

## Catch-up growth in children after acute and protracted diarrhea

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### *Abstract*

One hundred and ten children hospitalized because of acute and protracted diarrhea in the first year of life were followed up for an average period of 13.7 months. Three anthropological parameters were taken into consideration: body height, body weight and head circumference. At the time of the first examination all the parameters measured were significantly decreased but children tend to reestablish normal somatic growth pattern during the rehabilitation period through the acceleration of growth (phenomenon known as "catch-up growth").

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Child's development is a process proceeding regularly in accordance with the established growth pattern, which is probably genetically determined. At the same time that development is influenced by paragenetic and environmental factors [ASHWORTH, MILLWARD 1986; WOLAŃSKI 1972, 1983; KULIK-RECHBERGER 1991]. The latter modify processes of growth and maturation and when they are disadvantageous, children change their development paths [BRANCO 1979; CASEY, ARNOLD 1985; PRADER 1978; PRADER et al. 1963]. Nutrition is regarded as one of the most significant environmental factors [DŁUŻNIEWSKA & RAKOWSKA 1981, KONIECZNA 1968], but whether the organism is properly

nourished or not depends not only on quantity and quality of the supplied food, but also on ability to make use of it. Therefore malnutrition may result from disturbances of digestion or absorption, which often manifest themselves clinically as diarrhea [HOLMES et al. 1983; JALILI et al. 1982; ZALEWSKI 1985]. Depending on duration and intensity of the nourishment disturbance, it may result in underweight (together with disproportion between the body weight and height) and subsequently in deficit in height and head circumference [BRANCO 1979; BRIARES et al. 1975; GERKOWICZ et al. 1980; STOCH, SMYTHE 1976]. A lot of authors pointed out to the possibility of compensatory acceleration of growth in children afflicted with diarrhea after their recovery from an illness or when proper nutrition is restored, phenomenon

known as "catch-up growth" [ASHWORTH, MILLWARD 1986; BARR et al. 1972; BOERSMA et al. 1995; DAMEN et al. 1994; KULIK-RECHBERGER 1991; MOSIER 1990; MOSIER et al. 1985; PRADER 1978; PRADER et al. 1963; TANNER 1981].

The analysis of infants' development following malnutrition caused by acute and protracted diarrhea from an aspect of catch-up growth has been the objective of our research.

## Material and methods

One hundred and ten children hospitalized because of acute and protracted diarrhea in the Infant Clinic of Medical University in Lublin were subject to long-term examination. The youngest child with early diarrheal symptoms was six days old and the oldest one – eleven months and fourteen days old (average estimated age – three months and two days). The researched group was divided as follows:

1. boys who suffered from acute or protracted diarrhea (n=64);
2. girls who suffered from acute or protracted diarrhea (n=46);
3. boys and girls who suffered from acute diarrhea (n=55);
4. Boys and girls who suffered from protracted diarrhea (n=55).

The first anthropological measurements of the children were taken during their hospital convalescence (examination I). Subsequent checkups were done (on call) after – on average – 3.6 months (examination II), 7.7 months (examination III), and 13.7 months (examination IV) from the first examination. Each time the children were subject to thorough physical examination together with an-

thropological measurements. At the same time detailed information was gathered as regarded their psychomotor development and other factors influencing their growth (parent's education, social and economic conditions, diseases they suffered from, nutrition, etc.). Moreover, during each checkup, mothers were advised how to properly feed and take care of their children. Somatometric examination was done with Wolański's liberometer and Martin's set of measuring instruments. The selection of measuring points and the technique of measurements were standard.

This study has taken into consideration three basic morphological features: body height, body weight and head circumference. The values of parameters measured were compared to "Tables of Physical Development Indexes for Children of Lublin" [CHRZĄSTEK-SPRUCH, SZAJNER-MILART 1973] being in use at the time of the research. The results were expressed as the percentage of deficit or excess of measured parameters in relation to their mean values (treated as standard, 0% of deficit or excess) for the population. That technique made it possible to compare the level of the same feature as well as different ones in the consecutive examinations. The obtained data were subject to statistical analysis employing *T*-student test and *C*-Cochran-Cox test.

