

# An Introduction to MUAC and Z-scores for Clinical Practice

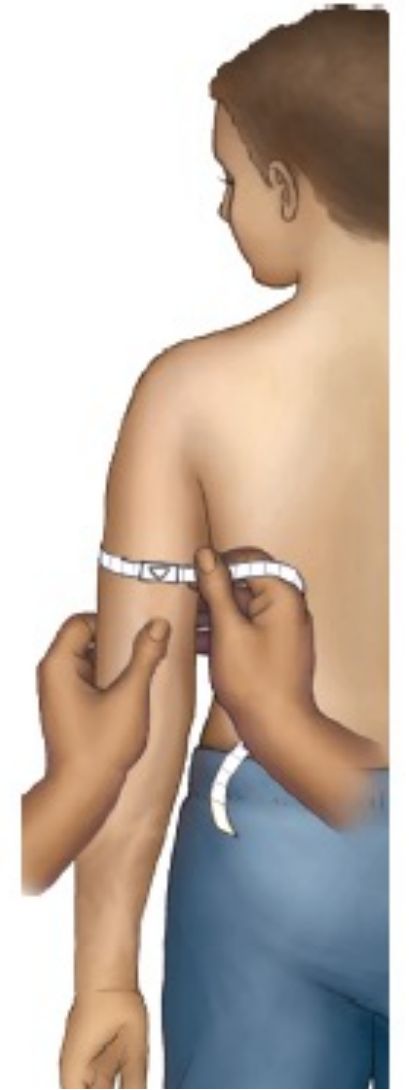
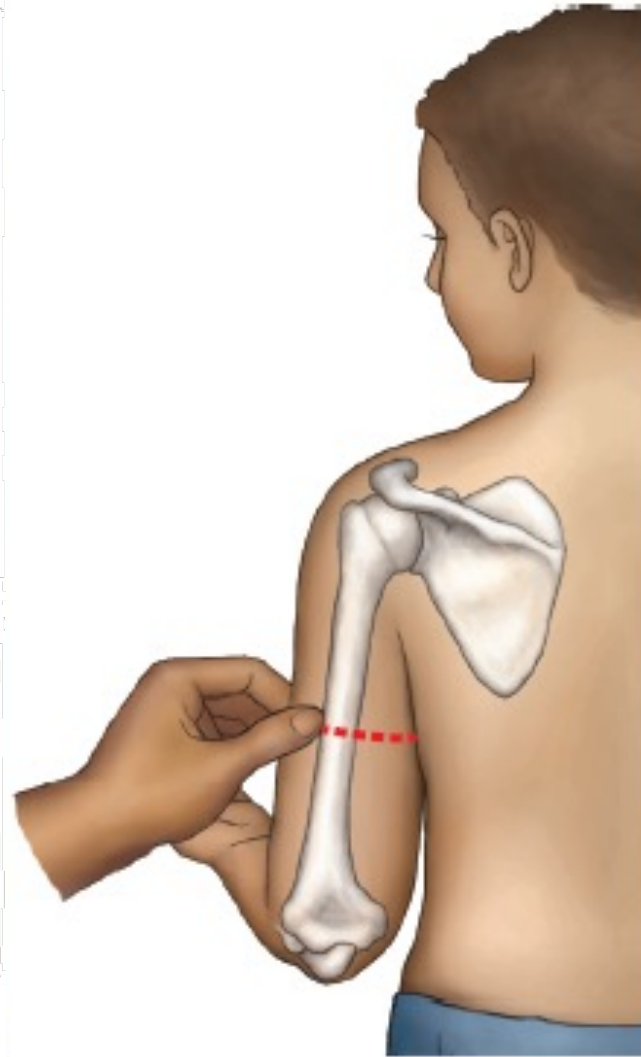
