PAEDIATRIC RENAL NUTRITION TASKFORCE

Assessment of nutritional status in children with kidney diseases

A practical guide

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Foreword

The Pediatric Renal Nutrition Taskforce (PRNT) is an international team of pediatric renal dietitians and pediatric nephrologists, who develop clinical practice recommendations (CPRs) for the nutritional management of various aspects of kidney diseases in children.

In 2020, the taskforce published clinical practice recommendations regarding nutritional assessment, including measurement of anthropometric and biochemical parameters, and evaluation of dietary intake.

This booklet aims to provide a practical guide on how to implement these recommendations in every day clinical practice and should be read in conjunction with the published paper.*

*Nelms CL, Shaw V, Greenbaum LA et al. Assessment of nutritional status in children with kidney diseases—clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatric Nephrology, 2020. doi.org/10.1007/s00467-020-04852-5
https://www.espn-online.org/nutrition-taskforce/

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Flow chart

Nutritional assessment is an important part of patient care and identifies those in need of nutritional intervention. It should be undertaken frequently, when a child is admitted to the hospital or seen as an outpatient.

Step 1: Anthropometric assessment

Primary measurements of weight, length/height, head circumference

Weight

Use euvolemic (dry) weight

Track grams of weight gain per day for children under 2 years

Length/Height

Use recumbent length in children under 2 years

Use standing height thereafter*

*If unable to stand use recumbent length

Use surrogate measurements for older children unable to stand

Head circumference

Measure up to 2 years, or up to 3 years if appropriate charts are available

Weight-for-length/BMI

Use weight-for-length in children under 2 years

Use BMI in children 2 years and older

Utilize trends in growth parameters to assist clinical decision making

Growth charts

Use WHO charts for all ages

Country-specific growth charts, where available, may be used after 2 years of age

Use disorder- or genetic condition-specific growth charts when applicable

z-scores

Calculate to complement growth chart plots

Calculate height/length velocity over a minimum of 6 months

Plot measurements serially

Short stature

Use height age for BMI z-score if height < 3rd centile on growth chart

Mid-parental height

Calculate mid-parental height

Plot to estimate growth potential

Premature infants

Plot weight, length, and weight-for-length for both gestational age and chronological age for:

- 2 years if born < 32 weeks
- 1 year if born 32-37 weeks

Monitor growth parameters routinely with increased frequency in younger children, those with advanced CKD, comorbidities, risk factors for growth delay and not meeting nutritional and growth targets

Flow chart
continued

Step 2: Dietary assessment

Estimation of food and fluid intake

Detailed

A prospective 3-day diet history is preferred for accurate comprehensive information

Simple

A retrospective diet history of at least one typical 24-hour period

Frequency and depth of dietary assessment should be guided by severity of kidney disease and nutritional concerns, including height, weight, abnormal biochemical values, and history of excessive intake, inadequate intake, poor quality of diet, or gastrointestinal symptoms

Assess appetite to guide the need for supplementary feeding if not meeting nutritional goals

Step 3: Biochemical assessment

Routine management

Calculate nPCR* for adolescents on HD

*Follow trends to evaluate dietary protein adequacy

Only consider serum albumin as a measure of nutritional status after all non-nutritional causes of hypoalbuminemia have been excluded

Step 4: Monitor and review

- Growth parameters
- Dietary modifications
- Barriers to achieving adequate intake
- Medical management
- Activity level
- Current dietary intake and appetite
- Nutritional requirements
- Blood biochemistry
- Gastrointestinal symptoms

Step 1: Anthropometric assessment

Nutritional assessment is an important part of patient care which identifies those in need of nutritional intervention. It should be undertaken frequently (Table 2), when a child is admitted to the hospital or seen as an outpatient.

Practical points

Weight

- Use euvolemic weight (or 'dry' weight), the child's true weight, when determining nutritional requirements.
- Use of measured weight in those who retain fluid (e.g. those with oliguria or anuria, receiving dialysis, or with active nephrotic syndrome) may lead to miscalculations and errors in patient management.
- For children who receive dialysis, the aimed-for weight at the end of a mid-week hemodialysis (HD) session or after peritoneal dialysis (PD) should be utilized, recognizing that this measurement may still not reflect the euvolemic weight.
- In patients who receive automated PD with a last fill, or in those who receive continuous ambulatory PD, the volume of the instilled dialysis solution should be subtracted from the measured weight.
- In children with high urine and sodium losses, dehydration may cause weight to fall below euvolemic weight.
- Given that some children with kidney diseases have poor linear growth, weight gain must be evaluated in the context of linear growth to ensure proportionality.
- Track grams of weight gain per day for children under 2 years of age (Table 1).
    - Use intervals of as little as 1 week to determine adequate or appropriate weight gain.
    - Divide total grams of weight gained over a set interval by the number of days in that interval.

