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# MOTOR DEVELOPMENT OF BENGALI INFANTS BY NUTRITIONAL STATUS IN THE FIRST YEAR OF LIFE

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**Abstract:** Gross motor development of 199 (106 males and 93 females) healthy infants of Bengali parentage have been studied in relation to their nutritional status. The children who were provided with adequate nutritious foods (rich in protein and vitamins) are found to attain necessary motor skills for performing head-lifting, rolling, sitting, crawling, standing or walking significantly earlier than their counterparts having inadequate nutritious foods (rich in carbohydrate). In the study significant correlations between the time (age) of attaining the six stages of development have been obtained. For efficient prediction of the age of attaining the stage of sitting, standing, or walking it is sufficient to know the ages of reaching the immediate two preceding stages of any one of these three motor abilities, but for age of crawling appropriate information about sitting-age is only required.

*Key words:* Motor development, Bengali infants, Nutritional status; Developmental stages: Head-lifting, Rolling, Sitting, Crawling, Standing, Walking-with-support.

## Introduction

In the measurement of an infant's achievement in different functional areas his 'behavioural repertory' is generally assessed by developmental examinations. Development means here an increase in the number of abilities which emerge ultimately from an interaction between nervous system properties and environmental experiences (TOWEN 1981). For the study of motor development the importance of several factors as genetic, nutritional, emotional, socio-economic ones, etc. has already been highlighted (NELIGAN and PRUDHAM 1969, VAUGHAN and MCKAY 1975, MALINA 1980).

That nutrition is fundamental to human development and again, that it has far-reaching effects on physical and psychomotor development has been shown in several researches (JELLIFFE 1966, CRAVITO 1968, WHO 1972, GRANTHAM-MCGREGOR et al. 1980). It has universally been accepted that satisfactory nutritional intake is essential to support the needs of normal growth and development including, of course, motor development (MALINA 1980). The present paper aims to examine some motor abilities of the Bengali infants in the first year of life by nutritional status.

## Material and Methods

In 1971—72 the data were collected in a longitudinal study of 200 healthy infants (107 males and 93 females) of the Bengali parentage, of mixed birth order, and of unequal socio-economic levels. The details about survey design,

selection of infants, procedure of determination of nutritional status of infants, etc., have already been presented previously (BANERJEE 1976, BANERJEE and BANERJEE 1978, BANDYOPADHYAY et al. 1981).

For the purpose of the present study the infants have been studied under two broad nutritional groups, namely,

1. *Group A:* includes those who were given limited breast feeding for less than 6 months and had higher consumption of nutritious foods through more balanced weaning diets (rich in starch, protein and vitamins), and

2. *Group B:* consists of those infants who were given prolonged breast feeding for more than 6 months and supplied with less balanced nutrient foods (rich in starch but poor in protein and vitamins) after weaning.

With respect to early developmental milestones each mother was asked whether her child has already achieved head lifting and other motor skills. If the answer was 'yes', she was asked to report the age of the infant at head lifting in months and the same procedure was followed for each one of the other skills. Attempt to obtain returns of age in weeks was thought to be futile because such attempt would have generated more incorrect information due to recall lapse. The information given by the mother who is in contact with the child everyday and witness his progress intimately, was checked thoroughly in every home visit at regular interval by the investigator (JB).

The milestones whose results are reportee here were defined as follows:

a) *Head-lifting:* when the infant is able in prone position to hold chin and shoulder off couch (bed) prolongedly so that plane of face appears to be at an angle between 45—90 degrees from couch (bed).

b) *Rolling:* when the infant is able to turn or roll from supine to prone position.

c) *Sitting:* when the infant is able to sit alone with hands forward for support.

d) *Crawling:* when the infant is able to creep or move using all the four limbs.

e) *Standing:* when the infant is able to stand alone.

f) *Walking:* when the infant is able to walk holding on to furniture.

The distributions of the infants per milestone (stage) of motor development are censored in the sense that all the infants were not found to have attained the last landmark of walking within twelve months after birth. The log transform of the present data on age of reaching the given stages has been used to compute means and variances and again, to do tests for differences in time (age) of attainment of motor skills. The second set of means and variances has further been computed by fitting a logarithmic normal distributions to the present data.

