Malnourishment in a Population of Young Children With Severe Early Childhood Caries

Martha Clarke, RDH, BA, MSc[1] David Locker, BDS, PhD[2] Glenn Berall, BSc, MD[3] Paul Pencharz, MB, ChB, PhD[4]
David J. Kenny, BSc, DDS, PhD, DPaed[5] Peter Judd, BSc, DDS, DPaed, MSc[6]

Abstract

Purpose: The purpose of this study was to describe the nutritional status of children with severe early childhood caries (S-ECC) using several clinical measurements.

Methods: Children aged 2 to 6 years with S-ECC were measured for height, weight, triceps skinfolds (TSF), and measurement of upper mid-arm circumference (MAC). Blood samples assessed: (1) hemoglobin; (2) mean corpuscular volume (MCV); (3) serum ferritin; and (4) serum albumin. Weight-for-height was converted into ideal body weight (IBW) percentiles. Body mass index (BMI) was calculated as kg/m2. TSF and MAC were converted into measurement of arm muscle circumference (MAMC). All measurements were compared with population reference values.

Results: Using weight for height centiles, 17% were diagnosed as being malnourished and 66% as within normal limits. Using BMI centiles, only 4% were identified as being malnourished and 75% as being normal. Conversely, the body fat of 24% was assessed as low (<10th percentile). Serum albumin was low for 16%. The majority had evidence of inadequate iron intake with low serum ferritin (80%), iron depletion (24%), iron deficiency (6%), or iron deficiency anemia (11%).

Conclusions: All tests detected levels of malnutrition, with blood tests finding the most severe cases. The results suggest that severe Early Childhood Caries may be a risk marker for iron deficiency anemia. Since iron deficiency has permanent effects on growth and development, pediatric dentists should recommend assessment of iron levels in S-ECC patients regardless of their anthropometric appearance. (Pediatr Dent 2006;28:254-259)

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There is a substantial body of research that shows a strong association between the frequency of sucrose ingestion and the development of Early Childhood Caries (ECC).[1-7] High sucrose diets are of concern because it has been suggested that such diets may be low in micronutrients and may compromise nutrient intake.[8] Despite this concern, to date, no published reports have described the nutritional status of young children with Severe Early Childhood Caries (S-ECC).

[1]Ms. Clarke is research associate, and [2]Dr. Locker is director, Community Dental Services Research Unit, Faculty of Dentistry, University of Toronto, Toronto, Ontario, Canada; [3]Dr. Berall is Chief of Paediatrics, North York General Hospital, Toronto; [4]Dr. Pencharz is senior scientist, Research Institute, The Hospital for Sick Children, Toronto, and professor of Paediatrics and Nutritional Sciences, University of Toronto, Toronto; [5]Dr. Kenny is a pediatric dentist and Director of Dental Research and Graduate Studies, and [6]Dr. Judd is a pediatric dentist and Director of Paediatric Dentistry, both at the Hospital for Sick Children.
Correspond with Ms. Clarke at martha.clarke@utoronto.ca

The limited research regarding the nutritional status of S-ECC children has involved weight as the sole measurement of nutritional health. The conclusions are conflicting. Early research concluded that ECC children had lower mean weights than those of caries-free comparisons, thereby suggesting that ECC children had inadequate caloric consumption.[9-12] More recently, Thomas and Primosch[13] compared the weights of ECC children against population reference values and concluded that ECC children were not significantly underweight.

A limitation of such research is that the use of weight as the sole measure of nutritional status does not account for the multifactorial nature of the clinical assessment of nutrition.[20]

There were 2 aims of this study:

1. to describe the nutritional status of a population of young children with S-ECC attending a hospital dental clinic for complete oral rehabilitation while under general anesthetic;
2. to assess the ability of several clinical measurements of nutritional status to detect malnutrition in S-ECC children.

