition and behavioral development. Nutr. Rep. Intern. 11:477, 1975.

11. Soberanes B. Suplemento alimenticio, actitudes de los padres y la incapacidad aprendida en adolescentes campesinos. Tesis. Escuela de Ciencias Sociales, Departamento de Psicologia, México, 1992.

12. Schlaepfer L.V. A longitudinal study in a rural Mexican community: Analysis of the growth, health and nutrition aspects (0 through 10 years of age). Doctoral Thesis, University of Maryland, College Park, 1986.

13. Chávez A., Martínez C., Ramos Galván R., Coronado M., Bourges H., Díaz D., Basta S., Nieves M. and Garcidueñas O. Nutrition and development of children from poor rural areas IV. Differences attributable to sex in the utilization of mothers milk. Nutr. Reports Intern. 7: 603, 1973.

14. Muñoz Ch. M. y Martínez C. El nivel de vida de la mujer campesina. Ed. Div.de Nutr. L-25, México, D.F., 1975.

LIST OF FIGURES

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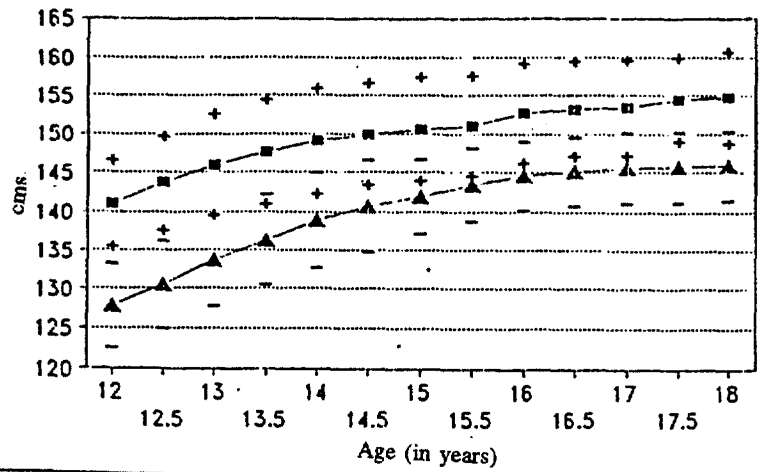

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2. AVERAGE WEIGHT
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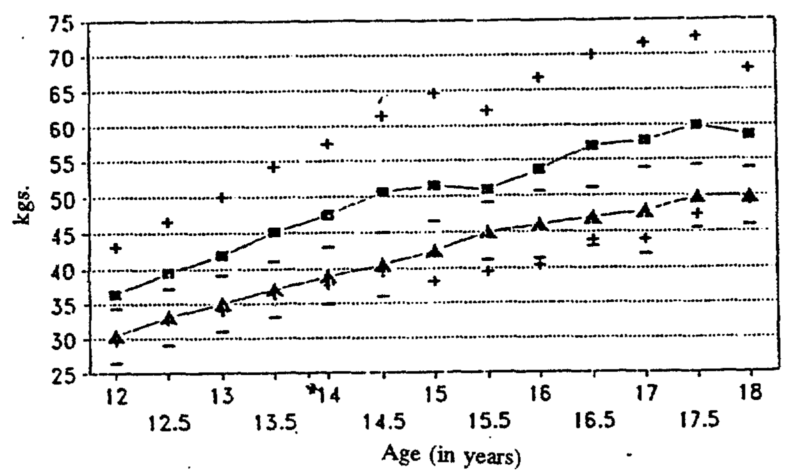

-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

3. AVERAGE BODY MASS INDEX
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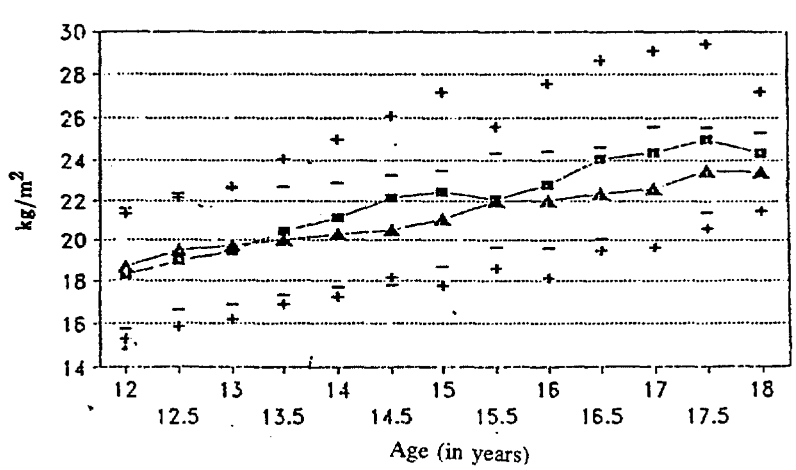

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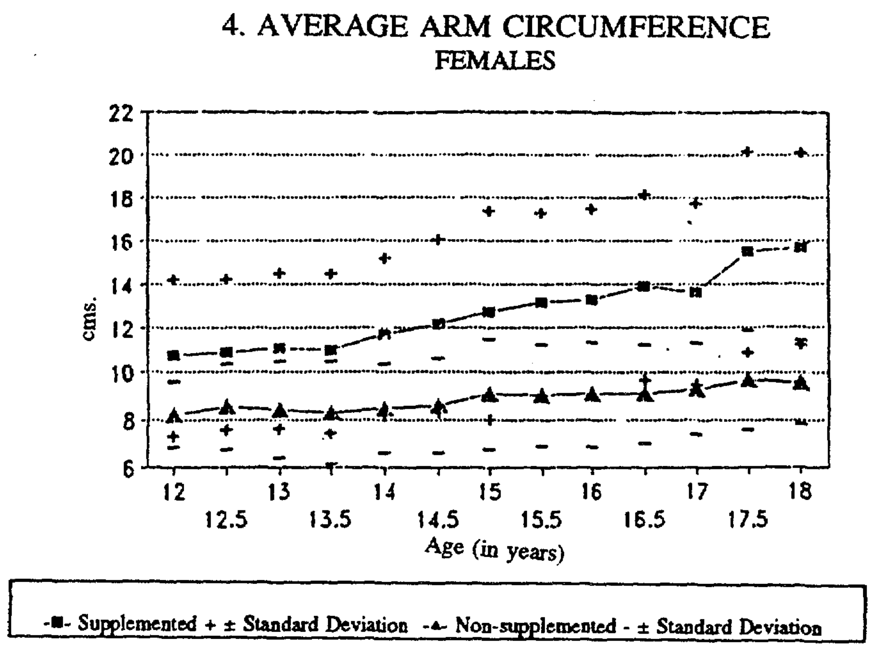
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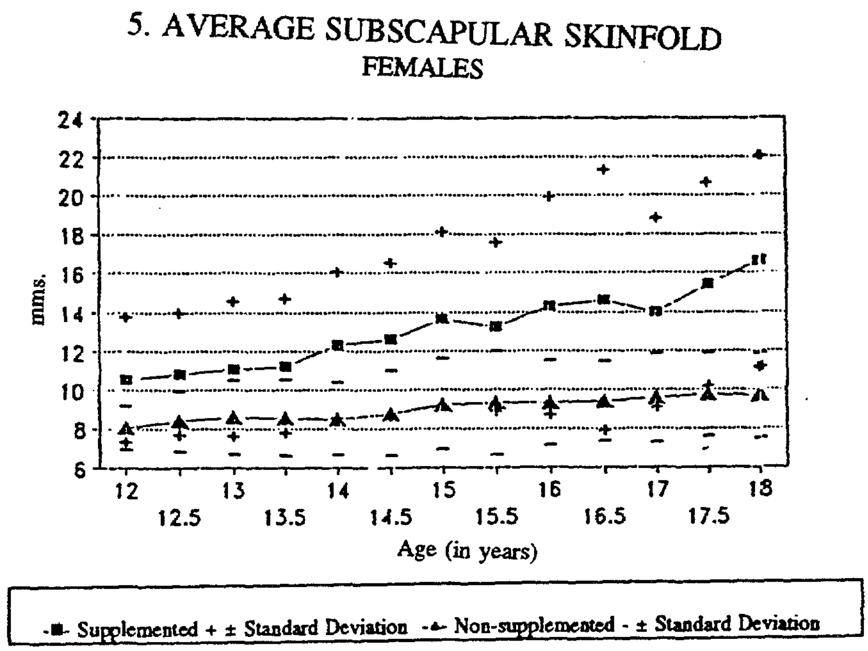
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation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Age (in years)
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

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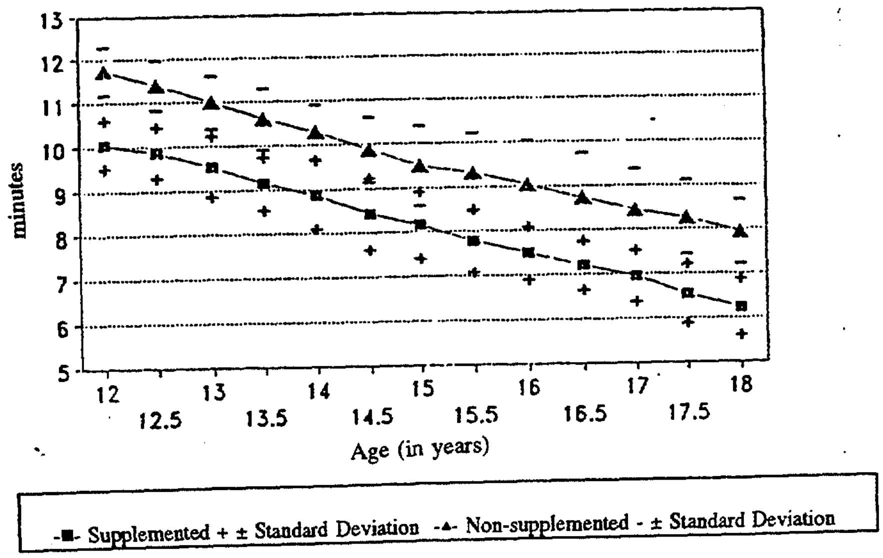

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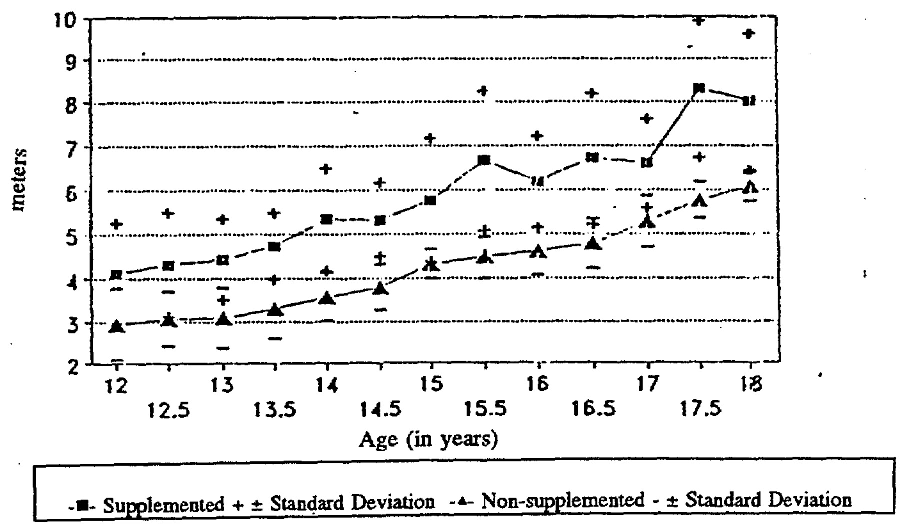

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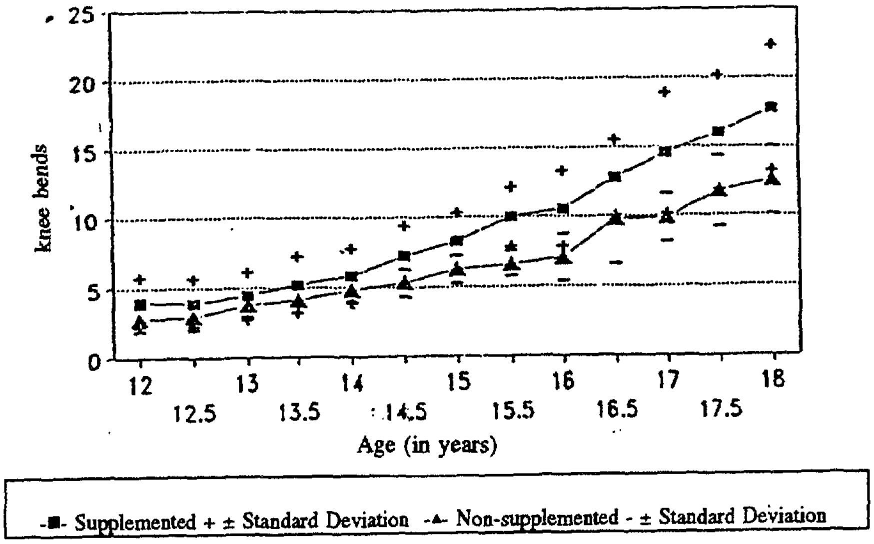

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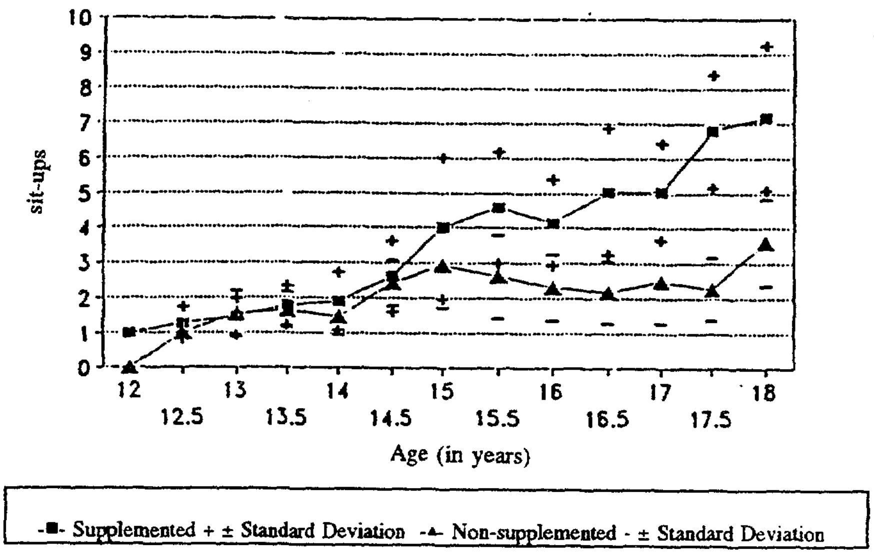

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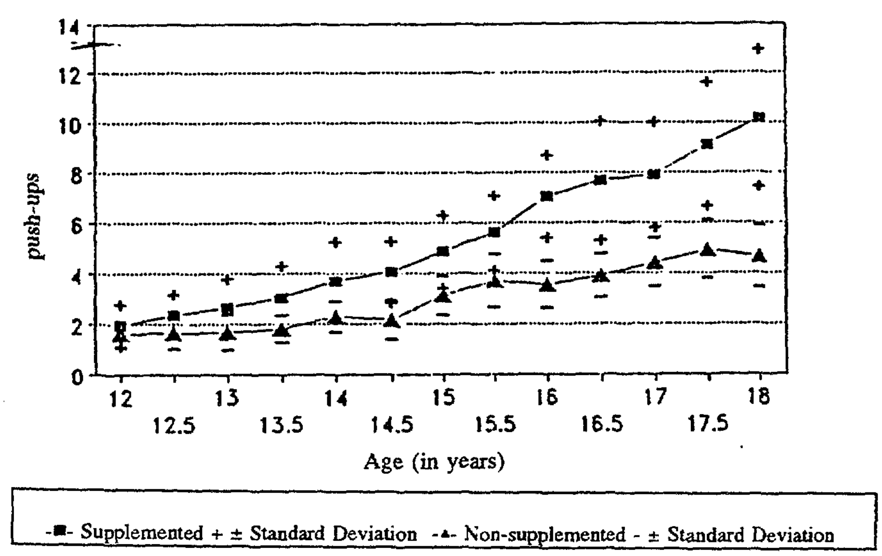

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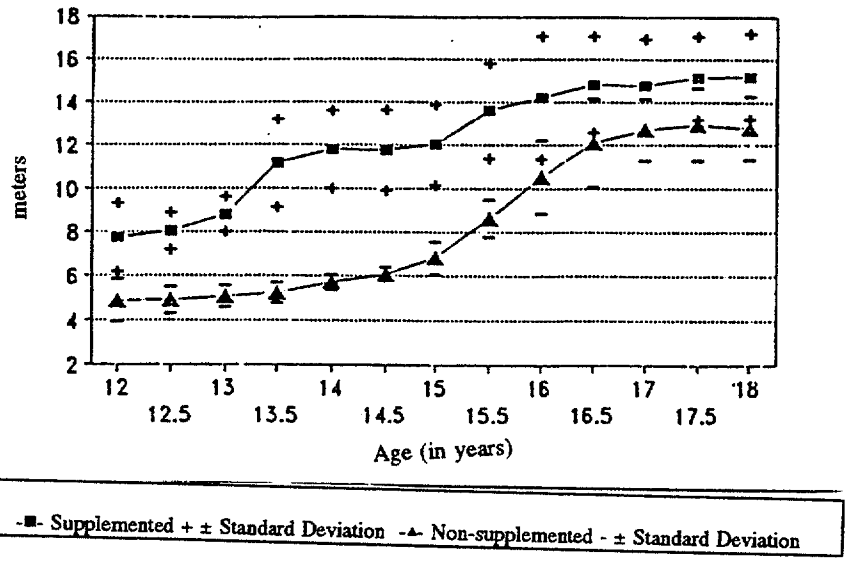

