Nutrition's Role in Feeding Children's Brains

Research into how children metabolize the nourishment they receive aims to help young minds reach their full potential later in life.

Many factors affect how our brains develop from an early age. Nutrition and diet are obviously important. But to more than 200,000 infants born each year in the United States, a mysterious condition is holding them back. They're normal children in most ways, but unknown factors hinder their growth, and they begin to fall behind their peers in learning.

"Failure to Thrive" is a term used by pediatricians to describe this condition in which a child has an abnormally low weight for his or her age or has an abnormally low weight gain over time. Unlike some children who simply don't grow as tall as their peers, FTT children can't make use of adequate nutrition to gain weight and grow as expected. It is not a specific disease but a general diagnosis with many possible causes. In most studies, children who didn't have a low birth weight but who fall into the lowest 5 percent later on in weight measures are classified as FTT. A main question is whether FTT is a disorder that blocks or interferes with the absorption of nutrients or if it is caused by lower than normal food intake.

It's not known exactly when FTT develops. Science hasn't determined whether it occurs in the womb or during the early years of infancy and toddlerhood. Children who were born prematurely and those who were carried to full term can be diagnosed with the condition. It's known that nutrition can permanently affect physical growth, brain structure, and function, but precisely how this happens is not well understood.

Poor nutrition during the first 3 years often permanently hampers a child's mental development. Some children start out growing well but over time begin to fall off, both in weight gain and then in height. If the condition progresses, FTT children may become apathetic and irritable and may not reach milestones, such as sitting up or walking at the usual age. It is possible that FTT children don't process needed nutrients as efficiently as non-FTT children and that this results in central nervous system defects, such as hyperactivity and disorders of attention and learning.

Researchers at the Arkansas Children's Nutrition Center (ACNC) in Little Rock, Arkansas, are interested in how children diagnosed with FTT process what they eat and how the brain is affected. ACNC is managed in cooperation with ARS and the Arkansas Children's Hospital. Roscoe A. Dykman and Terry Pivik are psychophysiologists at the center's Brain Functions Laboratory. With the support and collaboration of Dr. Patrick Casey, director of the FTT Clinic at the hospital, they're studying the effects of food intake on FTT in children and trying to find biochemical indicators that can be used to identify FTT children at an early age.

What's Going Wrong?

Researchers recruited infants and toddlers 6-20 months of age for a study of growth-retarded and normally developing children. Parents were asked to measure and report exactly what and how much their children ate over a period of 3 days. This information was then processed with a computer program known as the Minnesota Nutrition Data System, a nutrient calculation/diet assessment tool that converts amounts of foods reported to gram weights and calculates the total proteins, calories, and fat and other nutrient information.

STEPHEN AUSMUS (K10838-1)

Clinical coordinator Jill Brackenbury measures height and weight of a study participant.

"We found FTT children were eating more than the study's control group, regardless of their lower weight," Dykman says. "Food availability was not an issue. We found that food in FTT children wasn't having the effect it was supposed to have. FTT children were provided adequate diets, but they apparently processed the food differently."

Dykman says that reports in the scientific literature suggest that FTT children need to consume far more calories to grow than is the case for normally growing children. And these studies do show that an increased intake improves growth of infants and toddlers. But there is no evidence that these positive changes are sustained over time.

Dykman believes nutrients may not be processed in the same way by FTT kids as they are in normal children. "We determined that even though growth-retarded children consumed more food than the control group did, they were smaller and scored lower on development tests of mental and motor skills," Dykman says. "Blood chemistry analyses showed differences between the two groups in 8 of 29 nutrients—all 8 of which were involved in different aspects of bone growth. This suggests that the metabolism of FTT children is different and that they require either greater food intake or different foods than normally growing children do."

For example, ACNC researchers found that though FTT children's bodies are not usually iron deficient, they have an abnormally high capacity to bind iron in their blood and make it unavailable. Such findings could be clues to the problems with mental and physical growth that these children face.

Now that they have a baseline database of what FTT children eat, ACNC researchers are working to develop new diets that promote brain development and function in babies born before full term. These diets could help these children maximize their growth and learning potential.

Food for Thought

Dykman and Pivik believe that nutritional deficits occurring during early development may be associated with long-term effects on the processing of language-related information. Evidence of this was provided in a study of 8- to 15-year-old growth-retarded children, diagnosed with FTT before the age of 3, and normal (control) children in the same age range.

They found that many children, particularly boys, have difficulties with reading, spelling, and arithmetic as they age. They also found, by measuring brainwave responses, that the children who developed normally were more efficient at processing information. FTT children had slower word recognition than controls and were shown to question their own decisions during testing, indicating an element of uncertainty in information processing.

A second study on these same subjects used a task that was originally designed to test the vigilance/attentiveness of radar

A study participant, fitted with a cap with electrodes for recording EEG activity, completes a math speed test being presented on a computer monitor.

