Nutritional status in children with cancer
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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2014

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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CHAPTER 9

SUMMARY AND GENERAL DISCUSSION: FINDINGS, CLINICAL IMPLICATIONS, AND FUTURE RESEARCH
Florence Nightingale, one of the founders of nursing, was the first to demonstrate the added value of systematic data collection and statistical analysis. By providing diagrams of mortality rates of English military hospitals during the Crimean War (1853-1856), she convinced the Ministry of Defense to introduce hygienic measures to prevent diffusion of cholera and typhus. Florence Nightingale was, in fact, the first to demonstrate the added value of nursing research. Her approach to obtain simple data such as weight, vital signs, symptoms, and impairments in functioning is very valuable because these data can play an important role in improving patient care.

When a child is diagnosed with cancer its food intake and nutritional status is at risk. Many children have a decreased nutrient intake because they feel ill or because their taste is altered and they dislike many foods. Other children have an increased appetite and can’t stop eating because of the dexamethasone. Some children lose weight and become undernourished; whereas others gain weight and become obese. A variety of problems regarding food intake and nutritional status occurs. The Pecannut study aimed to identify these problems by registration of, among others, weight and food intake. The study determined the course of nutritional status, the factors related to nutritional status, and the consequences of malnutrition.

In the next sections the main findings of the Pecannut study will be summarized and discussed, implications for clinical practice will be presented, and this chapter will end with directions for future research.

**FINDINGS: WHAT IS KNOWN**

The results of the systematic review reveal that four decades of research have still not resulted in a definition of reliable prevalence rates of malnutrition (Chapter 2). The limited number of studies, particularly in children with solid and brain malignancies; the small samples sizes; and the use of different criteria to define malnutrition mean that prevalence rates can only be estimated. Furthermore, because the number of longitudinal studies is limited, little is known about the timing and onset of weight loss or weight gain. In addition, it is not known whether energy deficiency or inflammation contribute to malnutrition during treatment, and evidence for an increased metabolic rate is inconclusive (Chapter 2). Although energy intake has been
found to be lower than recommended daily allowances (RDA), the impact of inadequate intake on nutritional status has not yet been tested (Chapter 2). Moreover, low levels of physical activity may have compensated for low energy intake, thus preventing energy deficiency. Finally, very little research has explored the process of inflammation in relation to cachexia in children with cancer. The presence of increased inflammatory markers at diagnosis seems likely. However, a relationship with weight loss has not been found. Based on the systematic review the following points seem to be essential:

- Longitudinal studies assessing nutritional status, weight loss, and body composition in heterogeneous sample of childhood cancer patients are needed;
- Well-designed studies are needed to establish the energy needs of childhood cancer patients and to evaluate the consequences of energy deficiency on nutritional status;
- More research is needed on the presence of inflammatory processes and the impact of inflammation on nutritional status.
- The first two points are addressed in the Pecannut study.

**FINDINGS: WHAT IS NEW**

**Prevalence of malnutrition**

Based on actual data of weight and height, 2%, 4%, and 7% of the children were undernourished at diagnosis according to weight-for-age (WFA), height-for-age (HFA), and weight-for-height (WFH) below -2 standard deviation score (SDS) respectively (Chapter 3). However, compared with their growth charts another 20-24% of the children lost more than 0.5 SDS in WFA, HFA, and WFH. In fact, children’s real nutritional status at diagnosis was worse than the actual data of weight and height indicated and more children were undernourished.

During the first 12 months after diagnosis, weight, body mass index (BMI), and fat mass (FM) increased (Chapter 4). In patients with brain malignancies, increase of BMI started immediately after diagnosis; whereas BMI in patients with hematological and solid malignancies initially decreased, only to increase later on during treatment. Prevalence rates of overnutrition based on BMI >2 SDS doubled from 5% at diagnosis to 10% after 12 months; whereas prevalence rates of undernutrition based on BMI <-2SDS decreased
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from 8% at diagnosis to 2% after 12 months. When FM and fat free mass (FFM) were included to define the nutritional status, even more children were under- or overnourished (Chapter 4). Contrary to high FM, FFM was low at diagnosis and remained low during the study period; approximately 17% of the patients were undernourished on the basis of low FFM. Patients with brain malignancies had the lowest FFM and the highest FM. Patterns of increase in FM did not differ between patients with hematological, solid, or brain malignancies.