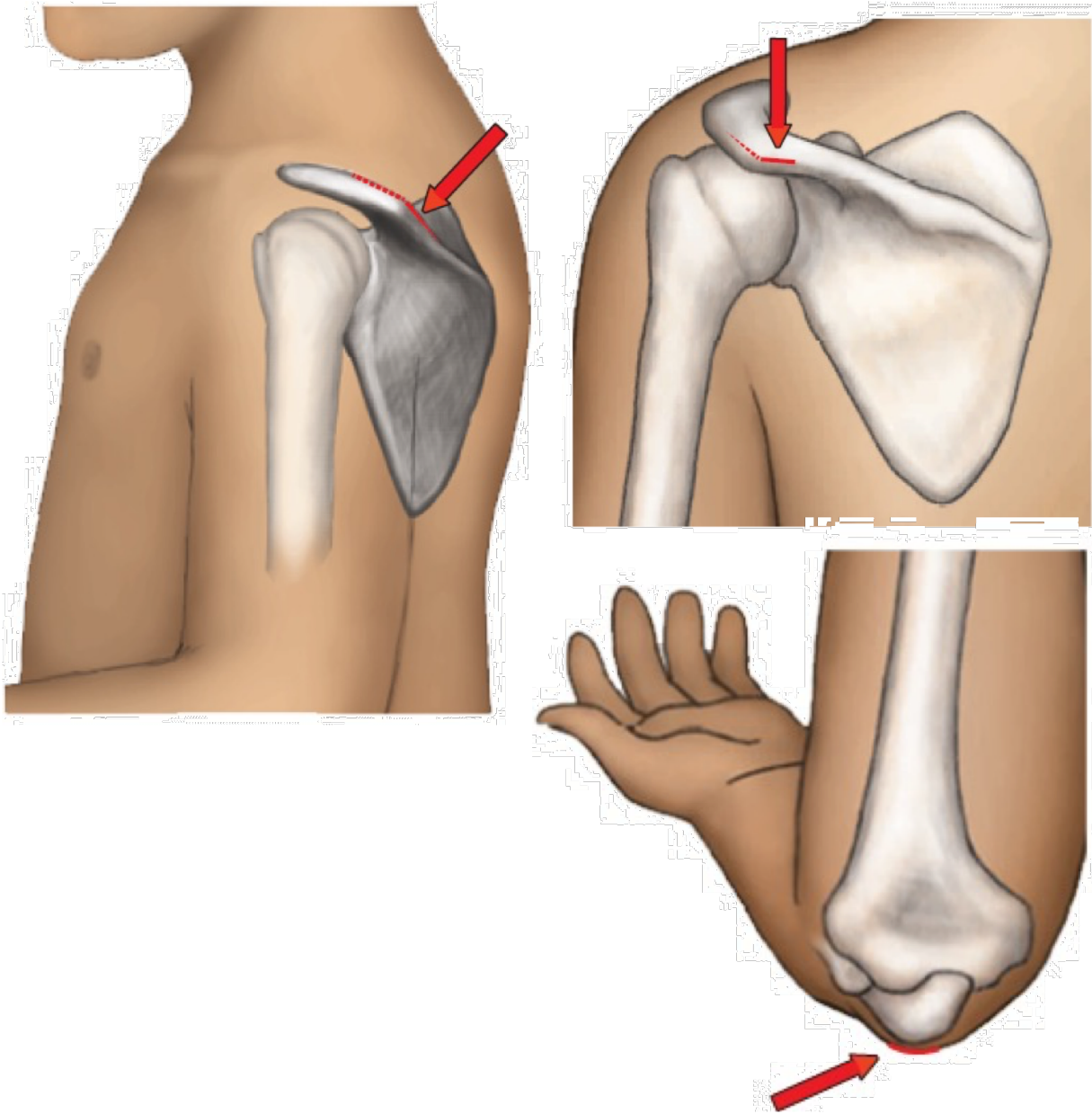
Susan Abdel-Rahman, Pharm.D.  
Professor Emeritus, UMKC School of Medicine  
Chief Scientific Officer, HDSI

