BONE AGE IN MALNUTRITION

Abdullah Kenanoğlu, M.D.* and Tuğrul Pırnar, M.D.**

It is obvious to those concerned with preventive medicine and public health how important a thorough knowledge of child development, and of factors causing its retardation, should be. Many methods have been used to determine the speed and degree of development of children. Among these methods, the observation of childrens' skeletons during the process of development has been found to be a relatively objective measurement of general development and has become one of the most common yardsticks used in the measurement of children's development today.

After skeletal development of children began to be widely observed in this way, the factors causing its retardation were also investigated by many researchers. However, the effect of malnutrition on the skeletal system, which constitutes the subject of this study, has not been completely investigated so far. Some text books and some studies on bone growth mention the adverse effects of malnutrition; but such studies are usually experimental and reflect the personal opinions of persons concerned with pediatrics and radiology.[1,2,3] To date there has not been a fullscale study of the effect of malnutrition on a developing skeleton as can be seen from a review of the medical literature at this time.

And yet malnutrition is one of the most important, if not the most important, menaces to child health in this country. In fact, a survey done among outpatients of Hacettepe Children's Hospital revealed a malnutrition rate of 43 per cent among babies under two years of age. We thought therefore, that a statistical analysis of the effect of malnutrition on bone development would be useful.

Growth and development in children are two separate processes which usually proceed together but not always at a parallel rate. In fact, growth, which shows itself as an increase in mass, and in volume, can be easily followed by weight and height measurements. Whereas, the process of development, that is, the maturing of the

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From Ankara University Hacettepe Medical Center and Hacettepe Children's Hospital.
* Chief, Radiology Department.
** Radiologist.

whole organism, cannot be evaluated with height and weight measurements alone.[4] This can be illustrated with these two examples : in cases of *pubertas praecox* the degree of development of the child greatly exceeds his growth rate as shown by his height and weight. By contrast, in cases of hypogonadism the child's height and weight greatly exceed the degree of development in the genital system. In both such pathological conditions, and in children with normal development, the degree of skeletal development can be easily determined through a wrist roentgen ray film, and this, in turn, always shows the true maturity level of the genital system.[5] There is no doubt that the level of maturity of the genital system is the most dependable criterion for the degree of development of the body as a whole, (the degree of development of the neuromuscular system, internal and external secretion glands, secondary sex characteristics, psychological behavior, etc.) Therefore, it is necessary for a full understanding to correlate the developmental information obtained by following the development of the child's wrist bone structure with his growth rate as obtained through weight and height measurements.

The presence of growth retardation is readily apparent in cases of malnutrition where the child's weight is below the minimum weight indicated for his age. Is there also a retardation in development and maturation in such children? As we have mentioned above, the best way to discern this is to compare the child's chronological age with his bone age, which will be both a measurement of and an indication of his general development.

The Choice of Suitable Standards

It is necessary to know the normal standards of bone age for every chronological age in order to determine the bone age of a particular child by comparing his bone films and chronological age with the standard. A child's bone age may be described as retarded or advanced only if the normal bone age, (obtained by observation of normal bone development at given intervals), for that particular chronological age, is known.

Greulich and Pyle's standards were established following surveys made in the U.S.A. of white children of both sexes during the years 1931 to 1947. They were prepared through the observation of 1000 children over a period of ten years. Physical examinations, intelligence tests, radiologic examinations of the wrists and ankles

were carried out on the children once every three months during the first year, once every six months from the first to the fifth years and once every year after that. These standards have proven to be the most dependable and also the largest series so far published and accordingly, we wanted to use them as the standards for this study.

Applicability of Standards to Turkish Children

The accepted standards were prepared after a study involving American children and therefore it was necessary to prove that these standards could be applied equally well to Turkish children. Without this proof the American standards could not be considered valid as criteria for comparison.