In addition to low values of BMI and FFM, significant weight loss (>0.5 SDS) was prevalent in 28% of the patients during the first 3 months, particularly in patients with hematological and solid malignancies. As we demonstrated in Chapter 6, these patients had a higher risk of infections.

In sum, our study demonstrates that the issues regarding nutritional status in children treated for cancer are complicated. This patient group is not only confronted with undernutrition, weight loss, and a low FFM, but also with overnutrition and high fat mass. The current results indicate that in industrialized countries the focus on undernutrition might very well lead to neglect of overnutrition. The alterations in body size and body composition during treatment are of serious concern in both the short and the long term; in fact, the literature reports increased levels of FM and BMI even years after cessation of therapy in survivors of childhood cancer.2,3

**Factors related to malnutrition**

*Dietary intake*

Dietary intake is one of the main factors contributing to nutritional status. Inadequate intake is associated with weight loss; whereas excess intake is associated with weight gain. In Chapter 5, these associations were studied in children treated for cancer. The results show that children’s energy intake was, on average, 105% of the energy requirements, which were calculated using Schofield’s equation.4,5 In contrast, children’s intake was 80% of RDA and 84% of intake in healthy controls. Thus, while the children’s energy intake broadly matched the calculated energy requirements, it was inadequate compared with the last two norms. The gain in weight, BMI, and FM, as described in Chapter 4, suggests that energy intake was sufficient to meet or even exceeded patients’ requirements. These results imply that the norms of RDA and intake in healthy controls are too high for children treated for cancer. Apparently, childhood cancer patients require less energy than RDA and less energy than healthy children.
General discussion

Energy intake was also negatively associated with nutritional status. Lean children with low body weight had higher intakes than children with high fat mass and high body weight. An obvious explanation for this inverse relation is that lean children were more often fed by tube feeding and that this type of feeding increased their intake. Another possible explanation might be found in the timing of the assessment which was between the courses of therapy and not during therapy. Presumably, patients experienced alternating periods of poor and good intake; whereas we just registered the good periods. The higher intakes in lean children, as registered in the periods between the courses of therapy, might be a compensation for their lower intake during prior periods.

Another finding was that protein intake was almost twice the recommend allowances and the individual requirements. Unfortunately, the high protein intake did not have a beneficial effect on FFM. As reported in Chapter 4, FFM was low at the beginning of treatment and remained low. This finding could be explained by the fact that the protein requirements needed to improve FFM may be higher than the current recommendations. In addition, a certain level of physical activity is necessary to improve FFM and children treated for cancer are known to be less active because of the side effects of their treatment regimens.

**Patient characteristics, treatment related factors, and physical activity**

In addition to energy intake, patient characteristics, treatment related factors, and level of physical activity were tested for their association with changes in nutritional status (Chapter 4). Type of malignancy was the only factor related to weight loss in the beginning of treatment; patients with hematological and solid malignancies first lost weight; whereas patients with brain malignancies gained weight from the beginning of treatment. The increase in BMI during the first 3 months was related to initial nutritional status and tube feeding. The faster increase in BMI in children who were poorly nourished at the time of diagnosis may be seen as catch-up growth. As we demonstrated in Chapter 3, weight and height at diagnosis were lower than estimated weight and height based on children’s growth curves. Catch-up growth may be interpreted as beneficial weight gain. In addition, children receiving tube feeding demonstrated more weight gain than children without tube feeding. The general aim of tube feeding is to maintain or to improve nutritional status. However, it is difficult to draw the line between catch-up growth and overfeeding. Given that weight
continuously increased during the 12 months after diagnosis, and given that z-scores of weight during treatment (Chapter 4) were higher than the predicted values of weight based on children’s growth curves (Chapter 3), we conclude that weight gain was partly due to catch-up growth and partly due to overfeeding by tube feeding. The results of Chapter 5 confirm that average energy intake was more than patients’ requirements and that energy intake in tube fed patients was 10% higher than in children without tube feeding. In order to prevent and treat undernutrition, children were fed too aggressively, resulting in overweight.

Contrary to findings in other studies, we did not find an association between increase in BMI and age, gender, or parental BMI, nor did we find an association between increase in BMI and treatment intensity, symptoms, or physical activity. All these factors were interrelated to tube feeding, making tube feeding the main related factor for weight gain. Treatment with corticosteroids is often linked to increase in BMI, because energy intake increases during corticosteroid treatment. However, studies testing the impact of corticosteroids on BMI have shown contradictory results. In our study, an association with corticosteroid use was not found.