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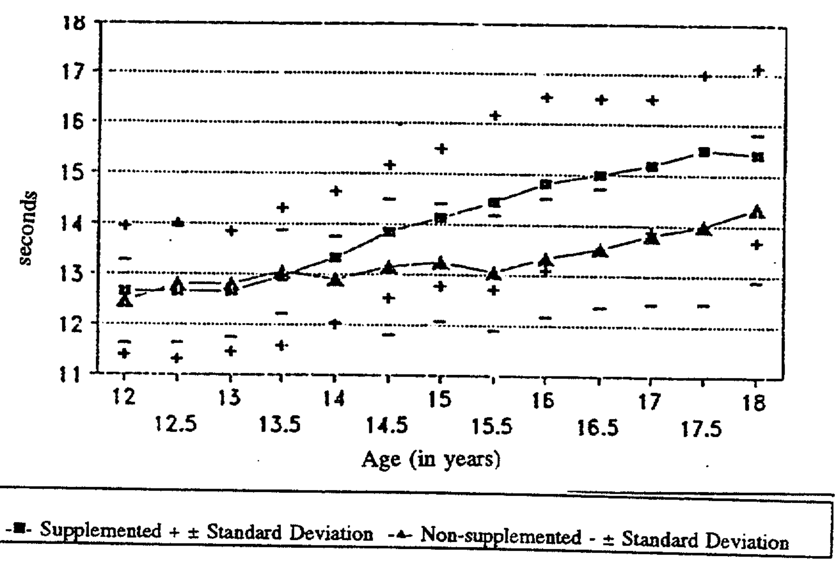

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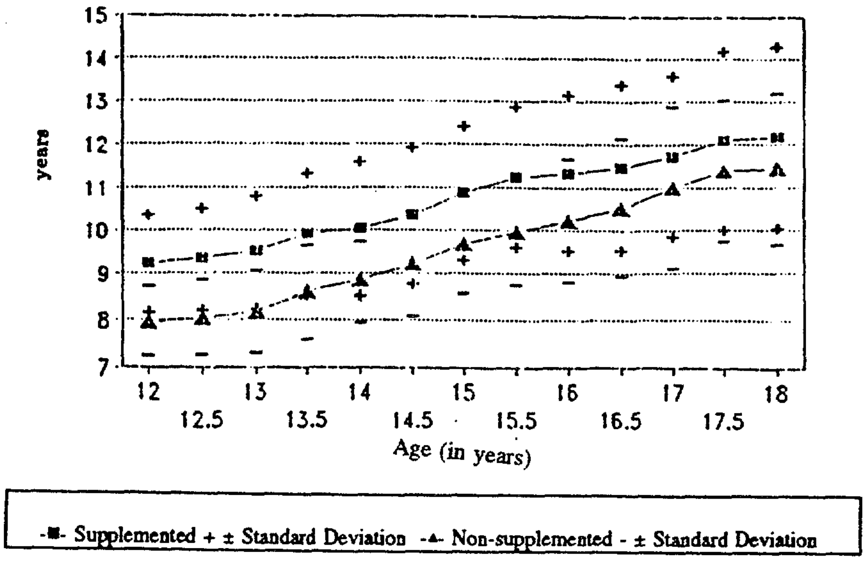

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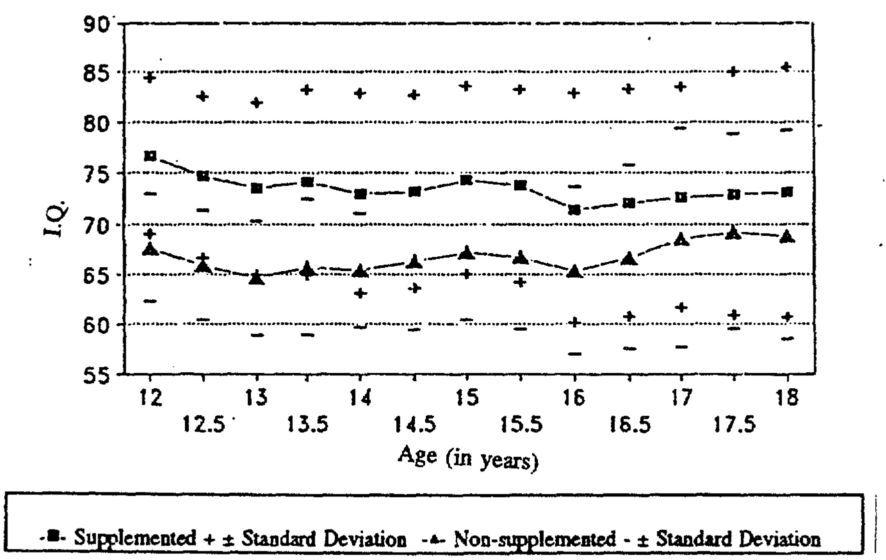

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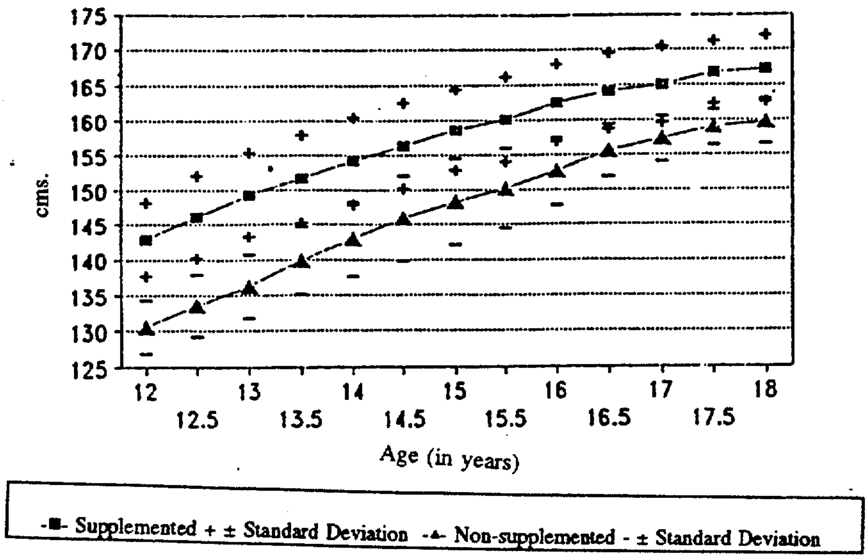

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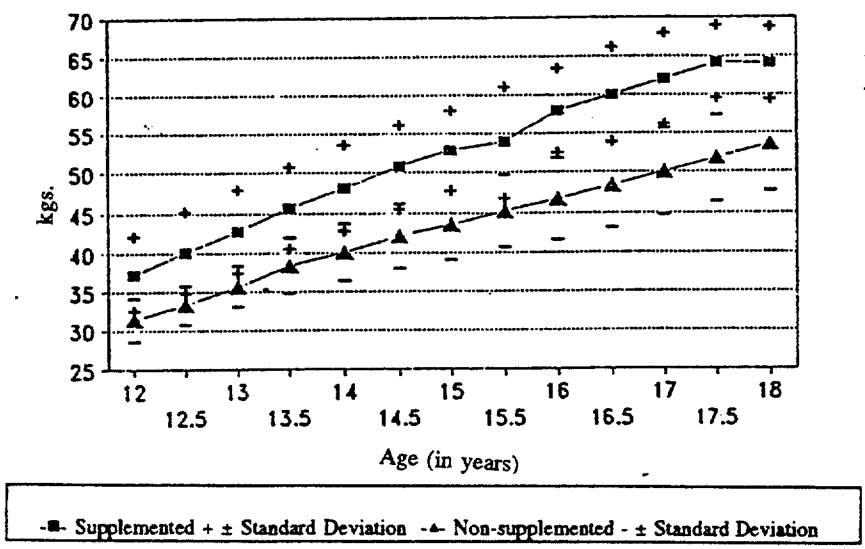
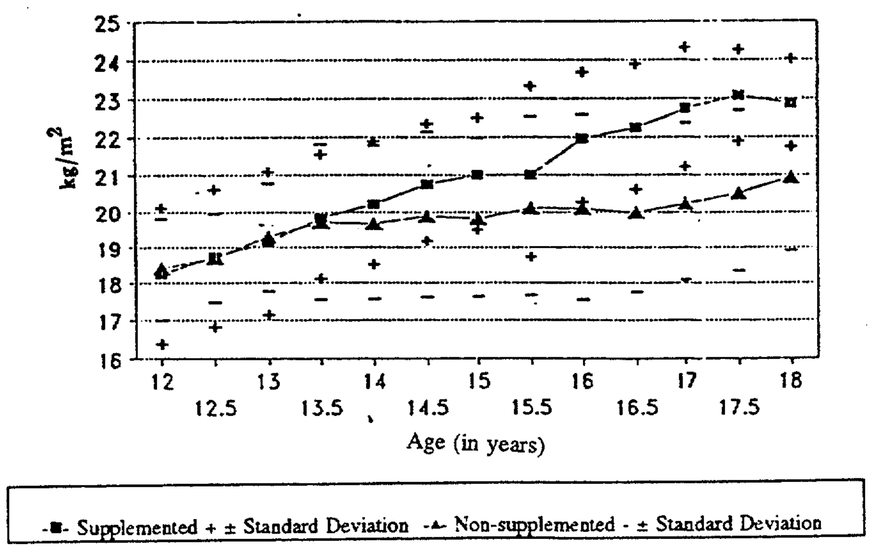
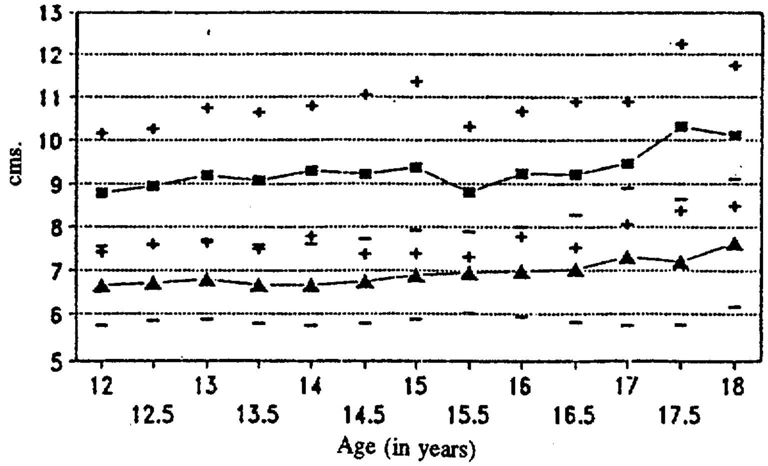
MALES



17. AVERAGE BODY MASS INDEX
MALES

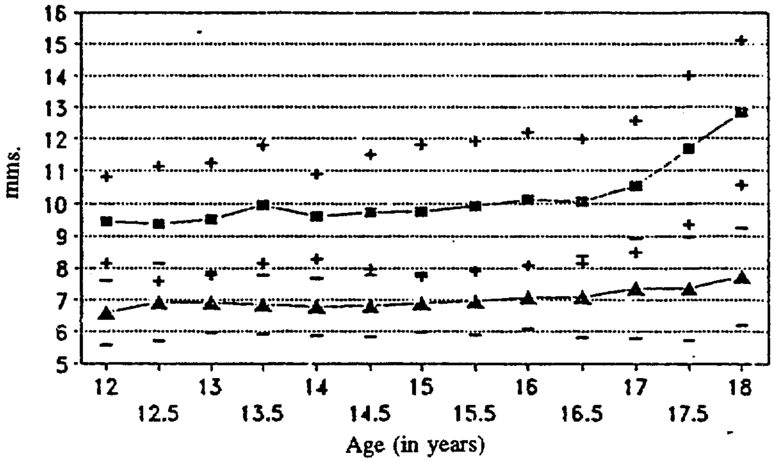


18. AVERAGE ARM CIRCUMFERENCE
MALES



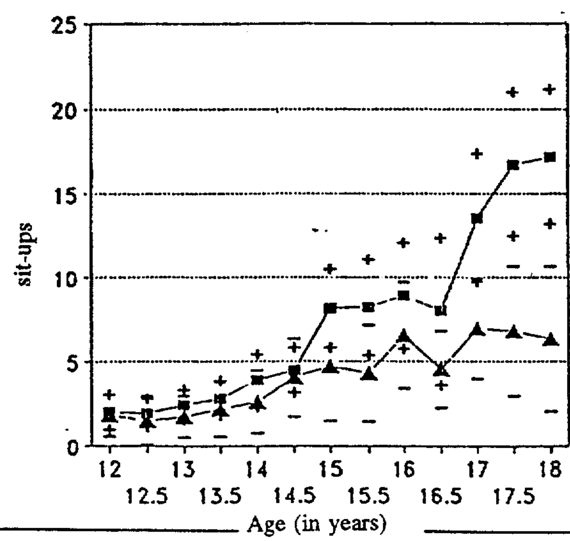
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

19. AVERAGE SUBSCAPULAR SKINFOLD
MALES



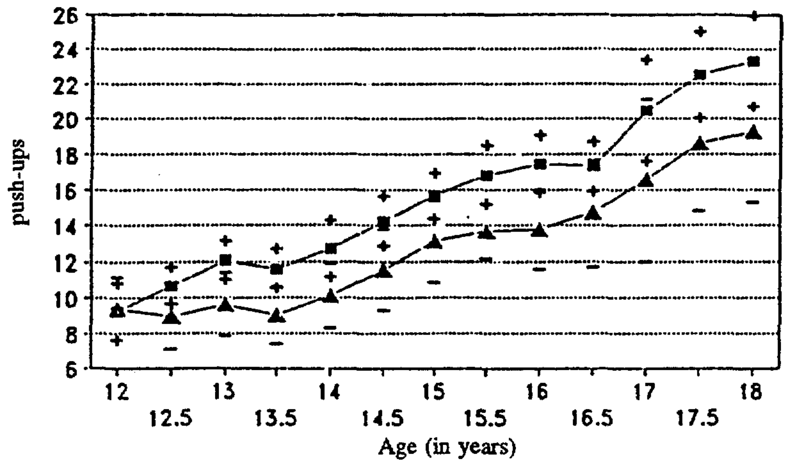
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

20. AVERAGE NUMBER OF SIT-UPS
MALES



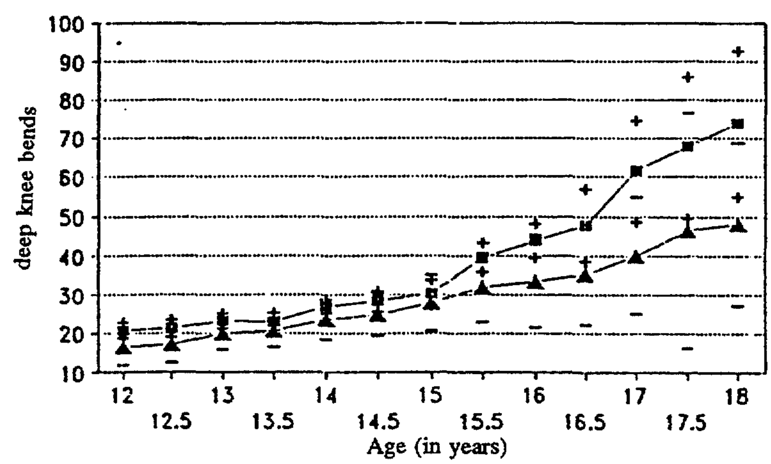
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

21. AVERAGE NUMBER OF PUSH-UPS
MALES



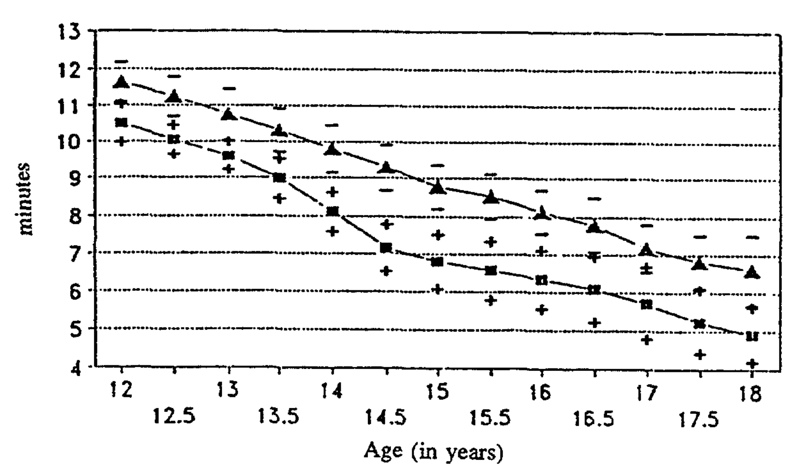
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

22. AVERAGE NUMBER OF DEEP KNEE BENDS
MALES



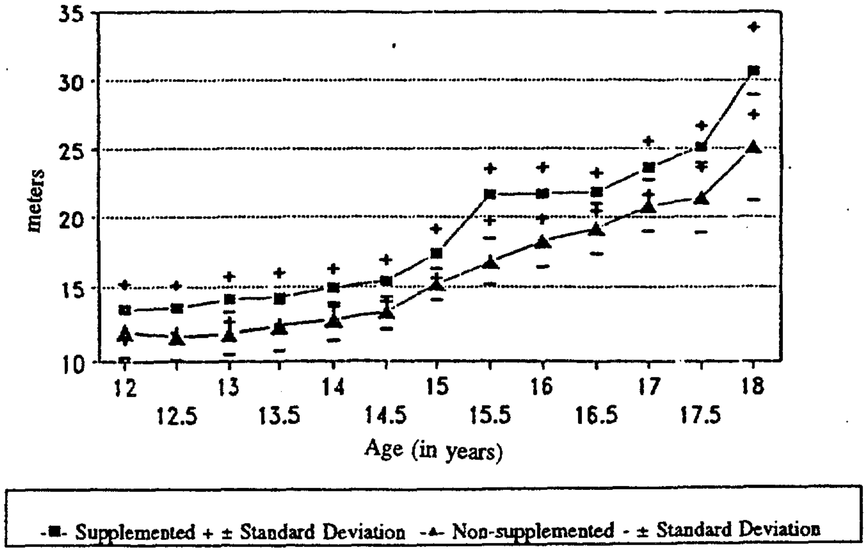
-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