Table 1: Expected daily weight gain for age

Age/Parameter	Daily weight gain (g/d)
Premature, currently <2 kg*	15-20
Premature, currently >2 kg*	20-30
0-4 months	23-34
4-8 months	10-16
8-12 months	6-11
12-16 months	5-9
16-24 months	4-9

*Use only until reaching term gestational age of 37 weeks.
Adapted from: Beer et al. Texas Children's Hospital Pediatric Nutrition Reference Guide, 11th ed. 2016

Tracking growth

- Measure weight and determine z-score. Use euvolemic (dry) weight when indicated.
- Measure length and determine z-score. Use recumbent length for children up to 2 years of age and standing height for those over 2 years. For children unable to stand for an accurate height measurement, recumbent length can be measured or use a surrogate measurement of height.
- Measure head circumference in all children up to 2 years of age. When appropriate centile charts are available, continue to measure head circumference until 3 years of age.
- Plot anthropometric measurements serially using World Health Organization (WHO) growth charts. If available, country-specific growth charts may be used for children beyond 2 years of age.
- Calculate weight-for-length in children younger than 2 years of age and body mass index (BMI) for those over 2 years. Calculate weight-for-length or BMI z-scores/standard deviation scores (SDS) to complement growth chart plots.
- Use height age for determining BMI z-score/SDS if the child is shorter than the 3rd centile, provided they have not reached their adult height.
    - Height age is the age that corresponds to the child's height when plotted at the 50th centile on a growth chart.
- Utilize trends in growth parameters to assist clinical decision-making.
- The extent to which a child's length/height is outside the range of the 3rd-97th centiles is most accurately identified with the use of z-scores.
- Consider comorbidities when assessing length or height in children with other medical conditions.
- Use condition-specific growth charts for children with genetic or metabolic disorders where growth potential may be impacted (e.g. Trisomy 21 (Down syndrome), Wolf-Hirschhorn syndrome, Prader Willi syndrome). Following growth trends is important when evaluating children with these conditions to best assess growth progress.

BMI and body composition

- BMI, or weight-for-length for children younger than 2 years, is the best primary measure of malnutrition or adiposity for children with kidney diseases (Appendix 2).
- BMI calculation: weight in kilograms/height in m^2.
- Children with chronic kidney disease (CKD) have increased fat to muscle ratios and decreased lean mass. Muscle deficits are common because of lean mass wasting. BMI does not allow for distinction between muscle mass and fat mass.
- BMI may be misleading in children with CKD due to poor growth. Short children may have a normal weight, but on calculating their BMI, their short stature results in an apparently raised BMI. Use of BMI for height age may more accurately reflect true lean mass or adiposity.
- Height age is also considered to be a good surrogate of physical development in the peripubertal or pubertal periods. However, this adjustment is inappropriate once a child has attained final adult height.

- While poor linear growth can be a marker of inadequate nutrition, other factors in CKD such as abnormality of IGF-GH axis, metabolic acidosis, excessive sodium losses can also be the cause. Increases in weight should not greatly outpace linear growth to ensure that BMI/weight-for-length remains within appropriate range.
- Children on dialysis with either very high or low BMI values are at greater risk for mortality.
- BMI typically rapidly increases in children post-kidney transplantation. In the first 18 months, obesity rates double with the most significant changes in weight taking place in the first 6 months, particularly when taking corticosteroids.
- Malnutrition remains prevalent in a sub-set of transplant recipients, especially those with medication-related gastrointestinal (GI) side effects or low BMI prior to transplant.

Mid-parental height

- Calculate mid-parental height to assess a child's linear growth potential. For best accuracy, measure the heights of both the biological mother and father.
- A standard deviation of 8.5 cm in the calculation is the expected variation in achieved height; thus, the majority of healthy children will be within 8.5 cm of their predicted final adult height.
- Compare a child's current height centile to the height centile of the child's calculated mid-parental height at age 18-20 years.
- Use sex-specific equations:
  - Boys: [(Mother's height + 13 cm) + Father's height]/2
  - Girls: [Mother's height + (Father's height – 13 cm)]/2

NB Equations are not reliable if parents' heights differ by 20 cm or more.

