APPENDIX V-d

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Correlates of Heights Among Poor Children:
Parental Heights and Early Nutrition

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ABSTRACT

Coefficients of correlation were calculated for height at each year of age with mid-parental, maternal or paternal height for three groups of children from the same urban poor families: a) children who had been severely malnourished in early life (1-17 yr: 2-115 boys, 2-47 girls), b) their presumably "healthy" siblings (1-19 yr: 3-126 boys, 7-135 girls), and c) siblings "protected" during first 1-2 years of life (1-10 yr: 4-14 boys, 3-8 girls). "Healthy" boy-father "r" rose from 0.349 ($P<0.05$) at one yr to 0.538 ($P<0.0001$) at 10 yr, then declined to 0.109 (N.S.) at 17 yr. "Healthy" boy-mother was 0.161 (N.S.) at 1 yr, 0.504 ($P<0.0001$) at 11 yr, 0.308 (N.S.) at 16 yr, then 0.528 ($P<0.02$) at 17 yr. "Healthy" boy-mid-parent was 0.398 ($P<0.02$) at 1 yr, 0.673 ($P<0.0001$) at 11 yr, 0.279 (N.S.) at 16 yr, 0.443 (N.S.) at 17 yr. Malnourished boy-mid-parent was 0.056 at 1 yr, 0.477 ($P<0.001$) at 12 yr, 0.310 (N.S.) at 13 yr, negative at 14-16 yr. "Protected" boy-mid-parent was 0.383 (N.S.) at 1 yr, 0.794 ($P<0.01$) at 6 yr, 0.898 ($P<0.02$) at 10 yr. "Healthy" girl-father "r" was -0.028 at 1 yr, 0.370 ($P<0.001$) at 8 yr, 0.225 ($P<0.05$) at 10 yr, 0.507 ($P<0.001$) at 14 yr, 0.276 (N.S.) at 18 yr. "Healthy" girl-mother was 0.109 (N.S.) at 1 yr, 0.348 ($P<0.0001$) at 7 yr, 0.209 ($P<0.02$) at 9 yr, 0.017 (N.S.) at 11 yr, -0.017 (N.S.) at 14 yr, 0.630 ($P<0.05$) at 19 yr. "Healthy" girl-mid-parent was -0.033 at 1 yr, 0.444 ($P<0.0001$) at 8 yr, 0.201 ($P<0.05$) at 10 yr, 0.422 ($P<0.01$) at 15 yr. Malnourished girl-mid-parent was 0.362 ($P<0.05$) at 1 yr, 0.515 ($P<0.001$) at 4 yr, 0.383 ($P<0.05$) at 7 yr, -0.015 at 12 yr, 0.462 (N.S.) at 15 yr. "Protected" girl-mid-parent was 0.393 (N.S.) at 1 yr, 0.770 ($P<0.01$) at 3 yr, 0.458 (N.S.) at 7 yr. Moderate undernutrition does not significantly attenuate strong influence of parental stature on child stature during prepubertal

years. Temporary decline in coefficients during puberty and adolescence is probably due to early growth spurts in short children of short parents. Severe malnutrition in early life temporarily obscures genetic influences, more in boys than girls. Near-maximal growth during first 1-2 yr probably canalizes growth despite loss of advantage in stature from chronic undernutrition later in childhood.

In highly developed societies the adult statures of both parents can be expected to reflect their own genetic endowments and to be predictive of their children's statures. In groups of children from such environments correlations between infant lengths and mid-parental heights are relatively weak at birth, increase during the first year, and become particularly strong after three years of age, when the coefficients are consistently above 0.5 and in some series, above 0.6 (Bayley 1954, Tanner et al 1970). In the Bayley study the heights of boys seemed to be more strongly correlated with their fathers' heights and those of girls with their mothers' but this was not the case in the Tanner study nor in others (Kagan and Moss 1959, Livson et al 1962). As might be expected, the correlations with mid-parental heights are stronger than those with either parent (Roche et al 1975).

When similar studies were made in 8-12 year old children from a Polish population of somewhat lower socio-economic status, among whom it was less certain that the parents had enjoyed adequate nutrition during their growing years and among whom some of the children evidently experienced better nutrition than others, the same correlations were found to be weaker (Bielicki and Welon 1966). The fact that they were lower in boys than in girls was thought possibly to be due to a "better canalization" of growth in the female or, put differently, to a better resistance to adverse environmental circumstances.