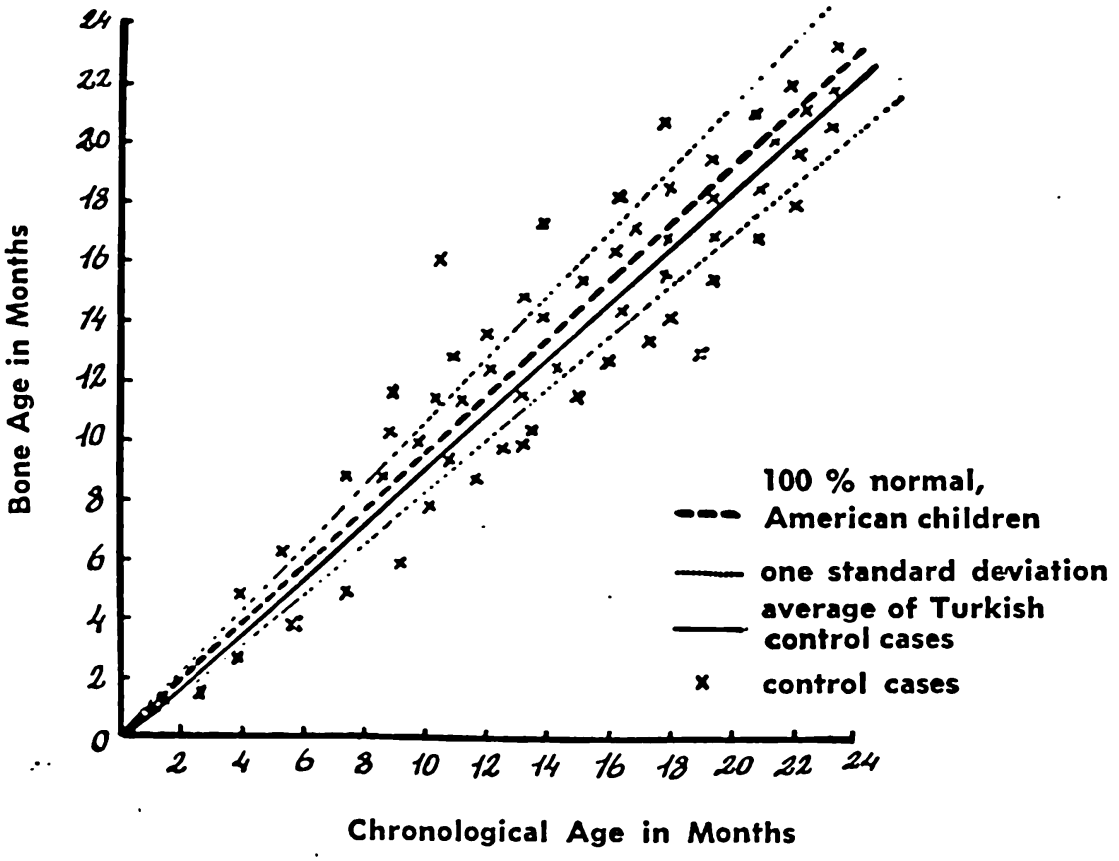

Figure 1. A comparison of Turkish control cases with American standards (Greulich and Pyle[5]).

Among 60 healthy outpatient clinic children, chosen for the purposes of control, (32 boys and 28 girls), the bone ages were determined in the following way. The chronological ages of these children and their wrist bone films were compared with the same chronological ages and normal bone ages as indicated in the Greulich and Pyle atlas. The results of these comparisons are shown as percentages of the normal in figure 1, according to age distribution.

The percentage here means the percentage of the child's bone age as compared with the bone age which he should have according to his chronological age, judging by the Greulich and Pyle standard As can be seen, in our control series 98.7 per cent of the Turkish children of this normal group fall within the normal American range, according to the Greulich and Pyle atlas, with respect to their comparative bone ages. Only one per cent of these children fell outside the American range. Because of this statistical agreement between normal American children and normal Turkish children, it was decided that the chosen standards of Greulich and Pyle could be applied to the children forming the subject of this study, at least up to two years of age, and used in the determination of their bone ages.

Material and Methods

All the records of malnutrition patients under the age of two years, both from the inpatient and outpatient departments, since 1958 when Hacettepe Children's Hospital was opened, were investigated. Those among this group whose wrist or ankle roentgen ray films were taken, for any reason, were chosen as the basis of this study. Those whose body weight was not recorded during a maximum of five days before and five days after the taking of the wrist films, were not included in the study, because the weight of a child at the time when the film was taken was considered to be an important factor, from the point of view of the degree of malnutrition. In the same way other children with any disease which might affect normal bone development were left out. Among such cases were, for instance, two certain cases of hypothyroidism and three cases of possible hypothyroidism.

In a large number of the 180 cases selected for the study in this way, clinical and radiological findings of rachitism were present. Actually, the cases upon which the results of the study are based were cases of pure malnutrition, not involving rachitism, since rachitism can affect bone age. However, since we were faced with such a large number of cases of rachitism we have placed those cases of malnutrition with rachitism in a separate group, in order to investigate the relationship between rachitism and malnutrition.

Of the 180 patients, 99 were boys and 81 were girls. The distribution of these 180 children according to age and weight is shown in figure 2. They were divided into four groups indicating the degree of malnutrition.

Wrist films were taken with a Super-Dynamax tube without a Bucky diaphragm, using 100 milliamperes and 35-38 kilovolts according to the child's age and weight, at a timing of 0.60-0.80 seconds. The right hand wrist was preferred. From these films of cases of pure malnutrition the bone ages were calculated according to the standards in the Greulich and Pyle atlas for boys and girls, separately. Following that the percentage of each child's bone age, as calculated above, compared to his chronological age was determined and the results in the graphs were based on this bone age percentage as compared with the standards.