For the developmental stages of standing and walking-with-support means and variances have been estimated for all the infants on the basis of observed distribution (GUPTA 1952, GRUNDY 1952). Kolmogorov-Smirnov test (SIEGEL 1956) has been made for testing differences in time of attainment of motor skills.

Percentiles for distribution of age attainment of the skills by nutritional status of the infants have been presented. For smoothing the percentile curves logarithmic normal distribution has been fitted to the observed sets of time (age) of attaining the stages of sitting, standing and walking-with-support.

Correlations and partial correlations between the ages of attainment of the given six gross motor skills by nutritional status of the infants have been

calculated. As stated earlier, not all the infants reached the stages of standing and walking-with-support within twelve months and hence, the correlations based on all infants would have been slightly higher or lower than those obtained in the present study. But as the correlations are fairly high which may be due to sample being homogeneous or rounding of time (age) of attainment of a skill in month than in weeks, the significance is unlikely to be altered.

## Salient Findings

Table 1 shows that nutritional status-wise difference in the proportions of infants reaching ultimate developmental stage of walking-with-support is highly significant ($t = 5.99$).

Mean ages of attaining the developmental stages for the Group A (with adequate nutritional intake) in contrast to the Group B (with inadequate nutritional intake) are presented in Table 2. The Group A shows in general relatively earlier (by a month in some stages) achievement of the motor skills.

Differences in mean log time of attainment of each stage of development between the Group A and the Group B are found to be highly significant for all skills (Table 3).

*Table 1*

Number and proportion of infants attaining successively the six milestones of motor development by nutritional group

| Nutritional group | Milestone of motor development | | | | | |
|---|---|---|---|---|---|---|
| | Stage 1 Head-lifting | Stage 2 Rolling | Stage 3 Sitting | Stage 4 Crawling | Stage 5 Standing | Stage 6 Walking-with-support |
| A | 130 (100.0) | 130 (100.0) | 130 (100.0) | 129 (99.2) | -127 (97.7) | 127 (97.7) |
| B | 69 (100.0) | 69 (100.0) | 69 (100.0) | 66 (95.6) | 47 (68.1) | 47 (68.1) |
| All | 199 (100.0) | 199 (100.0) | 199 (100.0) | 195 (98.0) | 174 (87.4) | 174 (87.4) |

*Table 2*

Estimated mean age (± s.e.) of attaining six milestones of motor development based on logarithmic distribution by nutritional group

| Nutritional group | Age (in month) of attaining milestone | | | | | |
|---|---|---|---|---|---|---|
| | Stage 1 Head-lifting | Stage 2 Rolling | Stage 3 Sitting | Stage 4 Crawling | Stage 5 Standing | Stage 6 Walking-with-support |
| A | 2.99 ±0.06 | 3.67 ±0.07 | 6.87 ±0.10 | 8.72 ±0.11 | 10.07 ±0.12 | 10.28 ±0.11 |
| B | 3.60 ±0.09 | 4.44 ±0.10 | 8.29 ±0.15 | 10.08 ±0.14 | 11.00 ±0.14 | 12.02 ±0.12 |

*Table 3*

Mean of logarithm of time (± s.e.) of attainment of six milestones of motor development by nutritional group

| Nutritional group | Stage 1 Head-lifting | Stage 2 Rolling | Stage 3 Sitting | Stage 4 Crawling | Stage 5 Standing | Stage 6 Walking-with-support |
|---|---|---|---|---|---|---|
| A | 1.07 ±0.02 | 1.28 ±0.02 | 1.91 ±0.01 | 2.15 ±0.01 | 2.30 ±0.01 | 2.32 ±0.01 |
| B | 1.26 ±0.02 | 1.47 ±0.02 | 2.10 ±0.02 | 2.30 ±0.01 | 2.39 ±0.01 | 2.48 ±0.01 |
| t-values | —5.74** | ±6.40** | —8.00** | —7.29** | —4.50** | —8.82** |

** Significant between group mean differences at 1% level.

The pattern of age progression in the maturing of six motor skills for the two nutritional groups A and B is shown in Table 4. In the course of developmental process a good proportion of the Group B is observed to mark relatively greater degree of retardation, especially in earlier ages during the first post-natal year. As a result, for each stage of motor development when 70% or little more of the Group A reached a stage concerned, not even one-half of the Group B could achieve the same stage by the same time.