In studies of children from underdeveloped areas, in which undernutrition is the rule and malnutrition is common, there is considerable interest in determining whether the stunting commonly

observed is primarily of nutritional origin or if it is largely determined by genetic influences. For the individual child being rehabilitated from malnutrition this distinction is of considerable practical importance. In the formulation of food and nutrition policies it is equally important to determine if the low statures found among poor people are not susceptible to much improvement or if they are primarily of nutritional origin and potentially preventable. The literature contains numerous remarks as to the permanence of stunting caused by malnutrition in early life but our own experience suggests that the observed short statures are more the result of undernutrition during the entire growth period than of a severe episode of early malnutrition and that the survivors, particularly the girls, differ very little in stature from their own siblings who did not experience such episodes (Graham et al 1982).

Mariscal et al (1966) studied 76 Mexican families in which at least one child had been treated for severe malnutrition. They calculated predicted adult height for each child in the family from actual height and chronologic age (instead of the recommended skeletal age) and studied the correlations of these predicted heights with maternal and paternal heights. In general, the coefficients were very low; only between predicted heights for girls and the heights of their fathers were these fairly consistently positive in most age groupings. The authors speculated that these poor correlations were due to the probability that neither the parents nor their children were expressing their genetic potential. More recent reports from New Guinea found equally poor

correlations between parent and child heights among very poor rural families (Malcolm 1974).

In a longitudinal study of the subsequent growth of children who were severely malnourished in early life, of their presumably healthy siblings who were not, and of other siblings reared in a protected environment during the first one to two years of life, we have found that the ex-malnourished tend to catch up to their "healthy" siblings (Graham et al 1982), that the "protected" siblings lose their early advantage in size within less than a year after returning to their original homes (Baertl et al 1976), and that ex-malnourished children adopted into better homes far outstrip the others in growth (Graham and Adrianzen 1972). Taken together these results suggest that environmental circumstances during all of childhood have a strong influence on achieved growth and eventual adult stature. Along with the obvious role of nutrient intakes, it is important to assess the importance of other environmental factors as determinants of growth, and to do so in a meaningful manner the genetic endowment of each child, as represented by parental size, must be taken into account. The present report examines the correlations of mid-parental, paternal, and maternal heights with those, at each year of age, of ex-malnourished children, their apparently healthy siblings, and their siblings who were reared early in a protected environment.

MATERIALS AND METHODS

Between 1961 and 1966 periodic anthropometric measurements were made of children who had been discharged from the British American Hospital in Lima after treatment for marasmus or kwashiorkor and diarrhea. In 1966 regular yearly examinations were begun on all available ex-patients and their siblings as well as on patients discharged between 1966 and 1971 and their siblings. All measurements were discontinued in 1976 after support for the study had been terminated. Mean age on admission had been 1.09±0.74 years for boys and 0.89±0.58 years for girls. Mean durations of hospitalization had been 0.66±0.43 and 0.61±0.67 years, respectively.

A number of next-born siblings of ex-patients were reared in a protected environment from shortly after birth until one to two years of age. At the time of return to their original homes they were significantly taller than children reared continuously at home but within 6 to 12 months their advantages in stature had virtually disappeared (Baertl et al 1976).

In this analysis all siblings who were never treated in the hospital for malnutrition and who were not reared outside their home at any time are referred to as "healthy", although it is recognized that, coming from generally very poor homes which had produced at least one severely malnourished child, they were almost certainly undernourished during parts if not all of their growing years.

Only those "healthy" siblings who had at least one true parent (as reliably as could be determined) available for measurement and those ex-patients or "protected" siblings who had both parents available for

measurement are considered. Mid-parental height is the arithmetic average of paternal and maternal heights.

Some of the children were measured within a few days of their birthday but most were not. If there were two measurements not further than 15 months on either side of the 3rd to 19th birthdays, the height on the birthday was determined by interpolation. For the 2nd birthday the limits were seven months, and for the 1st birthday, six months after and three months before. If these conditions were not met but there were two measurements within six and 15 months after or before the 3rd to 19th birthday, the height on the birthday was determined by linear extrapolation backward or forward. For extrapolation to the 2nd birthday the two measurements had to be within six and 12 months after or before, and for the 1st birthday, within three and six months after or 1½ and three months before the birthday. If on some occasions none of these conditions could be met, the child was not included at that year of age.