23. AVERAGE TIME FOR WALKING 700 YARDS
MALES

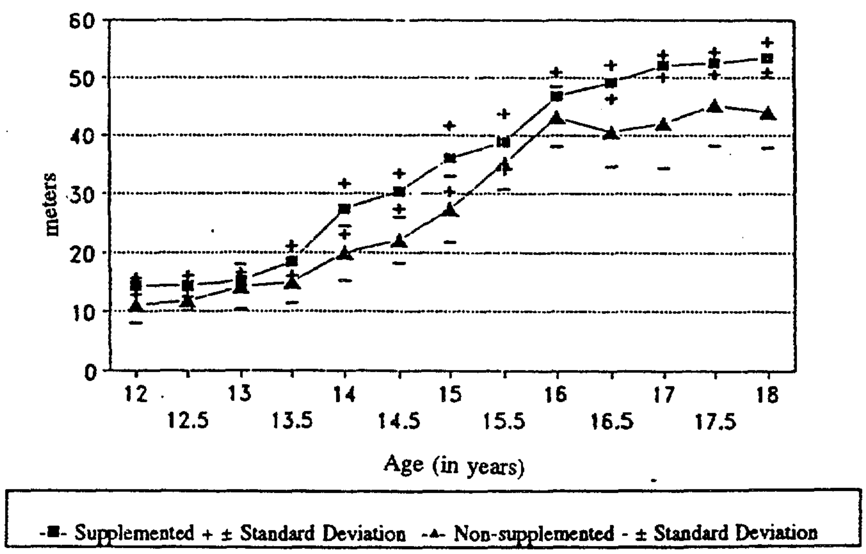


-■- Supplemented + ± Standard Deviation -▲- Non-supplemented - ± Standard Deviation

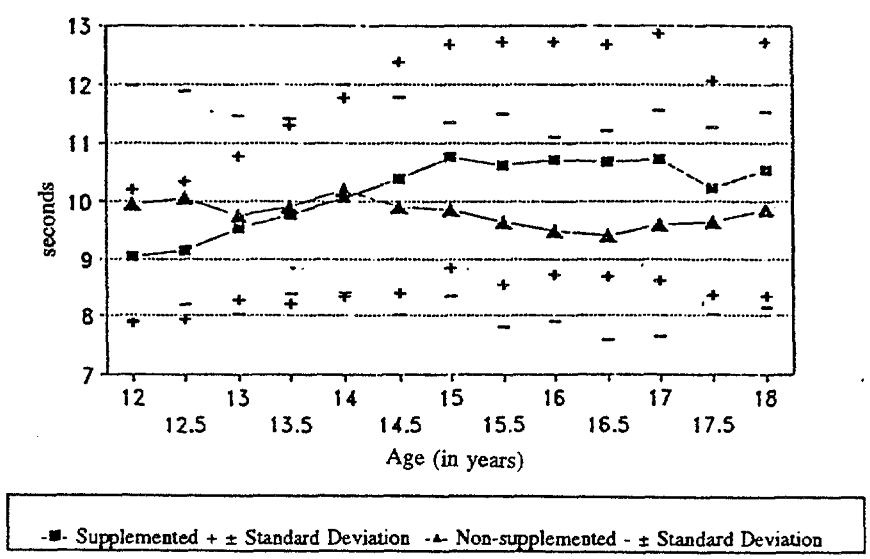
24. AVERAGE DISTANCE FOR KICKING A BALL
MALES



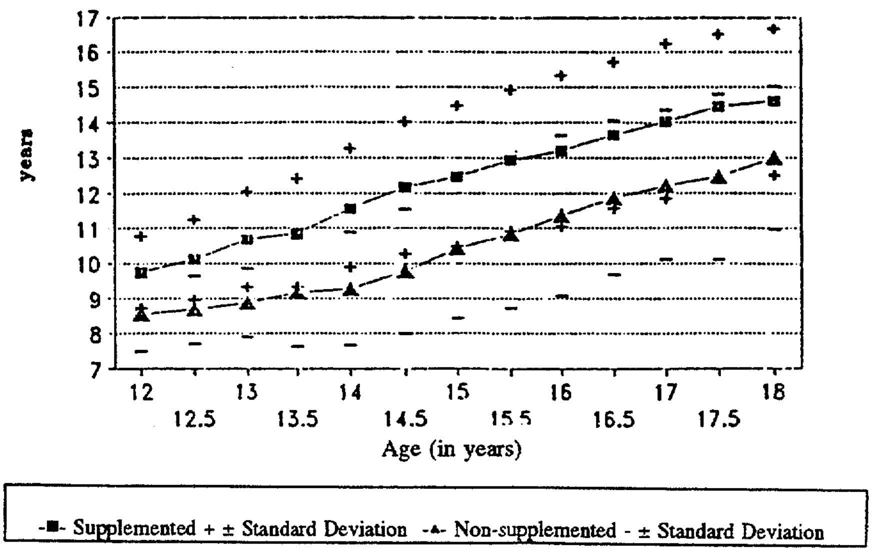
25. AVERAGE DISTANCE FOR THROWING A BALL
MALES



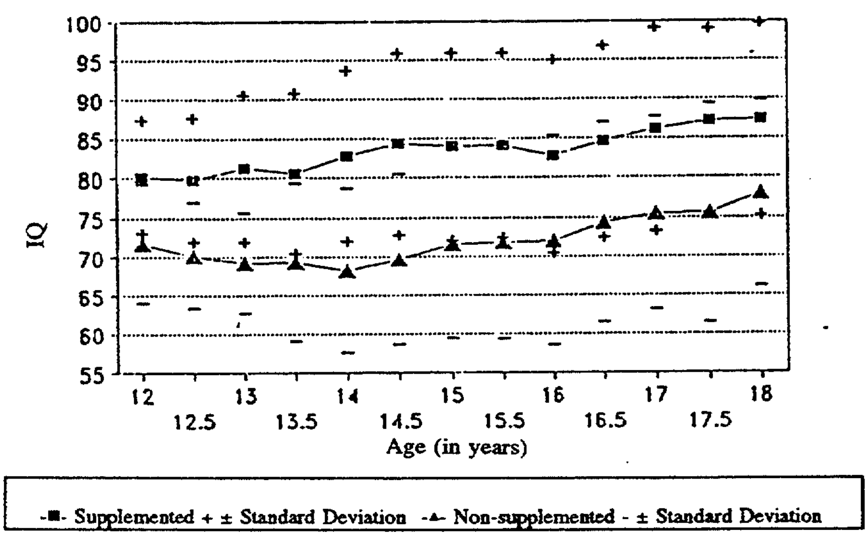
26. AVERAGE TIME FOR RUNNING 50 YARDS
MALES



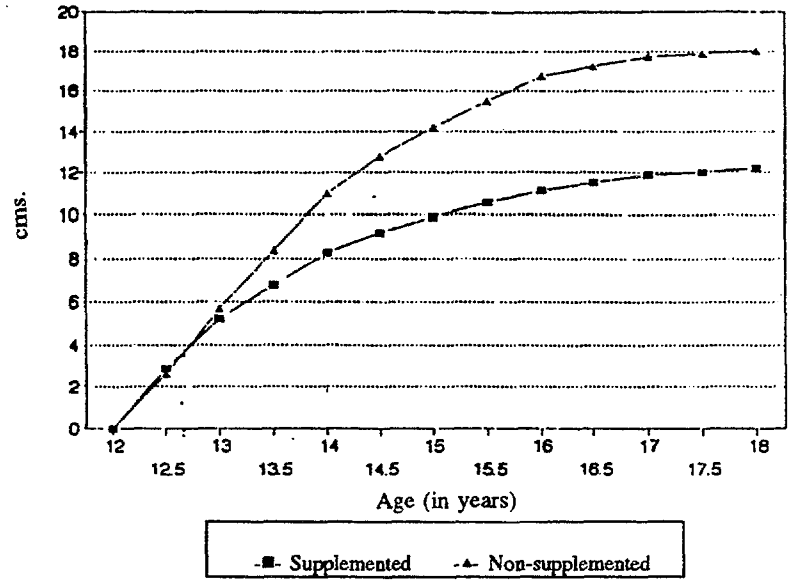
27. AVERAGE MENTAL AGE
MALES



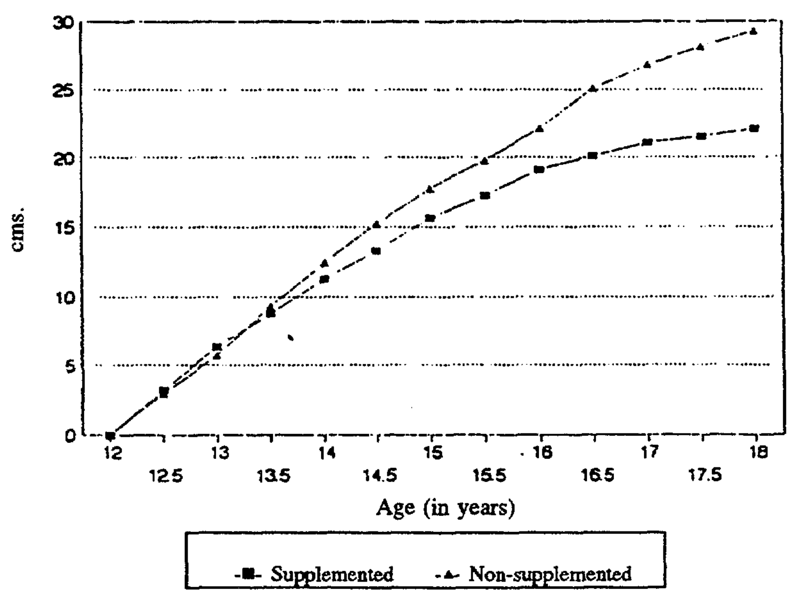
28. AVERAGE INTELLIGENCE QUOTIENT
MALES



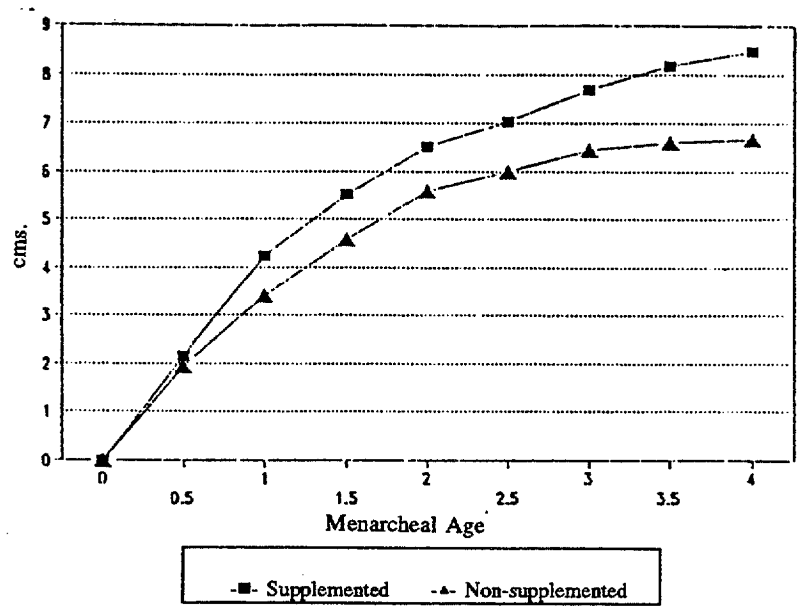
29. INCREASE IN HEIGHT AFTER AGE 12
FEMALES



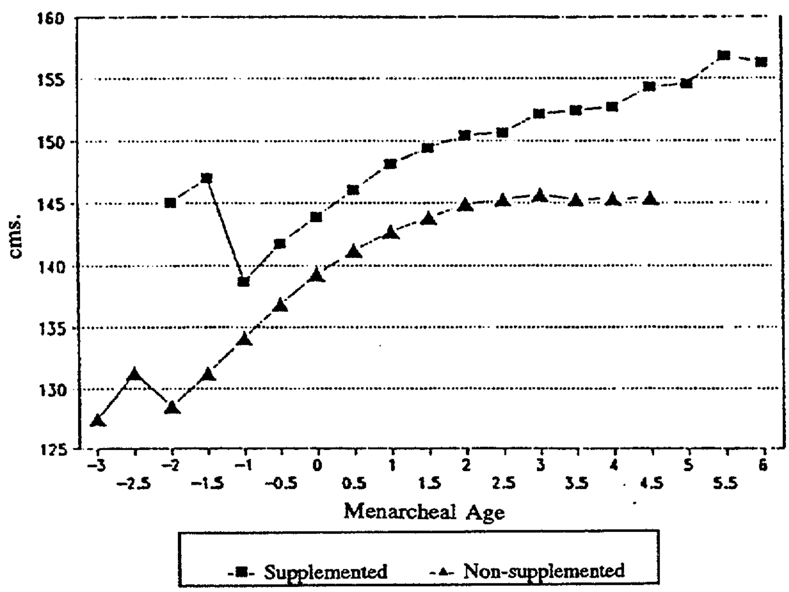
30. INCREASE IN HEIGHT AFTER AGE 12
MALES



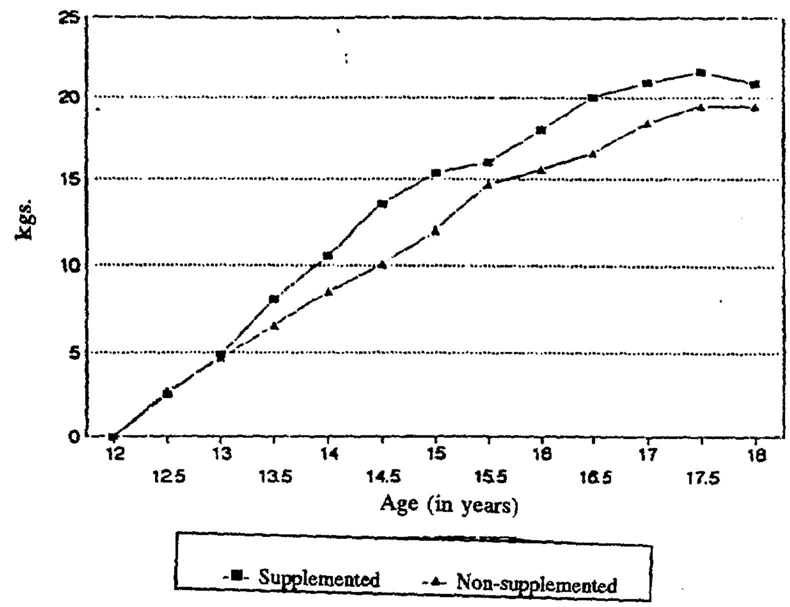
31. INCREASE IN HEIGHT AFTER MENARCHE



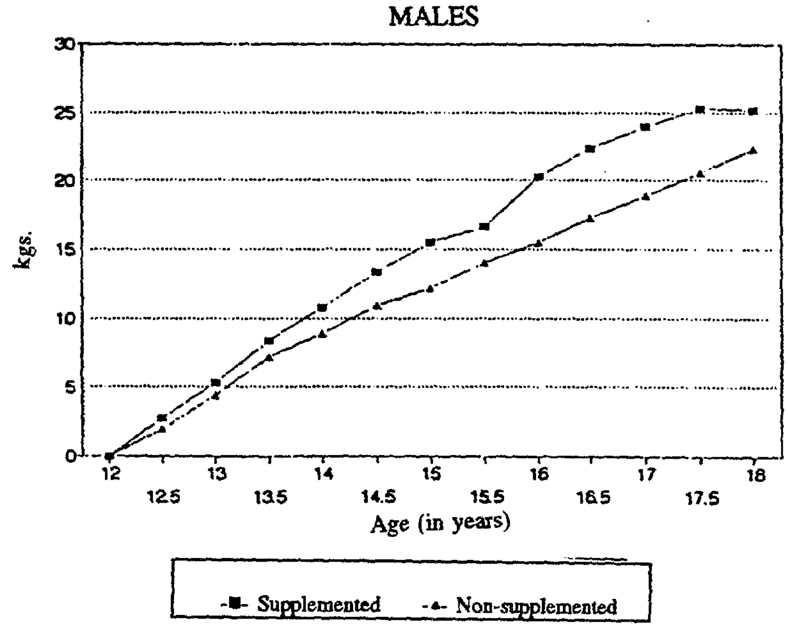
32. HEIGHT BY MENARCHEAL AGE



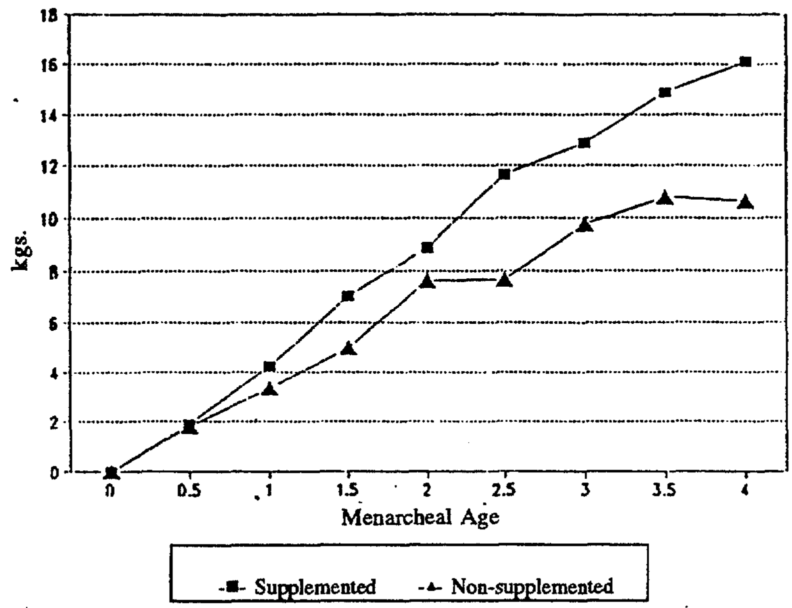
33. AVERAGE WEIGHT GAIN AFTER AGE 12
FEMALES