## Results

Immediately after recovering from diarrhea (examination I) the researched children had significantly ( $p < 0.001$ ) decreased values of body weights and, to lesser degree, body heights and head circumferences (Fig. 1) in comparison to

the standard levels. As the children recovered and were given conditions advantageous for their growth (proper care and nutrition), the parameters measured tended to compensate their deficits by accelerated growth ("catch-up growth" mechanism). The rate of the process was the fastest for body weight, which already in examination II, and then in the subsequent ones, did not significantly differ from the standard value (Fig. 1). Body height and head circumference growth were much slower. Although the initial deficit in height considerably decreased over the period of the research, it did not reach the desired value of 0% (Fig. 1). Similarly, head circumference did not catch up with the normal value, even if its deficit diminished significantly already between examinations I and II.

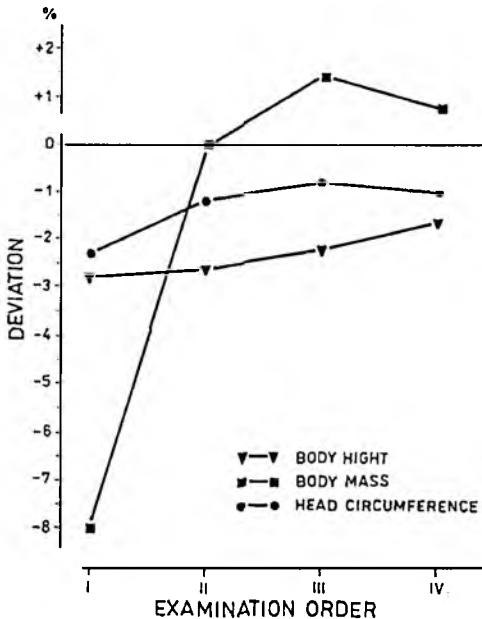


Fig. 1. Percentage variation from norm in body height, body mass and head circumference in successive studies

In order to determine the influence of gender on child's development disturbed by a disease, the analysis of deficits in body height, weight and head circumference was made for separate groups of girls and boys (Fig. 2). The obtained results proved that as regards body weight, sex did not influence the catch-up growth. In the case of each group the initial deficit in this parameter was similar and beginning from examination II body weight was at the normal level both for girls and for boys. The influence of sex was also unimportant in the case of head circumference. At the same time that feature neither significantly accelerated its growth nor reached the desired value. The research has shown, however, a difference between genders in the case of body height. In examinations I, II and III the deficits in this parameter were significant and equal for boys and girls, but in examination IV the average height for the girls' group reached the desired value, while in the boys' group remained considerably decreased.

The analysis of the obtained values of the researched parameters in regard to a type of diarrhea (acute or protracted) (Fig. 3) revealed that the initial deficit in body weight and height was almost twice as much, and head circumference deficit almost significantly higher in children who suffered from protracted diarrhea, than in those who recovered from acute one. As early as in examination II (and then in III) body weight in both groups reached the desired value, but in examination IV the children who had been afflicted with protracted diarrheal syndrome showed significant overweight.

Considerable decrease in height deficit in children who suffered from protracted diarrhea took place between ex-