Methods

This descriptive report summarizes the baseline data from a 3-stage longitudinal study investigating the nutritional status of young children with S-ECC. The study was conducted on 56 otherwise healthy 2- to 6-year-old children with S-ECC who attended the Hospital for Sick Children (HSC), Division of Pediatric Dentistry in Toronto, Ontario, Canada for oral rehabilitation under general anesthesia. Ethical approval was granted by the Research Ethics Office of the University of Toronto, Toronto, and by the Research Ethics Board of The Hospital for Sick Children, Toronto.

Children were sequentially enrolled as they presented for dental treatment between October 2002 and January 2004. Participants were required to meet the following inclusion criteria:

1. no medical problems;
2. age between 2 and 6 years;
3. minimum of 6 severely decayed teeth with at least 1 tooth that had pulpal involvement;
4. no prior dental treatment (restorations or extractions);
5. all treatment to be completed at 1 appointment while under general anesthesia.

Parents were required to give consent due to the subjects' young ages. The procedures, possible discomforts or risks, and possible benefits were explained fully to the parents or guardians of the human subjects involved and their informed consent was obtained prior to the investigation.

Measurements and data collection

Anthropometric measurements

Data collection occurred on the day of each child's dental treatment at the hospital clinic. After obtaining informed consent prior to dental treatment, 4 anthropometric measurements were conducted on each child: (1) height; (2) weight; (3) arm circumference; and (4) triceps skinfold thickness. All measurements followed standardized techniques[14] using accurate equipment that was regularly calibrated. The sole examiner was trained and standardized for the correct use of all instruments by a specialist in pediatric nutrition. For all measurements, children wore light clothing and were in stocking feet.

Height was measured with a portable stadiometer (Seca model 214, Seca Corporation, Hanover, Md) to the nearest 0.1 cm. Weight was measured with a portable electronic digital scale (Scaletronix model no. 5602, Scaletronix Inc, White Plains, NY) in kilograms to the nearest 100 grams. The mid-upper arm circumference (MAC) was measured to the nearest 0.1 cm with a metric, nonstretch tape measure following methodology by Frisancho.[14] The triceps skinfold (TSF) measurement followed Frisancho[14] using Harpenden skinfold calipers (Harpenden Corporation, West Sussex, UK). All measurements were performed at least twice, and the average was computed.

Blood collection

While each child was sedated, a blood sample (approximately 2.5 mL) was collected by a physician from the anesthesia venipuncture site. The blood sample was used to determine serum albumin, hemoglobin, mean corpuscular volume (MCV), and serum ferritin. The physician followed standard HSC collection and laboratory techniques. The reference values to which the results were compared were based on the HSC's accepted values for the age range of 2 to 6 years.

Data conversion for comparison with reference values

To be compared with population reference values, the anthropometric measurements were converted with several calculations as follows:

1. Ideal body weight (IBW) percentiles: Actual body weight was expressed as a percentage of the IBW for age, gender, and height (derived from the growth charts of Tanner and Whitehouse).[15] These percentages were then interpreted using the Waterlow classification of malnutrition.[16]
2. Body mass index (BMI): BMI uses weight and height measurements (kg/m^2) to determine if weight is appropriate for height. The calculation is plotted on age- and gender-specific charts from the Centers for Disease Control and Prevention (CDC) 2000,[17] and the resulting percentile category for the calculation is categorized into levels of overweight, health, or malnutrition using standards published by the CDC.[17]
3. Measurement of mid-arm muscle circumference (MAMC): MAMC is estimated from measures of mid-arm circumference (MAC) and triceps skinfolds using a simple calculation: $MAMC=MAC-(TSF \times \pi)$. TSF and MAMC measurements were compared to percentile distributions for age and gender from Frisancho[14] that uses data from the United States National Health and Nutrition Examination Surveys (NHANES I and II).

Given that the data were compared to reference population data, no comparison group was required in this study. Binomial tests assessed the significance of differences in observed and expected proportions.

