Magnitude of macro- and micronutrient deficiency in pediatric oncology patients aged 2-18 years

Skala niedoboru makro- i mikroelementów u dzieci w wieku 2-18 lat z chorobami nowotworowymi

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Wprowadzenie. W krajach rozwiniętych, rak stał się jedną z najbardziej wiodących przyczyn zgonów związanych z chorobami u dzieci – i rośnie w Trynidadzie i Tobago. Niedożywienie oraz kacheksja należą do czołowych przyczyn zgonów wśród dzieci z chorobą nowotworową w krajach rozwijających się.

Cel badań. Oszacowanie skali niedoboru makro- i mikroelementów u dzieci w wieku 2-18 lat z chorobami nowotworowymi.

Materiał i metody. Badaniami objęto 25 dzieci (16 dziewczynek i 9 chłopców) z pediatrycznej poradni onkologicznej Mt. Hope, (EWMSC), Eric Williams Medical Sciences Complex w Republice Trynidad i Tobago. Sposób żywienia badano przy pomocy kwestionariusza żywieniowego dotyczącego częstotliwości spożycia różnych produktów obejmującego okres 3-dniowego bieżącego notowania. BMI obliczono na podstawie danych zawartych w dokumentacji medycznej: wysokości ciała i masy ciała.

Wyniki. Średnia masa ciała onkologicznych pacjentów pediatrycznych objętych niniejszym badaniem wynosiła 14,7 funtów (7,9 kg) dla grupy wiekowej 1-3 lata, 26,4 funtów (12 kg) dla grupy wiekowej 4-8 lat, 51,3 funtów (23,32 kg) dla grupy wiekowej 9-13 lat i 87,5 funtów (39,77 kg) dla grupy wiekowej 14-18 lat. Wartości te były poniżej normalnej masy ciała w porównaniu do zdrowych dzieci w analogicznym wieku. Pobory wszystkich makro- i mikroelementów były niższe niż zalecane, z wyjątkiem tłuszczu i witaminy C. Ogólnie dieta spożywane przez większość pacjentów była słabej jakości i żaden z pacjentów nie używał suplementów diety.

Wnioski. U badanych dzieci z chorobami nowotworowymi stwierdzono niskie spożycie makro- i mikroelementów. Odpowiednia interwencja żywieniowa może podnieść jakość życia tych pacjentów i zmniejszyć ryzyko powikłań. Sposobem na promowanie wiedzy nt. zdrowego żywienia tych pacjentów mogą być sesje edukacyjne dla rodziców, które mogą być prowadzone w poradni w określonych dniach. To może pomóc nie tylko w zwiększeniu świadomości rodziców o ilości i jakości żywności, którą winni podawać swoim dzieciom, ale również przyczynić się do zwiększenia skuteczności różnych rodzajów terapii nowotworowych.

Słowa kluczowe: *makroelementy, mikroelementy, niedobór, nowotwór, dzieci*

Introduction. In developed countries, cancer has become one of the most leading causes of death-related illnesses in children and is rising in Trinidad and Tobago. Likewise, cancer related malnutrition and cachexia in this particular population is among the most familiar contributors of death among pediatric oncology patients in developing nations.

Aim. To assess the magnitude of macro- and micronutrient deficiencies in pediatric oncology patients aged 2-18 years.

Material & Methods. A total of 25 (16 females, 9 males) pediatric oncology patients from the outpatient clinic, Mt. Hope, (EWMSC), Eric Williams Medical Sciences Complex in the Republic of Trinidad and Tobago participated in the study. Food frequency questionnaire and conducting 3-day dietary records were used to assess nutritional habits of the subjects. BMI was computed using height and body weight from the patients' hospital records.

