INCAP Publication PCI/055
In: Nutrition in sustainable environment. Proceedings of the XV International Congress of Nutrition: IUNS Adelaide. Wahlqvist ML, Truswell ST, Smith R, Nestel PJ, eds. United Kingdom, Smith-Gordon Nishimura, 1994, p. 651-654.

Proceedings of the XV International Congress of Nutrition: IUNS Adelaide

Nutrition in a Sustainable Environment

Editors
Mark L. Wahlqvist
A. Stewart Truswell
Richard Smith
Paul J. Nestel

SMITH-GORDON
NISHIMURA
1994

Influence of malnutrition on physical activity of children and adults

B. TORUN

Institute of Nutrition of Central America and Panama (INCAP), Apartado Postal 1188, Guatemala City, Guatemala.

Severe malnutrition is accompanied by a decrease in physical activity. This is clearly evident under conditions of famine and in patients with marasmus or kwashiorkor, and it has been described in classical publications such as that by Keys et al[1] on starvation. However, few studies have investigated the extent to which physical activity is affected by light and moderate forms of malnutrition, which account for the vast majority of cases with this nutritional deficiency throughout the world.

This paper summarizes the main results of the limited number of studies that have explored the differences in physical activity of well-nourished and undernourished individuals within their natural environment, dedicated to their customary activities and lifestyle. Interpretations are made and conclusions drawn that may apply to all or most of them.

Children under 2 years in Mexico

In a rural Mexican community, Chavez and coworkers[2] supplemented women with milk, vitamins and minerals throughout pregnancy and lactation, and their babies' diet was also supplemented with milk and strained foods. These children grew more in length and weight than their non-supplemented counterparts, and before one year of age they already were more active based on the following observations. After 40 weeks of age, supplemented babies tended to sleep less during the day, and by 1 year of age they slept approximately 25% less than the non-supplemented group. Play activities were observed in several supplemented babies beginning at 6 months of age, which was 12 weeks earlier than in most of the non-supplemented group. During the second semester of life, supplemented infants were carried by their mothers 30% less time than the others, partly because they were more restless. Physical activity was quantified in 19 supplemented and 17 non-supplemented children by counting their leg movements in six 10-minute periods at 2- or 3-month intervals. After 13 months of age, the supplemented group was consistently more active[3].

Children 12 to 24 months old in Jamaica

Seventy-eight stunted (<-2 s.d. below the NCHS standards for length) and 26 non-stunted children were studied by Gardner et al.[4] They were observed for four hours on two different days and their activities were recorded on a minute-by-minute basis. Stunted children were less active, as they spent 5% more time lying down, sitting or being carried, and proportionately less time walking.

Children 1.5 to 3 years old in Uganda

Rutishauser and Whitehead[5] recorded the daytime activities of 20 undernourished Ugandan children and 5 well-nourished children of European parents, 1.5 to 3 years old. Mean daily dietary energy intakes of both groups were 280 and 455 kJ (67 and 107 kcal)/kg, respectively, and the Ugandan children were shorter and lighter.

Compared with the European children, the Ugandans spent more time sitting (mean ± s.d.: 300 ± 64 vs 190 ± 43 min/d) and standing (265 ± 93 vs 143 ± 54 min/d), and less time walking (108 ± 46 vs 234 ± 54 min/d) and running (17 ± 17 vs 54 ± 32 min/d).

Preschool children in Guatemala

Daytime activities were recorded by our group on two different days in 69 boys and girls, 2 to 6 years old, who lived in a low-income peri-urban area of Guatemala city[6]. Activities were classified according to the physical effort to perform them. Twenty-one children were mildly malnourished (3rd to 20th centile of weight-for-height). Compared with their 48 well-nourished counterparts, the malnourished children spent 11% more time in sedentary activities, and 5, 2 and 3% less time in light, heavy and very heavy activities, respectively.

Sixty of those 69 children were studied again after 4 months of a nutritional education and supplementation program in the community[6]. Weight-for-height had improved in 23 children, not changed in 27 and deteriorated in 10. The analysis of daytime activities before and after that 4-month period showed that the children whose nutritional status improved became more active, reducing by 5% the time dedicated to sedentary and light activities, and increasing by 4% the time spent in moderate activities. In contrast, those whose nutritional status deteriorated, increased by 4% the time spent in sedentary and light activities, and reduced in a similar proportion the time dedicated to heavy activities. No significant changes occurred in the group that maintained their weight-for-height unaltered.

School-age children in Colombia

Spurr and Reina[7] used minute-by-minute heart rate recording and its relation with energy expenditure to calculate the time spent by school children from Cali in activities classified as light, moderate, heavy and very heavy. Well-nourished and mildly undernourished children (<95% of Colombian medians of weight-for-height and height-for-age) were compared.