The relationships between child heights and parental heights were examined by polynomial regression analysis up to the third degree (Ostle 1954). If both the linear and the quadratic components of the relationship were significant at a given age, it could be assumed that the relationship increased or decreased after a certain parental height was reached. If both the linear and cubic components were significant at a given age, it could be assumed that the relationship decreased after a certain parental height was reached and then increased again after another parental height was passed. This would indicate that shorter parents had shorter children and that taller parents had taller children but that more average parental height was not as predictive. Such a

relationship might be and was actually encountered. The other possible explanation for significant linear plus cubic components, that average parental height was more predictive of child height than short or tall stature would be unusual and was not found. When a significant quadratic component was found along with highly significant linear and cubic components it was due to a stronger relationship to child height at one extreme of parental height than at the other.

Covariance analysis was used to determine if the relationship between child height and parental height at a particular age was different between boys and girls, between ex-patients and same-sex "healthy" siblings, and between "protected" siblings and same-sex "healthy" siblings of ex-patients.

An independent "t" test was used to compare at the same age the heights of ex-patients and "healthy" siblings and those of "protected" and "healthy" siblings of the same sex.

For ex-patients the number represented at each age increased up to three years of age, as many were not admitted until after one year of age and some until after two years of age. Many of the measurements in the first three years were made while the child was still under treatment. The decreasing number of ex-patients represented after three years of age was due to the shorter duration of "follow-up" for those recruited later. For the "healthy" siblings, some older and some younger than the ex-patients, the changing numbers represented at each age were in great part due to different ages at first recruitment into the study. The greater fall-off in numbers for boys than for girls in the late teens

was due to their greater tendency to leave home. The "healthy" siblings were each represented an average of almost exactly five times, slightly higher for girls than for boys. For the "protected" children the falling off in numbers after certain ages was due to the decreasing numbers who had reached those ages when the study was terminated.

RESULTS

Table 1 represents the regression analyses for the relationships between the heights of "healthy" brothers and sisters of malnourished children and their respective fathers and mothers.

At one year of age "healthy" boys' heights were significantly ($P<0.05$) related to their fathers' heights, with a correlation coefficient of 0.349, but not to their mothers' heights. The degree of correlation with both paternal and maternal height increased during the next few years, and was highly significant between five and eleven years of age. Between seven and ten years of age the relationship with mothers' heights had a highly significant cubic component resulting from the stronger predictive value of short and tall mothers for their sons' heights. After eleven years of age the relationship between fathers' heights and their sons' heights became less and less marked, no longer being significant at 14 years and thereafter. The relationship to mothers' heights, though also decreasing after eleven years of age, remained stronger until the decreasing numbers of boy-mother pairs caused the "r"s to lose significance.

"Healthy" girls' heights had no significant relationship to their fathers' heights until five years of age and no consistently significant

relationship to their mothers' heights until the same age. The relationship to their fathers' heights remained significant until the age of 16 years, decreasing somewhat between nine and 12 years and increasing again between 13 and 15 years. The relationship to mothers' heights increased in strength and significance until seven years of age, was lower but still significant at eight and nine years of age, and then disappeared. The "r" increased at 17 years and became significant at 19 years but the very small number of mother-daughter pairs at this age greatly detracts from the seeming importance of this relationship.

When the above relationships were examined by covariance analysis for sex, there were some important differences. The P value for the reduction sum of squares (P_{reduct}) for the relationship with fathers' heights was significant (<0.05) at 1, 3, 6, 9, 10 and 15-18 years. The P_{slope} was significant (0.01) only at ten years of age. The P value of the mean child heights adjusted for paternal heights (P_{mean}) was significant (<0.05) at 1, 6, 8-10 and 15-18 years of age. The greater differences in the mid-teen years were due to the boys finally becoming much taller than the girls. Until eleven years of age median male height in this population had been minimally greater than female height, but at 12 and 13 years the reverse had been true.

In the relationship with mothers' heights the P_{reduct} was significant (<0.05) at four and 9-18 years. The P_{slope} was significant (<0.05) from 10 through 14 years and the P_{mean} was <0.05 at 4, 9, 12, 13 and 15 to 18 years.