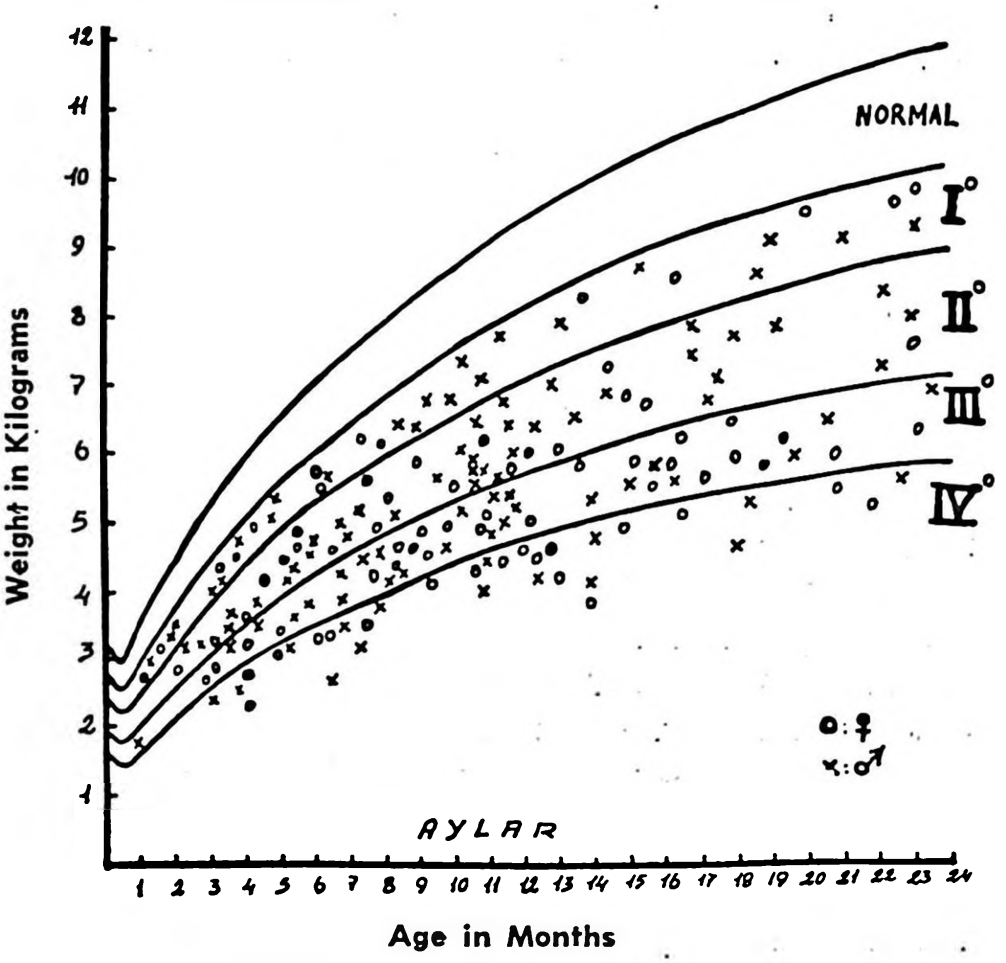

Figure 2. Distribution of Turkish children by age and weight.

Discussion

Out of 180 cases of malnutrition, a percentage as high as 42.2 per cent, (76 cases), showed the presence of rickets as well as malnutrition. With this observation, the necessity of changing, to a certain extent, the long accepted view that rickets occurs only in bones which are growing well, becomes obvious. This belief still exists as a general opinion and the presence of a growing bone is considered a must in order to secure radiologic findings consistent with rickets.

It is also accepted that in such conditions, such as malnutrition, where the normal growth of protein-rich matrix in the bone structure shows a slowing down, symptoms of rickets remain latent. Whereas, as can be seen in table 1, symptoms of rickets can be found in cases of various degrees of malnutrition. However, as it is seen

TABLE 1

RICKETS IN MALNUTRITION

Degree of Malnutrition	I°	II°	III°	IV°
Number of patients with malnutrition showing symptoms of rickets	17	33	25	1

also in table 1, it is true that rickets is almost never found in very severe cases of malnutrition. In fact, in this series, in only one case out of the 32 cases of fourth degree malnutrition were symptoms of rickets seen. Rickets was seen in 25 out of 53 third degree cases, 33 out of 59 second degree cases and 17 out of 36 first degree cases of malnutrition. These observations show that, generally speaking, symptoms of rickets can be found radiologically in cases of malnutrition but that the possibility of finding a great number of them in cases of severe malnutrition is extremely unlikely.