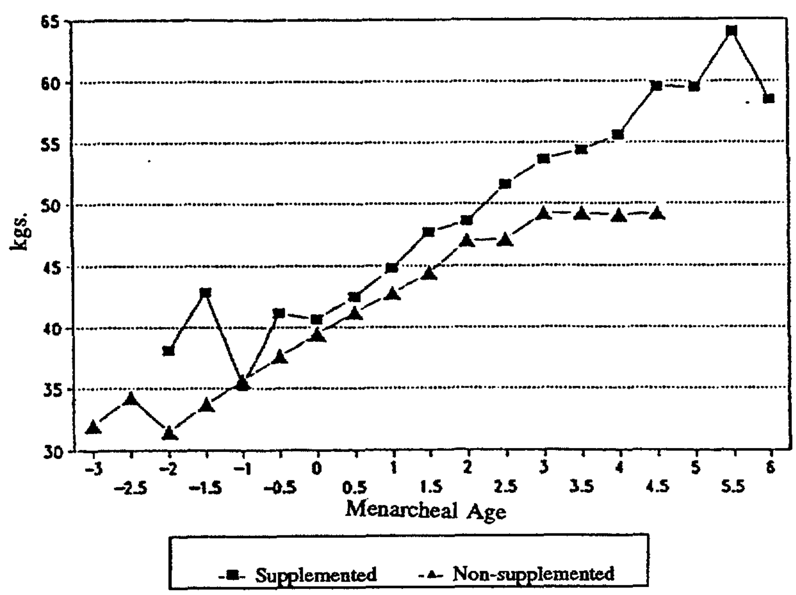
34. AVERAGE WEIGHT GAIN AFTER AGE 12
MALES



35. WEIGHT GAIN AFTER MENARCHE

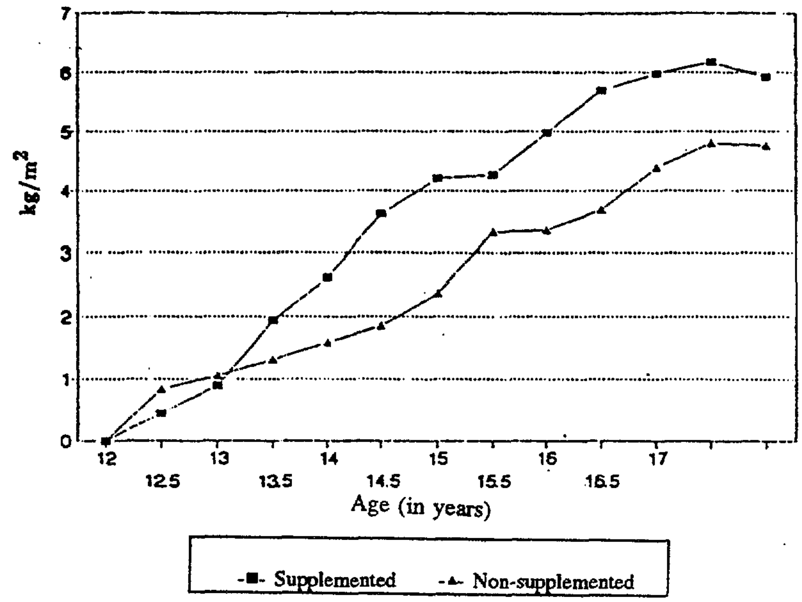


36. WEIGHT BY MENARCHEAL AGE



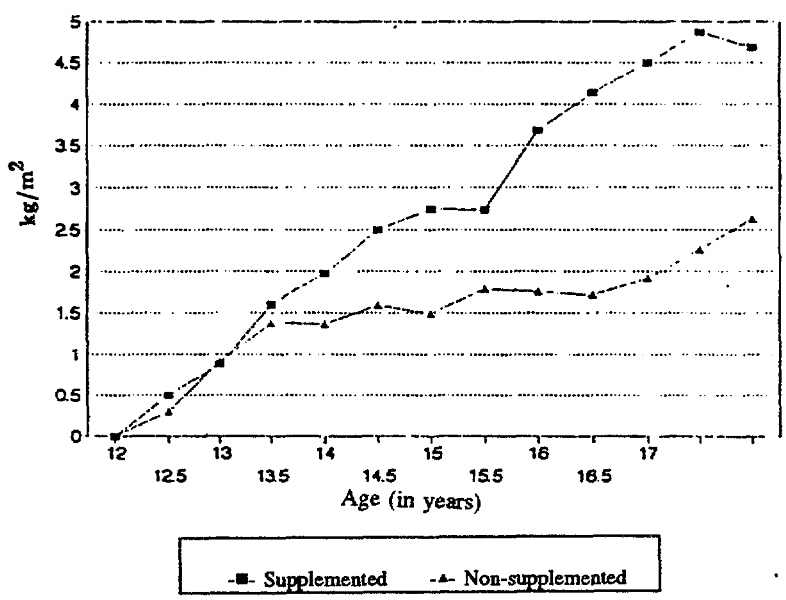
37. AVERAGE GAIN IN BODY MASS INDEX AFTER AGE 12

FEMALES

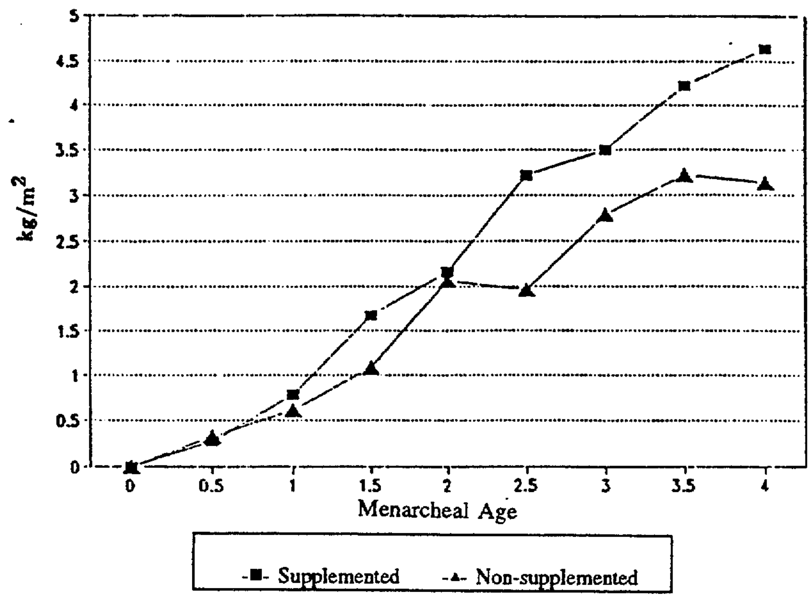


38. AVERAGE GAIN IN BODY MASS INDEX AFTER AGE 12

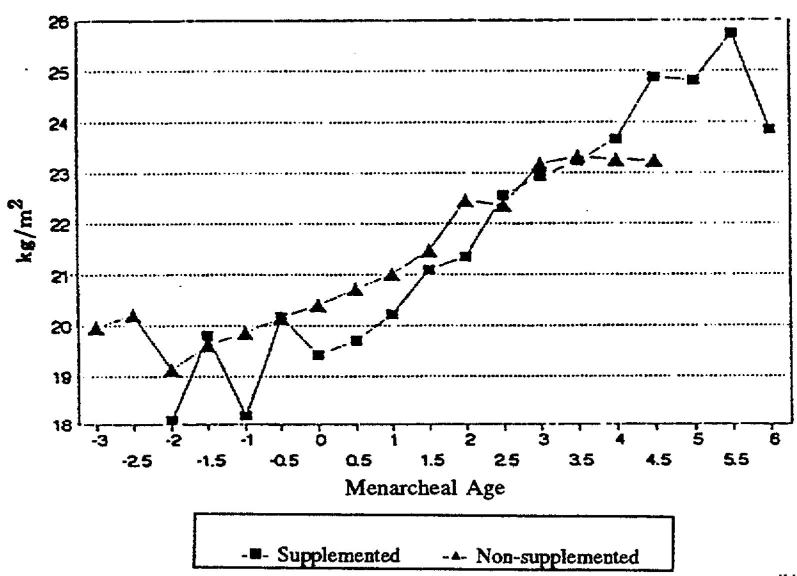
MALES



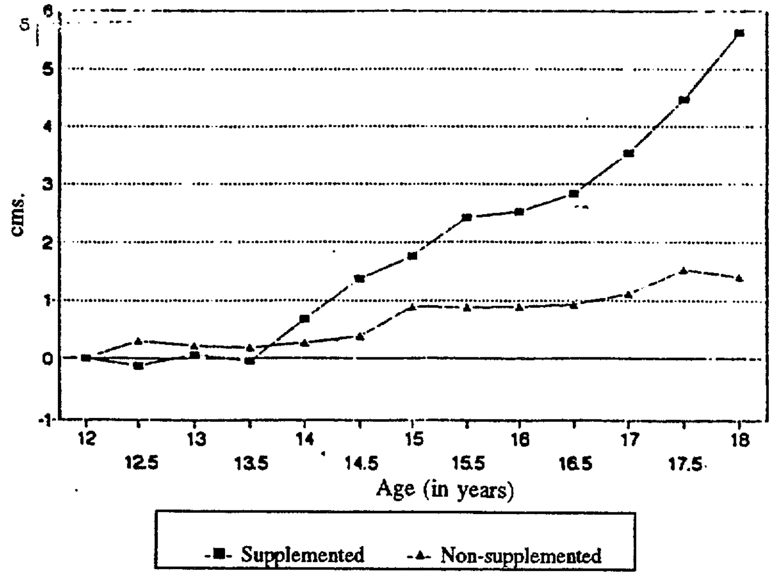
39. GAIN IN BODY MASS INDEX AFTER MENARCHE



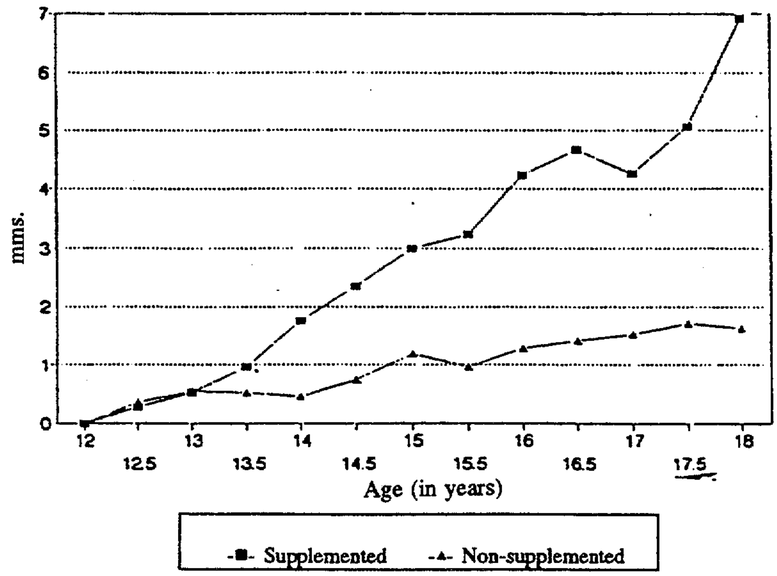
40. BODY MASS INDEX BY MENARCHEAL AGE



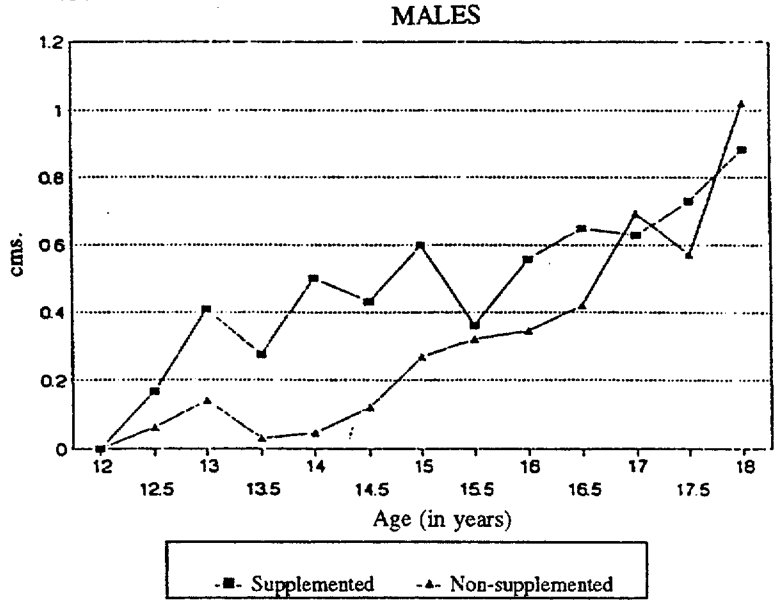
41 GAIN IN ARM CIRCUMFERENCE AFTER AGE 12
FEMALES



42. AVERAGE GAIN IN SUBSCAPULAR SKINFOLD AFTER AGE 12
FEMALES

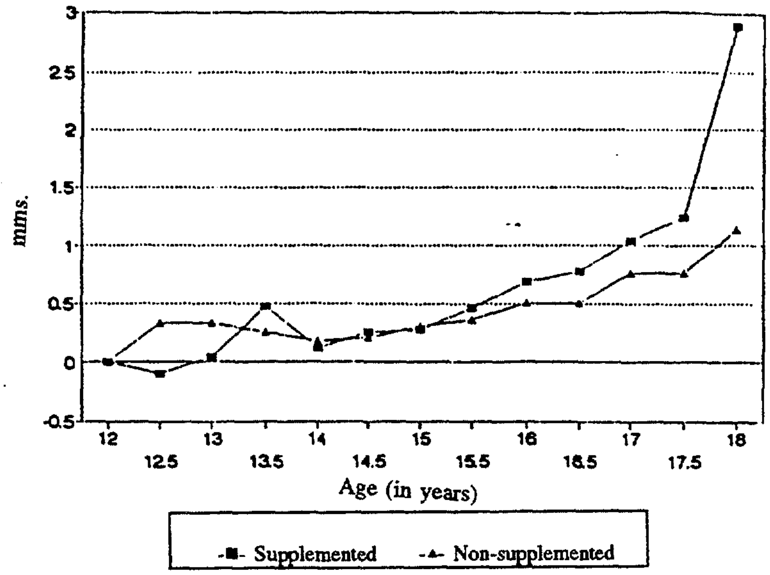


43. GAIN IN ARM CIRCUMFERENCE AFTER AGE 12
MALES

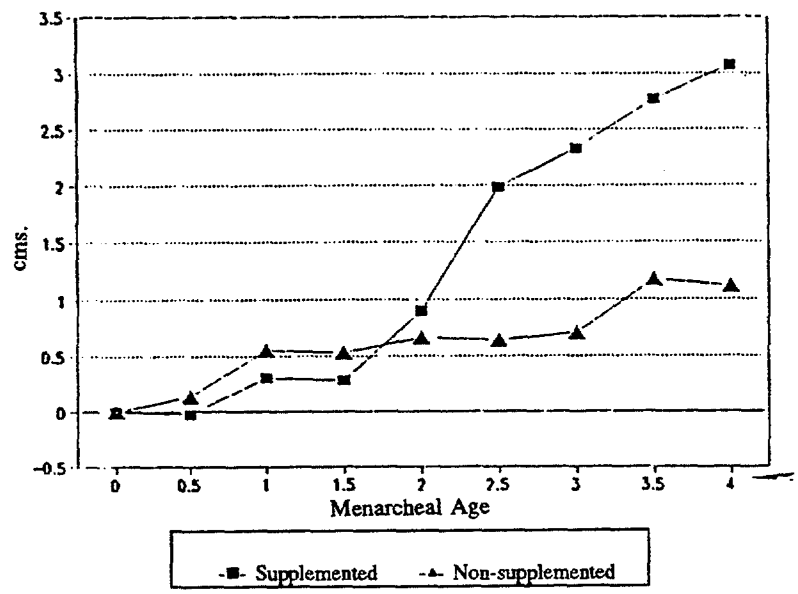


44. AVERAGE GAIN IN SUBSCAPULAR SKINFOLD AFTER AGE 12

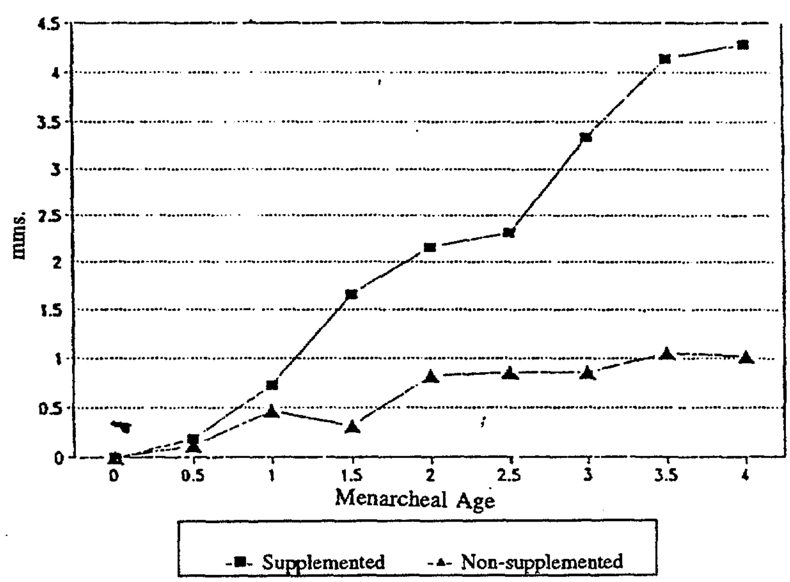
MALES



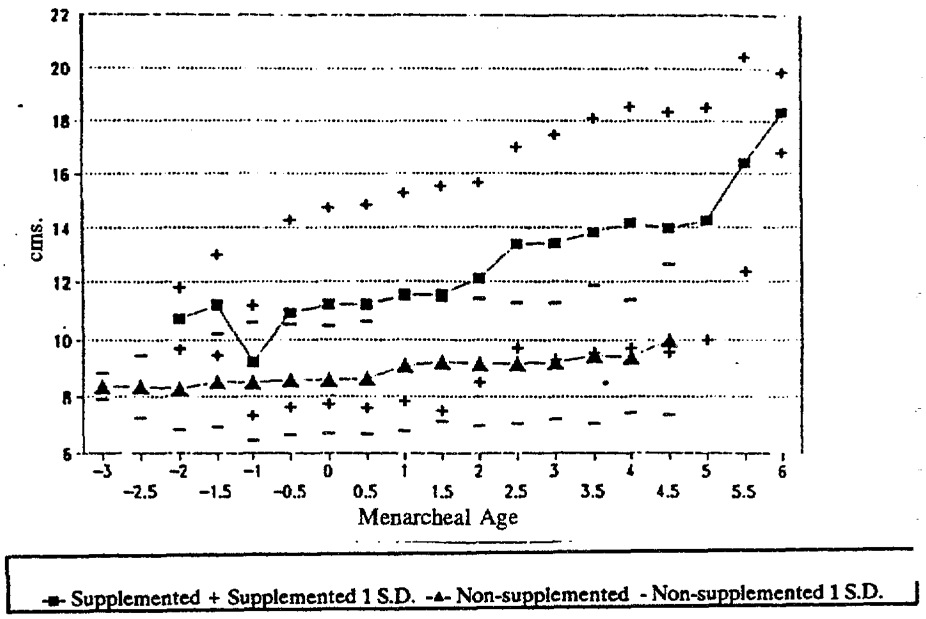
45. GAIN IN ARM CIRCUMFERENCE AFTER MENARCHE



