EFFECT OF PHYSICAL ACTIVITY UPON GROWTH OF CHILDREN RECOVERING FROM PROTEIN-CALORIE MALNUTRITION (PCM)

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It has been claimed that the inactivity that accompanies moderate protein-calorie malnutrition is a compensatory response to reduce calorie expenditure and make more energy available for growth. In our experience, however, children under such conditions do not grow adequately. On the other hand, experiments conducted by Viteri with calorically restricted rats showed that physically inactive animals grew significantly less than their pair-fed counterparts.

These and other considerations prompted our testing the hypothesis that physical activity may have beneficial effects on children going through a period of rapid growth, and that it may improve recovery from protein-calorie malnutrition.

Twenty patients with non-complicated edematous protein-calorie malnutrition were admitted to INCAP's Clinical Center. After initial recovery, when they were no longer edematous and their initial apathy and irritability gave way to willingness and ability to participate in this study, they were divided into two groups paired according to age, size, nutritional history and nutritional status. At that moment their chronologic age ranged from 24 to 48 months, with a mean height-age of 17 months. There were no differences between groups in terms of size as determined from height and weight, nor in growth impairment as determined from weight-for-height retardation and from the creatinine-height index. Basal metabolic rate was also similar in both groups.

Nutritional rehabilitation treatment was continued during the following 6 weeks with a diet that provided 1 gram of milk protein, 1 gram of egg protein and ½gram of corn protein per kilogram per day, and 120 calories per kilogram per day which were derived from carbohydrate 58%, protein 12%, and fat 30%. The actual intakes were determined from the exact weight of food eaten by each child, and from Kjeldahl and Bomb calorimetry analysis of the food. There was an excellent coincidence with the theoretical intakes.

Children in the Control group followed the pattern of physical activity and rest periods most commonly observed in hospitals and other institutions dealing with malnourished patients. While out of bed they walked and moved in their room and in the playing areas, and they were encouraged to play with toys and to participate in games that did not require running or jumping. In addition, children in the Active group were encouraged to participate in games and activities which require walking at a grade, running, and climbing stairs. Those activities alternated with periods of rest or sedentary play to avoid fatigue and boredom.

Physical activity was constantly monitored for purposes of quantification, using heart beat accumulators. Daily energy expenditure was estimated from the relationship between heart rate and oxygen consumption. Since that relationship varied as the patients improved clinically, individual regressions of oxygen consumption on heart rate were established weekly with each child.

Children in the Active group were significantly more active as documented from the increment in their mean heart rates during the active hours of the day above their mean nocturnal pulse, and from the increment in energy expenditure above their basal metabolic rate. In this last respect, it should be considered that the basal metabolic rate of patients in the Active group became increasingly higher than that of the Control group. This magnifies even more the difference in diurnal energy expenditure between groups.

In the 6 weeks of the study both groups showed similar clinical improvement. They gained, on the average, 2 kilograms of body weight their weight-for-height reached 96% of expected, and the creatinine-height index became 0.91 for the Control group and 0.97 for the Active children. There was also no difference between groups in their increments in skinfold thickness measured at 3 sites nor in the perimeters of arm and leg.

Significant differences between groups were observed in height and in basal metabolic rate, and in the last 2 weeks of the study there was also a significantly greater increment in the urinary creatinine excretion of the Active group.

In the Active group height increased 22 mm over the 6-week period compared with only 14 mm in the Control group. Both the total increment and the rate of longitudinal growth were significantly greater in the Active group.

Basal metabolic rate, expressed either in absolute terms of oxygen consumption or normalized for body weight or surface area, increased more and at a greater rate in the Active group. While in the Control group basel metabolic rate remained around 50 kcal/hr/m^2 of body surface, it reached 60 kcal/hr/m^2 in the Active group. The value was much greater than that of children of the same age or size growing at a normal rate.

The daily urinary excretion of creatinine increased gradually in both groups by approximately 6 milligrams per week during the first 4 weeks. During the last 2 weeks, the rate of increment fell in the Control group to around 3 milligrams per week, while it increased in the Active group to 8 milligrams per week. This accounted at the end of the study for an increment of 10.7 mg. of creatinine/ day, higher in the Active than in the Control group. If we assume that a daily excretion of one milligram of creatinine represents 22 grams of lean body mass, the children in the Active group would have increased their lean mass by 235 grams more than the Control group.

Caloric retention can be calculated from the total energy expenditure and the energy intake corrected for fecal caloric excretion. The patients in the Control group retained almost twice as much energy as the Active group. Since intake and absorption were the same in both groups, there was no evidence of water retention, and both groups gained the same amount of weight during the 6 weeks of the study. This can be interpreted as a difference in the type of tissue that was synthesized to store the energy retained.

Studies in animals have shown that the cost to synthesize 1 gram of fat is 11.6 kcal, while only 7.5 kcal are required to synthesize 1 gram of protein. The Control group retained 9.3 kcal per gram of weight gained whereas the Active group retained only 5 kcal per gram.

These results, as well as the greater increments in height, basal metabolic rate and urinary excretion of creatinine, suggest that the Active group gained relatively more lean body mass and less fat than the Control group.

NERVE AND MUSCLE IN CHILDREN WITH PROTEIN-CALORIE MALNUTRITION:
Clinical Aspects and Correlations with Pathology

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There are few studies on muscle and nerve in children with malnutrition. In 1954 one of us (P.M.U.) reported muscle changes in malnutrition, in 1960 various neurological manifestations in Kwashiorkor and in 1962 Kwashiorkor myelopathy. There was also strong evidence of brain damage in a child with Kwashiorkor at autopsy. In 1970, Parekh et. al. and Bhat et. al. observed lesser brain weights and smaller heads in fetal infants in children of poor nutrition. Also there was a close correlation between I.Q. and height and weight. The greater the deficit in height and weight, the lower were the I.Q. and head circumferences. Since 1960, we have also carried out studies on mental development in Kwashiorkor (Udani et. al., 1972). This work indicated that in severe protein-calorie malnutrition (PCM) there were structural changes in the brain and spinal cord resulting in their dysfunction. As the brain and spinal cord are not easily available for histopathological study we thought it was desirable to study the histology of nerve and muscle of control and malnourished children, and at the same time correlate the clinical findings with the pathological data. Moreover, similar studies in children have not been reported in the past.

The clinical material consisted of 6 healthy children with their height and weight above 90% and 80%, respectively, of Harvard standards for children of comparable ages. There were 49 cases of PCM who fell below these standards, and generally below 80% of height and 50% of weight of Harvard standards. They were classified into two groups.

Type I: 20 cases of predominantly calorie malnutrition (CM) where there was wasting and weight loss but there were no overt signs of protein malnutrition line edema, hair changes, dermatosis, etc.

Type II: 29 Kwashiorkor children who had edema, hair changes, dermatosis, etc., in addition to other signs of malnutrition.

The pathology findings on the muscles are given in the *next paper* (Dastur et. al., 1975). Thirty