The 104 cases of pure malnutrition which made up our real subject constituted 57.7 per cent of the 180 cases. The distribution of this number according to sex and degree of malnutrition is seen in table 2. The results were obtained by calculating the averages of the bone age percentages of the children (boys and girls) in every degree of malnutrition.

TABLE 2

INCIDENCE AND DEGREE OF MALNUTRITION BY SEX

	I°	II°	III°	IV°	Total
Girls	8	11	12	17	48
Boys	11	15	16	14	56

In girls from the first degree malnutrition group, the average bone age percentage according to the standards was found to be 95.05 per cent. In boys the percentage for this same first group is

82.46 per cent and the average for all the children in this group becomes 88.75 per cent. These results are shown in figure 3 and the place of each patient according to his chronologic and bone age is also shown in this graph.

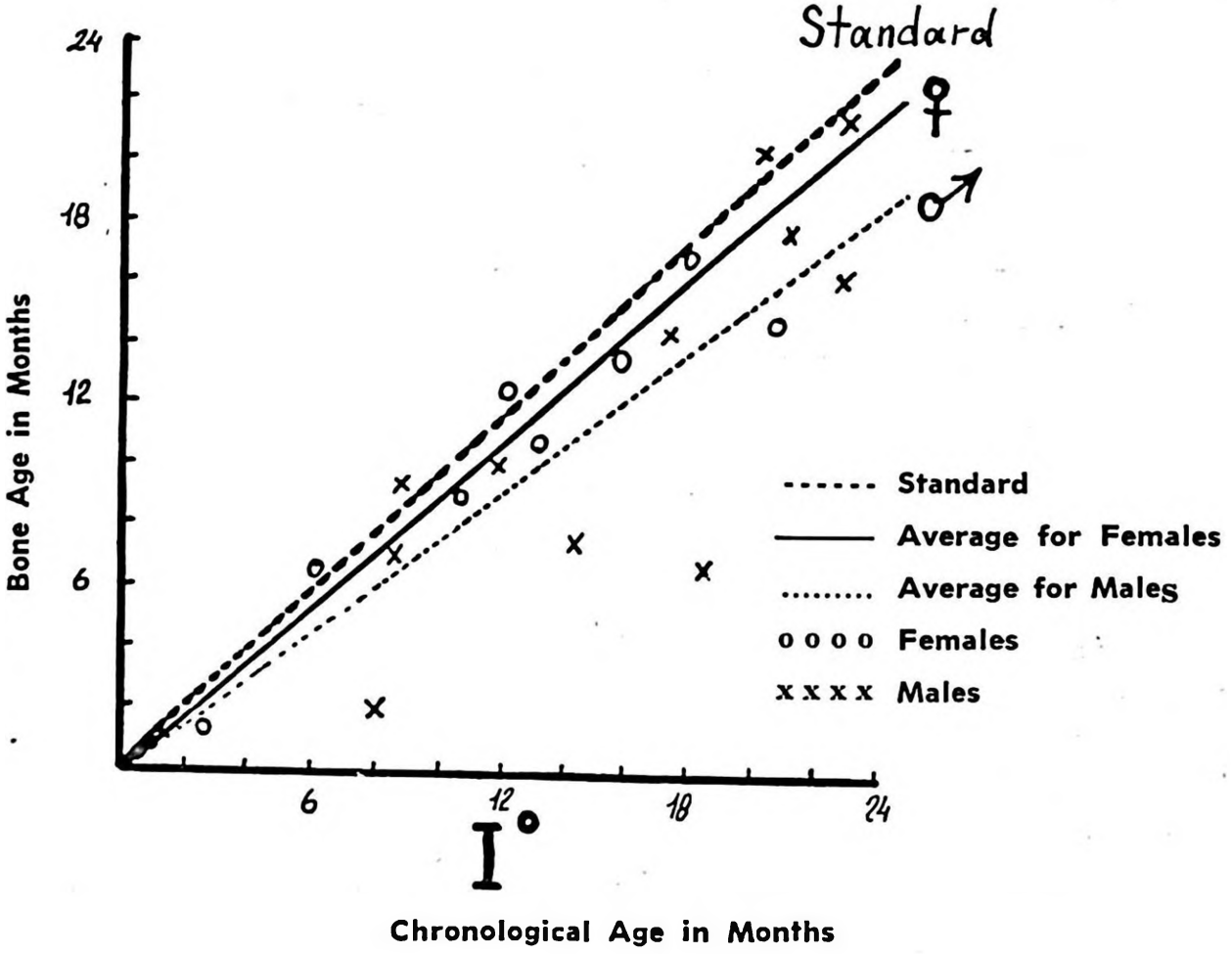

Figure 3. Bone ages of patients with first degree malnutrition compared with the standard.

The average bone age for girls with the second degree of malnutrition was 71.60 per cent and for boys 70.79 per cent. The average for the whole group, boys and girls, was 71.22 per cent and these results are shown in figure 4.