Results. The mean weight of oncology pediatric patients examined in this study was 14.7 lbs (7.9 kg) for age group 1-3, 26.4 lbs (12 kg) for age group 4-8, 51.3 lbs (23.32 kg) for age group 9-13 and 87.5 lbs (39.77 kg) for age group 14-18. These values were below the normal weight as compared to healthy children of comparable ages. The intakes of all macro- and micronutrients lower than the recommended values, except for fat and vitamin C. Generally, the diet consumed by most patients was poor and none of the subjects used dietary supplements.

Conclusions. Low intakes of macro- and micronutrients were found in the pediatric oncology patients. Appropriate nutrition intervention can increase the quality of life of the patients' and decrease the risk of morbidity. A remedy for promoting knowledge of healthy-eating guidelines in these patients may include educational sessions for parents which may be conducted at the clinic on specific days. This may help not only in increasing the parents' awareness of the quantity and quality of foods being served to their children, but also help to increase the efficacy of different types of cancer therapies.

Key words: *macronutrients, micronutrients, deficiency, cancer, children*

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Introduction

In developed countries, cancer has become one of the most leading causes of death-related illnesses in children and is rising in Trinidad and Tobago. Likewise, cancer-related malnutrition and cachexia in this particular population is among the most familiar contributors of death among pediatric oncology patients in developing nations. Stages of anticancer therapy within the pediatric population is very energy-consuming and may negatively affect their nutritional status, which in turn can bring about perturbations in psychological and physical development. Nutritional status affects the prognosis for children and young people with cancer [1]. Pediatric oncology patients, who are well-nourished are also better able to resist infection and tolerate treatment [2].Therefore, adequate assessment of nutritional status and nutritional habits is of major importance for timely and appropriate nutritional intervention to prevent malnutrition-related complications and subsequent cachexia in pediatric oncology patients.

Aim

The main objective of the study was to determine the magnitude of malnutrition as well as macro- and micronutrient deficiencies among pediatric oncology patients aged 2-18 years at the EWMSC, outpatient clinic, Mt Hope in the Republic of Trinidad and Tobago.

Material and method

The research was carried in a group of 25 pediatric patients (16 females and 9 males) with cancer aged 2-18 years at the Pediatric oncology outpatient clinic EWMSC, Mt. Hope during the period between January and March, 2013. During the period of this research, the total number of pediatric patients registered as diagnosed with cancer in Trinidad and Tobago was one hundred and forty-five; therefore, the sample size was still appropriately represented. Subjects were chosen based on accessibility and relatives' openness in participating in the study. A written consent for willingness to take part in the study was obtained from the participants' parents. The majority of the patients 48% (n=12) were of African descent, while 36% (n=9) were of East Indian descent. Additionally, 16% (n=4) were of other ethnicities.

The majority of the patients 32% (n=8) were in the age group of 1-3 and 4-8 years, 28% (n=7) in the 9-13 group and a minority of 8% (n=2) were between the ages of 14-18 years.

The study design was divided into two components, namely data collection questionnaire and anthropometric measurements. Anthropometric data, including weight and height were obtained from the patients' hospital records and the calculation of BMI was carried out using specific growth charts. The questionnaire was furtherly divided into 4 sections: a. demographic and anthropometric data with 8 questions, b. collecting data pertaining to the subject's nutritional habits as well as current medications and medical therapies and consisted of twenty-four questions, c. food frequency questionnaire (FFQ) of 20 commonly consumed foods and beverages, d. 3-day 24-hour dietary recall, which was done for 3 days, i.e. 2 weekdays and 1 day of the weekend. A nutritionist at the hospital site distributed the FFQ. The interviewer followed a script to probe for details about intakes. All foods and drinks consumed during this period were catalogued. Anthropometric measurements included in the study were height and weight which were obtained from the participants' clinical records. The data gathered were subsequently analyzed using the program Microsoft Office Excel 2007 and the statistical software SPSS 20.0 for windows. A number of statistical tests were used to generate frequencies and calculate means. These tests included ANOVA F test which is commonly used to arbitrate the difference in means. Descriptive statistics were also generated using the SPSS software.