Results

There were 56 subjects (males=61%) enrolled in the study, and complete data were collected for 46 cases. There were no blood tests conducted for 10 children because of technical difficulties at the time of blood collection. An additional case was missing the blood value for ferritin due to technical difficulties in the laboratory. There were no differences in anthropometric measures, age, or gender between those who had blood tests and the 10 who did not.

Demographic data

The age range of participants was 2 to 5.4 years (median=3.8 years). Parents tended to be immigrants; two thirds reported that they were not born in Canada, while most of the children in the study were Canadian born (87%).

Dental diagnosis and treatment

The children in this study had severe ECC. The number of decayed teeth per person ranged from 6 to 20 teeth (mean=13), and 42% had 4 or more pulp-involved teeth (mean=7).

Anthropometric data

Using Waterlow's classifications of malnutrition,[15] the distribution of the ideal body weight (IBW) percentiles is presented in Figure 1. Most cases are considered to be of ideal body weight, with 66% being within the 90th to 110th percentile range. This proportion, however, is significantly lower than the 95% considered to be IBW in the reference population (P<.001; binomial test). Some subjects showed evidence of malnutrition, with 12% classified as suffering from mild malnutrition and a further 5% considered to be moderately malnourished. The data also showed that 16% were categorized as overweight or obese.

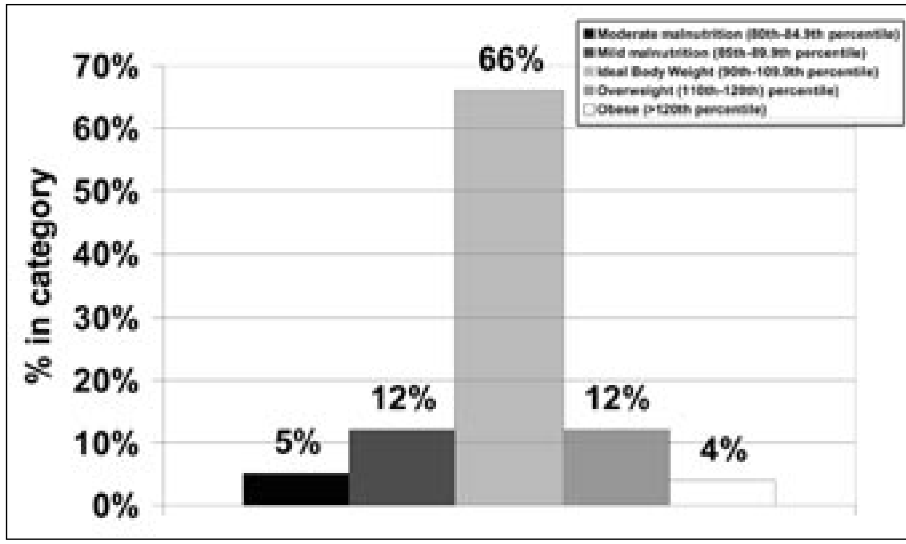

Figure 1. Distribution of ideal body weight (IBW) percentile categories (n=56).

Figure 2 depicts the distribution of the BMI percentile categories. With 75% classified within the fifth to 85th percentiles, the findings were not significantly different than the proportion expected in the reference population (P=.08; binomial test). The BMI test identified more cases of risk of overweight and obese and less cases of underweight than did the IBW test.

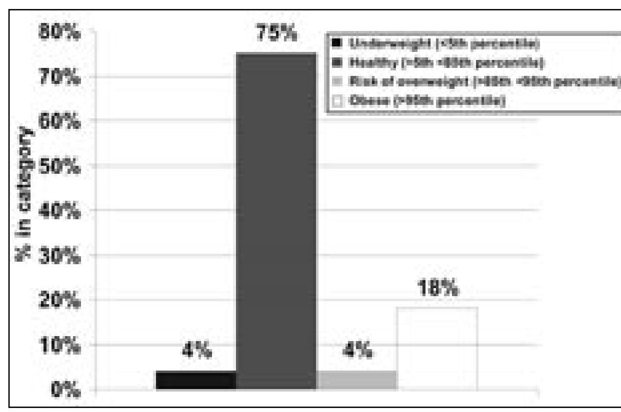

Figure 2. Body mass index (BMI) percentile categories (n=56).