Prematurity

- Ideally, the premature infant should gradually increase both weight and length centiles, maintaining an appropriate weight for length.
- For premature infants (32 to 37 weeks gestation), plot weight, length, and weight-for-length for both gestational and chronological ages for the first year of life.
- For premature infants born prior to 32 weeks gestation, continue to plot both gestationally and chronologically until 2 years of age.

Surrogate measurements for length/height

- Arm span: measure from tip of the middle finger with a non-stretchy tape measure, flat against the body to the tip of the third finger on the other hand to determine estimated height.
- It may be easier to measure demi-span:
  (measure from midline of the body to the tip of the third finger) x 2 = arm span
- Ulnar length:
  - Males: Height (cm) = (4.605 x U) + (1.308 x A) + 28.003
  - Females: Height (cm) = (4.459 x U) + (1.315 x A) + 31.485

  A = age, in years U = ulnar length

Table 2: Parameters and frequency of nutritional assessment in children with CKD stages 3b–5D#

Measure	Age 0-1 year∞ Minimum interval (weeks)		Age 1-3 years Minimum interval (months)		Age >3 years Minimum interval (months)	
	CKD 3b-5	CKD 5D	CKD 3b-5	CKD 5D	CKD 3b-5	CKD 5D
Height or length for age, centile or SDS	6	2-4	2	1	3	3
Height or length centile or SDS	8	4	3	2	6	6
Height velocity for age SDS	N/A	N/A	3	2	6	6
Estimated euvolemic weight and weight for age, centile or SDS	6	4	2	1	3	3
BMI for height age centile or SDS	N/A	N/A	2*	1*	3	3
Weight-for-length* centile or SDS	6	6	2*	1*	N/A	N/A
Head circumference for age centile or SDS	6	4	2	2	N/A	N/A

Adapted from: KDOQI Clinical Practice Guideline for Nutrition in Children with CKD, 2009.
Earlier stages of CKD and other renal diseases are not addressed in this Table, as clinical conditions can vary and physician discretion is required. Further details are addressed in KDOQI, 2009.
*Weight-for-length should be used for children <2 years of age, or up to 3 years if accurate standing height measurement is not possible.
∞ Infants and toddlers cannot be categorized with stage of CKD as there may be spontaneous improvement in kidney function up to 2 years of age. A suggested method to characterize stage of CKD in this age group is to use the KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease, substituting a GFR >1 but ≤2 SDS below the mean for moderate reduced GFR (stage 3-4) and severely reduced GFR >2 SDS below the mean for stage 5.

Step 2: Dietary assessment

Practical points

- Frequency of dietary assessment should be guided by the severity of kidney disease and nutritional concerns, including abnormal growth parameters, excessive or inadequate dietary intake, poor quality of diet, gastrointestinal symptoms and abnormal biochemical values.
- Assess appetite to guide the need for supplementary feeding if a child is not meeting nutritional goals.
- Conduct a prospective minimum 3-day diet history when accurate, comprehensive information is needed.

- A retrospective diet recall over a 24-hour period, preferably inclusive of more than one 24-hour period, may also be acceptable.
- Determine type of dietary evaluation needed based on importance of precision and social factors, with 3-day or more prospective food records being typically more accurate, but food recalls being less burdensome.
- Any information gleaned about dietary practices may be beneficial.
- The dietary management of calcium and phosphate in children with CKD stages 2-5 and on dialysis – clinical practice recommendation from the Pediatric Renal Nutrition Taskforce*, provides information on the pros and cons of different dietary assessment methods.

*McAlister L, Pugh P, Greenbaum L et al. The dietary management of calcium and phosphate in children with CKD stages 2-5 and on dialysis–clinical practice recommendation from the Pediatric Renal Nutrition Taskforce. Pediatric Nephrology, 2020. 35: 501–518. doi.org/10.1007/s00467-019-04370-z

Prospective food diaries

- Instruct patients and families to record amounts, brand names, and food and beverage preparation methods.
- If appropriate, include descriptions of unique features of foods and beverages or preparation.
- Provide instructions on how to measure or estimate portion sizes.
- Instruct patients and families to record all food and beverages consumed at any time of day, including snacks.

Food recalls

- Use language that does not assume traditional meal patterns when recording intake, e.g. “what was the first thing you ate after you woke up?” rather than “what did you have for breakfast?”
- Use food models and measuring devices to help patients and families understand portion sizes when recalling foods consumed.
- Review the recall by enquiring about anything that might have been inadvertently forgotten, such as beverages and small snacks.