# Disclosures

- I am the inventor of the MUAC z-score tape which is owned by Children's Mercy Hospital and licensed by Abbott.
- I do not receive any revenue from its sale or use.

# Learning Objectives

1. (Re-)introduce mid-upper arm circumference (MUAC) and z-scores
2. Examine the relationship between MUAC and other anthropometric measures
3. Discuss the use of MUAC in pediatric subspecialty populations
4. Introduce the MUAC z-score tape



# Mid-upper Arm Circumference (MUAC)

late-50s:	<b>Caribbean Food and Nutrition Institute</b> added to existing measures	<i>reduce costs, increase throughput, limit mistakes in PCM diagnosis</i>
late-60s:	<b>International Committee of the Red Cross</b> adapted during Nigerian civil war	1-10 yr <b><u>Polish</u></b> reference
mid-70s:	Insertion tape  color-coded insertion tape	1-5 years
late-90s:	<b>World Health Organization</b> reference standards published	<b><u>American</u></b> reference
2007:	<b>United Nations</b> endorse as independent diagnostic criterion	6-59 mos (11 cm, 12.5 cm) <b><u>International</u></b> standard
2009:	<b>World Health Organization</b> modified malnutrition thresholds	6-59 mos (11.5, 12.5 cm) <i>overlooks overweight and obesity</i>