The distributions of the TSF and MAMC measurements were grouped into 3 categories of percentile distributions: (1) low (<10th percentile); (2) acceptable (10th to 90th percentile); and (3) high (>90th percentile). Table 1 shows that for the TSF distribution the proportion of cases between the 10th and 90th percentile was significantly lower than the 80% expected to fall within this category (P<.05; binomial test). The proportion of cases (22%) with low TSF measurements is significantly higher than the 10% expected to fall in this category (P=.001; binomial test).

Table 1. Triceps Skinfold and Measurement of Arm Muscle Cicumference Percentile Categories Distributions (n=56)

Measurement	<10th percentile n (%)	10th to 90th percentile n (%)	> 90th percentile n (%)
Triceps skinfolds	15 (23)	38 (68)	3 (5)
Measurement of arm muscle circumference	1 (2)	45 (80)	10 (18)

For the MAMC distribution, Figure 3 shows that the majority of cases (80%) were in the acceptable 10th to 90th percentile distribution. This proportion is the same as that expected in the population.

Blood tests

The distribution of serum albumin values is depicted in Table 2. Serum albumin categories were based on the acceptable reference range for children's albumin: 33 to 58 g/L. The values for serum albumin in this investigation ranged from 32 to 46 g/L. Almost all the children had serum albumin levels in the acceptable range, with only one case below 33 g/L. There were 6 cases (13%) between 33 and 35 g/L, considered to be the low end of the acceptable range.

Table 3 depicts the distribution of the hemoglobin blood test results for 46 cases. The categories are based on the acceptable reference range for children's hemoglobin, 110 to 140 g/L. The hemoglobin values in this study ranged from 71 to 130 g/L. While the majority had acceptable hemo-

Table 2. Serum Albumin Values (N=45)	
Serum albumin category	n (%) in category
Below acceptable (<33 g/L)	1 (2)
Low acceptable (33.1-35 g/L)	6 (13)
Acceptable (35.1-58 g/L)	38 (85)

Table 3. Hemoglobin Value (N=45)	
Hemoglobin category	n (%) in category
Low (<110 g/L)	13 (28)
Low acceptable (110-120 g/L)	21 (46)
High acceptable (121-140 g/L)	12 (26)

Table 4. Serum Ferritin Values (N=45)	
Serum ferritin category	n (%) in category
Iron depletion (<10 µg/L)	11 (24)
Low (10.1-22 µg/L)	25 (56)
Acceptable (22.1-400 µg/L)	9 (20)

globin levels, the proportion of those with low hemoglobin (<110 g/L) was significantly higher than the 7% prevalence rate reported by Zlotkin et al[18] in 1996 for a population-based sample (P<.001; binomial test).

Table 4 shows the distribution of the serum ferritin values for 45 cases. The categories are based on the reference range for children (22-400 µg/L). The values for ferritin in this study ranged from 1 to 51 µg/L. Acceptable ferritin levels were found in only 20% of the children. For the majority of cases (80%), the serum ferritin levels are unacceptably low (<22 µg/L). One quarter (24%) of the cases had evidence of iron depletion, with serum ferritin levels less than 10 µg/L. The proportion of those with iron depletion was not significantly different than the 34% population prevalence rate reported by Zlotkin et al in 1996[18] (P<.116; binomial test).

Discussion

This study was designed to further existing knowledge about the nutritional status of S-ECC children. Previous research has used weight as the sole measurement of nutritional status. The study design was based on the premise that the clinical assessment of nutritional status requires several tests to accurately diagnose malnutrition. Such tests include anthropometric measures such as height, weight, skinfolds, and arm circumference measurements. In addition, blood tests are essential for the assessment of the presence of nutrients vital for proper growth and development. Most tests require analysis by age and gender.