Methods of collection

- Paper food records are traditional and may suit some patients and families best.
- Electronic or picture records may be helpful to some – taking a picture of “before” and “after” meal plates, using e-mail or text to share information, or utilizing food apps for record keeping.
- Technology-based food records have not been evaluated in the pediatric renal population; however, they have been found to be useful in other populations; more research in this area is warranted.

Nutrients to assess

- Adequate, deficient or excess energy and protein intakes.
- Nutrients that may affect serum levels or blood pressure, e.g. phosphorus, calcium, potassium, sodium.
- Assess other potential micronutrient deficiencies or excesses, e.g. water-soluble vitamins, fat-soluble vitamins, trace elements and investigate further if of concern.
- Note: longer food record periods are required to estimate intake of micronutrients and trace elements.
- Age-appropriate dietary intake in terms of quality and quantity, as well as guidance regarding solid food introduction and advancement, is important and is discussed in Energy and protein requirements for children with CKD stages 2-5 and on dialysis – clinical practice recommendations from the Pediatric Renal Nutrition Taskforce*.

* Shaw V, Polderman N, Renken-Terhaerdt J et al. Energy and protein requirements for children with CKD stages 2-5 and on dialysis–clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatric Nephrology, 2020. 35: 519–531 doi.org/10.1007/s00467-019-04426-0

Frequency

- Frequent dietetic contact can promote adequate dietary intake for growth. This is particularly important in the first 2 years of life when growth is predominantly nutrition dependent.
- Table 3 provides the minimum frequency for dietary assessment, but more frequent assessment, possibly in earlier CKD stages, may be necessary if the child is not growing adequately or if there are other concerning nutritional issues.

Table 3: Frequency of dietary assessment

Age 0-1 year∞ Minimum interval (weeks)		Age 1-3 years Minimum interval (months)		Age >3 years Minimum interval (months)	
CKD 3b-5	CKD 5D	CKD 3b-5	CKD 5D	CKD 3b-5	CKD 5D
8	8	3	3	6	4

∞ Infants and toddlers cannot be categorized with stage of CKD as there may be spontaneous improvement in kidney function up to 2 years of age. A suggested method to characterize stage of CKD in this age group is to use the KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease, substituting a GFR >1 but ≤2 SDS below the mean for moderate reduced GFR (stage 3-4) and severely reduced GFR >2 SDS below the mean for stage 5.

- The frequency of assessment may need to increase after a dietary modification is made or a supplement is started to determine the effectiveness of that intervention.
- More frequent assessment is warranted in those who are not growing well, have a decline in kidney function, experience an alteration in appetite, have GI symptoms, make poor quality diet choices, or exhibit changes in serum levels affected by diet.

Practical points
(continued)

Protein energy wasting (PEW)

- Inadequate linear growth, BMI or mid-upper arm circumference (MUAC) <5th centile for height age, and BMI or MUAC change of 10% or more from the first to second visits in non-obese children, have been suggested as pediatric specific criteria.
- It is important to recognize that PEW in children with CKD is associated with increased risk of hospitalization or emergency room visits and poorer quality of life.

Gastrointestinal symptoms

- GI symptoms are common in pediatric CKD and may include abdominal fullness, vomiting, gastro-esophageal reflux, diarrhea or constipation.
- As dietary intake can be altered by such findings, the presence of GI symptoms should prompt a thorough dietary assessment and possible GI consultation.

Appetite

- Appetite can serve as a valuable parameter to monitor because of its correlation with patient outcomes.
- A poorer appetite is associated with a lower quality of life rating, increased risk for hospitalization and emergency room visits.
- There is an increased incidence of reported poor appetite in children under the age of 5.
- Appetite may be an important surrogate marker for nutritional status or overall well-being. Enquiring about appetite at each clinical visit is a simple and important step in determining risk.
- Appetite may also be influenced by abnormal hormone levels (e.g. leptin and ghrelin).

Step 3: Biochemical assessment

Practical points

- Ensure any abnormal laboratory values have not been altered through procedural issues (e.g. hemolysis) before taking action.
- Monitoring blood urea nitrogen (BUN)/serum urea levels may help determine adequacy of protein intake, although is affected by issues such as urine output, size, age and degree of renal function. BUN (mg/dL) x 0.36 = serum urea level (mmol/L).