Low physical activity was found to be the main factor contributing to increase in %FM. This finding is congruent with research in healthy children and adolescents. Similar to increase in BMI, high energy intake or treatment with corticosteroids are assumed to cause increase in FM. Again, similar to the BMI results, such a relationship was not found in our study. Physical activity was found to be the only contributing factor to increase in %FM. Children treated for cancer have lower levels of physical activity, but their energy intake is adequate or even higher than adequate. Thus, it can be concluded that increase in weight was caused by increase in FM.

In sum, energy intake is assumed to be the main factor affecting children’s nutritional status. However, the results of the Pecannut study revealed that in clinical practice associations between energy intake and nutritional status are complex. Not energy intake but tube feeding, representing the children with the highest intake and the lowest scores for physical activity, contributed to increase in BMI. The positive energy balance and the low level of physical activity resulted in increase of FM. In fact, the same mechanisms that cause obesity in healthy children seem to play a predominant role in the development of overnutrition in children treated for cancer.
Consequences of malnutrition
Clinical implications of malnutrition

In Chapter 6, we explored the role of malnutrition at diagnosis and at 3, 6, and 12 months with respect to survival rates and risk of infection. We found that survival rates were worse in children undernourished according to BMI <-1.5 SDS at diagnosis and BMI <-1 SDS at 3 months. Weight loss in the first 3 months after diagnosis was associated with more bacterial infections during the first year. Weight loss, overnutrition at diagnosis and 3 months, and nutritional status at 6 and 12 months did not influence survival rates. The added value of this study is that for the first time the consequences of weight loss have been demonstrated. Rapid weight loss appears to make children more vulnerable to bacterial infections. Similar to severe undernutrition, moderate undernutrition at diagnosis and at 3 months was also associated with reduced survival rates. This implies that nutritional support is required from the beginning of treatment to prevent weight loss and to improve nutritional status in children with BMI z-scores below -1 SDS.

The impact of malnutrition on health-related quality of life

Besides clinical implications, we also studied the impact of nutritional status on health-related quality of life (HRQOL). HRQOL was assessed by two different measures. Because HRQOL was measured longitudinally, first we tested whether these measures were sensitive to response shift. The response shift phenomenon was explored on two sequential measurements of HRQOL (Chapter 7). We found that both child- and parent-report ratings of overall HRQOL, measured using Cantril’s ladder, were affected by response shift resulting in an underestimation of the change in HRQOL. In contrast, measurements of the PedsQL instruments were not biased by response shift. Therefore, the PedsQL measures are recommended in studies that assess changes in HRQOL over time.

The results of the Pecannut study indicate that both undernourished and overnourished children experienced worse HRQOL compared with well-nourished children (Chapter 8). Significant weight loss and weight gain also contributed to worse HRQOL. Previous studies have shown that children treated for cancer had significantly poorer HRQOL when compared with healthy children or children with other diseases. The current study, however, demonstrates that under- and overnourished patients have the poorest HRQOL of all cancer patients. When examining the domains of HRQOL, undernourished children and children with weight loss reported impaired physical and social
functioning. In addition, undernourished children reported more side-effects of treatment. Overnourished children and children with weight gain reported worse functioning in the psycho-social domain, particularly in emotional and cognitive functioning. In contrast, parent-report scores of overnourished children were lower on social functioning. These findings again stress the importance of a good nutritional status and of adequate nutritional support during treatment.

**IMPLICATIONS FOR CLINICAL PRACTICE**

The results of this thesis highlight important issues regarding the nutritional status in children with cancer. The main areas of concern are:

- underestimation of deterioration of the nutritional status at the time of diagnosis;
- significant weight loss in some children in the beginning of treatment;
- gain in weight and FM during treatment in all patient groups;
- relatively low FFM in all patient groups, particularly in children with brain malignancies;
- more bacterial infections and lower survival rates in undernourished children and children with significant weight loss;
- worse HRQOL in malnourished children and children with significant weight loss or weight gain.