As we are not sure if there is any agreement between the two cumulative distributions for the nutritional groups, *Kolmogorov—Smirnov test* has been applied to examine whether the time (age) taken for achieving stages of Sitting, Standing and Walking-with-support is *earlier* for the Group A than for the Group B. The test statistic $\chi^2$ (with 2 d.f.) is highly significant for each stage of development. As a matter of fact, for Sitting, Standing and Walking $\chi^2$-values are 31.35, 22.03, and 26.08, respectively. This confirms that the infants — male or female — with higher nutritional status achieve in general the milestones of motor development significantly earlier than those of the lower nutritional status.

The interrelations between the ages at which the infants attain definite stages of motor development have been examined with respect to differential nutritional status of the babies (Table 5). It is interesting to note that irrespective of nutritional status all the correlation coefficients, except between the stages of Head-lifting and Standing for the Group B, are significant at 1% level. But in another case namely, between Rolling and Standing for the Group A, significance is at 5% level. The findings confirm that motor development occurred in an orderly, predictible manner in cephalocaudal direction. All the correlations are fairly high and the same between any two succeeding stages are always maximum.

We have examined if the correlation coefficients as obtained between any identical pairs of adjacent stages of motor development for the infants belonging to high or low nutritional status are statistically different. As in most cases no significant differences in correlations exist it may be stated that correlations do not in general depend upon nutritional status of the infants.

For prediction of time (age) of achievement of different motor skills partial correlation analysis has been carried out (Table 6). For Group A, after eliminat-

*Table 4*

Cumulative percentage distribution of the infants by time of attainment of six milestones and nutritional group

| Milestone attained by each nutritional group | Time (age) of attainment of milestone (in month) | | | | | |
|---|---|---|---|---|---|---|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ |
| *Head-lifting* | | | | | | |
| A | 0.9 | 18.5 | 84.6 | 97.7 | 100.0 | — |
| B | — | 7.2 | 34.8 | 98.5 | 100.0 | — |
| *Rolling* | | | | | | |
| A | — | 1.5 | 47.7 | 89.2 | 96.1 | 98.5 |
| B | — | — | 13.0 | 49.3 | 94.2 | 100.0 |
| *Sitting* | | | | | | |
| A | — | — | — | 0.80 | 10.0 | 39.2 |
| B | — | — | — | — | — | 5.8 |
| *Crawling* | | | | | | |
| A | — | — | — | — | 0.8 | 5.4 |
| B | — | — | — | — | — | — |
| *Standing* | | | | | | |
| A | — | — | — | — | — | 0.8 |
| B | — | — | — | — | — | — |
| *Walking-with-support* | | | | | | |
| A | — | — | — | — | — | 0.8 |
| B | — | — | — | — | — | — |
| | 7+ | 8+ | 9+ | 10+ | 11+ | 12 |
| *Head-lifting* | | | | | | |
| A | — | — | — | — | — | — |
| B | — | — | — | — | — | — |
| *Rolling* | | | | | | |
| A | 100.0 | — | — | — | — | — |
| B | — | — | — | — | — | — |
| *Sitting* | | | | | | |
| A | 69.2 | 96.1 | 98.5 | 99.2 | 100.0 | — |
| B | 27.5 | 56.5 | 84.1 | 97.1 | 100.0 | — |
| *Crawling* | | | | | | |
| A | 13.1 | 35.4 | 76.1 | 96.9 | 98.5 | 99.2 |
| B | — | 5.8 | 34.8 | 60.9 | 82.6 | 95.6 |
| *Standing* | | | | | | |
| A | 0.8 | 9.2 | 31.5 | 68.5 | 77.7 | 97.7 |
| B | — | — | 5.8 | 20.3 | 42.0 | 68.1 |
| *Walking-with-support* | | | | | | |
| A | 0.8 | 4.6 | 27.7 | 59.2 | 75.4 | 97.7 |
| B | — | — | 1.4 | 11.6 | 24.6 | 68.1 |