When the relationships between "healthy" sibling heights and mid-parental heights (Tables 2 and 3) were examined by covariance analysis for

child sex, P_{reduct} was <0.05 at 1, 3-6, 9-12 and 15-18 years of age. P_{slope} was <0.05 at 1, 2, 4, 6 and 10-12 years. P_{mean} was <0.05 at 3, 9, 10 and 15-18 years of age.

The relationships of male ex-patients' heights to mid-parental heights were compared with those of male "healthy" siblings' heights to mid-parental heights (Table 2). Whereas the latter were highly significant until 15 years of age, particularly between three and 12 years, those of the ex-patients did not reach significance until four years and lost it entirely after 13 years of age. During the interim ages the relationships were much weaker than those of the "healthy" siblings with their mid-parental height. By covariance analysis P_{reduct} was highly significant until ten years and just significant (P<0.05) at 11, 14 and 15 years of age. P_{slope} was significant from two to ten years of age. P_{mean} was significant from one to eleven years, particularly from one to five years of age. By independent "t" testing, mean "healthy" sibling height was significantly greater than ex-patient height until 12 years, particularly between one and four years of age.

The relationship of female ex-patients' heights to mid-parental heights were compared with those of female "healthy" siblings' heights to mid-parental heights (Table 3). These last did not become significant until five years of age and remained so, most strongly from seven to nine years, until 15 years of age. By contrast the heights of female ex-patients were significantly correlated with mid-parental height from one to seven years of age and not thereafter. By analysis of covariance the P_{reduct} for the relationship of the two groups of girls to their parents

was <0.001 at one and two years and <0.05 at three, four and five years. It was not significant after five years of age. The P_{slope} was never significant and the P_{mean} was <0.05 from one to five years. By independent "t" testing, mean "healthy" sibling height was greater than mean ex-patient height, from one to nine years, significantly so only until five years. After nine years of age mean ex-patient height was greater than "healthy" sibling height but never significantly so.

The child height-parent height relationship was examined for a limited number of children who had been reared in a protected environment for the first one to two years of life and compared with the same relationship for "healthy" siblings of malnourished children. At one and two years of age the correlation coefficients with mid-parental height were similar for boys from both groups (Table 4). After that the correlation coefficients were consistently higher for the "protected" boys, despite the fact that their height advantage was minimal and never statistically significant by independent "t" testing (Table 4). For the female siblings of ex-patients (Table 4) the correlations between their heights and mid-parental heights were not significant until five years of age and fell off again at ten years. For "protected" girls the correlations of their heights with those of their parents were consistently stronger from one to nine years of age despite the fact that their seeming advantage in height from one to three years became a seeming disadvantage from four to nine years of age. By independent "t" testing (Table 4) these differences were never statistically significant. By covariance analysis the child height-parent height relationships were not different between "protected" children and the "healthy" siblings reared at home.

When the heights of "protected" children were compared by dependent "t" tests with those of their own same-sex "healthy" siblings, the differences for boys were never significant while those for girls were significant ($P<0.05$) from five through nine years of age, but in favor of the "healthy" siblings.

DISCUSSION

The parent height-child height correlation coefficients found in this study are surprisingly high when compared with the low ones found in a population from Mexico also selected on the basis of having had at least one severely malnourished child. In that study Mariscal et al (1966) included in a single group the children who had been severely malnourished and their siblings who had not, and indicated that the predictions of adult height which they made were not different for the two categories. For the correlations, their children were divided into age groups: 0-23, 24-47, 48-83, 84-101 and 132-203 months. Not surprisingly, the lowest coefficients were found at both extremes of the age categories. The mean heights of the fathers in the Mexican study were 163.5±8.2 cm for the boys and 161.9±6.2 cm for the girls, somewhat taller than the mean of 160.8±6.8 (median 161.5 cm) for all fathers in our study. The mean heights of the mothers in the Mexican study were 149.2±6.4 cm for boys and 148.8±6.9 cm for the girls, again slightly taller than the 147.6±6.3 (median 147.7 cm) for all mothers in our study. These means and the differences suggest that both sets of parents had been significantly undernourished during their growing years, the Mexicans somewhat less so, if similar genetic potentials are assumed. The lower correlation

coefficients found in Mexico seem to be due in part to the inclusion of the malnourished in the younger age categories. Additionally, the Mexican study was exclusively cross-sectional while our study was a combined longitudinal-cross sectional study.