Results and Discussion

The mean weight of oncology pediatric patients examined in this study was 14.7 lbs. for age group 1-3, 26.4 lbs. for age group 4-8, 51.3 lbs. for age group 9-13 and 87.5 lbs. for age group 14-18. These values were below the normal weight as compared to healthy children of comparable ages. No weight loss was observed in these patients during the period of this study, which could have been related to short duration of the observation, lasting only 2 months. The results of this study are not in concordance with the data obtained by Warner [3], who observed body weight loss in a group of pediatric oncology patients. However, it should be underlined that in children with cancer, body weight can be influenced by tumor mass and hydration, particularly during chemotherapy, masking loss of fat and skeletal muscle. The measurement of body compartments, performed in the present study, provided useful information about the nutritional status at the time of diagnosis. Table I presents the body mass index (BMI) of the subjects.

So far, there have not been any studies of this kind in Trinidad and Tobago and therefore this is a pioneer research in this area. Loss of weight and inability to gain weight regularly in childhood cancer are attributed to a negative balance of energy and changes in metabolism and are frequent adverse effects of cancer. Energy balance is negative due to diminished intake,

elevated expenditure, or a combination of both. Alterations in the metabolism of carbohydrate may include the uptake of glucose by tumor and relative insulin resistance [4]. Changes in the metabolism of protein involve the uptake of amino acids by the tumor itself. As a result, these changes in metabolism end in growth failure in pediatric oncology patients. In cancer patients, either reduced caloric intake or increased caloric expenditure or a combination of both result in negative energy balance, cessation of growth and weight loss. Based on observation and initial interviews with the parents of the study population, it was seen that risk factors, such as protein energy malnutrition and subsequent cancer cachexia might have been present; prompting the need to intervene with appropriate medical nutrition therapies among these subjects (Table II).

On average, the subjects in this study did not follow very healthy dietary patterns. None of the children met the dietary requirements of macro- and micronutrients that were analyzed, with the exception of fat and vitamin C. This might have been due to socioeconomic status as well as higher energy requirements of the children related to cancer cell activities as revealed by Tisdale [4]. The findings from this study suggest that there was an insufficient intake of energy among the pediatric cancer patients at the EWMSC, who were investigated. Food consumption may be considered to be insufficient either in absolute terms or in terms relative to an increased energy use. The increased energy expenditure of cancer patients includes energy expenditure within the tumor and energy demands placed on host by the presence of the tumor [5]. If increased amounts of food need to be ingested and digested, this may increase energy utilization within the digestive system [6].

The statistical analysis showed that the patients were consuming more fat than the required 30% recommended in their diets. During interviews it was surprisingly found that the patients consumed a fair amount of fast foods than traditionally home-cooked meals. The information from the National Food Consumption Survey indicates that children coming from low socioeconomic backgrounds consume a large proportion of daily calories as fat (Fig. 1). Present U.S. dietary guidelines advise a value of no greater than 30% of dietary energy from total fat. In 1991, these guidelines were endorsed by the NCEP report of the Expert Panel on Cholesterol Blood levels in adolescents and children. The National Cancer Institute, the American Cancer Society and others are of the view that it is imperative to have a diminished level of total and saturated fat in childhood.

Studies have shown that children suffering from malignancy experience loss of body fat with a simultaneous increase in free fatty acid turnover and lipolysis. Lipogenesis is decreased in these children. Hence, sufficient dietary fat is important to provide not only essential fatty acids, but also to supply energy as fats help to increase the caloric density of food. High fat intake in pediatric oncology patients may be beneficial since fat mal-absorption may occur in malnourished children [7]. However, it should be stressed that after the initial mutagenic steps, mitotic activity is stimulated by dietary fat and in effect, promotes cancer growth. Spontaneous mutations can also occur as the result of the high intake of dietary fat, especially saturated fatty acids and omega-3 fatty acids [8].