*Table 5*

Linear correlation coefficients (r) between the stages (milestones) in motor development of the infants by nutritional group

| Milestone (Stage) | Milestone in motor development | | | | | |
|---|---|---|---|---|---|---|
| | Stage 1 Head-lifting | Stage 2 Rolling | Stage 3 Sitting | Stage 4 Crawling | Stage 5 Standing | Stage 6 Walking-with-support |
| | | | *Group A* | | | |
| 1 Head-lifting | — | 0.57** | 0.62** | 0.44** | 0.32** | 0.34** |
| 2 Rolling | — | — | 0.46** | 0.29** | 0.19* | 0.25** |
| 3 Sitting | — | — | — | 0.75** | 0.67** | 0.58** |
| 4 Crawling | — | — | — | — | 0.85** | 0.84** |
| 5 Standing | — | — | — | — | — | 0.86** |
| | | | *Group B* | | | |
| 1 Head-lifting | — | 0.61** | 0.58** | 0.41** | 0.23 | 0.45** |
| 2 Rolling | — | — | 0.60** | 0.58** | 0.42** | 0.46** |
| 3 Sitting | — | — | — | 0.79** | 0.69** | 0.57** |
| 4 Crawling | — | — | — | — | 0.77* | 0.68** |
| 5 Standing | — | — | — | — | — | 0.62** |

** Significant at 1% level.
* Significant at 5% level.

*Table 6*

Partial correlation between the stages (milestones) of motor development of the infants classified by nutritional group

| Partial correlation between stages | Value | Partial correlation between stages | Value | Partial correlation between stages | Value | Partial correlation between stages | Value |
|---|---|---|---|---|---|---|---|
| | | | *Group A* | | | | |
| $r_{23.1}$ | 0.16** | $r_{45.1}$ | 0.83 | $r_{45.123}$ | 0.70** | $r_{56.4}$ | 0.51** |
| $r_{34.1}$ | 0.68 | $r_{45.2}$ | 0.85 | $r_{56.1}$ | 0.84 | $r_{56.34}$ | 0.51** |
| $r_{34.2}$ | 0.73 | $r_{45.3}$ | 0.71** | $r_{56.2}$ | 0.85 | $r_{56.234}$ | 0.51** |
| $r_{34.12}$ | 0.68 | $r_{45.23}$ | 0.70** | $r_{56.3}$ | 0.78 | $r_{56.1234}$ | 0.51** |
| | | | *Group B* | | | | |
| $r_{23.1}$ | 0.38* | $r_{45.1}$ | 0.76 | $r_{45.123}$ | 0.49* | $r_{56.4}$ | 0.21** |
| $r_{34.1}$ | 0.74 | $r_{45.2}$ | 0.71 | $r_{56.1}$ | 0.59 | $r_{56.34}$ | 0.19** |
| $r_{34.2}$ | 0.68 | $r_{45.3}$ | 0.51* | $r_{56.2}$ | 0.53 | $r_{56.234}$ | 0.19** |
| $r_{34.12}$ | 0.68 | $r_{45.23}$ | 0.51* | $r_{56.3}$ | 0.38 | $r_{56.1234}$ | 0.19** |

*/(**) the value indicates that fall from total correlation is significant at 5%/(1%) level.

ing the time (age) of reaching the Stage 1 (Head lifting) the partial correlation ($r_{23.1}$) between the Stage 2 (Rolling) and the Stage 3 (Sitting) is only 0.16, where as the correlation coefficient ($r_{23}$) is 0.46. The fall in correlation coefficient from $r_{23}$ to $r_{23.1}$ is significant ($t = 2.67$). This shows that in efficient prediction of time (age) of achievement of the Stage 3 we must know not only the time of attainment of the Stage 2 but also that of the Stage 1. For the infants of Group B the similar trend is true.

For Group A, correlation coefficient between the Stage 3 and the Stage 4 ($r_{34}$) is significant, and the partial correlation coefficients for $r_{34.2}$ and $r_{34.12}$ do not fall significantly from $r_{34}$. Therefore, it may be stated that the information about the time (age) of reaching the Stage 3 is sufficient for predicting the time of attainment of the Stage 4. This feature is also true for Group B. Similar analyses show with respect to both Group A and Group B that for prediction of the age of Stage 5 (Standing) or the Stage 6 (Walking-with-support) necessary information about the ages of attaining two preceding stages only are essential.