# Anthropometric Comparisons\*

Setting	Findings for MUAC
Community	<ul style="list-style-type: none"><li>• Stronger predictor of mortality than height- or weight-based indicators</li><li>• Closer correlation with lean mass ratio</li><li>• Less affected by edema (kwashiorkor), ascites</li></ul>
Hospital	<ul style="list-style-type: none"><li>• Superior predictor of short- and long-term mortality risk</li><li>• Stronger correlation with duration of preceding illness</li><li>• Earlier discharge using MUAC criteria</li></ul>

\* varied methodologies

# Operational Advantages

Property	Indicator						
	Clinical	W/A	H/A	W/H	MUAC	MUAC/A	MUAC/H
Simplicity	No	No	No	No	Yes	No	Yes
Acceptability	No	No	No	No	Yes	Yes	Yes
Cost	No	No	No	No	Yes	Yes	Yes
Objectivity	No	No	No	Yes	Yes	No	Yes
Quantitativeness	No	Yes	Yes	Yes	Yes	Yes	Yes
Independence of age	Yes	No	No	No	Yes	No	Yes
Precision	No	Yes	No	No	Yes	Yes	Yes
Accuracy	No	No	No	No	Yes	No	Yes
Sensitivity	N/A	Yes	No	No	Yes	Yes	Yes
Specificity	N/A	Yes	No	No	Yes	Yes	Yes
Predictive value	N/A	Yes	No	No	Yes	Yes	Yes

W/A, weight-for-age; H/A, height-for-age; W/H, weight-for-height; MUAC, mid-upper-arm circumference; MUAC/A, mid-upper-arm circumference-for-age; MUAC/H, mid-upper-arm circumference-for-height; QUAC, Quaker arm circumference

## RESEARCH PAPER

### Validating the MUAC (Mid-upper arm circumference) Cut-off for Detection of Severe Acute Malnutrition in Children Aged 6-59 Months in Rural Maharashtra

R SOUGAIJAM, SS GUPTA, AV RAUT, MS BHARAMBE AND BS GARG

From Department of Community Medicine, Dr Sushila Nayar School of Public Health, Mahatma Gandhi Institute of Medical Sciences Sewagram, Wardha, Maharashtra, In

OPEN ACCESS Freely available online



### Optimal Screening of Children with Acute Malnutrition Requires a Change in Current WHO Guidelines as MUAC and WHZ Identify Different Patient Groups

Arnaud Laillou<sup>1</sup>, Sophonneary Prak<sup>2</sup>, Richard de Groot<sup>3</sup>, Sophie Whitney<sup>4</sup>, Joel Conkle<sup>1</sup>, Lindsey Horton<sup>5</sup>, Sam Oeurn Un<sup>1</sup>, Marjoleine A. Dijkhuizen<sup>6</sup>, Frank T. Wieringa<sup>7\*</sup>

<sup>1</sup> UNICEF, Maternal Child Health and Nutrition section, Phnom Penh, Cambodia, <sup>2</sup> National Nutrition Program, Maternal and Child Health Center, Phnom Penh, Cambodia, <sup>3</sup> National Nutrition Program, Maternal and Child Health Center, Phnom Penh, Cambodia, <sup>4</sup> World Food Programme, Patumwan, Bangkok, Thailand, <sup>5</sup> National Nutrition Program, Maternal and Child Health Center, Phnom Penh, Cambodia, <sup>6</sup> Wageningen University, Wageningen, The Netherlands, <sup>7</sup> Institut de Recherche pour le Développement, UMR 204, IRD/Montpellier1/

Nutrition Research and Practice 2019;13(3):247-255

©2019 The Korean Nutrition Society and the Korean Society of Community Nutrition

<http://e-nrp.org>

Performance of mid-upper arm circumference to diagnose acute malnutrition in a cross-sectional community-based sample of children aged 6-24 months in Niger

Sarah K Marshall<sup>1,5</sup>, Joel Monárrez-Espino<sup>1,2</sup> and Anneli Eriksson<sup>1</sup>