When the heights of boys who were typical for the families in our study and were labeled as "healthy" were examined, the correlations with both paternal and maternal heights (Table 1) were as strong or stronger than those from highly developed societies until eleven years of age. This suggests that despite growth in both generations which is well below the genetic potential, the relative rank in heights is maintained: this may well be due to the transmission from one generation to the other of very similar dietary patterns. Other studies in a sub-sample of this same population suggest that for boys in particular, certain nutrient sources are significantly associated with superior linear growth (Graham et al 1981). The falling off in the coefficients which begins at age 12 and which is more marked for boy-father than for boy-mother might be due to an earlier sexual maturation and growth spurt in boys who have shorter parents and may be destined to be shorter themselves. If this is the case then one would expect an increase in the coefficients as adult size is approached: this was apparent for boy-mother correlations but the smaller number of boy-father correlations does not allow any conclusions. The correlation coefficients between boys' heights and mid-parental heights (Table 2) were already strong (0.398, $P<0.02$) at one year and reached a very high 0.673 ($P<0.0001$) at ten years of age, after which they began to decline. The recovery to 0.443 at 17 years was not significant because of the small number.

For the "healthy" girls in the same families the correlations with either parent (Table 1) were much weaker than for the boys, particularly during the first four years. Although our published dietary surveys did not reveal any conscious sex bias in the feeding of children in these families when all age groups were combined (Creed and Graham 1980), further analysis by age (unpublished) suggests that very young boys tend to receive more cow's milk. When the growth of boys and girls is compared, boys have an advantage in height during the first three years and not again until after 13 years (Graham et al 1982). The fall in correlation coefficients (Table 1) begins at nine years against fathers' heights, reaches a low point at 12 years, a new high at 14 years, and then declines again. Against mothers' heights the fall is first apparent at eight years, and from ten through 16 years of age there is no correlation. This seems to re-emerge at 17 years but the numbers are too small for statistical significance. In Peruvian girls of similar race and social class the average age of menarche has been reported as 11.1±2.5 years (Bachmann Sanchez 1975) and preliminary analysis of our data suggests a very similar age for the girls in this study. The decline in the correlations for girls suggests again that short parents have daughters who mature sooner, have earlier growth spurts, and end up as shorter adults. The effect of the mothers' statures and their own probably earlier maturations would seem to be much stronger. The correlations with mid-parental heights (Table 3) became significant only at five years of age and increased to a maximum at seven and eight years but were much lower than for the boys, even though heights from four to ten years of age were not different by sex (Graham et al 1982). The subsequent decline

and later recovery in the correlations tended to parallel that seen against the fathers but the coefficients were actually lower, being influenced by those against mothers' heights.

The coefficients of correlation for male ex-patient heights with mid-parental heights (Table 2) did not become significant until four years of age and reached a maximum at twelve years of age but were consistently lower than those of "healthy" boys. Male ex-patients were significantly shorter than "healthy" boys until twelve years of age (Table 2). In paired comparisons (Graham et al 1982) the ex-patients were significantly shorter than their own brothers until ten years of age and were only 1.0 cm shorter at eleven and twelve years, after which ages the differences were re-accentuated, suggesting that their diets were inadequate to support continued efficient "catch-up". Female "catch-up" was more efficient, possibly because of lower nutrient requirements. After twelve years of age, when the "n" for male ex-patients declined abruptly there was a simultaneous sharp decline, to negative values, in the coefficients of correlation with mid-parental heights. Whether this more extreme divergence than that seen for "healthy" boys is due to differences in sexual maturation rates is not clear at this time.