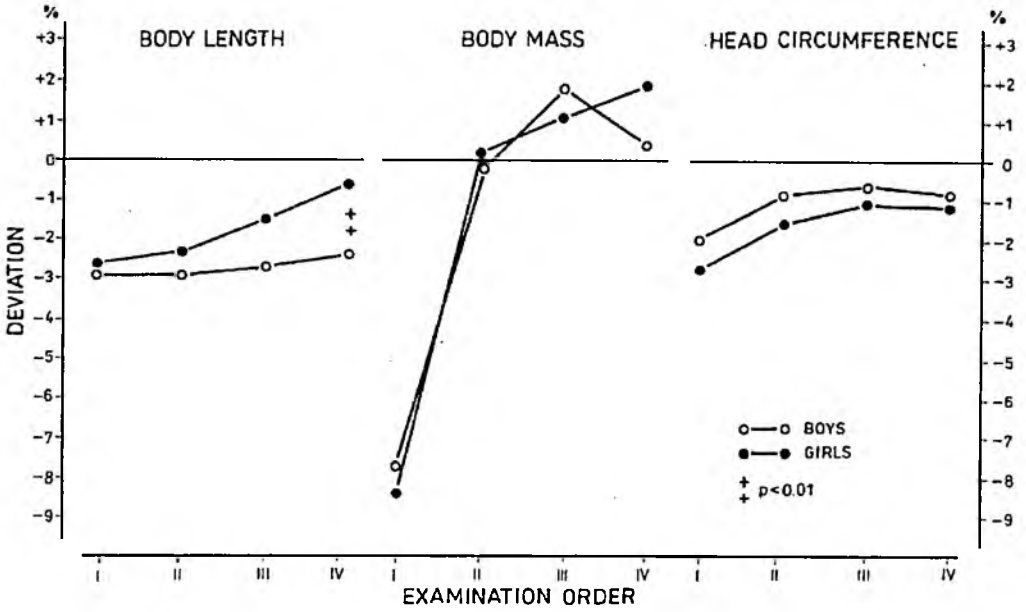


Fig. 2. Percentage variation from norm in body height, body mass and head circumference in successive studies according to sex

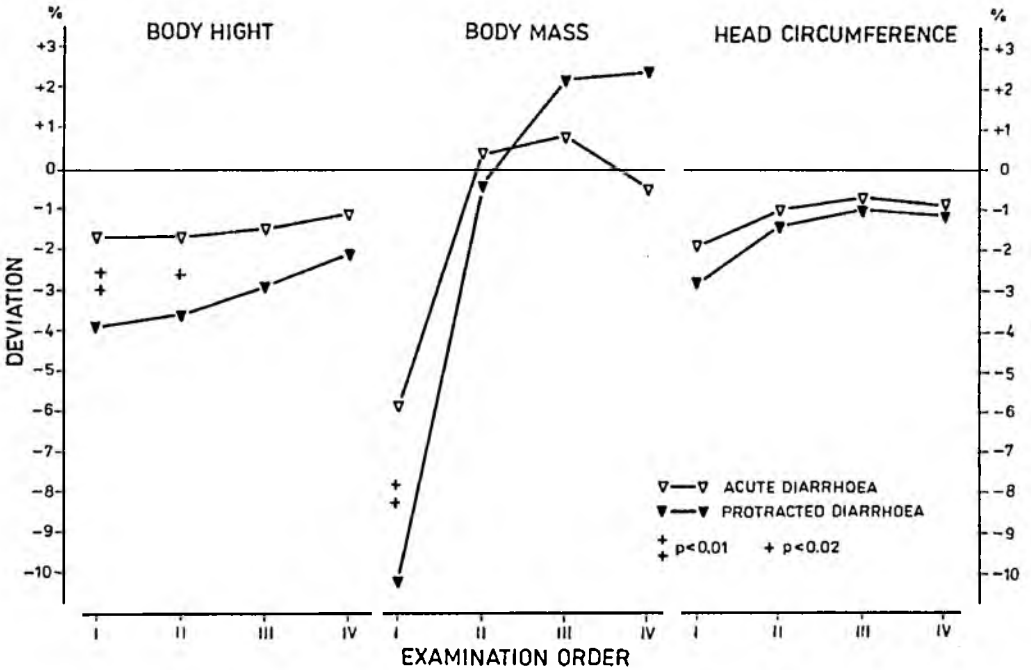


Fig. 3. Percentage variation from norm in body height, body mass and head circumference in successive studies according to diarrhoea syndrome

aminations I and III, as well as between I and IV, while in the case of head circumference the deficiency diminished between examinations I and II, I and III, I and IV. Due to those changes, beginning from examination III, the average values of height deficits, and beginning from examination II the average head circumference deficits did not depend on diarrheal syndrome; however, both parameters were still far from normal.