In cases with grade III malnutrition the average bone age of the girls was 54.55 per cent, of the boys 53.18 per cent, and for the whole group the average was 53.86 per cent. These results are shown in figure 5.

Finally, in the cases with grade IV malnutrition, the bone age average was 42.79 per cent for girls and 31.42 per cent for boys while 37.10 was the average for the whole group. These results are shown in figure 6.

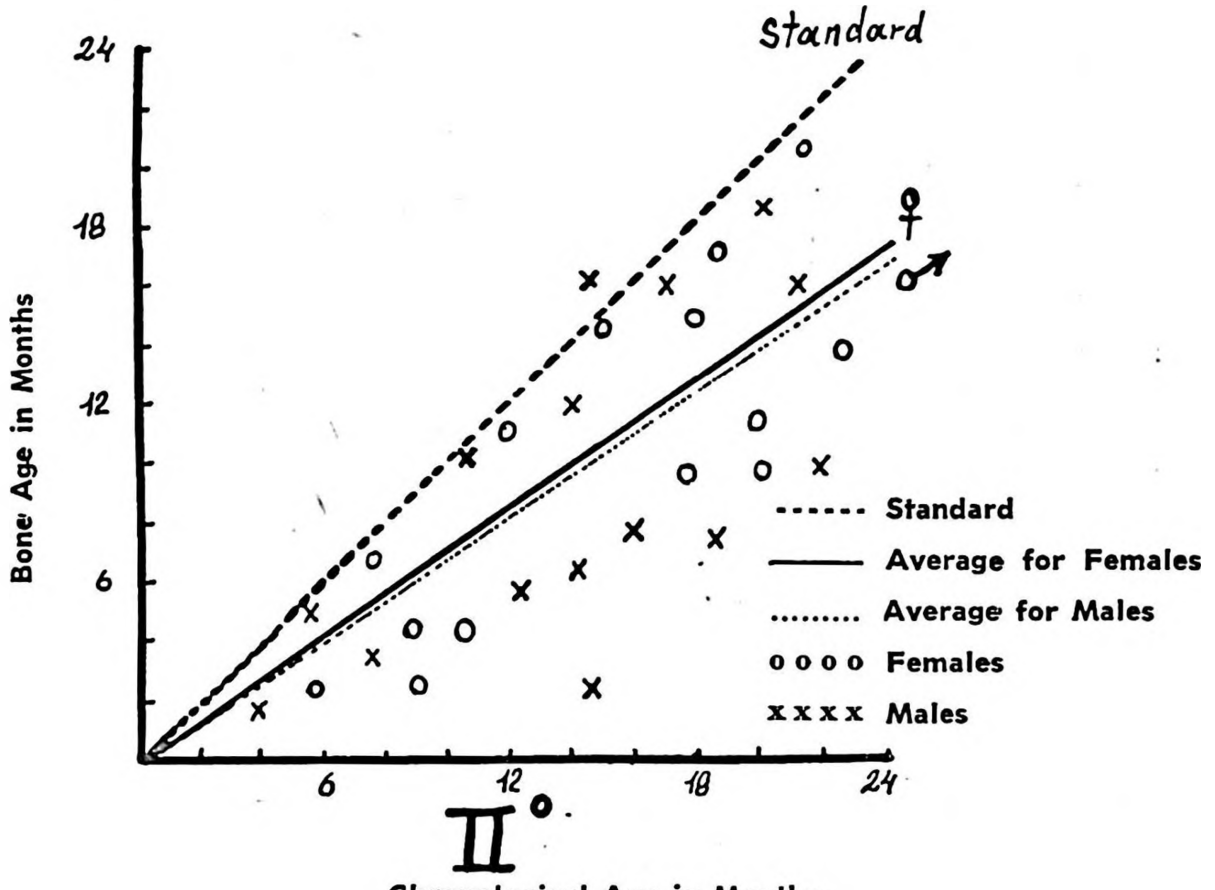

Figure 4. Bone ages of patients with second degree malnutrition compared with the standard.