The coefficients of correlation for female ex-patient heights with mid-parental heights (Table 3) were already significant at one year of age and surprisingly higher than those for "healthy" girls until six years of age. This was true despite the fact that they were significantly shorter than the "healthy" girls until five years of age and were taller, but not significantly, at ten years and thereafter (Table 3). In paired comparisons (Graham et al 1982) ex-patients were significantly shorter

(by 1.3 to 3.0 cm) until seven years, and very little shorter or not at all from eight to 15 years of age, suggesting a greater "catch-up" potential and no delay in sexual maturation for girls in these families. The earlier and much more severe decline in the coefficients for ex-patients than in those for "healthy" girls is not easily explained, as differences in height were minimal. The malnourished girls in this study were admitted at younger ages than the boys (10.7±7.0 vs. 13.1±8.9 months) and more of them (6 vs. 2) were adopted into better homes after hospital discharge: these two factors may have influenced their early canalization of growth and possibly their earlier and greater pubertal growth spurts than those of "healthy" girls.

The limited number of children (14 boys and 8 girls) who were reared in protected environments during the first one to two years of life requires that interpretation of the coefficients of correlation with mid-parental heights (Table 4) be interpreted with caution. The persistently stronger coefficients of correlation, despite the declines (or actual losses for girls after three years) in their height advantages over "healthy" children, suggest that their growth was more accurately canalized by their good start and that rank order in size was conserved more efficiently.

In conclusion these studies suggest that in chronically undernourished populations where children grow well below their genetic potential, the size of their parents, also influenced adversely by their own early nutrition, is still a powerful determinant of relative size and must be taken into account in the interpretation of the stunting which is

commonly found. Even when severe malnutrition in early life has very significantly distorted the correlations with parental height, the genetic influence on size becomes readily apparent during recovery. Like previous studies of "catch-up" growth in this same population, these correlations suggest that this compensatory growth goes on for many years. The fact that it seems more complete in girls than in boys may be due to sex-specific differences or to the lower nutrient requirements of adolescent girls. Improved nutrition in very early infancy and childhood may permit better canalization of growth along genetically determined paths despite the loss in height advantage which is dictated by unfavorable environments in later childhood.

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LITERATURE CITED

Bachmann Sanchez, C. 1975 Hemorragia uterina disfuncional en la adolescencia. Ginecol. Obstet. (Peru) 21:117-129.

Baertl, J.M., B. Adrianzen T. and G.G. Graham 1976 Growth of previously well-nourished infants in poor homes. Am. J. Dis. Child. 130:33-36.

Bayley, N. 1954 Some increasing parent-child similarities during the growth of children. J. Educ. Psychol. 45:1-21.

Bielicki, T. and Z. Welon 1966 Parent-child height correlations at ages 8 to 12 years in children from Wroclaw, Poland. Human Biol. 38: 167-174.

Creed, H.M. and G.G. Graham 1980 Determinants of growth among poor children. I. Food and nutrient intakes. Am. J. Clin. Nutr. 33: 715-722.

Graham, G.G. and B. Adrianzen T. 1972 Late "catch-up" growth after severe infantile malnutrition. J. Hopkins Med. J. 131:204-211.

Graham, G.G., B. Adrianzen T., J. Rabold and E.D. Mellits 1982 Later growth of malnourished infants and children. Comparison with "healthy" siblings and parents. Am. J. Dis. Child. 136:348-352.

Graham, G.G., H.M. Creed, W.C. MacLean, Jr., C.H. Kallman, J. Rabold and E.D. Mellits 1981 Determinants of growth among poor children: nutrient intake-achieved growth relationships. Am. J. Clin. Nutr. 34:539-554.

Kagan, J. and H.A. Moss 1959 Parental correlates of child's IQ and height: a cross-validation of the Berkeley growth study results. Child Develpm. 30:325-332.

Livson, N., D. McNeill and K. Thomas 1962 Pooled estimates of parent-child correlations in stature from birth to maturity. Science 138: 818-820.

Malcolm, L.A. 1974 Ecological factors relating to child growth and nutritional status in Roche, A.F. and F. Falkner, eds., Nutrition and Malnutrition, Identification and Measurement. Adv. in Exp. Med. and Biol., Plenum, New York, 49:329-352.

Mariscal, C.A., A. Viniegra C. and R. Ramos Galván 1966 Predicción de talla en niños desnutridos y talla de sus progenitores. Bol. Med. Hosp. Inf. (Mexico) 23:465-470.

Ostle, B. 1954 Statistics in Research, Ames, Iowa State College Press.

Roche, A.F., H. Wainer and D. Thissen 1975 Predicting adult stature for individuals, Monographs in Pediatrics, Vol. 3, S. Karger, Basel, p. 6.