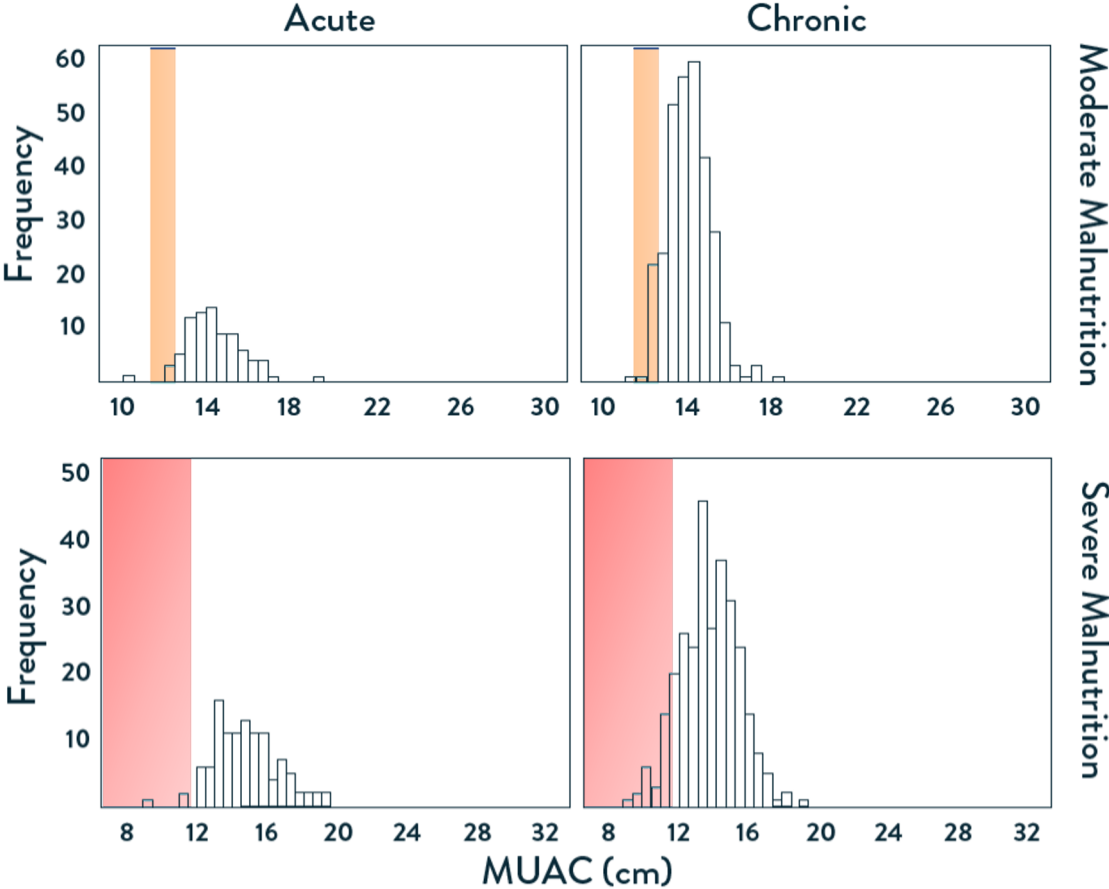
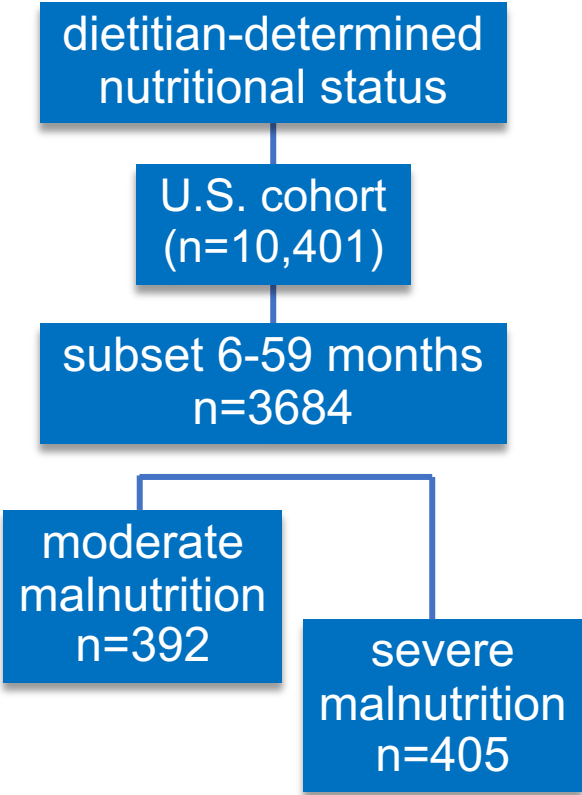
*The current MUAC cut-off for detecting severe acute malnutrition (SAM) needs to be increased*

*The current World Health Organization (WHO) cut-off for screening for SAM should be changed*

*A higher cut-off could improve case identification*



# MUAC Cutoffs vs. Dietitian Assessment



Adapted from: Stephens K, et al. *Nutr Clin Pract.* 2020;35(2):344-352.