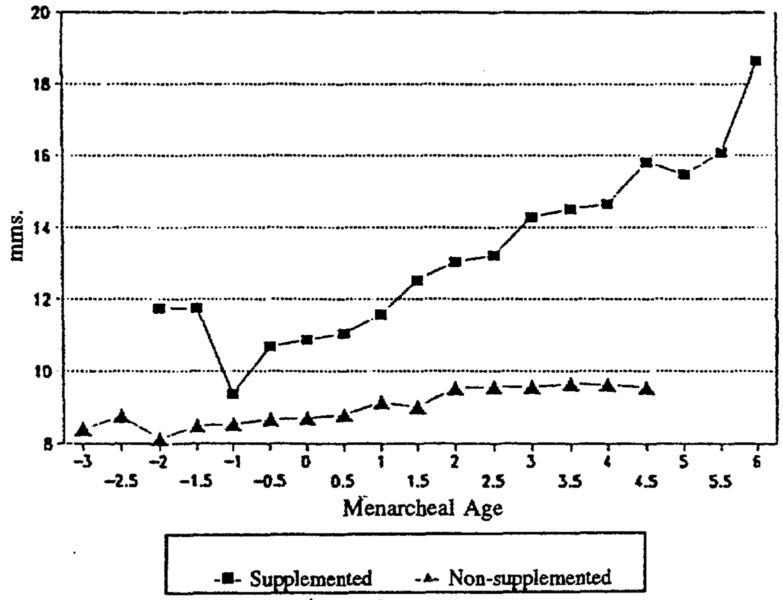
46. GAIN IN SUBSCAPULAR SKINFOLD AFTER MENARCHE



47. ARM CIRCUMFERENCE BY MENARCHEAL AGE

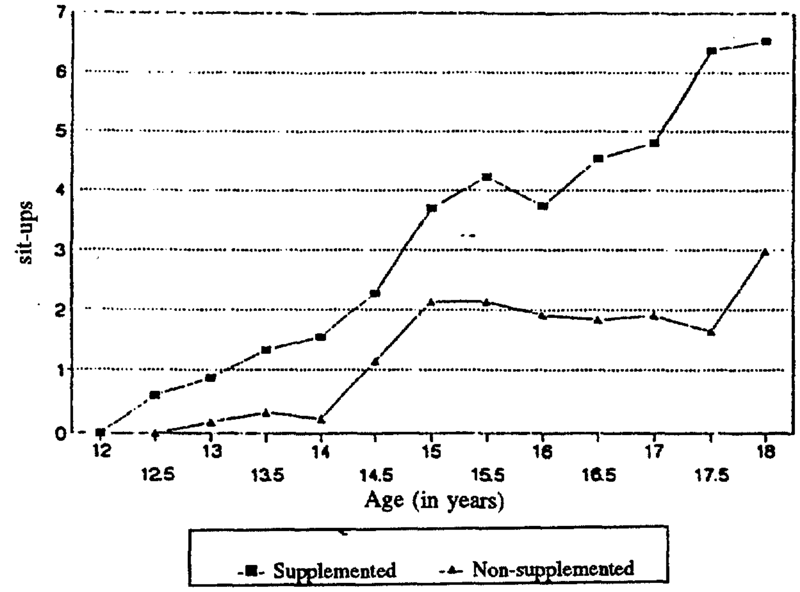


48. SUBSCAPULAR SKINFOLD BY MENARCHEAL AGE



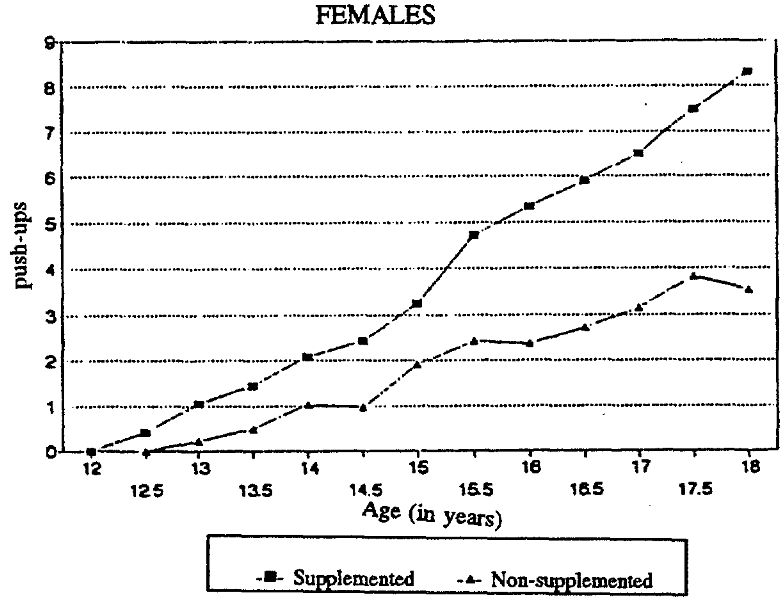
49. AVERAGE INCREASE IN SIT-UPS AFTER AGE 12

FEMALES



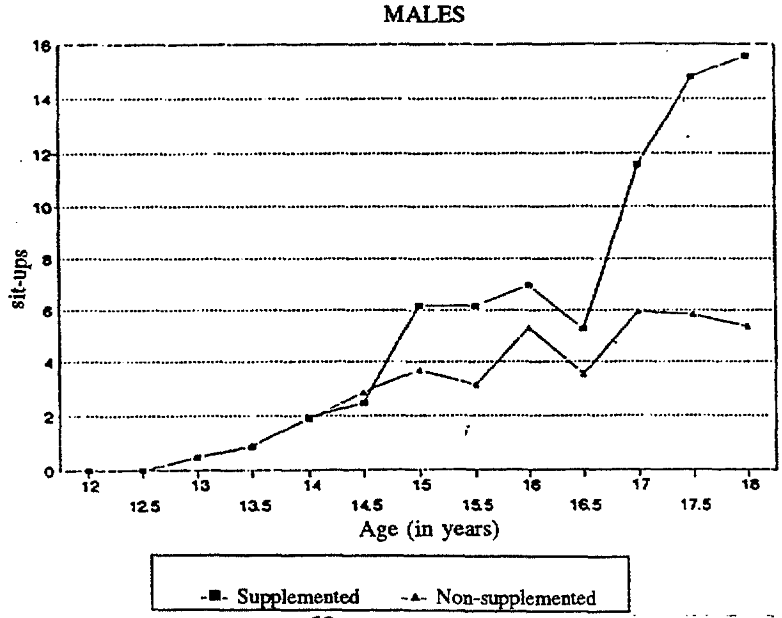
50. AVERAGE INCREASE IN NUMBER OF PUSH-UPS AFTER AGE 12

FEMALES



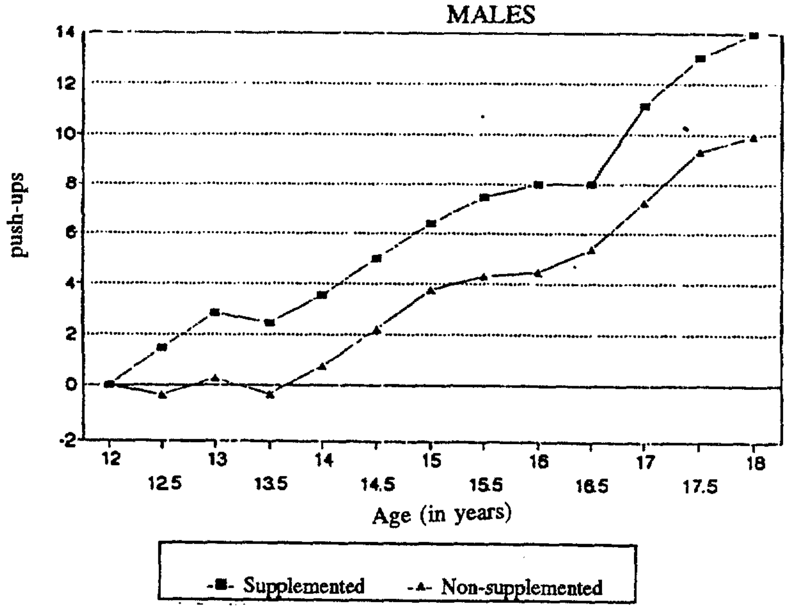
51. AVERAGE INCREASE IN SIT-UPS AFTER AGE 12

MALES

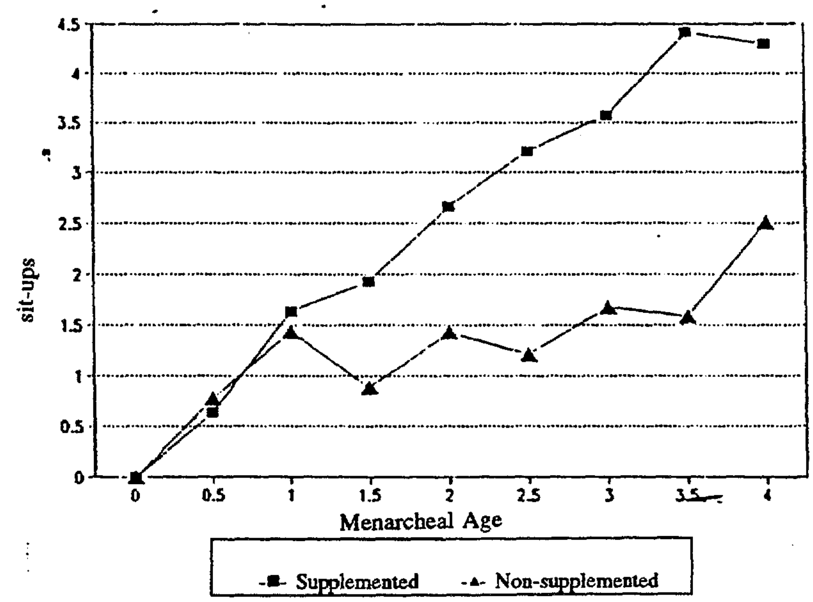


52. AVERAGE INCREASE IN NUMBER OF PUSH-UPS AFTER AGE 12

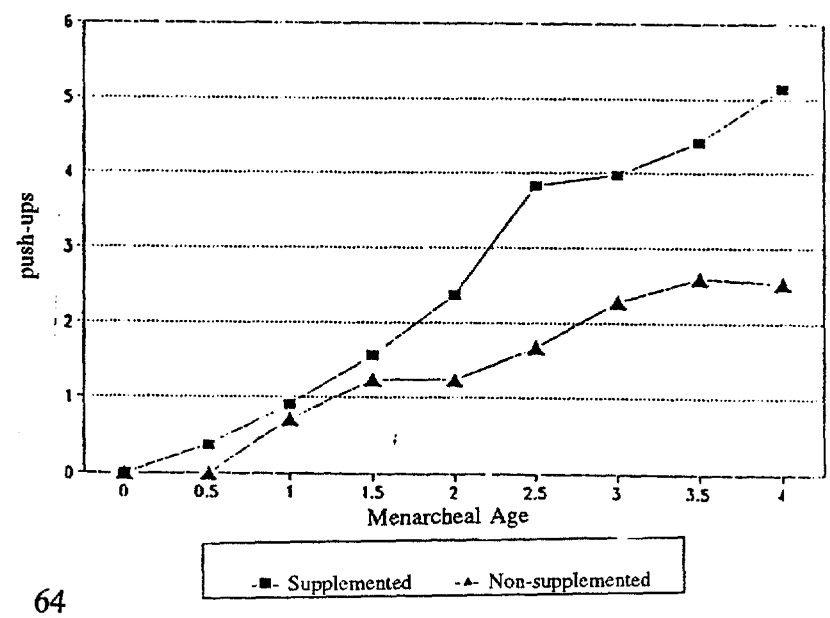
MALES



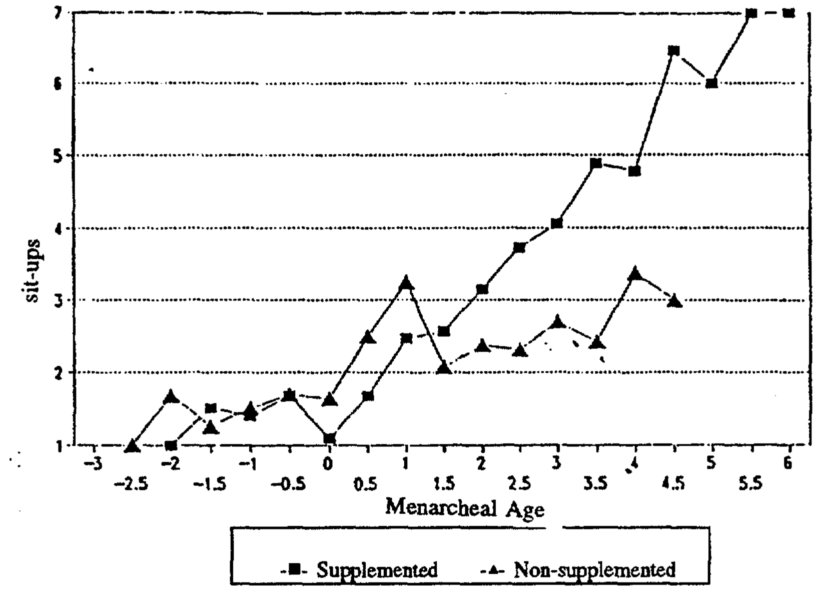
53. INCREASE IN NUMBER OF SIT-UPS AFTER MENARCHE



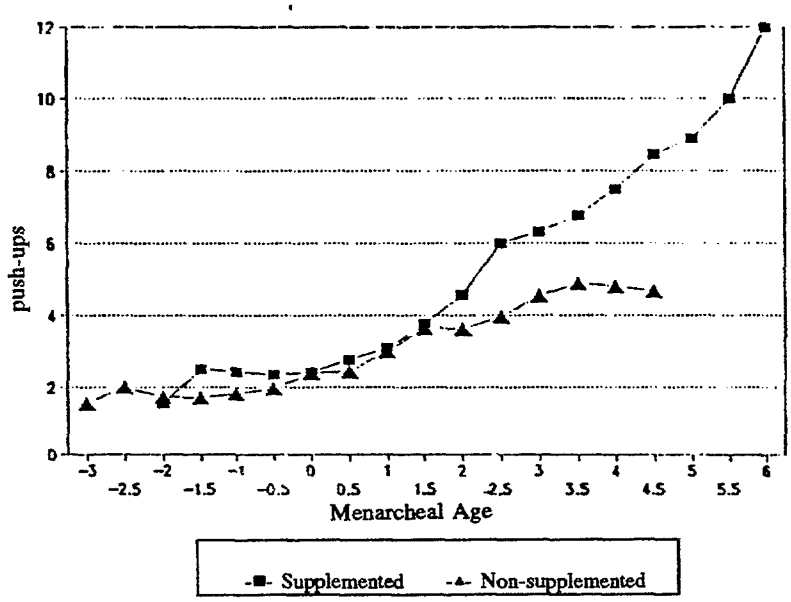
54. INCREASE IN NUMBER OF PUSH-UPS AFTER MENARCHE



55. NUMBER OF SIT-UPS BY MENARCHEAL AGE

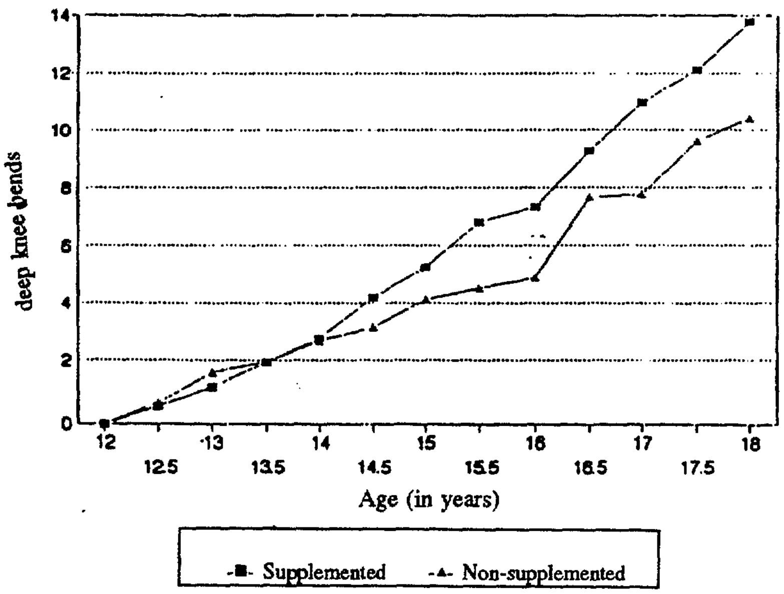


56. NUMBER OF PUSH-UPS BY MENARCHEAL AGE



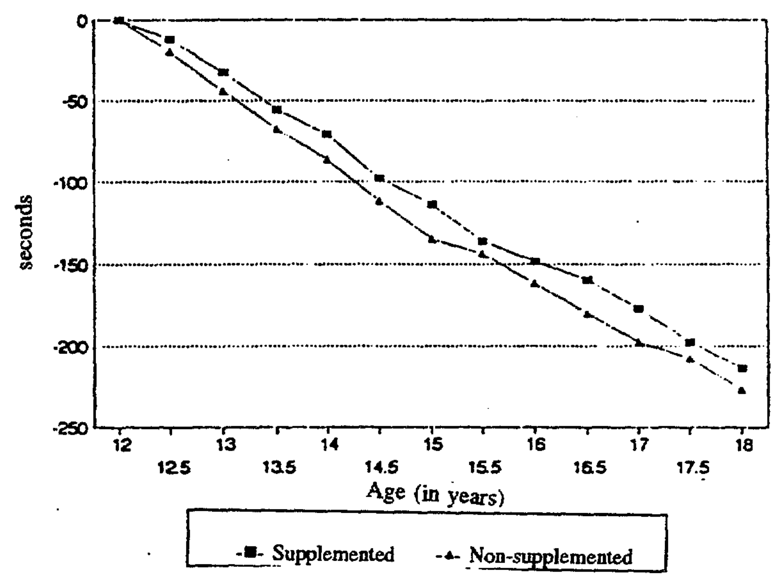
57. AVERAGE INCREASE IN NUMBER OF DEEP KNEE BENDS AFTER AGE 12