Weight as a percentage of ideal weight for height is a well-established method of screening populations for malnutrition.[16] Conversely, BMI has only been validated for screening populations for risk of overweight and obesity. In the present study, this limitation is evident by inspecting the data presented in Figures 1 and 2. The percentages of subjects classified as being overweight or obese by the 2 techniques were similar, being 16% and 22%, using weight for height and BMI criteria, respectively. Conversely, using weight for height criteria (WFH), 17% of the population was undernourished (malnourished) and only 4% was classified as underweight by BMI criteria. A recent publication comparing BMI and percentage of ideal body weight to screen for malnutrition in children with cystic fibrosis showed that a BMI percentile less than the 15th percentile was associated with malnutrition.[20] If this methodology was applied to the present study, approximately 15% of the subjects would have been categorized as being malnourished—essentially the same as the 17% defined by the WFH criteria.

To further explore the nutritional status of S-ECC children, this investigation incorporated 2 additional anthropometric measurements: (1) triceps skinfolds (TSF); and (2) mid-arm muscle circumference (MAMC) measurement. The TSF is a measure of fat stores, the proxy for energy storage. Low measurements are indicative of insufficient caloric intake. In this study, most cases had TSF within the acceptable 10th to 90th percentile range, indicating adequate energy reserves. There is a skew in the distribution to the left, however, with a subset of nearly one quarter of the cases with TSF measurements below the 10th percentile. The lower values for TSF are evidence that a subset of S-ECC children had energy deficiency probably as the result of an insufficient caloric intake that resulted in depleted fat reserves.

The MAMC is estimated from measures of arm circumference and triceps fatfold and is considered to be a proxy for protein stores or muscle mass. Low numbers indicate insufficient protein consumption. The MAMC data in this study suggest that protein or muscle mass were in the acceptable percentile range for the S-ECC children, indicative of adequate protein consumption in this group.

The TSF and MAMC findings in this study reflect the typical clinical progression of malnutrition as a result of reduced calorie intake. TSF's lower values reflect that there was a reduction in fat deposits as the body strived to maintain itself at equilibrium. It is only after extended caloric restriction that protein stores are affected. The TSF data suggest that malnutrition was either acute or mild to moderate at worst.

The blood tests performed in this study detected more cases of nutritional deficiency than anthropometry. This was encountered when the MAMC data were compared to the blood test results for serum albumin. The MAMC data, the proxy for protein and muscle, show that nearly all the S-ECC children had acceptable muscle or protein stores. In contrast, the blood test for serum albumin found that almost 16% had serum albumin values ranging from 33 to 35 g/L—the low end of the acceptable range. The lower values found in this study are evidence of protein undernourishment that was undetected by the MAMC measurement. This finding suggests that the children's dietary intake of protein and energy intake may be lower than acceptable.

There are several explanations for the low levels of serum albumin. The low serum albumin values for 16% of the children may indicate insufficient intake of dietary protein. This could reflect that young children often do not eat meat, perhaps because they do not like it or because they have difficulty chewing such foods. It has been shown, however, that serum albumin can be lowered due to illness in the 2 weeks prior to a blood test.[21] Some of the subjects may have been ill prior to their dental appointment. It is also possible that some of the children could have had low serum albumin values due to the presence of long-term, chronic dental infections.

The most remarkable blood tests results were those for markers of iron deficiency: hemoglobin and serum ferritin and MCV, to a lesser degree. The children in this study showed evidence of malnutrition with significant proportions with very low values for hemoglobin and or serum ferritin.

Low ferritin is evidence that the body has depleted storage iron in an effort to maintain hemoglobin at an appropriate level for good health. The results suggest that this mechanism was activated to some degree in the S-ECC population because there were children with acceptable levels of hemoglobin but low levels of serum ferritin. There was a high proportion of cases of iron depletion having serum ferritin values less than 10 μg/L.