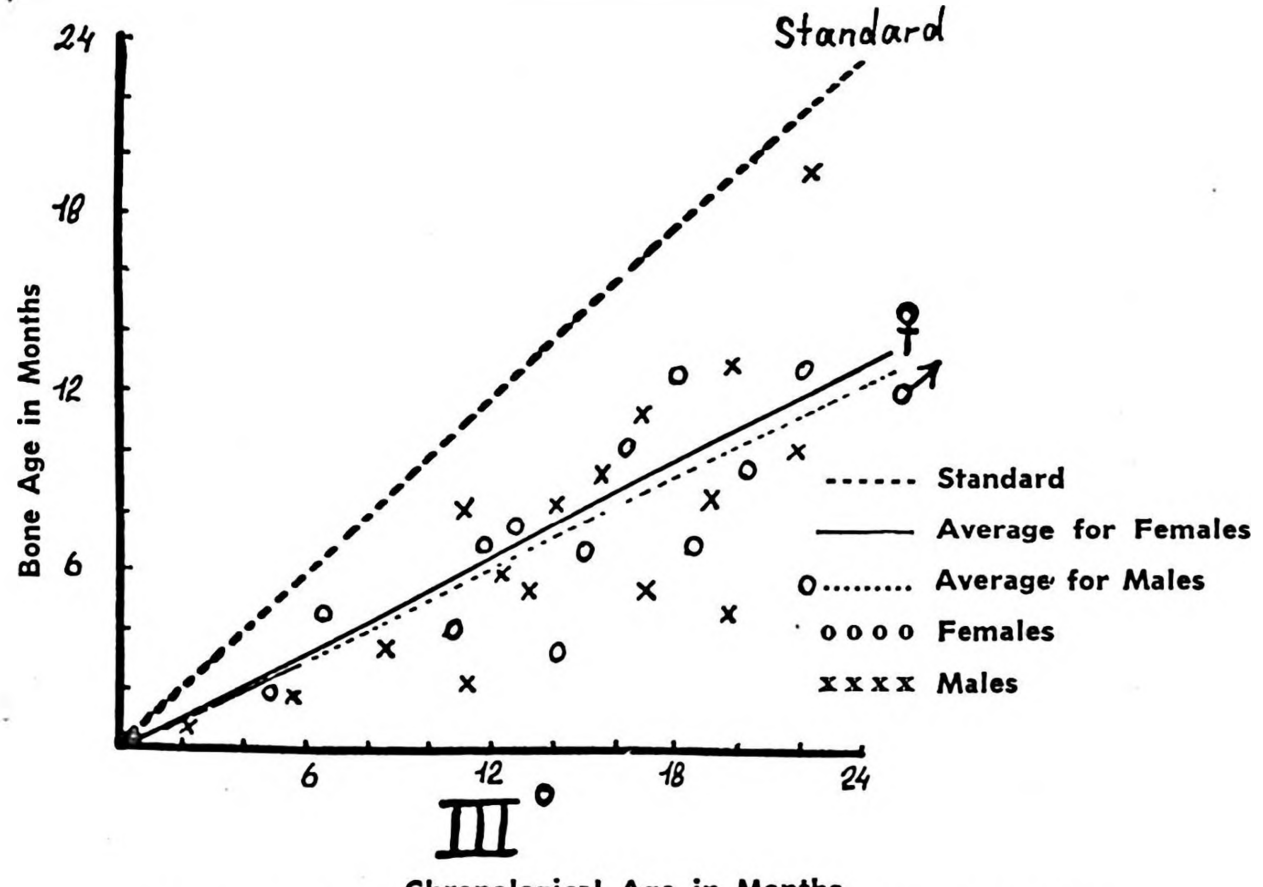

Figure 5. Bone ages of patients with third degree malnutrition compared with the standard.