### Discussion

Numerous studies have proved that sufficiently strong and long-lasting disadvantageous stimulus acting on young organism of a child disturbs its somatic development [PRADER 1978, SOLOMONS 1985]. In the case of our research that function was fulfilled by acute and protracted diarrhea. Although the somatic deficiencies resulting from that disease were not as serious as in some other described cases [BARR et al. 1972; BRANCO 1979, SOLOMONS 1985, STOCH, SMYTHE 1976], they were noted and follow-up observation confirmed that initial levels of body parameters had been improper. In subsequent examinations the acceleration of growth in order to "catch up with own development pattern" was recorded. The phenomenon was particularly apparent in the case of body weight, for which the catch-up growth was completed as early as in examination II, i.e. after an average of 3.6 months from the end of the disease, the weight reached the value adequate to body height. Boys and girls similarly reacted to the improved conditions for growth. Different were, however, reactions as regarded the type of diarrhea. The mean body weight, which in examination I was lower in children who suffered from protracted

diarrhea than in those recovering from acute one, in examination II was similar, and in examination III reached values significantly higher than the right ones.

Fast growth of body weight after recovery from an illness and institution of a proper diet is a commonly known phenomenon. In that period children have increased appetite and take more food. At the same time activation of anabolic processes and accelerated accumulation of substrates in tissues takes place [ASHWORTH, MILLWARD 1986]. Proper treatment of malnutrition in early childhood quite often results in overweight. The reason for that effect is the fact that the growth of body weight is faster than that of height [BARR et al. 1972]. Particularly fast rate of weight growth was usually noted in children with higher deficit in weight than in height. An average rate of weight growth for children with height deficit, but weight proper for that height was slower than in those with weight deficit only. [ASHWORTH, MILLWARD 1986; PRADER et al. 1963]. Our research has also proved that higher initial weight deficit in the group of children who suffered from protracted diarrhea resulted in faster rate of growth for that parameter.

Whereas the "catch-up" in body weight was complete already in examination II, height deficit was still significant in examination IV, although it had diminished, compared to examination I. It is possible that the time of observation was too short. A lot of authors have maintained that the "reconstruction" of the latter feature requires more time than of the former one [BARR et al. 1972; BRANCO 1979; SOLOMONS 1985; STOCH, SMYTHE 1976] and in some cases may be even impossible [BRIARES et al. 1975].

In the course of our observation the girls, contrary to the boys, completed their catch-up growth of body height already in the first year. Their case has illustrates the fact that the accelerated growth of body weight and height does not take place in the same time. Only after the body weight reaches the value proper in relation to its height, will the rate of its growth diminish and the acceleration of height growth begin. ASHWORTH, MILLWARD [1986] have observed the similar mechanism. On the basis of their own analysis of changes in body weight and height in the period of accelerated growth they advanced the hypothesis that the rates of weight growth and height growth in children with deficiency in both those parameters (body height deficits in relation to children's age, body weight deficits in relation to their height) limited each other. As has been proved on laboratory animals, the delay in compensatory growth of body height is caused by higher rate of increase in body weight, and lasts until the weight reaches the value proper for its height. Subsequent decrease in the rate of weight growth results from the accelerated growth of height. Hence the conclusion that organisms tend not only to compensate their growth, but also to restore proper proportions between body weight (consisting also of the soft tissue weight) and body height. At the same time it seems that it is weight that adjusts itself to height [MOSIER 1990, ISAKSSON 1990].