*Gender and age  
specific MUAC cut-offs  
drastically increased  
sensitivity*

RESEARCH ARTICLE

## Current MUAC Cut-Offs to Screen for Acute Malnutrition Need to Be Adapted to Gender and Age: The Example of Cambodia

Marion Fiorentino<sup>1\*</sup>, Prak Sophonneary<sup>2</sup>, Arnaud Laillou<sup>3</sup>, Sophie Whitney<sup>4</sup>, Richard de Groot<sup>5</sup>, Marlène Perignon<sup>1</sup>, Khov Kuong<sup>6</sup>, Jacques Berger<sup>1</sup>, Frank T. Wieringa<sup>1</sup>

### FROM THE ACADEMY

#### Consensus Statement

## Consensus Statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: Indicators Recommended for the Identification and Documentation of Pediatric Malnutrition (Undernutrition)

Patricia J. Becker, MS, RD, CSP, LDN, CNSC; Liesje Nieman Carney, RD, CSP, LDN; Mark Richard Corkins, MD, CNSC, SPR, FAAP; Jessica Monczka, RD, LDN, CNSC; Elizabeth Smith, RD, LDN, CNSC; Susan Elizabeth Smith, RD, CSP, LD; Bonnie A. Spear, PhD, RDN, LD; Jane V. White, PhD, RD, LDN, FADA, FAND



*The use of z-score, decline in z-score, and negative z-score to identify and document pediatric malnutrition/ undernutrition is now recommended*

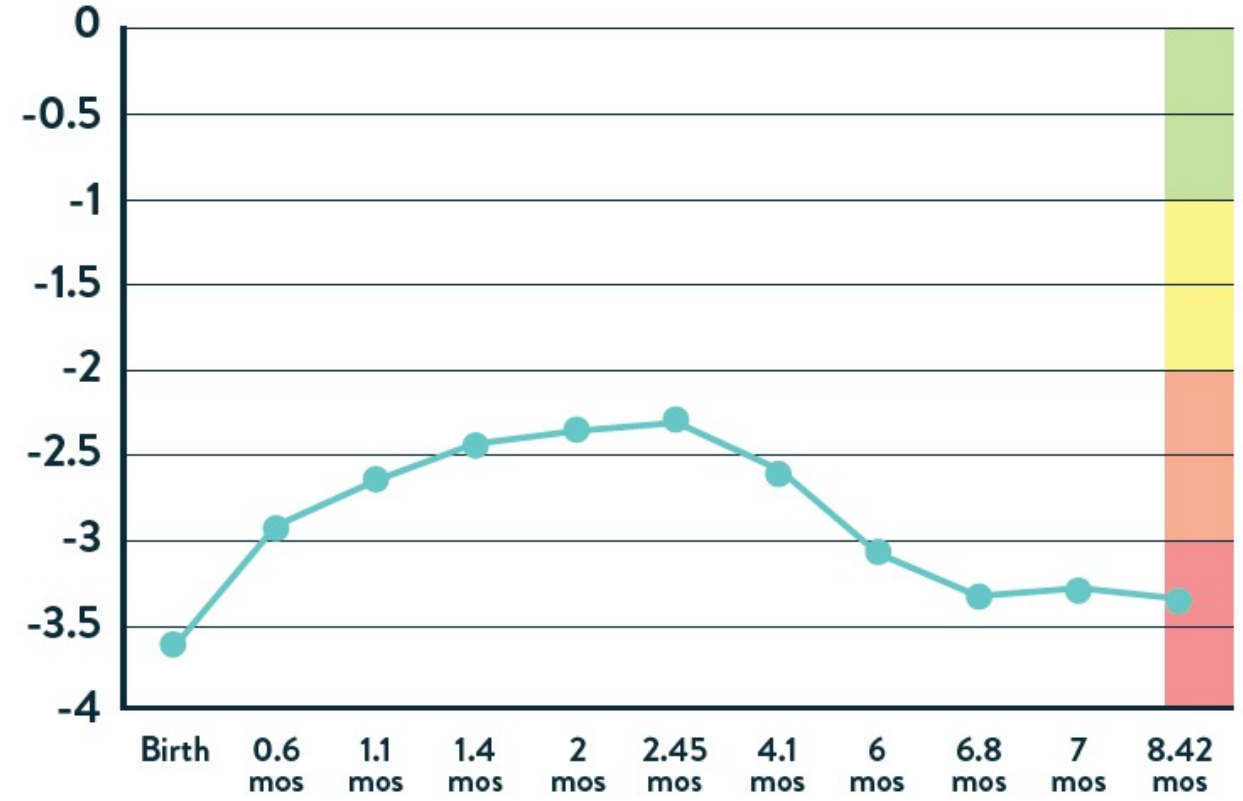
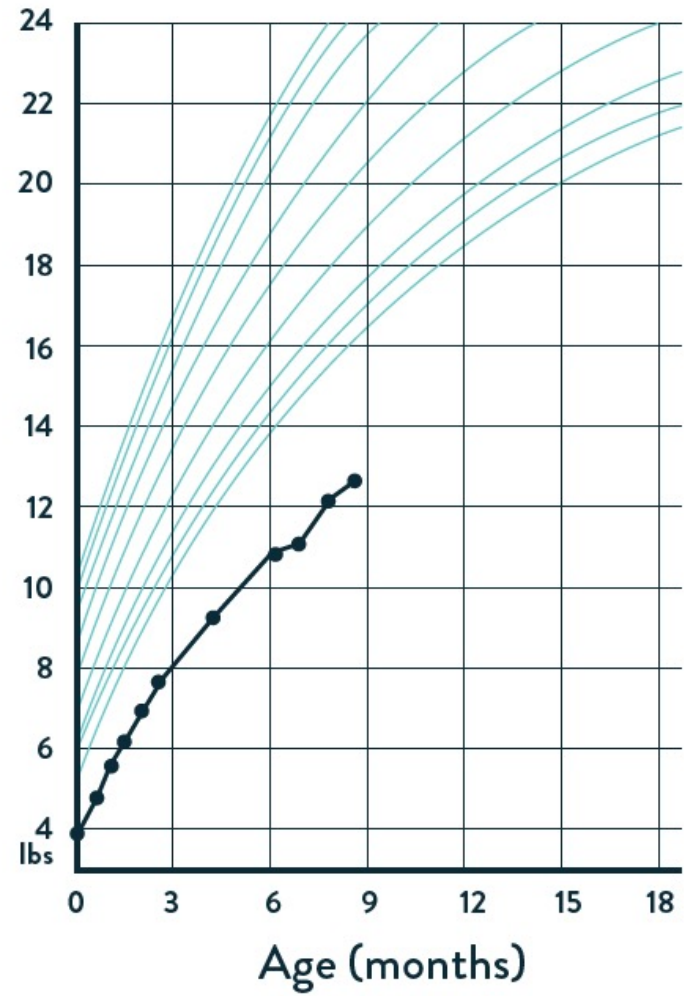
# Comparison of Z-Scores vs. Percentiles