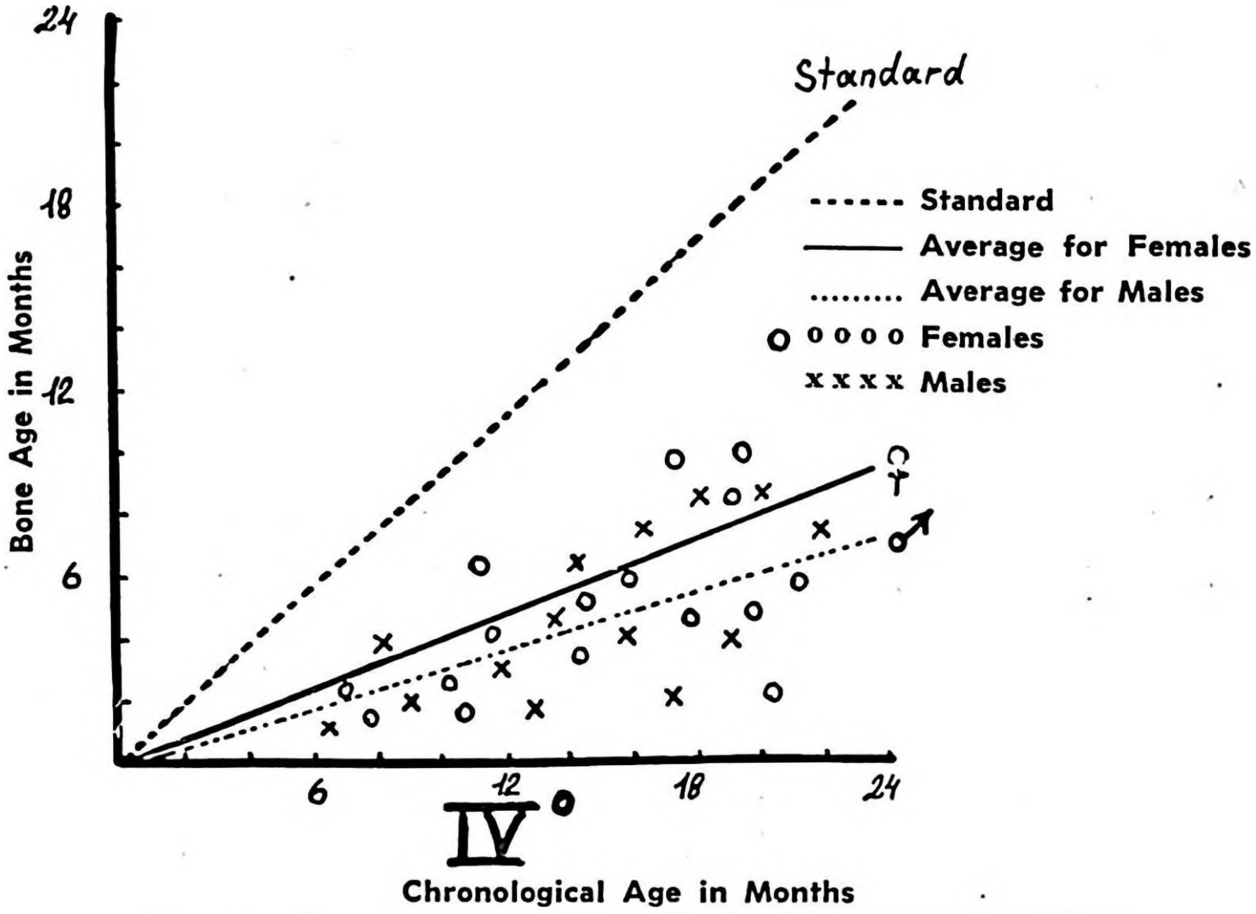

Figure 6. Bone ages of patients with fourth degree malnutrition compared with the standard.