Our research has also revealed that, similarly to body weight and height, although less clearly, head circumference deficit depends on the type of diarrhea (higher deficit following protracted diarrhea). The deficiency of that feature in

children diminished already in an early stage of our observation, so the acceleration of head circumference growth took place before the acceleration of body height growth. CASEY, ARNOLD [1985] have noticed the similar sequence. As in the case of body height or weight, the higher deficit in head circumference in children who suffered from protracted diarrhea caused faster growth of that parameter and in result, the values of the deficiency for both types of diarrhea were similar in examination II. As in the case of body height, different opinions exist in regard to the possibility of complete catch-up in head circumference in children with high deficit of that parameter [GERKOWICZ et al. 1980; STOCK, SMYTHE 1976]. In the case of our research it is possible that the catch-up growth of head circumference was not completed because the time of observation was too short.

Summing up, diarrhea has a slowing-down influence on infants' development. However, given the advantageous conditions, the organism has a potential to compensate deficits by the acceleration of its growth rate.

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## Streszczenie

Przeprowadzono badania długofalowe 110 niemowląt hospitalizowanych z powodu ostrej i przewlekłej biegunki. Pierwsze pomiary antropometryczne wykonano w czasie pobytu dziecka w szpitalu, w okresie jego rekonwalescencji, badania kontrolne przeprowadzono w odstępach średnio 3, 6 miesiąca (badanie II), 7, 7 mies. (badanie III) i 13, 71 mies. (IV) od badania pierwszego (I). W niniejszym opracowaniu uwzględniono trzy podstawowe cechy morfologiczne: długość (wysokość) ciała, masę ciała i obwód głowy. Wyniki pomiarów przedstawiono w postaci odsetkowych wielkości niedoboru lub nadmiaru cech w stosunku do ich średniej wielkości w populacji. Materiał liczbowy poddano analizie statystycznej przy pomocy testów *t* – Studenta oraz *C* – Cochran i Coxa.

W wyniku przeprowadzonych badań stwierdzono, że u dzieci, w krótkim okresie po biegunce (badanie I) charakteryzowały się istotnie ( $p < 0,001$ ) obniżonymi w stosunku do przyjętej normy wartościami, głównie masy ciała, a w mniejszym stopniu długości ciała i obwodu głowy (rys. 1). Po powrocie do zdrowia badane parametry wykazywały tendencję do wyrównania swoich niedoborów przez przyspieszenie tempa wzrastania („catch-up growth”). Najszybsze tempo obserwowano w przypadku masy ciała i już w badaniu II cecha ta nie wykazała istotnych odchyień od normy. Tempo wzrastania długości ciała i obwodu głowy było znacznie wolniejsze i „catch-up” tych cech nie był kompletny. Nie stwierdzono aby płeć miała wpływ na zachowanie się masy ciała czy obwodu głowy (rys. 2). Wykazano natomiast, że w badaniu IV średnia długość ciała dziewcząt osiągnęła wartość należną natomiast u chłopców

niedobór tej cechy pozostał nadal istotny. W wyniku analizy wielkości badanych cech w zależności od rodzaju przebytej biegunki (ostra bądź przewlekła) stwierdzono, że początkowy niedobór masy i długości ciała był niemal dwukrotnie większy, a niedobór obwodu głowy niemal istotnie większy u dzieci po biegunce przewlekłej niż po ostrej (rys. 3). Już w badaniu II a także i III w obu grupach masa ciała osiągnęła wartość oczekiwaną, natomiast w badaniu IV dzieci po zespole biegunkowym przewlekłym wykazywały istotną nadwagę. Tak szybkiego tempa wzrastania nie obserwowano w przypadku długości (wysokości) ciała i obwodu głowy. Począwszy od badania III, średnie wielkości niedoborów długości (wysokości) a od II średnie wielkości niedoborów obwodu głowy nie różniły się w zależności od rodzaju zespołu biegunkowego, jednakże cechy te nadal istotnie odbiegały od normy.

Wyniki naszych badań wykazują, że zaburzenie odżywiania w postaci ostrej czy przewlekłej biegunki hamuje rozwój dziecka, jednak, w optymalnych warunkach jego organizm posiada zdolność do „nadrabiania” niedoborów przez przyspieszenie tempa wzrastania.