- Calculate nPCR for adolescents on HD (Table 4) and follow trends to evaluate dietary protein adequacy.
- An nPCR of 1 or greater is indicative of adequate protein intake in adolescent HD patients.
- Routine measurement of serum albumin-adjusted calcium level (or ionised calcium where available), phosphate, potassium and urea levels may indicate necessary changes to the nutritional prescription. (Refer to the following Pediatric Renal Nutrition Taskforce practical guides for children with CKD stages 2-5 and on dialysis: The dietary management of calcium and phosphate; The dietary management of potassium; Energy and protein requirements).

Table 4: Variables used to calculate nPCR (nPCR = 5.43 x estG/V1 + 0.17)

Variable	Definition
G (mg/min)	[(C2 x V2) – (C1 x V1)]/T
C1	Post-dialysis BUN (mg/dL)
C2	Pre-dialysis BUN (mg/dL)
V1 (for G calculations)	Post-dialysis total-body water (dL)
V2	Pre-dialysis total-body water (dL)
T	Time from end of dialysis treatment to beginning of next treatment in minutes
V1 (for nPCR calculations)	Total body water (L)
Volume calculations for V values	5.8 dL/kg & pre- or post-dialysis weight in kg; for V1 in nPCR calculations: 0.58 & weight in kg

Adapted from: KDOQI Clinical Practice Guideline for Nutrition in Children with CKD, 2009.

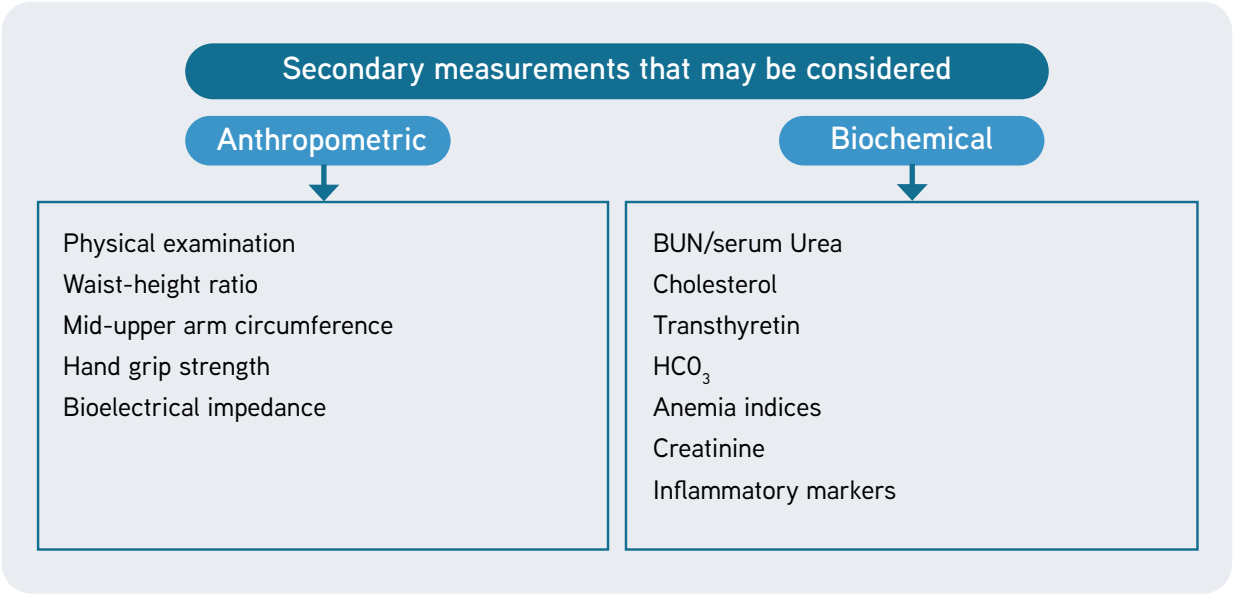
- Only consider serum albumin as a measure of nutritional status after all non-nutritional causes of hypoalbuminemia have been excluded, including inflammation, infection and fluid overload.

Step 4: Monitor and review

Continually monitor and review the following which all impact on the child's nutritional status. Frequency of monitoring and review are given in Tables 2 and 3.

Growth parameters	Current dietary intake and appetite
Dietary modifications	Nutritional requirements
Barriers to achieving adequate intake	Blood biochemistry
Medical management	Gastrointestinal symptoms
Activity level	

Appendix 1: Secondary tools



Secondary anthropometric tools (Table 5) may complement primary anthropometric measurements (Step 1). Further experience with these tools in clinical practice settings is necessary before their routine use can be recommended.