Most notable, there was a significant proportion of children with unacceptably low levels of both hemoglobin and serum ferritin, meeting the definition of iron deficiency. There were 6% with iron deficiency compared to 3% prevalence reported by Looker et al[19] in a population-based study (P=.001; binomial test). This finding suggests that the children had insufficient dietary intake of iron to maintain acceptable levels of either hemoglobin or serum ferritin.

Iron deficiency anemia is defined as 2 of 3 abnormal blood tests: in this investigation, tests of (1) serum ferritin; (2) haemoglobin; and (3) MCV. The 11% of children that met this definition is higher than 3% reported in a population-based study (P=.004; binomial test).[19]

The high proportion of cases with iron depletion, iron deficiency, or iron deficiency anemia in such a young population is of clinical concern because such disorders have the potential to cause impairment of body function. Research into the effects of iron deficiency has found that physical growth, behavioral development, and activity are impaired with low iron.[22] Most concerning is that chronic iron deficiency is associated with impaired brain development and function. Children with a history of low iron as infants do not do well in school achievement tests.[23,24] Population studies suggest that chronic iron deficiency can have permanent ill effects, as neither cognitive scores nor behavior improve after iron supplement therapy.[25]

There are limitations to this study and the interpretation of its results. First is that the sample is not representative of all ECC children. The study could not involve a systematic random sample because young children with ECC are difficult to identify and access. Since the sample is not representative, the results cannot be generalized and the conclusions can only apply to the children in the study.

The analysis was limited because the comparison with reference values required the categorization of the data into age, gender, and percentile groups. This resulted in subcategories that were too small for accurate statistical testing of groups or means.

Another limitation is the source of the subjects for this study—a hospital dental clinic that treated children with extremely severe caries. The study results only apply to a population with extreme dental disease and cannot be extrapolated to less severe cases of ECC. In this study, the comparison of blood values with population values does not address possible ethnic differences in values, as Canadian studies do not collect information on ethnicity.

Despite the limitations, the clinical importance of this study is that S-ECC has been identified as a risk marker for undernutrition. While this study identified an at-risk population, it cannot establish a causal relationship, nor can it detect the timing of the relationship. The results suggest, however, that physicians and dentists treating young children should consider that S-ECC is a risk marker for undernutrition. For physicians, nutritional deficiencies should alert them to the possibility that S-ECC is present and is a possible explanation for the deficiencies in their patients. For dentists, children presenting with S-ECC should be considered at risk for nutritional deficiencies that may affect long-term health and well-being.

The goal for both physicians and dentists should be the prevention, timely diagnosis, and treatment of the children suffering from S-ECC. This study's results strongly suggest that S-ECC patients should have a complete blood count (CBC) test, a serum ferritin test, a careful measurement of height and weight, and a dietary intake assessment, preferably performed by a clinical dietitian.

Conclusions

Based on this study's results, the following conclusions can be made:

1. All of the nutrition tests detected malnourishment in a group of young children with severe early childhood caries. The anthropometric measurements detected fewer cases of malnourishment than the blood tests.
2. The results of the anthropometric measurements show that a significant proportion of S-ECC children exhibits evidence of malnutrition, being below the 90th percentile for ideal body weight or having evidence of low fat stores with low triceps skinfolds measurements.
3. Body mass index tests, using the fifth percentile on childhood charts as a definition for malnutrition, were insensitive and missed many cases. It is suggested that subjects with BMI values less than the 15th percentile be regarded as malnourished.
4. The most notable finding is the high prevalence of children with blood values consistent with malnutrition.
5. The low values for both hemoglobin and ferritin as well as the presence of iron deficiency anemia for the children in this study imply that S-ECC may be a risk marker for the development of otherwise unexplained iron deficiency in young children. Further investigation could validate this with a matched control group design.

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