## Z-Score

- Estimation of how an individual compares to the mean
- Can be compared across measures and populations
- Positive or negative
- Useful at the extremes

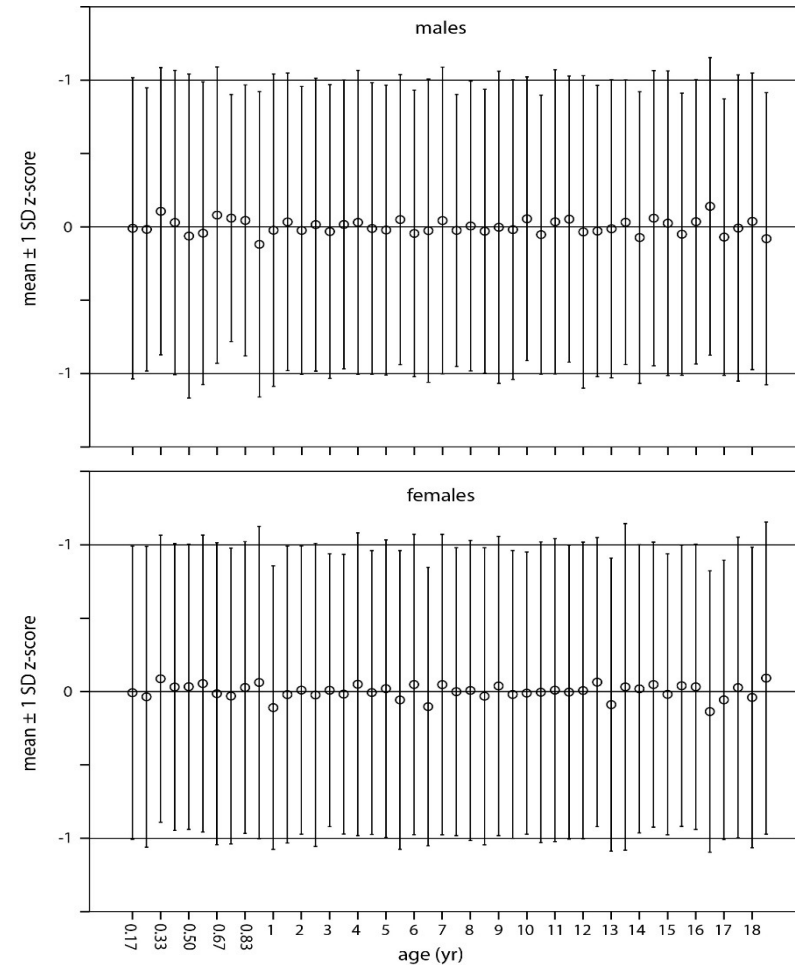
## Percentile

- Relative standing (ranking) of an individual in a population
- Stepwise increase may reflect different absolute changes
- Positive only
- Limited at the extremes



# MUAC Z-score Development

- development cohort:
  - n=28,995
  - CDC-NHANES 1999-2012
- validation cohort:
  - n=1,438
  - 2 independent studies



CDC- Centers for Disease Control and Prevention  
NHANES- National Health and Nutrition Examination Survey

Abdel-Rahman SM, et al. *Nutr Clin Pract.* 2017;32(1):68-76.

# MUAC Z-score Development

- development cohort:
  - n=28,995
  - CDC-NHANES 1999-2012
- validation cohort:
  - n=1,438
  - 2 independent studies
- estimate LMS values for z-score by month 2 months to 18 years

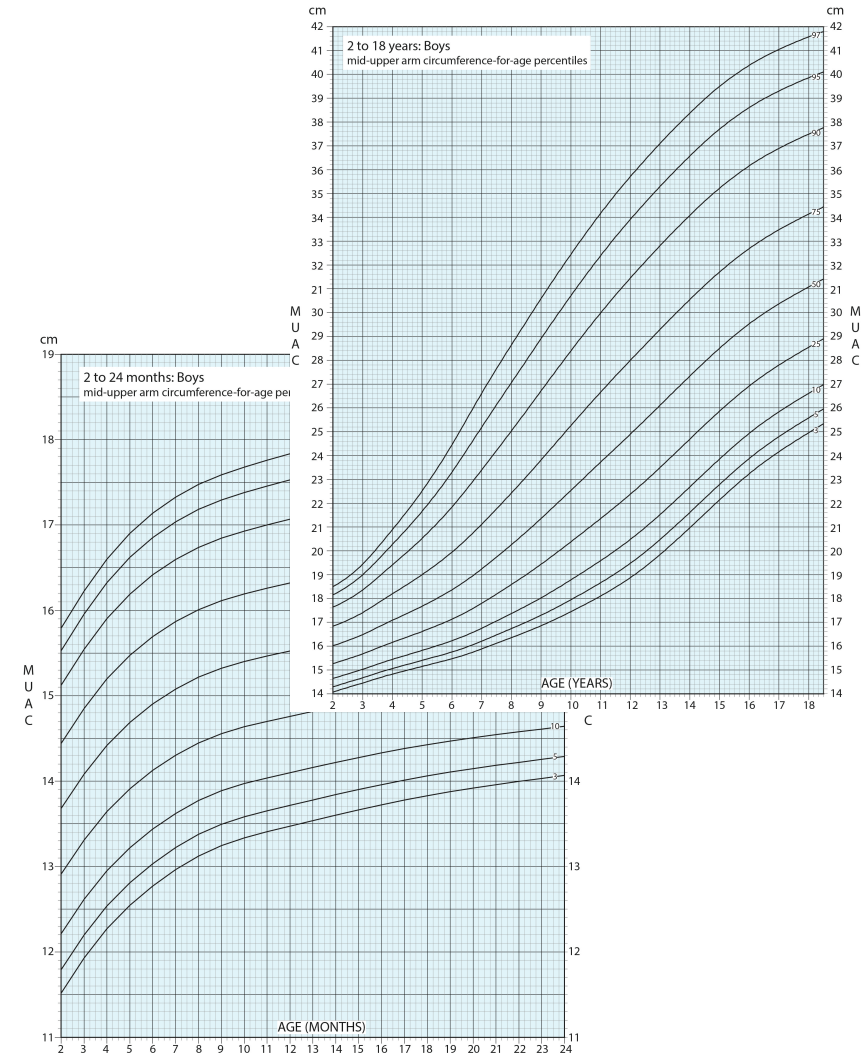
Age (mos)	Males			Females		
	L	M	S	L	M	S
2	1.162	13.680	0.083	-0.096	13.276	0.084
3	1.025	14.081	0.081	-0.119	13.635	0.083
4	0.899	14.419	0.080	-0.142	13.979	0.083
⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮
220	-1.136	31.300	0.130	-1.369	28.429	0.150
221	-1.142	31.355	0.130	-1.374	28.481	0.150
222	-1.147	31.409	0.130	-1.378	28.533	0.150

lambda mu sigma (LMS)