Percentiles in the field of motor development with respect to two nutritional groups are shown in Table 7. A close examination of the age norms

*Table 7*

Percentiles for six milestones in motor development (in months) of the infants from birth to twelve months by nutritional group

| Milestone (Stage) | Nutritional group | Percentiles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 10 | 25 | 50 | 75 | 90 | 97 |
| 1 Head-lifting | A | 1.13 | 1.52 | 2.10 | 2.48 | 2.85 | 3.41 | 3.95 |
| | B | 2.00 | 2.10 | 2.64 | 3.24 | 3.63 | 3.87 | 3.98 |
| 2 Rolling | A | 2.03 | 2.18 | 2.51 | 3.05 | 3.66 | 4.11 | 5.37 |
| | B | 3.00 | 3.00 | 3.33 | 4.01 | 4.57 | 4.90 | 5.27 |
| 3 Sitting | A | 4.24 | 5.00 | 5.51 | 6.36 | 7.21 | 7.77 | 8.37 |
| | B | 6.00 | 6.19 | 6.88 | 7.77 | 8.67 | 9.50 | 9.99 |
| 4 Crawling | A | 5.48 | 6.59 | 7.52 | 8.35 | 8.95 | 9.63 | 9.97 |
| | B | 8.00 | 8.13 | 8.62 | 9.50 | 10.50 | 11.27 | 11.78 |
| 5 Standing | A | 7.20 | 8.02 | 8.68 | 9.46 | 10.52 | 11.51 | 11.85 |
| | B | 9.00 | 9.07 | 9.77 | 10.63 | 11.35 | 11.74 | 11.92 |
| 6 Walking-with-support | A | 7.56 | 8.22 | 8.85 | 9.67 | 10.87 | 11.56 | 11.87 |
| | B | 9.06 | 9.53 | 10.42 | 11.22 | 11.61 | 11.84 | 11.95 |

*Table 8*

Estimated percentiles for three milestones in motor development (in months) of the infants from birth to twelve months by nutritional group

| Milestone (Stage) | Nutritional group | Percentiles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 10 | 25 | 50 | 75 | 90 | 97 |
| Sitting | A | 4.95 | 5.47 | 6.05 | 6.78 | 7.58 | 8.39 | 9.28 |
| | B | 6.22 | 6.79 | 7.43 | 8.20 | 9.06 | 9.91 | 10.82 |
| Standing | A | 7.83 | 8.46 | 9.15 | 9.99 | 10.90 | 11.79 | 12.74 |
| | B | 9.32 | 9.99 | 10.70 | 11.57 | 12.60 | 13.40 | 14.35 |
| Walking-with-support | A | 8.08 | 8.70 | 9.38 | 10.20 | 11.09 | 11.96 | 12.88 |
| | B | 10.07 | 10.60 | 11.17 | 11.84 | 12.55 | 13.22 | 13.92 |

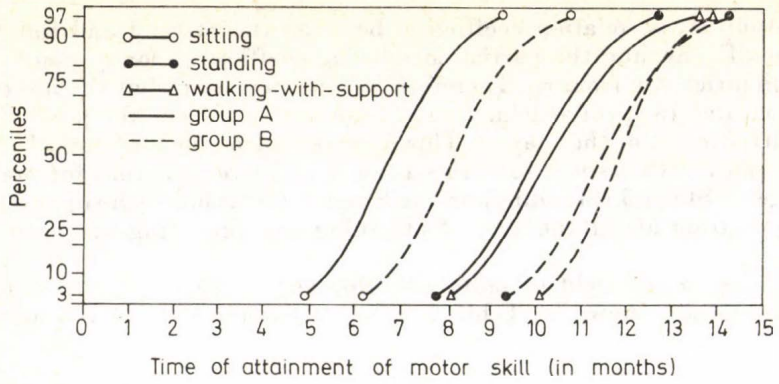


*Fig. 1.* Percentile curves for three standard developmental milestones of sitting, standing, and walking-with-support by nutritional group

(medians) for the developmental stages reveals that the infants of Group A reached each one of six stages of development earlier than those of Group B. As a matter of fact, except for the Stage 1 (Head-lifting), in the remaining cases (Stages 2 to 6) the infants of Group B lagged behind those of Group A by more than one month to reach a stage concerned. On applying Median test (SIEGEL 1956) the differences in time (age) of attaining the stages like Sitting, Standing, and Walking-with-support are found to be highly significant. The values of test statistic ($\chi^2$ with 1 d.f.) for the three stages are as follows: a) Sitting = 23.55; b) Standing = 10.11 and c) Walking-with-support = 27.62. This confirms that the two independent groups (A and B) do differ in central tendencies.