These issues stress the importance of adequate nutritional support. Nutritional support aims to prevent or reduce nutritional deficits, to improve physical condition, to maintain growth and development, and to maximize HRQOL. In order to achieve these goals, health care professionals (nurses, dietitians, and physicians) work together proactively with children and parents, each discipline offering its own knowledge and expertise. Nurses play a pivotal role in the assessment and monitoring of the nutritional status, as they aim to ensure an adequate dietary intake in children. Nurses are the first to notice (risk factors of) malnutrition and they can intervene immediately. In some cases, nurses may prevent or treat malnutrition independently; however, in more complicated cases, the specific expertise of the dietitian or physician is needed. Dietitians are the experts regarding nutrition and nutrients. Their expertise is essential to provide adequate nutritional support to this particular
patient group. Physicians are responsible for the treatment regimen and they aim to keep patients in a good nutritional condition so that they can finish their therapy. A good collaboration between nurses, dietitians, and physicians is therefore necessary for providing adequate nutritional support.

The first step in nutritional support consists of a nutritional assessment at the time of the first admission in order to identify those children with preexisting malnutrition or children at risk of malnutrition. Subsequently, nutritional status needs to be monitored and reassessed during therapy. Important elements of the nutritional assessment are anthropometry and estimations of energy requirements. In the following paragraph, we will make recommendations for anthropometry and estimations of energy requirements. Lastly, the clinical implications of tube feeding and physical activity will be discussed.

**Anthropometry**

*Body size*

Accurate measurement of weight and height is essential to identify malnutrition. The measurements of weight and height must be plotted into growth curves to determine the child’s nutritional status and to be able to monitor longitudinal changes in nutritional status over the course of therapy (Chapter 4).

In order to determine weight loss in the pre-admission period, comparison of data of weight and height at diagnosis with data of growth curves from preventive health care centers is recommended (Chapter 3) (see Box 1 for further details).

*Body composition*

Given the deviations in body composition and the serious consequences of low FFM and high FM in children with cancer, assessment and monitoring of body composition is recommended (Chapters 4 and 8). Skinfold measurement may be used to assess muscle and fat stores (see Box 2 for further details). The triceps skinfold measure in particular has been found to correlate well with fat mass. Skinfold measurements are simple and quick to obtain in most age groups; however, in obese children precision and accuracy is poor. Unfortunately, skinfold reference data are not always available or, in the case of the Netherlands, are very outdated.

Mid-upper arm circumference (MUAC) is very simple and quick to measure. Also, contrary to weight, MUAC is not sensitive to fluid alterations in the body. Although MUAC is referred to as a measure for muscle mass, it actually
measures muscle, bone, and fat mass of the upper-arm. In the Pecannut study, MUAC had higher correlations with BMI (r= 0.8) and FM (r= 0.5-0.7) than with FFM (r= 0.4-0.5). Therefore, **MUAC is recommended as a surrogate measure for BMI** in patients with edema or in patients in whom measurements of weight and height are not possible.

Bio-electrical impedance (BIA) measures impedance by sending a small electrical current through the body. Total body water (TBW) and FFM are estimated using special equations adjusted for age, gender, weight and height.\(^{25,28}\) Although BIA is quick, simple, and acceptable to children, it is insufficiently accurate in its estimations of body composition in individuals. In addition, population specific equations are required to estimate FFM. Unfortunately, such equations are not available yet for children with cancer.

**Energy requirements**
Contrary to the general opinion, we found that energy requirements in children treated for cancer were lower than in healthy children and lower than RDA (Chapter 5). In fact, RDA is not an appropriate norm for energy requirements during cancer treatment. Energy requirements are best estimated using the following equation:

\[
\text{Energy requirement} = \frac{(RMR \times PAL \times GF)}{EAC}
\]

This prediction formula is recommended by the Dutch Malnutrition Steering Group\(^4\) and includes metabolic rate (RMR), calculated using Schofield’s equations;\(^5\) physical activity (PAL); growth (GF); and energy absorption coefficient (EAC). We have omitted the illness factor from the equation because the evidence for increased energy requirements due to an increased metabolic rate is inconclusive\(^{29}\) and because our results (without using the illness factor) matched with changes in nutritional status. The equation provides a global estimation of the child’s energy requirements and is a starting point for the dietary advice given to the child. However, given that all factors in the equation rely on rough estimations and given that some factors can fluctuate, for instance, the level of physical activity, **close monitoring of weight is necessary to evaluate the adequacy of the energy intake.**

**Tube feeding**
In the Netherlands, tube feeding is the method of choice for children with insufficient oral intake who require intervention. **When calculating the**
amount of required nutrition for tube fed patients, it is important to control for the low level of activity in these patients. In general, children who require tube feeding experience more side effects of treatment, feel sicker, and are less active. These factors lower their energy requirements. During the period of tube feeding, close monitoring of weight and fat mass is recommended in order to prevent overfeeding. In addition, children should be encouraged to be as active as their physical condition allows.