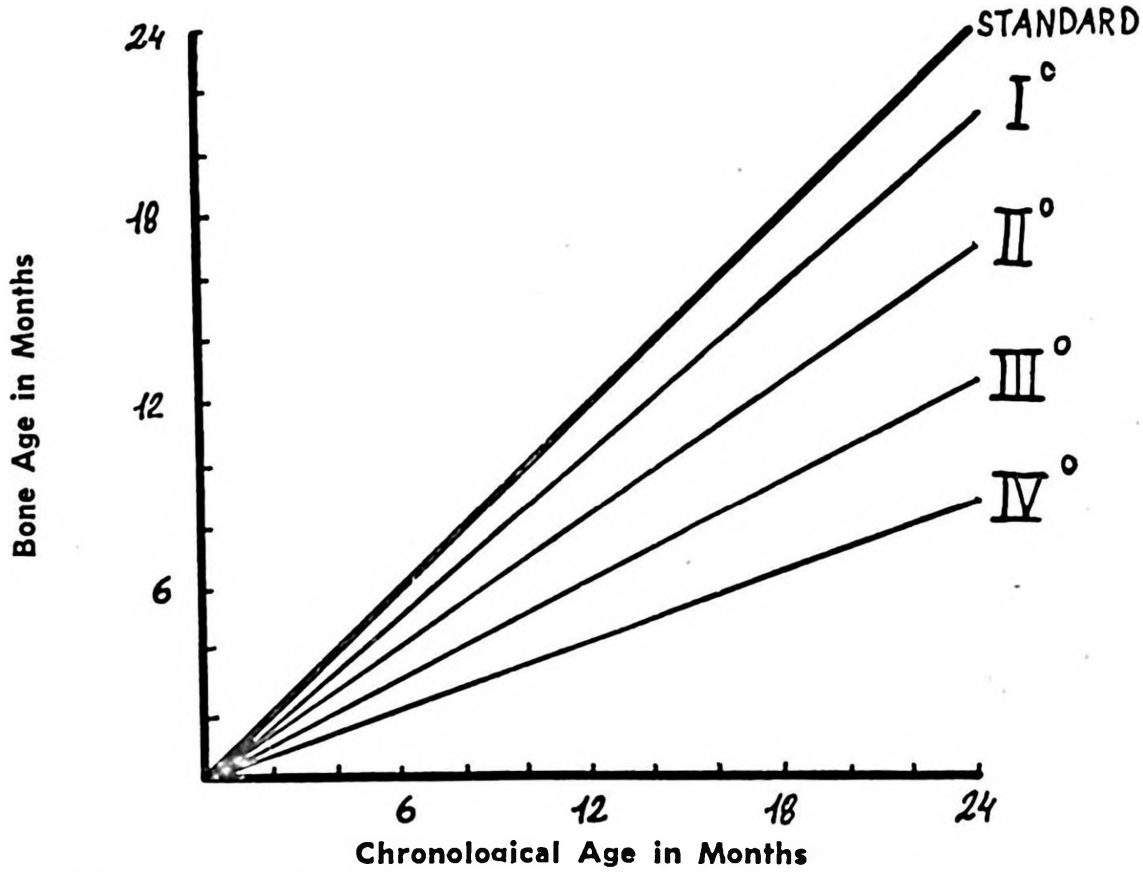

Figure 7. Comparison of the average bone age in each of the four degrees of malnutrition with the standard.

It can be seen from these results that there are various degrees of retardation of the bone age, which is an indication of bone development, in children with various degrees of malnutrition. In order to show better every degree of retardation we have compared them to the standard and gathered this information together in figure 7.

Conclusion

A survey of the bone ages of 104 children with pure malnutrition shows that in conditions of malnutrition the skeletal system is usually retarded in growth and development and, therefore, the bone age too is retarded compared to that of normal children. As skeletal development is an indication of the growth and development of the other systems of the body, this retardation of skeletal growth and development indicates that the other systems of the body are retarded too.

It becomes clear that the degree of retarded development is in direct correlation with the severity of the malnutrition. As can be seen in figure 7, the percentage of bone age retardation increases with the degree of severity of the malnutrition.

When the rate of bone age retardation in every degree of malnutrition is shown in two separate groups for boys and girls, (figure 8), the interesting fact is noted that the bone age of girls, in every

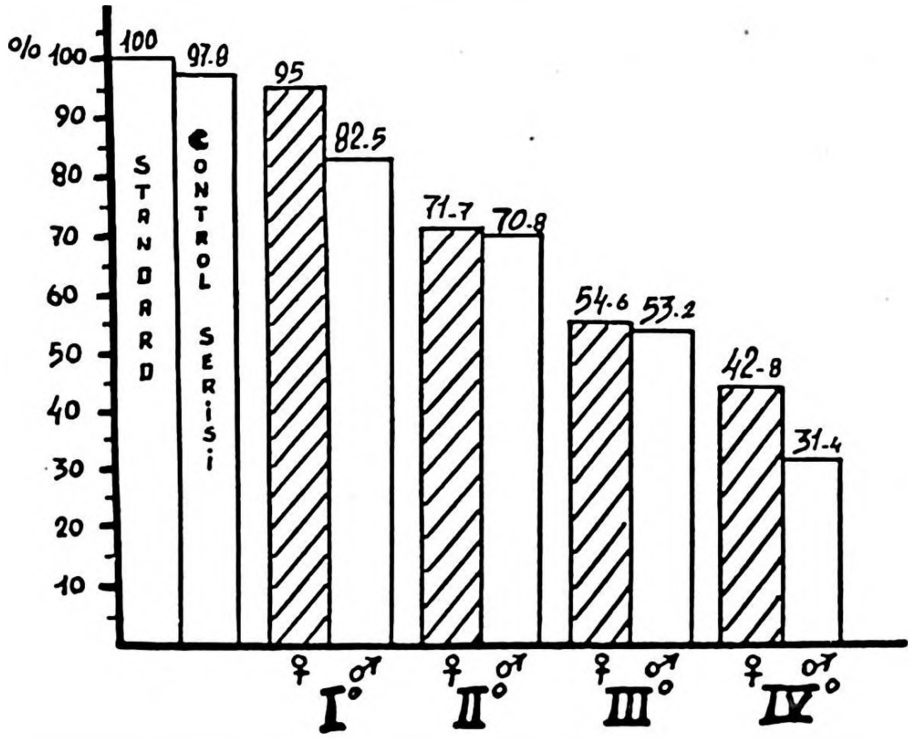

Figure 8. Comparison of male and female bone ages in every degree of malnutrition with the standard and with the controls. All are expressed as per cent of normal.

degree of malnutrition, is less retarded than that of the boys. It is not possible to express an exact opinion on this point since our series consisted of only 104 cases but it should be interesting to verify this observation on a larger group of children from the point of view of determining whether girls are possibly more resistant to the ill effects of malnutrition than boys.

Summary

Bone ages in 104 children with malnutrition were determined according to the Greulich and Pyle atlas, after it had been decided that there was no other disease present which could retard skeletal development. These children were then divided into four groups according to the degree of malnutrition. The averages of the percentages of bone age in every group was calculated and compared to the Greulich and Pyle standards. From these results it was seen that in children with malnutrition, there was retardation of the bone age in accordance with the degree of malnutrition. This retardation was found to be more marked in boys than in girls.

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