The estimated percentiles for three motor skills, namely, sitting, standing and walking-with-support by nutritional group have been presented in Table 8 and in Fig. 1.

That nutritional status has a significant role in directing the tempo of acceleration or retardation in motor development is thus confirmed from the study. But one point is noted especially here that the relationship between ill nourishment and retarded development is not depended upon food alone.

## Discussion

Information about precise date of birth of each infant facilitates greatly the task of determining accurate age of achievement of the motor skills in the first year of life. Analysis of the data confirm that (i) the sequence of development is same for all infants, (ii) the rate of development varies noticeably, and (iii) direction of development is cephalocaudal. These facts conform well with the general principles of motor development (Illingworth 1957, VAUGHAN and MCKAY 1975).

In different parts of India longitudinal studies on infant's motor development have already been carried out to assess the age norms of development on the basis of some standard tests (PATHAK 1969, PATEL and KAUL 1971, KANODH et al. 1971, DAS and SHARMA 1973, BHANDARI and GHOSH 1979).

But, the objectives of these studies are different from what has been stated for the present study.

From the previous studies on the Indian babies the degree of correlation between the ages by which infants reach definite stages of motor development can hardly be known. Moreover, none of these studies is helpful to discern the effect of nutritional factors on motor development of the infants.

In a study SOHI and DAYAL (1974) are reported to have found sex differences in development of functional maturity in mature and premature infants. Now the very dichotomy of the infants bespeak of their differential birth weight and nutritional condition. That differential birth weight can affect the rate of motor development in infants is already known (POTI and BISWAS 1963) and this may explain the finding of SOHI and DAYAL (1974).

The study has shown that the infants with adequate nutritious weaning food (low starch but high protein) do achieve six stages of motor development significantly earlier than their counterparts having poorer, inadequate nourishing diets (high starch but low protein) after weaning. This is very true particularly with respect to the stages of Standing and Walking-with-support. Our findings do not, of course, tally with POTI and BISWAS who studied only two motor skills (sitting and standing). Again, we have found that differences in mean log time of attainment of the motor abilities between the infants of higher and lower nutritional status groups are highly significant. The study also establishes significant difference in the pattern of age progression in the maturing of the motor skills by nutritional status.

We have seen that the degree of correlation between any two stages of motor development is generally high and significant. Though our results find general support from WOLAŃSKI and ZDANSKA-BRINCKEN (1973), yet in a few cases we are at variance with them.

Regarding the question of prediction of future development of the motor skills in question the present study indicates that in efficient prediction of the age of reaching the stage of Sitting, Standing or Walking-with-support it is sufficient to know the ages of attaining the immediate two preceding stages of the motor skill concerned, but in case of Crawling we must have information of the age of Sitting only.

The present study also helps to learn that the infants with higher nutritional status are always ahead of their peers with lower nutritional status in motor development. Thus, it may be suggested here that nutritional factors in conjunction with varying socio-economic forces do act as important 'modifiers' of sensorimotor developmental potential in the growing infants.

The present study has limitations. We had neither scope nor expertise to undertake any neurological examination for an evaluation of neural mechanisms which underlies sensorimotor development. Rather, we have concentrated on the data related to the ultimate achievement-level of the motor skills.

# BENGÁLI CSECSEMŐK MOTOROS FEJLŐDÉSE A TÁPLÁLKOZÁS FÜGGVÉNYÉBEN AZ ELSŐ ÉLETÉVBEN

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*Összefoglalás*

Bengáli származású 199 egészséges csecsemő (106 fiú és 93 leány) nagy-mozgásos fejlődését tanulmányozták táplálkozási viszonyaik függvényében. A helyesen táplált, gazdag fehérje- és vitamintartalmú táplálékot kapott gyermekek szignifikánsan korábban érték el az elvárható motoros ügyességet fejemelésben, átfordulásban, ülésben, mászásban, állásban vagy járásban, mint azok a kortársaik, akik nem megfelelő (szénhidrátdús) táplálékot kaptak. Hat fejlődési fokozat időbeli elérése közötti szignifikáns korrelációkat tanulmányozták. Megállapították, hogy az ülés-, az állás- vagy a járás-fokozat elérési idejének eredményes előrebecslésére elegendő ismerni e három motoros képesség valamelyikének két előző fokozatát, de a mászás-életkor becsléséhez ismerni kell az ülés-fokozat életkort is.

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