Tanner, J.M., H. Goldstein and R.H. Whitehouse 1970 Standards for children's height at ages 2-9 years allowing for height of parents. Arch. Dis. Childh. 45:755-762.

Table 1

Relations between parental heights and the heights of apparently healthy siblings of malnourished children at different ages by polynomial regression analysis

Yr of Age	Boys' Heights				Girls' Heights			
	Father's Height		Mother's Height		Father's Height		Mother's Height	
	(n)	Linear "r"	(n)	Linear "r"	(n)	Linear "r"	(n)	Linear "r"
1	(37)	0.349[a]	(46)	0.161	(30)	-0.028	(31)	0.109
2	(51)	0.345[b]	(58)	0.340[c]	(60)	0.148	(69)	0.160
3	(77)	0.400[d]	(88)	0.388[d]	(87)	0.094	(101)	0.224[a]
4	(85)	0.379[d]	(96)	0.389[d]	(99)	0.173	(118)	0.[illegible]51
5	(87)	0.436[e]	(99)	0.470[e]	(108)	0.247[b]	(130)	0.240[c]
6	(101)	0.508[e]	(117)	0.454[e]	(114)	0.275[c]	(131)	0.247[c]
7	(106)	0.509[e]	(122)	0.382[e,f]	(112)	0.342[d]	(135)	0.348[e]
8	(105)	0.476[e]	(123)	0.407[e,f]	(108)	0.370[d]	(126)	0.215[b]
9	(111)	0.482[e]	(126)	0.426[e,g]	(110)	0.311[c]	(129)	0.209[b]
10	(104)	0.538[e]	(123)	0.496[e,g]	(103)	0.225[a]	(125)	0.065
11	(105)	0.479[e]	(120)	0.504[e]	(95)	0.296[c]	(119)	0.017
12	(90)	0.391[d]	(110)	0.352[d]	(81)	0.261[b]	(103)	0.072
13	(75)	0.303[c]	(92)	0.319[c]	(73)	0.327[c]	(93)	0.056
14	(58)	0.253	(76)	0.371[c]	(56)	0.507[d]	(74)	-0.017
15	(48)	0.228	(57)	0.355[c]	(50)	0.441[c]	(62)	0.059
16	(24)	0.100	(29)	0.308	(38)	0.322[a]	(46)	0.076
17	(17)	0.109	(21)	0.528[b]	(29)	0.260	(31)	0.279
18	(7)	0.393	(10)	0.581	(15)	0.276	(17)	0.329
19	(3)	-0.988	(3)	0.988	(6)	-0.288	(7)	0.630[a]

P_{linear} <0.05[a], <0.02[b], <0.01[c], <0.001[d], <0.0001[e].

f Significant (P<0.05) quadratic plus highly significant cubic (P<0.01) components.

g Highly significant (P<0.01) cubic component.

Table 2

Effect of severe malnutrition in early life upon the relation between mid-parental heights and the heights at ages 1-17 years of male ex-patients and their "healthy" male siblings by polynomial regression analysis. Ex-patient and sibling heights compared by independent "t" tests.

Year of Age	Boys vs Mid-Parental Heights				Ex-Patients vs Sibs "t" tests - height	
	Ex-patients		Siblings			
	(n)	Linear "r"	(n)	Linear "r"	"t"	P
1	(75)	0.056	(35)	0.398[b]	-5.93	<0.001
2	(102)	0.107	(49)	0.447[d]	-3.82	<0.001
3	(115)	0.183	(73)	0.514[e]	-4.42	<0.001
4	(113)	0.204[a]	(80)	0.490[e]	-4.21	<0.001
5	(104)	0.276[c]	(84)	0.578[e]	-3.25	<0.01
6	(93)	0.292[c]	(98)	0.614[e]	-2.75	<0.01
7	(92)	0.293[c]	(100)	0.649[e]	-2.86	<0.01
8	(76)	0.315[c]	(99)	0.645[e]	-2.88	<0.01
9	(70)	0.344[c]	(102)	0.654[e]	-3.13	<0.01
10	(59)	0.356[c]	(99)	0.673[e]	-2.75	<0.01
11	(53)	0.391[c]	(99)	0.629[e]	-2.84	<0.01
12	(43)	0.477[d]	(85)	0.535[e]	-2.40	<0.02
13	(27)	0.310	(68)	0.404[d]	-1.22	N.S.
14	(18)	-0.113	(55)	0.434[d]	-1.81	N.S.
15	(14)	-0.290	(45)	0.439[c]	-1.39	N.S.
16	(7)	-0.727[a]	(24)	0.279	-1.27	N.S.
17	(2)	1.000	(17)	0.443	-0.10	N.S.