FEMALES



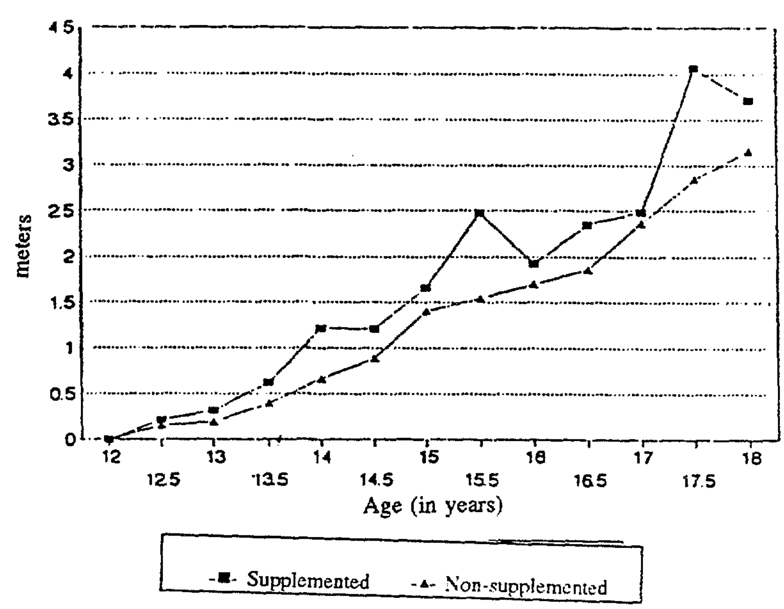
58. AVERAGE DECREASE IN THE TIME FOR WALKING 700 YARDS AFTER AGE 12

FEMALES



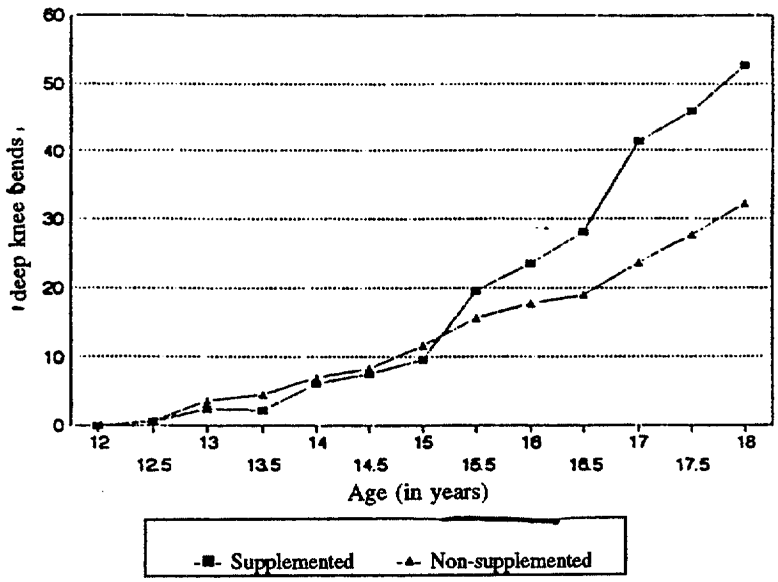
59. AVERAGE INCREASE IN DISTANCE FOR KICKING A BALL AFTER AGE 12

FEMALES



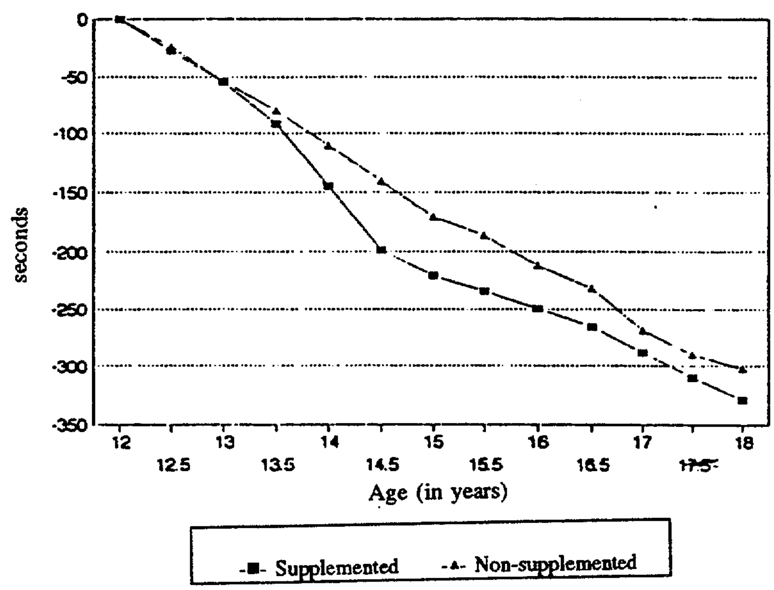
60. AVERAGE INCREASE IN NUMBER OF DEEP KNEE BENDS AFTER AGE 12

MALES



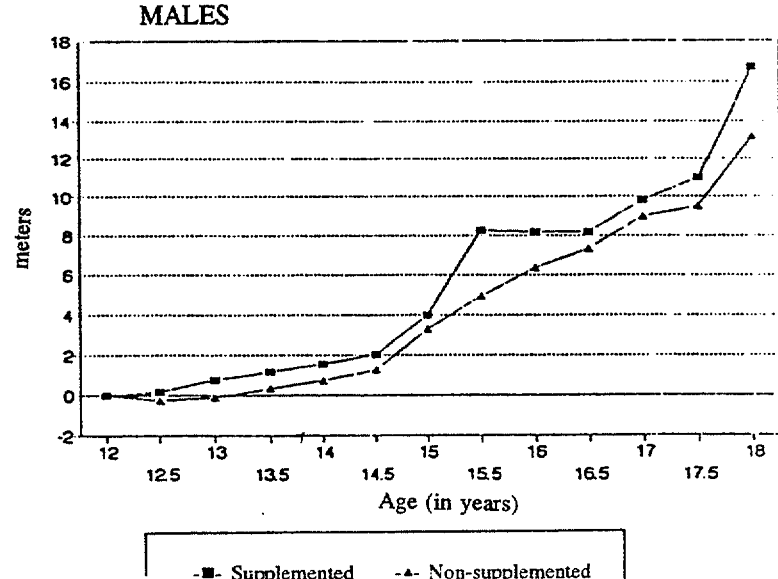
61. AVERAGE DECREASE IN THE TIME FOR WALKING 700 YARDS AFTER AGE 12

MALES

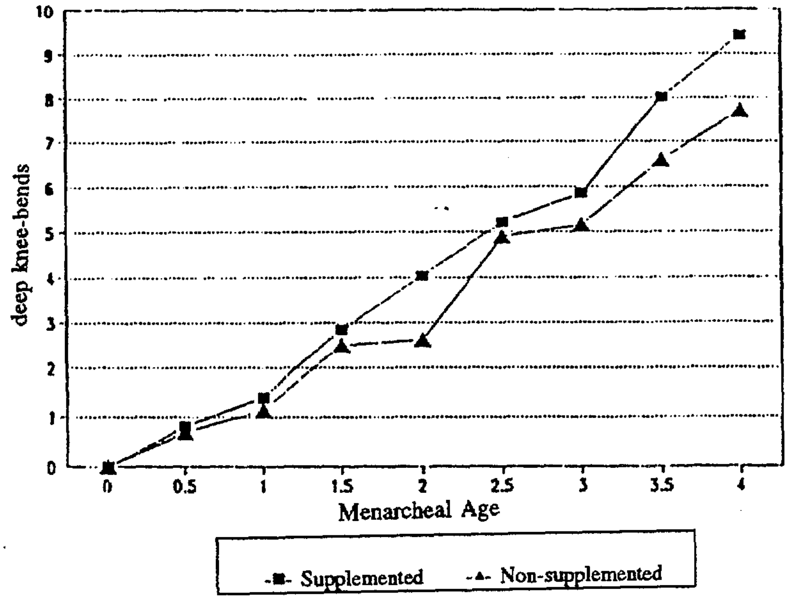


62. AVERAGE INCREASE IN DISTANCE FOR KICKING A BALL AFTER AGE 12

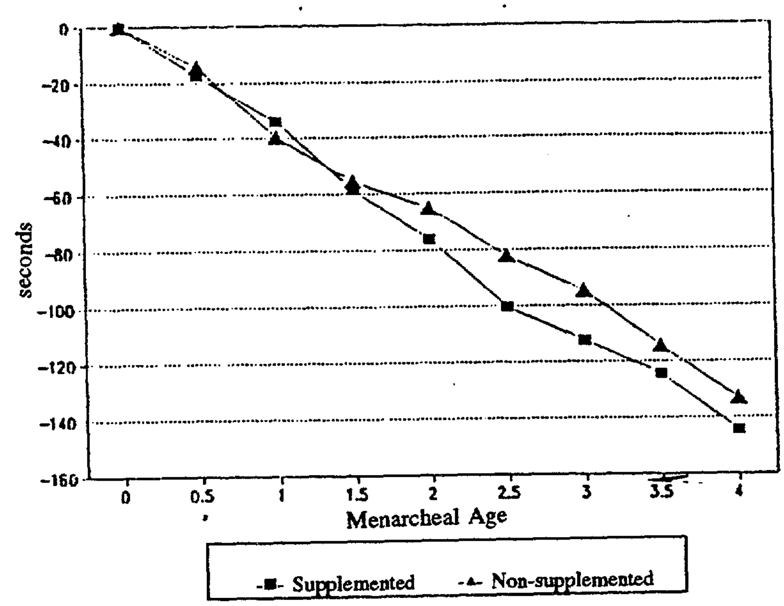
MALES



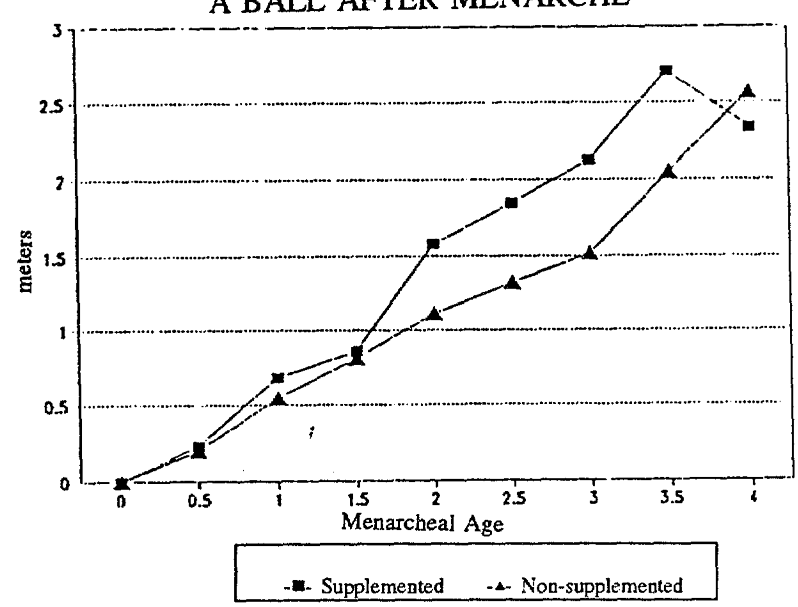
63. INCREASE IN NUMBER OF DEEP KNEE BENDS AFTER MENARCHE



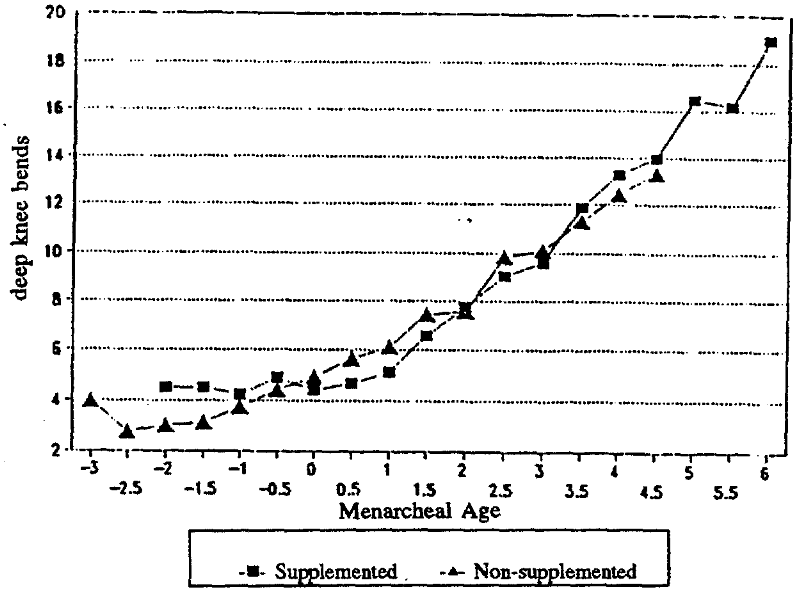
64. DECREASE IN THE TIME WALKING 700 YARDS AFTER MENARCHE



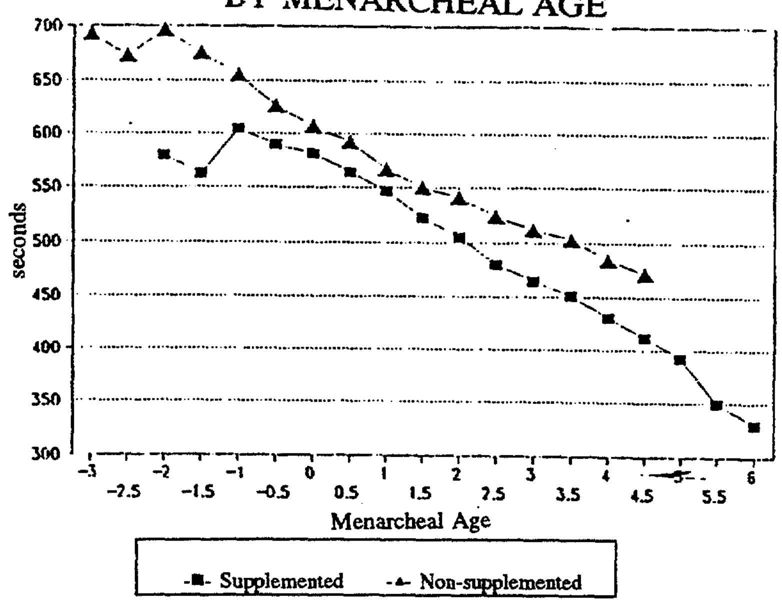
65. INCREASE IN THE DISTANCE FOR KICKING A BALL AFTER MENARCHE



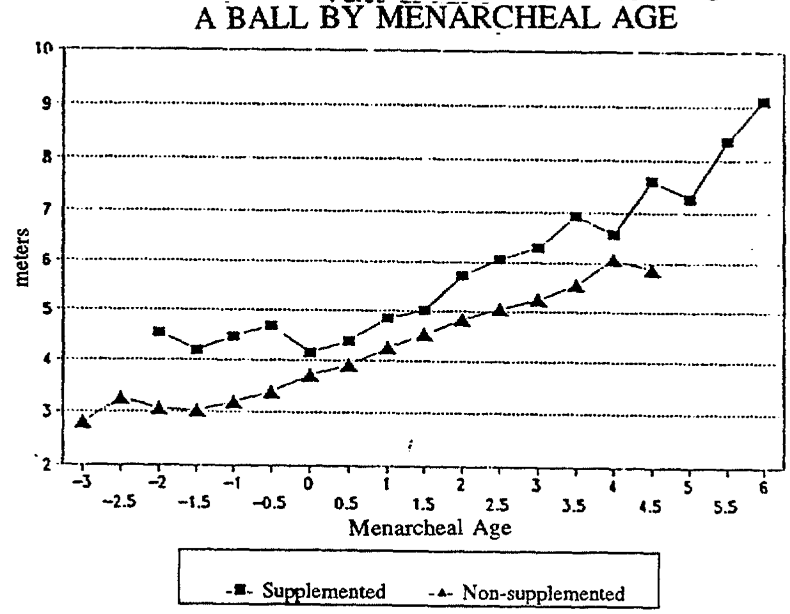
66. NUMBER OF DEEP KNEE BENDS BY MENARCHEAL AGE