The undernourished boys and girls in the youngest age group studied (6 to 8 years) spent more time in light or moderate activities than their well-nourished counterparts, and less time in heavy or very heavy activities. These differences were not seen among boys or girls 10 to 12, and 14 to 16 years old.

Using the same methods, Spurr and Reina[8] also studied the physical activity pattern of 14 well-nourished and 19 undernourished boys, 10 to 12 years old, during a school day and on a day when they attended a summer day camp where they were encouraged to participate in sports, calisthenics, walks and physical games. There were no differences between the two groups of children during the school day, but in the summer camp the well-nourished children had a pattern of energy expenditure consistent with a greater level of activity, and their total daily energy expenditure per kg body weight increased by 15% ($p < 0.01$) in relation to the school day, whereas it remained virtually unchanged (4%, $p > 0.1$) among the undernourished group.

Agricultural laborers in Guatemala

Viteri and collaborators[9-11] studied two groups of 18 agricultural laborers each, with similar ethnic and cultural backgrounds. One group had mean daily dietary intakes of 11.27 ± 1.84 MJ (2,693 ± 441 kcal) and 82 ± 13 g protein. The other group had eaten for three years a better diet, which included milk and a high-protein, high-energy gruel, with daily mean intakes of 14.87 ± 2.98 MJ (3,555 ± 712 kcal) and 107 ± 21 g protein with a higher amino acid score. Both groups tended to maintain energy balance, with total expenditures of 11.30 ± 1.81 and 15.16 ± 1.94 MJ/d, respectively, assessed by timed observations and indirect calorimetry.

They were assigned a series of standardized heavy tasks for 3 to 6 days, which included activities familiar to them (chopping wood, clearing an area of land with machete, and working the fields with a hoe or sickle). Both groups were able to complete the tasks, but the better-fed men worked faster (235 ± 40 vs. 397 ± 123 minutes) and spent less energy at work (4.99 ± 0.54 vs. 7.55 m 0.59 MJ, equivalent to 1192 ± 128 vs 1804 ± 141 kcal). The group with the lower diet went into a negative energy balance and lost 346 ± 740 g body weight in 3 days. They also walked back from work at a slower pace and with more rest stops, and they took long naps (173 ± 76 min). The better-fed group did not nap at all, they were more active after working hours, and they organized a soccer team.

Implications of reduced physical activity

The preceding studies indicate that persons of all ages with mild-to-moderate malnutrition become less active. This is more evident among younger children who have less restrictions to exert their physical activity; as children grow older, for example, school hours are longer and discipline tends to be more strict. The decrease in activity is also more evident in leisure time, when energy-demanding discretionary activities might be performed, as shown in school children[8] and agricultural laborers[9,11]. Gorsky and Calloway[12] reported that an experimental decrease in dietary energy also reduced the time spent by adult men in some higher-effort discretionary activities, whereas obligatory activities were not affected.

A tendency to compensate a reduction in energy intake by reducing energy expenditure or physical activity has been shown under controlled experimental conditions in preschool children[13-14] and adult men[12]. In those studies, the reduction in energy expenditure among the children was large enough to prevent growth impairment when daily energy intake decreased from 377 to 343 kJ/kg (90 to 82 kcal/kg)[12]. Although the changes in physical activity that were described in free-living individuals[2-11] may not have been significant in terms of conserving energy, they have important behavioral or biological significance. Children who are more sedentary explore their environment less and have lower social interactions than more active children. That was shown to occur in Chavez and Martinez's studies[2]. Furthermore, low physical activity may impair longitudinal growth[15].

Healthy adults with limited dietary intakes give priority to the obligatory activities that must be performed to generate a needed income, and they engage in lower-energy discretionary activities as substitute for others that are more energy-demanding, even though these might increase their comfort or improve their quality of life. When circumstances demand more intense physical work, they do it at the expense of their body reserves. This results in a weight loss that eventually will reach a point where more food must become available or work output will decrease.

Conclusions

Children and adults with a deficit in dietary energy reduce their energy expenditure in an attempt to maintain balance. This is usually done through a reduction in physical activity that has biological, behavioral or economic consequences. Therefore, this response to low dietary energy intake must be viewed as an *accommodation* through metabolic or behavioral modifications that allow survival and continued functions at the cost of actual or potential undesirable effects, rather than as an *adaptation*, which implies a more efficient use of dietary energy without producing undesirable effects.

At best, the reduction of physical activity should be considered as an adequate but short-term compensatory response to low dietary energy intakes.

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Nutrition in a sustainable environment. Ed M. Wahlqvist et al.
Proceedings of the XVth International Congress of Nutrition