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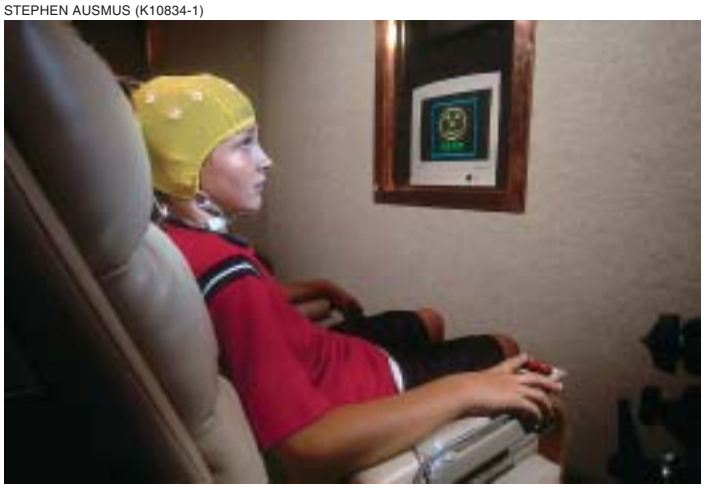

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Jill Brackenbury explains a computerized diet-assessment program to a study participant.

FTT children's bodies have an abnormally high capacity to bind iron in the blood and make it unavailable.

Study nurse Ellen Templeton draws blood from a study participant. Blood chemistry analyses of FTT and normal subjects show differences in 8 of 29 nutrients involved in bone growth.

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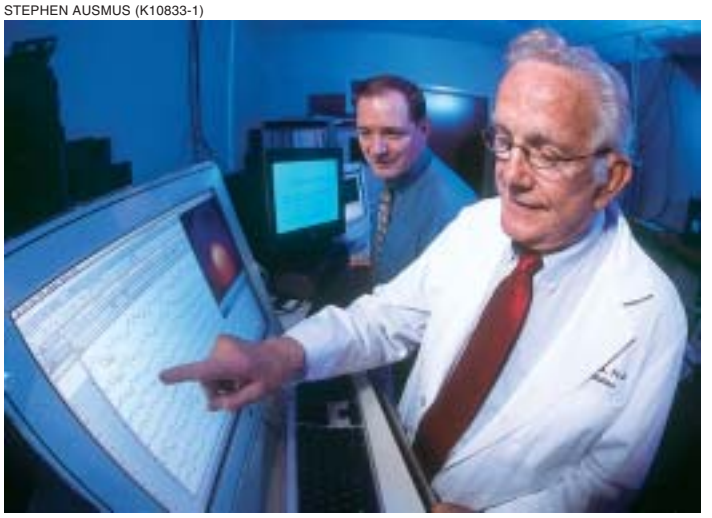

Psychophysiologists Roscoe Dykman (foreground) and Terry Pivik review a participant's brain wave (EEG) recording during a reaction-time test.

Nutrition problems early in life may later affect the brain area that controls behavior, thought, and emotion.

operators. The children pressed a reaction time key every time the letter A occurred followed by the letter X on a television screen as their brain activity was monitored. They were told not to press the key for anything but this sequence (not A alone, X alone, or any other letter). Researchers call the restraint people need to have in controlling their desire to respond to a stimulus the "no-go response." The brain is responding with response inhibition so that the child doesn't push the button. Though the number of errors made by the two groups did not differ, researchers found that the FTT children's brainwaves were different from those of the control subjects during the time when they had to decide to react or not.

This difference was seen in what is known as a long latency brainwave. The researchers found reduced responses to stimuli in growth-retarded subjects in brain areas involved in attention and language processing. This evidence points to the brain's frontal lobe as a factor in FTT. Dykman says the frontal lobe is involved with behavior, social judgment, reasoning, planning, speech and movement, emotions, and problem-solving (important functions that are referred to by psychologists as "executive functions"). This study suggests that nutritional problems occurring earlier in life may have subtle effects later in an area of the brain that controls much of our behavior, thought, and emotion.

It was thought for a long time that a mother's relationship with her child, her intelligence, the socio-economic status of the family, and the level of care for children were the main factors leading to FTT. But Dykman says their results, as well as those of others, contradict this. Neglect of any kind is not an issue in most cases. Studies by Dykman and Pivik showed there weren't significant differences in the social status of families or in the IQs (intelligence quotients) of parents with FTT children. It is likely, however, that these home environmental factors do, in fact, have some effect, but it is very small compared to nutritional status and to biological variables such as inherited physiological and biochemical anomalies, parental size, and virus infections early in life.

Also, the same parents can have both normally growing and FTT children. Dykman believes studying these families could provide some insight into FTT's causes and help show why some children are born with or acquire this condition.—By **Jim Core,** ARS.

This research is part of Human Nutrition, an ARS National Program (#107) described on the World Wide Web at www.nps.ars.usda.gov.

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