**Physical activity**

The level of physical activity was found to be the main factor contributing to increase in fat mass during treatment (Chapter 4). **Children with cancer should be stimulated to be as active as possible** within the limitations set by their illness or therapy. Improving the level of physical activity will be a great challenge because children often feel very sick during therapy. To date, several intervention programs have been developed that provide special training sessions to improve the level of activity. A disadvantage of these training sessions is that these are an additional burden to all the other obligations (hospital visits, school, care of siblings) children and parent experience, and the sessions only cover a defined period of time. After completing the training program, many children will relapse into their previous behavior patterns. Therefore, to improve children’s level of physical activity, we believe physical activity should be incorporated into their daily routine. In addition to receiving advice about the relevance of an adequate dietary intake, the relevance of physical activity from the start of treatment should also be stressed to children and parents. Raising awareness is the first step towards a more active lifestyle. Second, children and parents need to be advised about performing daily activities in an active way, for example, brushing one’s teeth while standing in front of the washbowl instead of lying in bed. In addition, more emphasis should be placed on active leisure time. Play and enjoyment are integral to an active life style.

At this moment, the Department of Pediatric Oncology and Hematology of the University Medical Center Groningen in collaboration with The Knowledge Center for Technology and Innovation of the University of Applied Sciences in Utrecht, has started a project to develop “tools” to improve dietary intake and physical activity in pediatric cancer patients. The project POKO (Participatief Ontwerpen voor de Kinderoncologie) aims to find solutions that will help children to become more active by means of close and interactive cooperation between children, parents, and professionals. Testing of the first prototypes of the tools developed in this project is expected for autumn 2014.
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FUTURE RESEARCH

The Pecannut study has generated valuable insights into the patterns of weight and body composition in children treated for cancer. Moreover, our study has provided further evidence for the importance of a good nutritional status in this particular patient group. The findings of our study have important implications for clinical practice and offer relevant information for future studies. Five areas of future research are discussed below.

Assessment of body composition

In order to measure body composition in clinical practice using BIA, the development of specific equations for children with cancer or validation of existing equations against deuterium dilution, or dual-energy X-ray absorptiometry (Dexa) is recommended. BIA relies on the assumption that FFM is constant. However, hydration and density of FFM vary during maturation and may vary during the disease period as well. The equation of Goran, used in the Pecannut study, was found to be the best model for predicting TBW and FFM in healthy children and children with AIDS. However, whether this equation is valid for children with cancer has never been tested.

Another promising method to assess body composition in clinical practice is the air-displacement plethysmography (ADP). ADP is similar to hydrodensitometry, yet ADP uses air displacement within a closed system as an alternative for water. ADP, performed by Bod Pod, is non-invasive and acceptable to children. However, ADP has the same pitfalls as BIA, in that population specific equations are needed for adequate estimation of FM and FFM in children treated for cancer.

Next to muscle mass (FFM), muscle function is a valuable indicator of both nutritional and functional status. Muscle function has been found to correlate with whole body protein, and body cell mass. In adult patients, measurement of hand grip strength as a measure of nutritional status has gained considerable attention. Reduced hand grip strength has been found to be an important predictor for health outcomes such as length of hospital stay, functional status, and survival rates. To our knowledge, in children hand grip strength has only been applied as a measure to evaluate muscle functions in relation to motor performance. However, because hand grip strength is quick, easy, acceptable to children, insensitive to fluid imbalances, and does not require skilled professionals, it is worth studying the applicability of this method to assess muscle function and muscle mass in children treated for cancer.
Estimation of energy requirements

Because it is not certain whether metabolic rate is increased at diagnosis or during treatment, indirect calorimetry should be measured longitudinally in large samples and in different diagnostic categories (not only in patients with ALL). In addition, more research is needed on inflammatory processes and on the impact of inflammation on nutritional status. To date, inflammation in relation to cachexia has hardly been studied in childhood cancer. Such studies might contribute to better estimations of energy requirements and nutritional interventions that are better tailored to the patients’ needs.