When analyzed by ANOVA, it was shown that for all age groups their intake of carbohydrate and protein were insufficient. This might have been due to an inadequate intake of foods such as wheat, potato

Table I. BMI (kg/m^2) of participants stratified by age

Age (yrs)	Mean BMI	St. error	95% Confidence Interval	
			Minimum	Maximum
1-3	14.3	0.25	13.8	14.8
4-8	13.2	0.25	12.6	13.7
9-13	14.2	0.26	13.7	14.8
14-18	17.6	0.49	16.5	18.6

Table II. Energy intakes of pediatric oncology patients stratified by age (kcal/d)

Age (yrs)	Mean (kcal/d)	St. error	95% Confidence Interval	
			Minimum	Maximum
1-3	1061.50	67.22	921.70	1201.30
4-8	1388.10	67.22	1248.26	1527.86
9-13	1308.31	71.87	1158.86	1457.77
14-18	1338.85	134.45	1059.25	1618.45

Table III. Intakes of carbohydrates stratified by age (g/d)

Age (yrs)	Mean (g/d)	St. Error	95% Confidence Interval	
			Minimum	Maximum
1-3	111.05	3.90	102.95	119.15
4-8	121.04	3.90	112.94	129.14
9-13	120.06	4.16	111.40	128.72
14-18	120.00	7.79	103.80	136.20

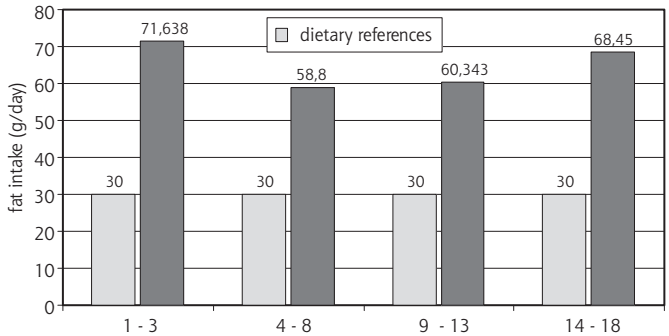

Fig. 1. Consumption of fat by different age groups in relation to dietary reference intakes

and legumes and insufficient foods of animal origin. As can be seen in table III above, most of the subjects consumed less than 130 g/d of carbohydrates, which is the minimum amount that should be in the diet [9]. Insufficient consumption of carbohydrates can cause an impairment of the metabolism of other macronutrients. In addition, in cancer patients glucose is converted into lactate by the sarcoma. The lactate then becomes reused by the liver, at an abundant cost of energy. This process, also known as the Cori cycle, is greatly increased in patients with advanced cancer [10]. It requires the use of muscle proteins, as well as a large proportion of amino acid intake, for gluconeogenesis. Additionally, there is an inexorable decline in total body fat which may also be attributed to the formulation of cachectic and tumor necrosis factor by the common macrophages in reaction to the tumor [11]. Individuals with cancer often present with an energy imbalance, elevated disintegration of fat and protein inclusive of energy-consumptive alterations in the metabolism of carbohydrate. The end result is a net energy loss. The consequence is weight reduction, and in particular lean body mass, including breakdown of protein and decreased synthesis of albumin [12, 13]. These deficiencies of both carbohydrate and protein may be corrected by educating the parents to introduce foods that are of higher carbohydrate and protein value, such as foods of animal origin, yogurt, nuts and seeds, oatmeal, bran muffins etc.

The mean intakes for total water and fiber among all age groups were small and lower than the dietary reference intakes recommended (Table IV). These findings were in agreement with the data from the Institute of Medicine [9], which show that the consumption of these nutrients is much lower than the recommended levels for a large portion of the US pediatric population. The low intake of water and fiber in the study population was most likely to be due to the small amounts of fruit and vegetables consumed by the subjects (Table V).