67. TIME REQUIRED FOR WALKING 700 YARDS BY MENARCHEAL AGE

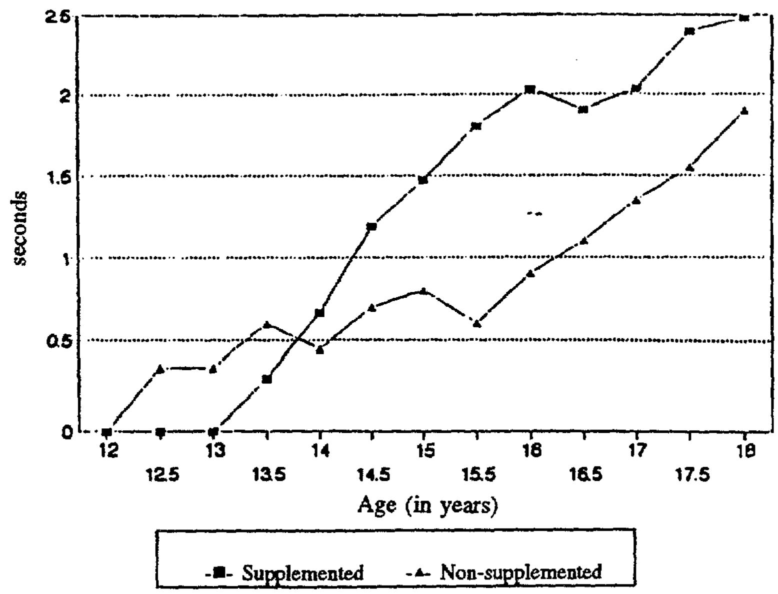


68. AVERAGE DISTANCE FOR KICKING A BALL BY MENARCHEAL AGE



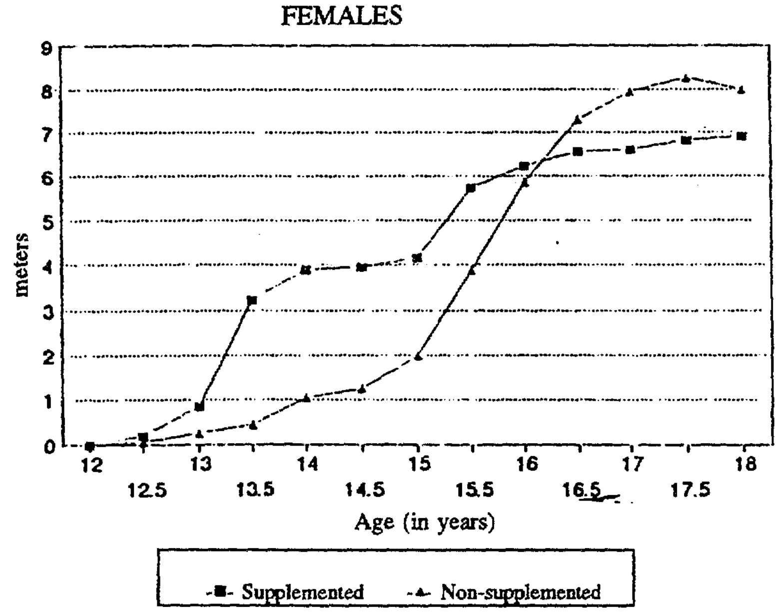
69. AVERAGE INCREASE IN TIME FOR RUNNING 50 YARDS AFTER AGE 12

FEMALES



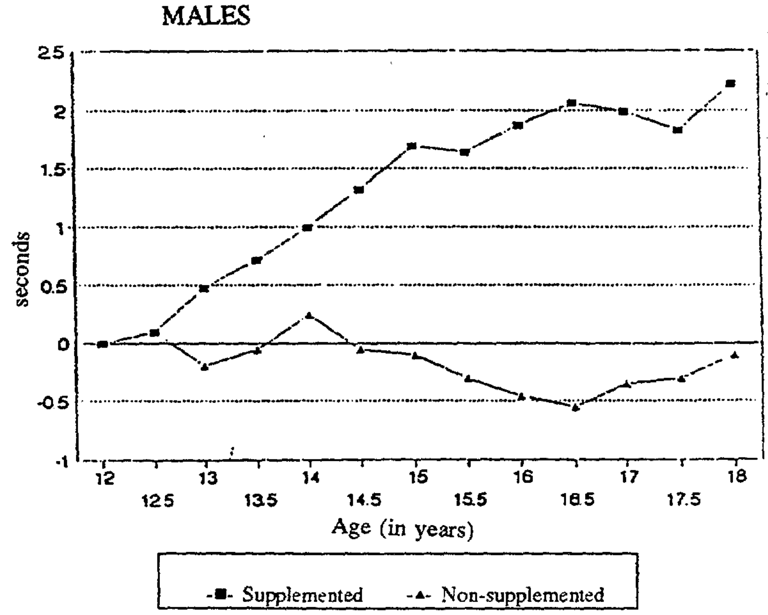
70. AVERAGE INCREASE IN DISTANCE FOR THROWING A BALL AFTER AGE 12

FEMALES

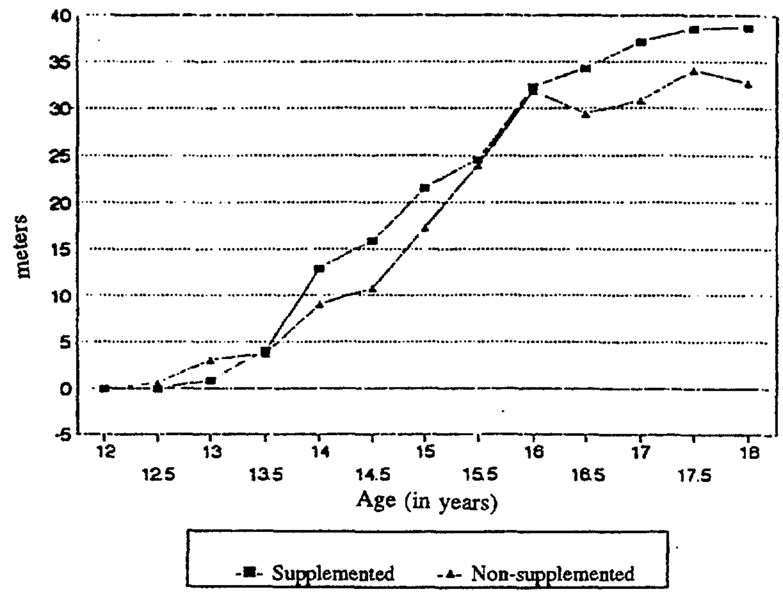


71. AVERAGE INCREASE IN TIME FOR RUNNING 50 YARDS AFTER AGE 12

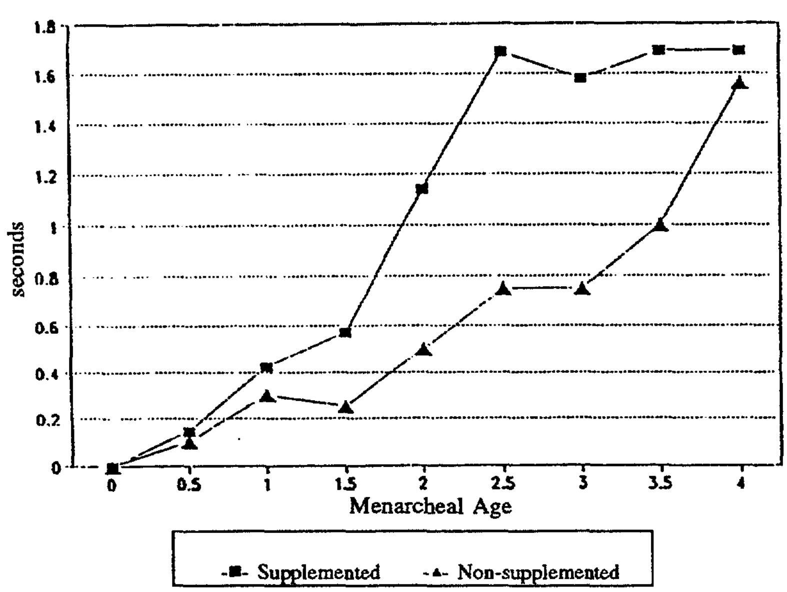
MALES



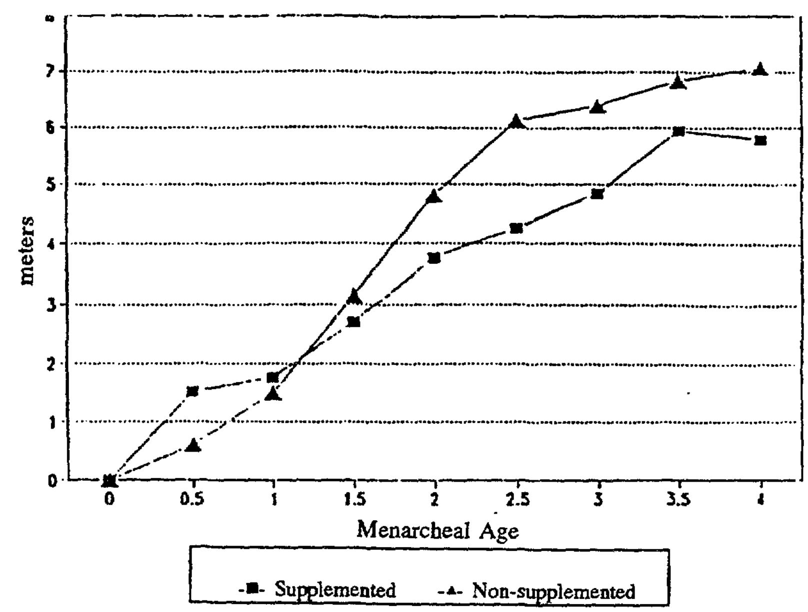
72. AVERAGE INCREASE IN DISTANCE FOR THROWING A BALL AFTER AGE 12
MALES



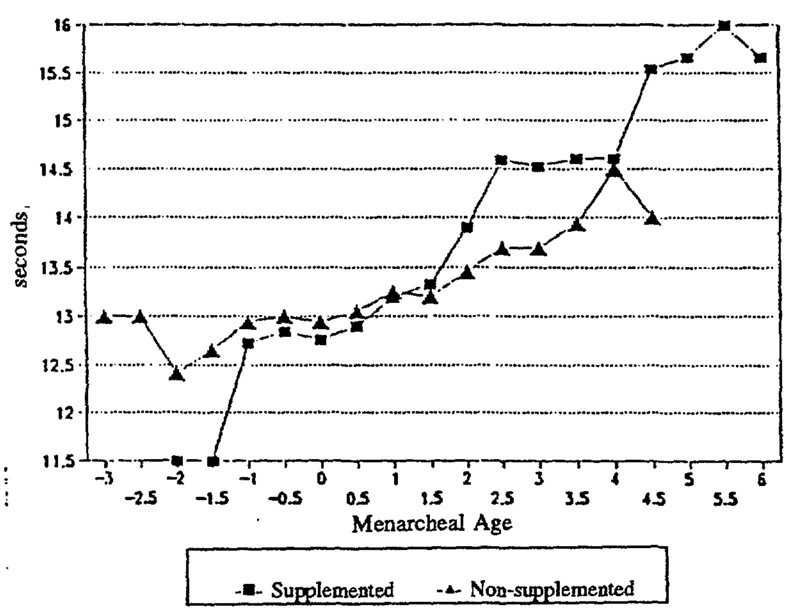
73. INCREASE IN TIME FOR RUNNING 50 YARDS AFTER MENARCHE



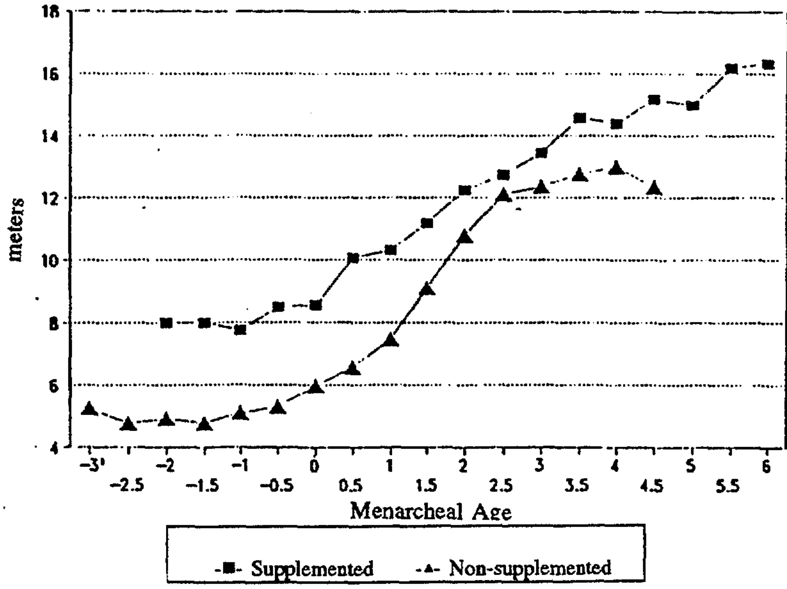
74. INCREASE IN DISTANCE FOR THROWING A BALL AFTER MENARCHE



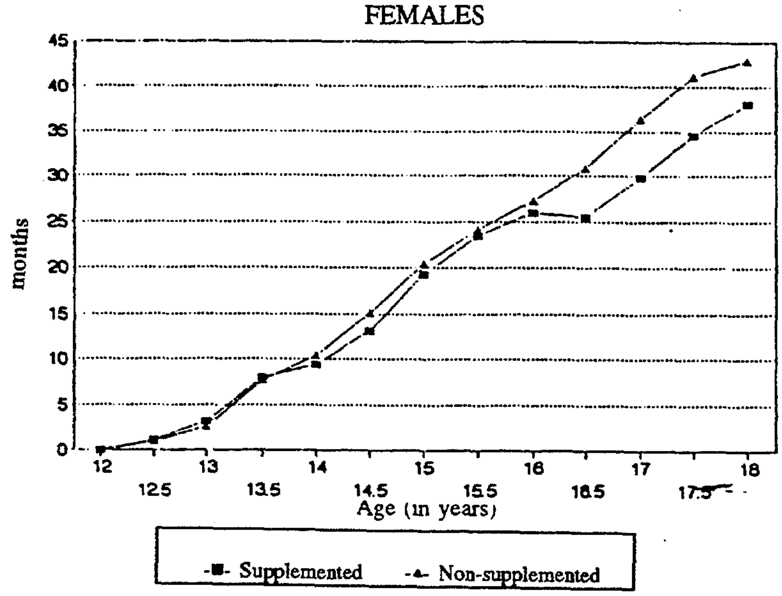
75. TIME FOR RUNNING 50 YARDS BY MENARCHEAL AGE



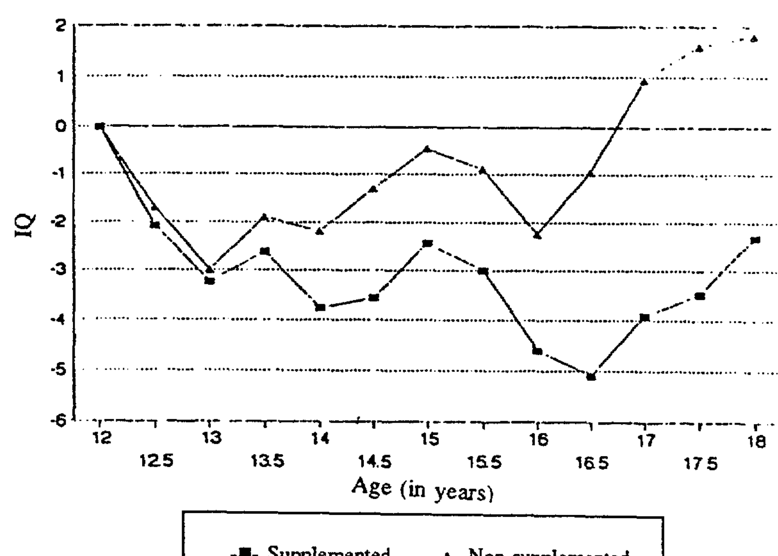
76. BALL THROW BY MENARCHEAL AGE



77. AVERAGE INCREASE IN MENTAL AGE AFTER AGE 12
FEMALES

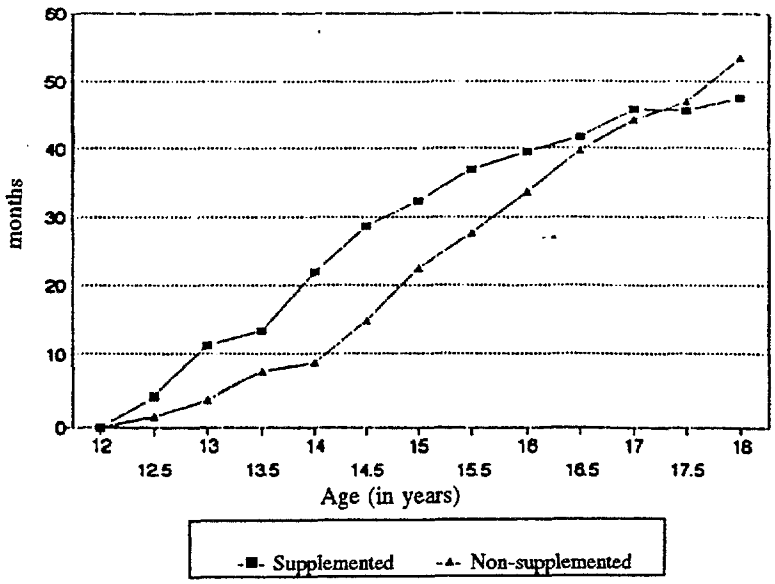


78. AVERAGE INCREASE IN INTELLIGENCE QUOTIENT AFTER AGE 12
FEMALES



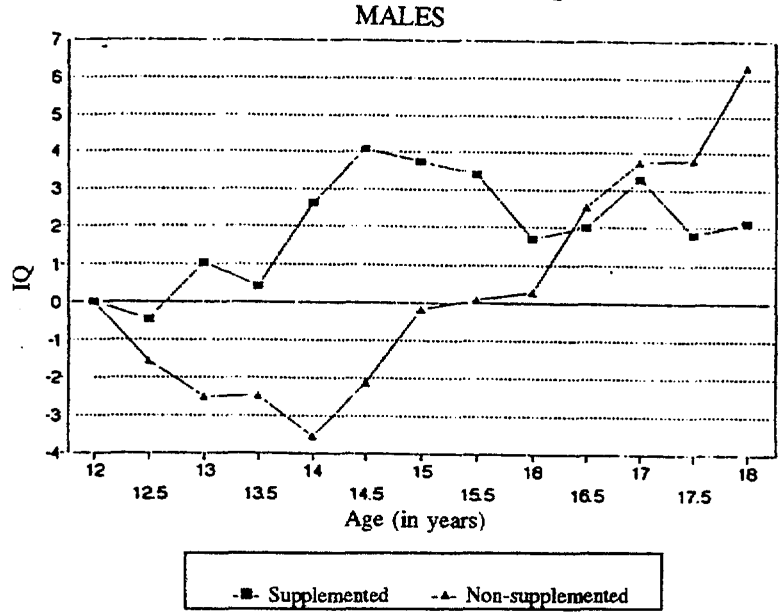
79. AVERAGE INCREASE IN MENTAL AGE FOLLOWING AGE 12