Method of feeding

In the Netherlands, nasogastric tube feeding is the method of choice for improving nutrient intake even in children who require tube feeding for more than 3 months. PEG tubes (percutaneous endoscopic gastrostomy) are only placed in special situations, i.e., in children with a nasopharynx carcinoma. In other countries, however, placement of PEG tubes is part of routine care; a PEG is placed simultaneously with the Port-a-Cath (or Venous Access Port VAP) just before the start of chemotherapy. Proponents of tube feeding claim that tube feeding is less invasive than PEG feeding and that PEG feeding is associated with many potential complications such as wound infection, necrotizing fasciitis, and peristomal leakage. In contrast, proponents of PEG feeding argue that tube feeding places a great burden on children and that it is less acceptable to children and parents than PEG feeding. To date, no consensus has been reached on which intervention should be used. Therefore, future studies are needed that evaluate patient preferences, efficacy of feeding, and complications of both methods. In addition, systematic research is recommended to compare the benefits and drawbacks of enteral feeding versus parenteral feeding. It is believed that enteral feeding should be preferred above parenteral feeding in order to keep the gastrointestinal tract functioning. However, evidence for this assumption is lacking.

Improvement of physical activity

The alterations in body composition as demonstrated in our study are of serious concern. Therefore, intervention studies that aim to improve children’s body composition are urgently needed. As was stated in the section on clinical implications, measures should be developed to increase the level of physical activity. Subsequently, intervention studies are needed to examine the efficacy of such measures.
Evidence based guidelines

Guidelines for nutritional support should be more evidence-based. Additional research is recommended, among others, to define the best criteria for a nutritional risk assessment. Existing pediatric screening tools, for instance, STRONG-kids, differentiate insufficiently in the childhood cancer population. Currently, a special assessment tool for children with cancer called Pediatric Oncology Nutritional Screening Tool (PONS) is under development and awaiting validation in clinical practice.

Finally, as one of the ambitions of the coming decades is to improve quality of life of children treated for cancer (Chapter 1), HRQOL should be included as an outcome measure in future studies that aim to improve feeding practices, nutritional status, and physical activity.
GUIDELINES FOR CLINICAL PRACTICE BASED ON THE PECANNUT STUDY

Box 1. Body size: measurement of weight and height

- Measure weight and height at diagnosis and regularly during treatment (height monthly and weight at least weekly).
- Determine the child’s nutritional status prior to the cancer diagnosis by asking parents and child for recent measurements of weight and height or by using data from the so-called “Groene boekje” from the preventive health care center (PHCC) (Chapter 3).
- Plot measurements of weight and height in growth charts and monitor changes in nutritional status over the course of therapy (Chapter 4).
- For infants (aged <1 year) growth curves of weight-for-age (WFA) are used; whereas for children 1 year and older weight-for-height (WFH) (or BMI-for-age) are used to define the nutritional status.\(^{43}\)
- Set a target value for WFA and WFH. For some children this target value can be -1 SDS; whereas for other children a target value of +2 SDS is acceptable. This depends on the child’s stature and nutritional status before the cancer diagnosis.
- Cut-off scores of <-2 SDS define undernutrition; whereas scores of >2 SDS define overnutrition.
- Report deviations of >0.5 SDS because an increase or decrease of >0.5 SDS may have impact on the child’s condition (Chapter 8). A gradual change in weight may indicate an increase or decrease in body mass; however, rapid weight changes frequently indicate fluid retention or depletion.
- Growth curves can be plotted on paper or in digitalized programs, for instance, Growth Analyzer. An advantage of a digitalized system is that SDS scores are calculated and changes can be identified immediately. In addition, a digitalized system is accessible to more professionals working from different places.
- MUAC is recommended as a surrogate measure for BMI in patients with edema or in patients in whom measurements of weight and height are nor possible.
To determine fat mass, skinfold measurement is recommended, in particular triceps skinfold.

Skinfold measurement should only be taken by specially trained professionals (nurses, dietitians, physicians).

Skinfold data are best used as raw data or should be converted to standard deviation scores and growth curves.

In obese children, precision and accuracy of skinfold measurement is poor because of the large skinfolds.

MUAC is not an accurate measure for fat free mass. It corresponds better with BMI than with fat mass.

As long as specific equations to estimate total body water and fat free mass in children with cancer are not available, bio-electrical impedance is insufficiently accurate in its estimation of body composition in individual patients.
REFERENCES

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