The statistical analysis revealed very low intakes of the following micronutrients: calcium, selenium, zinc, phosphorous, potassium, vitamin A, E and vitamin C. This is of concern, since some studies have demonstrated derangement in the metabolism of vitamins and minerals, which finally can lead to their deficiencies. Nutritional deficiencies can develop as a result of the treatment itself or of complications that arise from the chemotherapy or radiation, such as xerostomia, mucositis, nausea, and vomiting. Patients who are malnourished at diagnosis may have a poorer outcome, may experience more infections and may be less able to tolerate therapy [14]. Children with cancer, who are not on any additional feeds or supplements and who only eat a limited variety of foods may benefit from a general multivitamin supplement. It is preferable, however, for a child to receive the vitamins they need from food; therefore, the family should be counseled on how to incorporate more fruit and vegetables into the child's diet.

The metabolism of zinc is frequently displaced in patients with cancer. Zinc redistribution can be mediated by the acute-phase response and can accumulate in skeletal muscle tissue and thereby contribute to the stimulation of the ubiquitin-proteasome pathway that is involved in the regulation of the catabolism of protein degradation. Zinc becomes deprived in various tissues and organs in this chronic readjustment and in turn critical physiological functions in the patient's body becomes compromised [15].

The consumption of selenium and other antioxidants, except vitamin C, by the subjects were found to be inadequate, which is in concordance with the studies by Cunzhi et al. [16] and Kennedy et al. [17]. Among pediatric patients, who are newly diagnosed with cancer, selenium deficiency is frequently found, even if malnutrition is absent at the time of diagnosis [16]. The intakes of vitamin C were exceptionally very high among patients aged 1-3 and 14-18 years, which might be due to higher consumption of fruit and vegetables.

The mean intakes for calcium, phosphorous and potassium in all groups of children were lower than the recommended values. Calcium and phosphorous are important minerals which are depleted. Many children may develop milk aversion or cannot tolerate a high milk diet and thus miss one of the most important sources of calcium and phosphorous [7].

Gastrointestinal disorders, cancer and heart disease are all associated with low potassium levels. Children who suffer from inadequacies of potassium often present with weakness of the muscles and even muscle paralysis, which interfere with normal

Table IV. Fiber consumption stratified by age (g/d)

Age (yrs)	Mean (g)	Std. Error	95% confidence interval	
			Minimum	Maximum
1-3	7.9	2.0	3.6	12.1
4-8	15.6	2.0	11.3	19.8
9-3	16.3	2.2	11.8	20.8
14-18	20.5	4.1	12.0	28.9

Table V. Water ingestion stratified by age (l/d)

Age (yrs)	Mean (l)	Std. Error	95% confidence interval	
			Minimum	Maximum
1-3	0.915	0.108	0.690	1.140
4-8	1.310	0.108	1.085	1.535
9-3	1.737	0.116	1.496	1.978
14-18	1.700	0.216	1.250	2.150

breathing mechanisms, thereby causing respiratory failure [9]. The treatment may involve administering a potassium supplement to the child, or increasing the intake of high potassium foods in the child's diet, such as bananas, nuts, and green, leafy vegetables.

Conclusions

It is evident from this study that the children were not following the guidelines for healthy eating given in the Six Caribbean Food Groups, which brought about inadequate intakes of macro- and micronutrients, except for fat and vitamin C. Following dietary guidelines can help in the reduction of the risk for development of cancer cachexia. A remedy for promoting knowledge of healthy-eating guidelines in these patients may include educational sessions for parents which may be conducted at the clinic on specific days. This would act not only towards increasing the parents' awareness of the quantity and quality of foods being served to their children but would also help to increase the efficacy of different types of cancer therapies. The main limitation of the study was the inadequacy of the instruments used to predict dietary intake: the 24-h dietary recall tends to underestimate and the FFQ tends to overestimate nutrient intakes. Further studies of macro- and micronutrient intakes by a larger group of pediatric oncology patients are warranted. Future studies might include an investigation of nutritional counseling and its effect on increasing the intakes of macro- and micronutrients from the diet or supplementation.

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