MALES

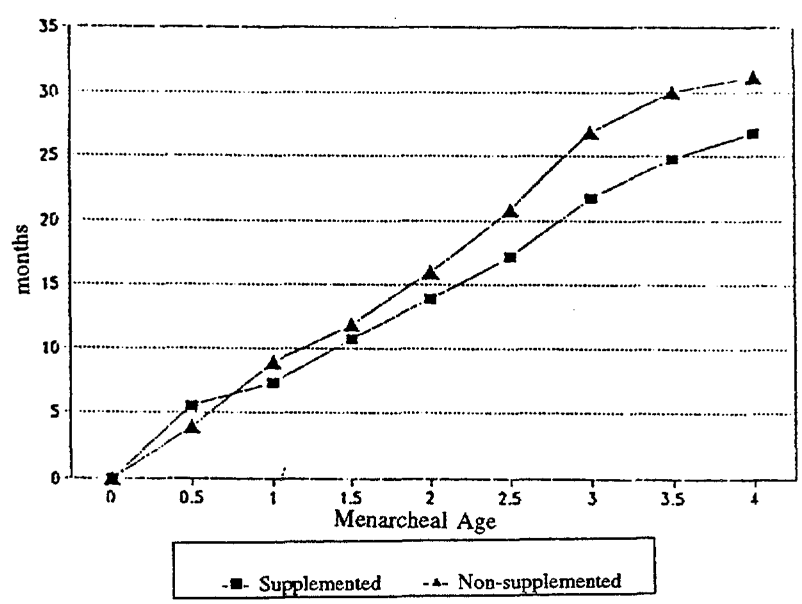


80. AVERAGE INCREASE IN INTELLIGENCE QUOTIENT AFTER AGE 12

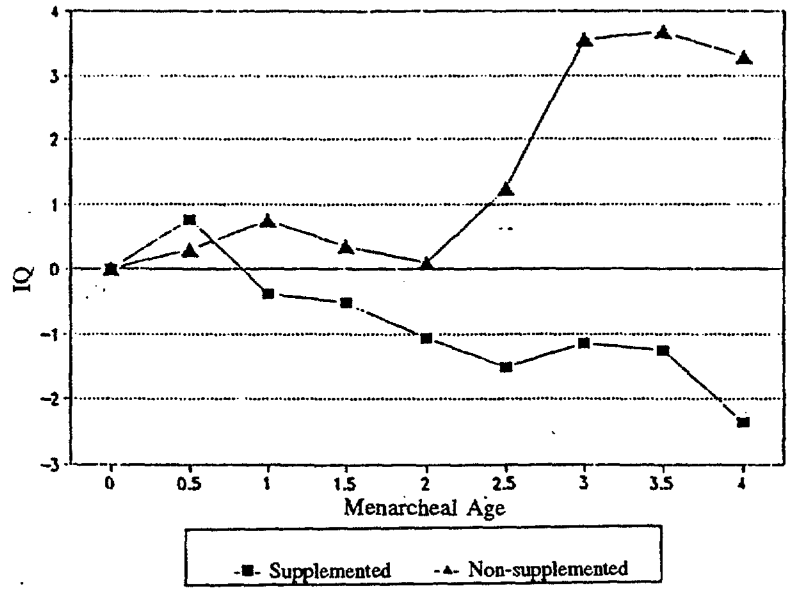
MALES



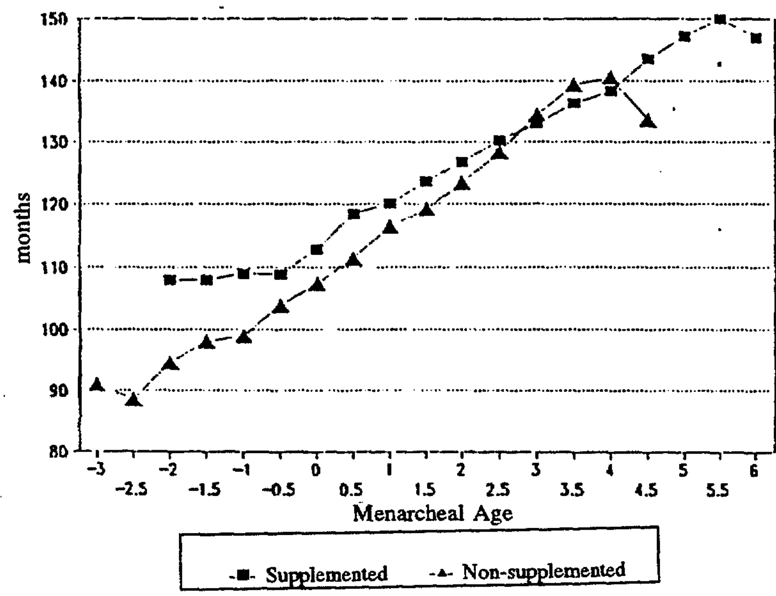
81. INCREASE IN MENTAL AGE AFTER MENARCHE



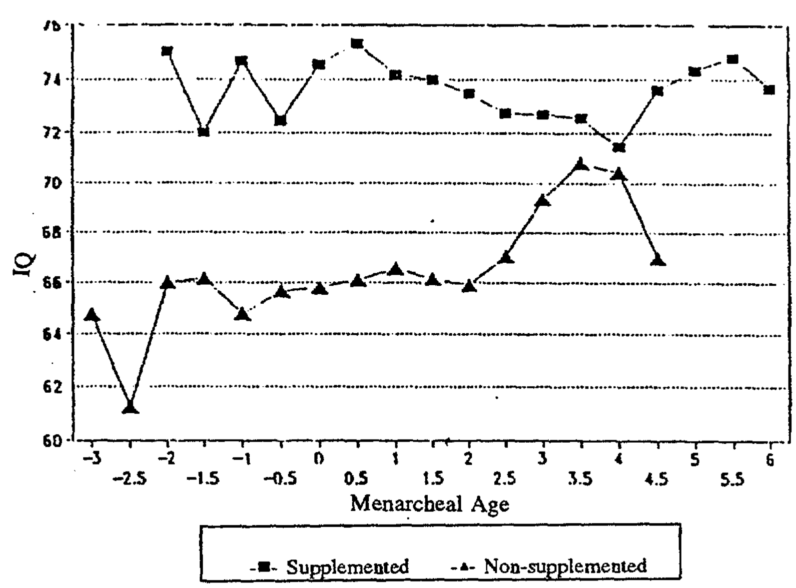
82. INCREASE IN INTELLIGENCE QUOTIENT AFTER MENARCHE



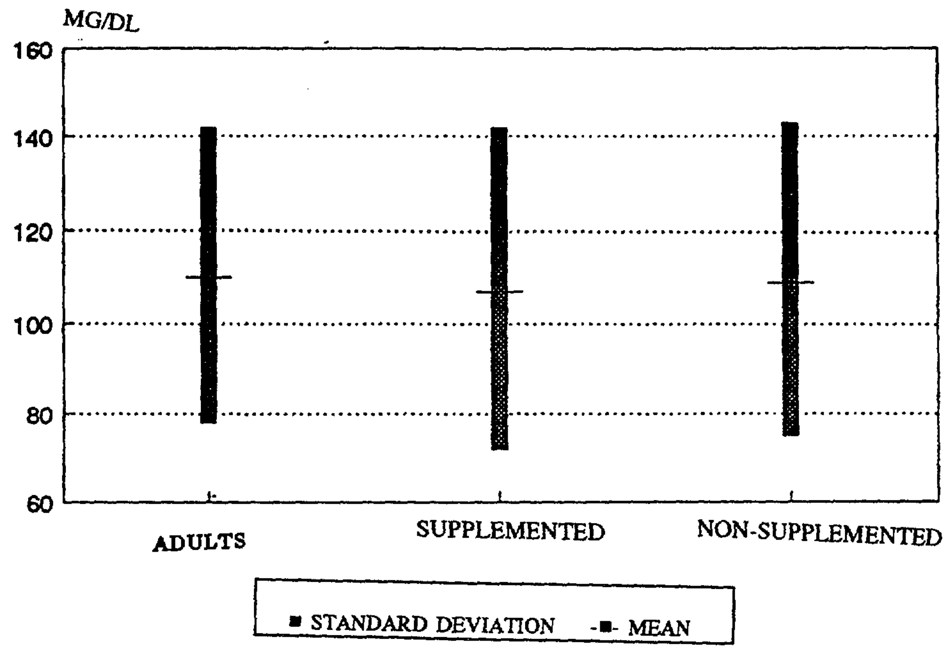
83. MENTAL AGE (TERMAN-MERRILL) BY MENARCHEAL AGE



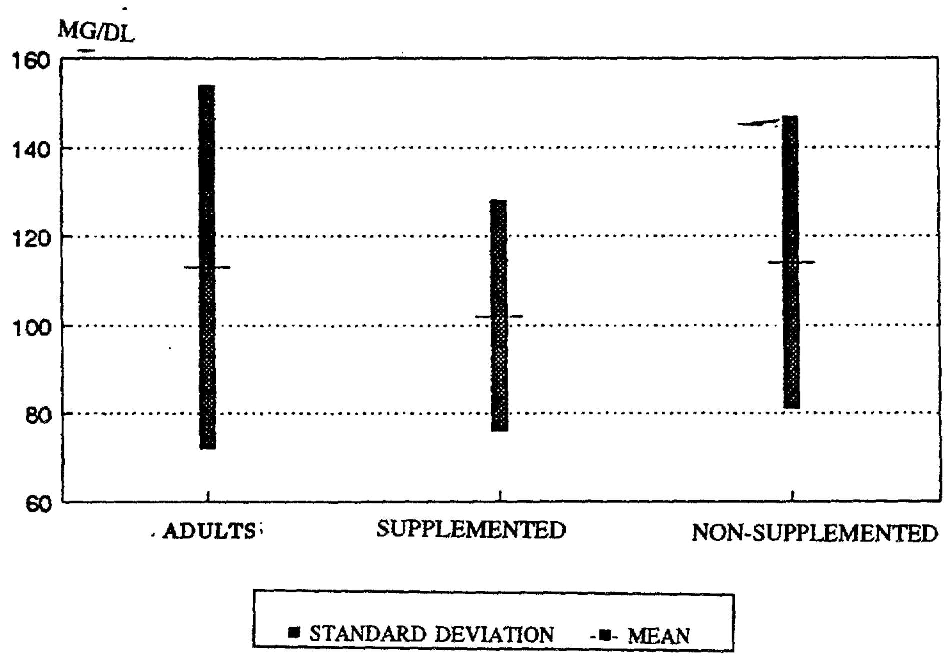
84. INTELLIGENCE QUOTIENT BY MENARCHEAL AGE



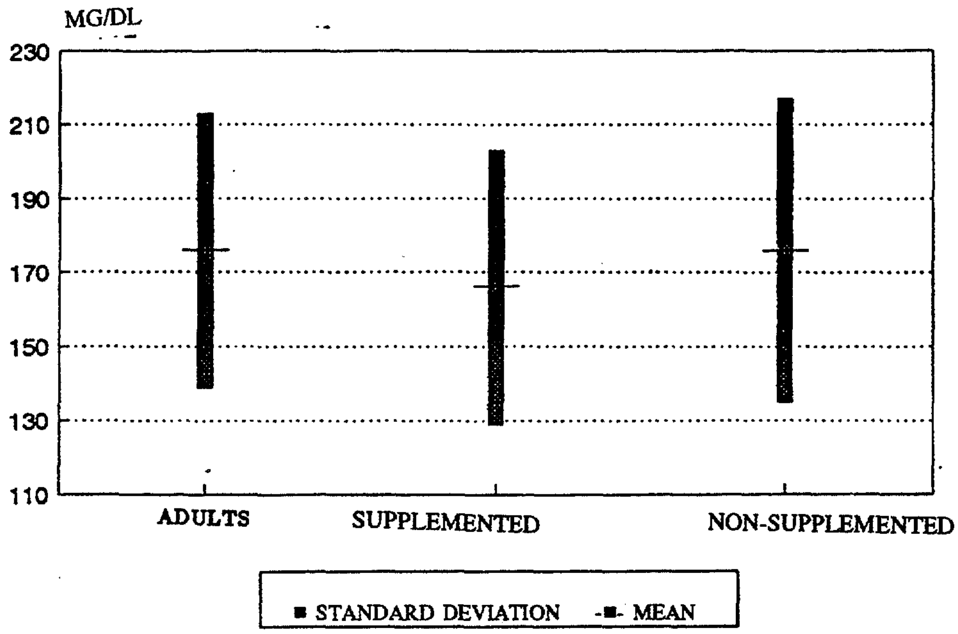
85. SERUM CHOLESTEROL
FEMALES



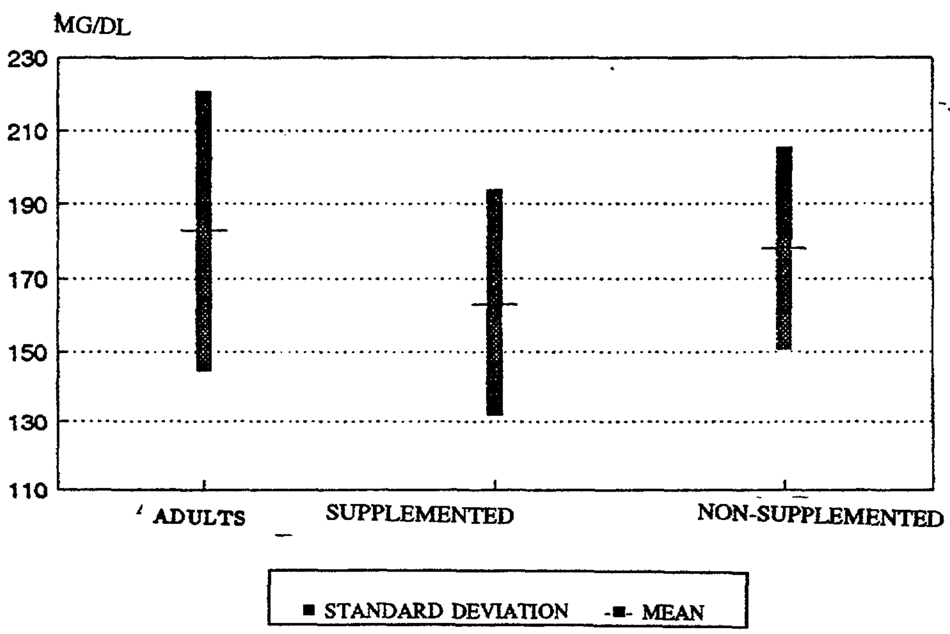
86. SERUM CHOLESTEROL
MALES



87. SERUM LDL
FEMALES



88. SERUM LDL
MALES



About the Nutrition of Adolescent Girls Research Program

The Nutrition of Adolescent Girls Research Program was established in 1990 through a cooperative agreement with the Office of Nutrition, U.S. Agency for International Development. The premise for the Research Program was that the period of adolescence should be viewed as a window of opportunity for enhancing the lives of adolescents in developing countries, both for the present and for their future adult roles. Investments during adolescence can help girls and boys realize social and educational opportunities, manage their home and market responsibilities, and improve their nutritional and health status. However, little information is available to guide the formulation of policies and programs to address adolescent nutrition. The objective of the Research Program was to provide information on the many factors that affect and are affected by nutritional status, including physical growth, morbidity, food intake, energy expenditure, education level, family structure, intrahousehold distribution, social and economic status, and self-perceptions. The program includes 11 research projects: five in Latin America and the Caribbean, four in Asia, and two in Africa.

Publications from the Nutrition of Adolescent Girls Research Program

Investing in the Future: Six Principles for Promoting the Nutritional Status of Adolescent Girls in Developing Countries *by* Kathleen M. Kurz, Nancy L. Peplinsky, and Charlotte Johnson-Welch.

Addressing Needs and Opportunities: A Survey of Programs for Adolescents *by* Nancy L. Peplinsky.

Report Series:

No. 1. Nutritional and Health Determinants of School Failure and Dropout in Adolescent Girls in Kingston, Jamaica *by* S.P. Walker, S. Grantham-McGregor, J.H. Himes, and S. Williams.

No. 2. Response of Endogenous Growth Factors to Exercise and Food Supplementation in Stunted Pubertal Girls in Guatemala *by* B. Torún, F. Viteri, M. Ramírez-Zea, M. Rodríguez, and K. Guptill.

No. 3. Nutrition, Health and Growth in Guatemalan Adolescents *by* R. Martorell, J. Rivera, and P. Melgar.

No. 4. Early Nutrition and Physical and Mental Development in Mexican Rural Adolescent Women *by* A. Chávez, C. Martínez, B. Soberanes, L. Domínguez, and A. Avila.

No. 5. A Multidimensional Study of Nutritional Status of Adolescent Filipinas *by* A.T. Roldan, V. Bautista, and R. Manalo.

No. 6. A Study on the Factors Influencing Nutritional Status of Adolescent Girls in Nepal *by* S. Regmi and R. Adhikari.

No. 7. Understanding Gender-Differentiated Constraints to Philippine Farm Household Investments in Adolescents: Implications for their Nutritional Status *by* H.E. Bouis, M. Palabrica-Costello, O. Solon, and A.B. Limbo.

No. 8. Influence of Women's Social Status on the Nutritional Status of Adolescent Girls in Bénin *by* S. Inoussa, E. Alihonou, S. Vissoh, V. Capo-Chichi, O. Houndebasso, C. Quenum, and A. Sagbohan.

No. 9. Role of Domestic Workload, Intra-family Situation and Attitudes on Nutritional Status of Urban Slum Adolescent Girls and Boys in India *by* R.D. Potdar, I. Parikh, and S.M. Rege.

No. 10 Study of the Factors that Influence the Nutritional Status of Adolescent Girls in Cameroon *by* J. Ngo Som and K.M. Kurz.

No. 11. Improving Nutritional Practices of Ecuadorian Adolescents *by* Y. de Grijalva and I. Grijalva.

A final paper synthesizing results from all research projects will be forthcoming.