P_{linear} <0.05[a], <0.02[b], <0.01[c], <0.001[d] <0.0001[e]

Table 3

Effect of severe malnutrition in early life upon the relation between mid-parental heights and the heights at ages 1-17 years of female ex-patients and their "healthy" female siblings by polynomial regression analysis. Ex-patient and sibling heights compared by independent "t" tests

Year of Age	Girls vs Mid-Parental Heights: Ex-Patients (n)	Ex-Patients Linear "r"	Siblings (n)	Siblings Linear "r"	Ex-Pts vs Sibs "t" tests-height: "t"	P
1	(36)	0.362[a]	(28)	-0.033	-6.37	<0.001
2	(39)	0.269	(56)	0.152	-3.98	<0.001
3	(47)	0.304[a]	(83)	0.212	-2.45	<0.02
4	(40)	0.515[d]	(97)	0.159	-2.35	<0.02
5	(34)	0.379[a]	(107)	0.296[c]	-2.12	0.05
6	(30)	0.372[a]	(112)	0.318[d]	-1.65	N.S.
7	(29)	0.383[a]	(110)	0.445[e]	-1.09	N.S.
8	(25)	0.191	(106)	0.444[e]	-1.41	N.S.
9	(24)	0.195	(109)	0.378[d]	-0.71	N.S.
10	(24)	0.214	(103)	0.201[a]	0.69	N.S.
11	(23)	0.090	(95)	0.205[a]	0.41	N.S.
12	(22)	-0.015	(81)	0.232[a]	0.33	N.S.
13	(17)	0.011	(73)	0.290[b]	1.06	N.S.
14	(11)	-0.109	(56)	0.385[c]	0.71	N.S.
15	(6)	0.462	(49)	0.422[c]	1.00	N.S.
16	(5)	0.460	(37)	0.275	0.82	N.S.
17	(2)	1.000	(28)	0.363	1.36	N.S.

P_{linear} <0.05[a], <0.02[b], <0.01[c], <0.001[d], <0.0001[e]

Table 4

Effect of early life in a protected environment upon the relation between mid-parental height and height at ages 1-10 years of "protected" children and same-sex children living always at home, both groups being siblings of malnourished children. None of independent "t" tests for height was significant (P<0.05)

Yr of Age	Boys vs Mid-Parental Height				"t" test Ht	Girls vs Mid-Parental Height				"t" test Ht
	Protected		At Home			Protected		At Home		
	(n)	Linear "r"	(n)	Linear "r"		(n)	Linear "r"	(n)	Linear "r"	
1	(14)	0.383	(35)	0.398[b]	1.59	(8)	0.393	(28)	-0.033	0.74
2	(14)	0.437	(49)	0.447[d]	0.85	(8)	0.307	(56)	0.152	0.24
3	(14)	0.661[c]	(73)	0.514[e]	0.50	(8)	0.770[c]	(83)	0.212	0.31
4	(13)	0.731[c]	(80)	0.490[e]	0.30	(8)	0.579	(97)	0.159	-0.35
5	(11)	0.704[c]	(84)	0.578[e]	0.95	(8)	0.566	(107)	0.296[c]	-0.71
6	(10)	0.794[c]	(98)	0.614[e]	0.81	(8)	0.544	(112)	0.318[d]	-1.08
7	(9)	0.739[c]	(100)	0.649[e]	0.60	(8)	0.489	(110)	0.445[e]	-1.24
8	(6)	0.832[b]	(99)	0.645[e]	0.82	(8)	0.470	(106)	0.444[e]	-1.77
9	(6)	0.828[b]	(102)	0.654[e]	0.60	(8)	0.458	(109)	0.378[d]	-1.45
10	(4)	0.898[b]	(99)	0.673[e]	0.06	(3)	-0.905	(103)	0.201[a]	0.76

P_{linear} <0.05[a], <0.02[b], <0.01[c], <0.001[d], <0.0001[e]