Table 5: Parameters for use of secondary tools in nutritional assessment of children with CKD 2-5D

Measurement	Frequency	Stages of CKD	Age parameters	Comments for usage
Physical examination	As per clinical judgment	All	All	Serial evaluation valuable to assess changes; may be influenced by PD fluid
Waist-height ratio	6-12 months	CKD 2-5	≥4 years of age	Can be used concurrently with BMI; may better reflect body composition
Mid-upper arm circumference	6 months	All	See WHO guidelines by age	Marker of malnutrition
Hand grip strength	6 months	All	≥6 years of age	Marker of malnutrition, musculature; further research needed before standard use can be recommended
Bioelectrical impedance	As per clinical judgement	Dialysis only	≥1 year of age	Used to assess fluid status; serial measurements by trained personnel with ongoing evaluation to assess trends

Physical examination

- Consult standard references for complete physical assessment guidelines.
- Use to evaluate protein and energy deficiencies and excesses, micronutrient deficiencies.
- Pay attention to edema, and changes to skin, nails, hair.

Waist-height ratio

- Well researched, but limited use in regular clinical practice.
- Necessary to obtain linear height with methods described above and use tape measure to measure waist circumference.
- A WHr > 0.49 indicates overweight status.

See https://link.springer.com/article/10.1007%2Fs00467-018-3987-2

Mid-upper arm circumference

- Must measure non-dominant arm – find the mid-point between the olecranon process and acromium.
- Measure around the mid-point of the arm. Use standard tables to evaluate for malnutrition or obesity. Resources are available to measure MUAC and calculate z-scores.

See https://www.who.int/childgrowth/standards/ac_for_age/en/

Hand grip strength

- Well researched, but limited use in regular clinical practice.
- Standards available for grip strength and nutritional risk due to poor musculature.

See https://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Examination&CycleBeginYear=2013

Bioelectrical impedance

- Use to evaluate fluid status.
- Should be done serially, by a trained clinician for best outcomes in accuracy.

Appendix 2: WHO definitions for underweight, overweight and obesity

Using WHO child growth standards charts

- Underweight children < 5 years: weight-for-age < –2 SD
- Overweight children < 5 years: weight-for-height > +2 SD
- Obese children < 5 years: weight-for-height > +3 SD

See growth charts https://www.who.int/toolkits/child-growth-standards/standards

Using WHO growth reference charts

- Thinness children 5-19 years: BMI < -2 SD
- Severe thinness children 5-19 years: BMI < -3 SD
- Overweight children 5-19 years: BMI > +1 SD
- Obese children 5-19 years: BMI > +2 SD

See growth charts https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age

Appendix 3: Glossary of terms

Arm span – Span from tip of third finger on one hand, across the body to the third finger on the other hand

Bioelectrical impedance – Method for measuring body composition based on the rate at which an electrical current travels through the body

BMI (body mass index) – A measure of body size: weight in kilograms divided by the square of the person's height in metres (kg/m^2)

BUN (blood urea nitrogen) – Measures the amount of nitrogen in the blood that comes from urea

Demi-span – Span from center of the chest to the tip of the third finger

Euvolemic weight – Weight without extra or insufficient body fluid

Food recall – Verbal retrospective collection of past food intake

Food record – Prospective record of food intake over 24-72 hours or longer

Hand grip strength – Measurement of the amount of static force that the hand can squeeze around a dynamometer

Height age – The age that corresponds to the child's height when plotted at the 50th centile on a growth chart

Length – Recumbent linear measurement

Length or height for age – Length or height in relation to age norms

MUAC (mid-upper arm circumference) – Measurement of arm circumference in between the elbow and shoulder

nPCR (normalized protein catabolic rate) – a calculation of protein nitrogen appearance in patients on hemodialysis and used to assess dietary protein intake

PEW (protein energy wasting) – A term for malnutrition specific to muscle losses related to specific medical conditions

Physical examination – Physical evaluation of a patient to determine risk for malnutrition and potential micronutrient, protein or fluid concerns

SDS (standard deviation score) – Amount of positive or negative distance from the mean

Ulnar length – Length from olecranon process to the scaphoid process used to estimate linear height via use of standard equations

Weight for length – The ratio of weight to linear growth in young children

Weight for age – The ratio of weight in relation to age norms

WHr (waist-height ratio) – The numerical ratio of waist circumference to linear height

z-score – Distance from the mean

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