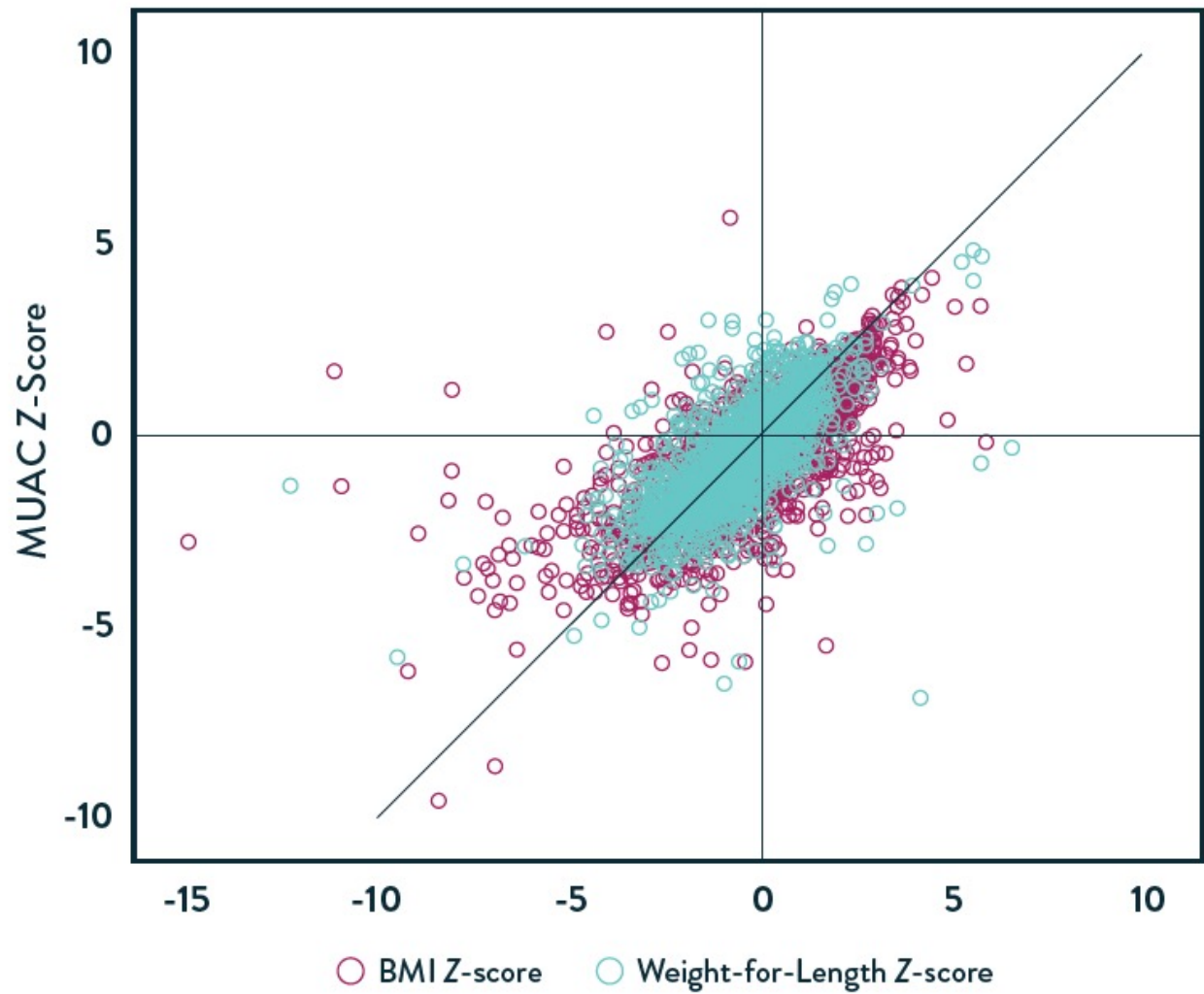
$$z_{ind} = \frac{\left[ \frac{y}{M(t)} \right]^{L(t)} - 1}{S(t)L(t)}$$

# MUAC Z-score Development

- development cohort:
  - n=28,995
  - CDC-NHANES 1999-2012
- validation cohort:
  - n=1,438
  - 2 independent studies
- estimate LMS values for z-score by month 2 months to 18 years
- *continuous* centile reference curves



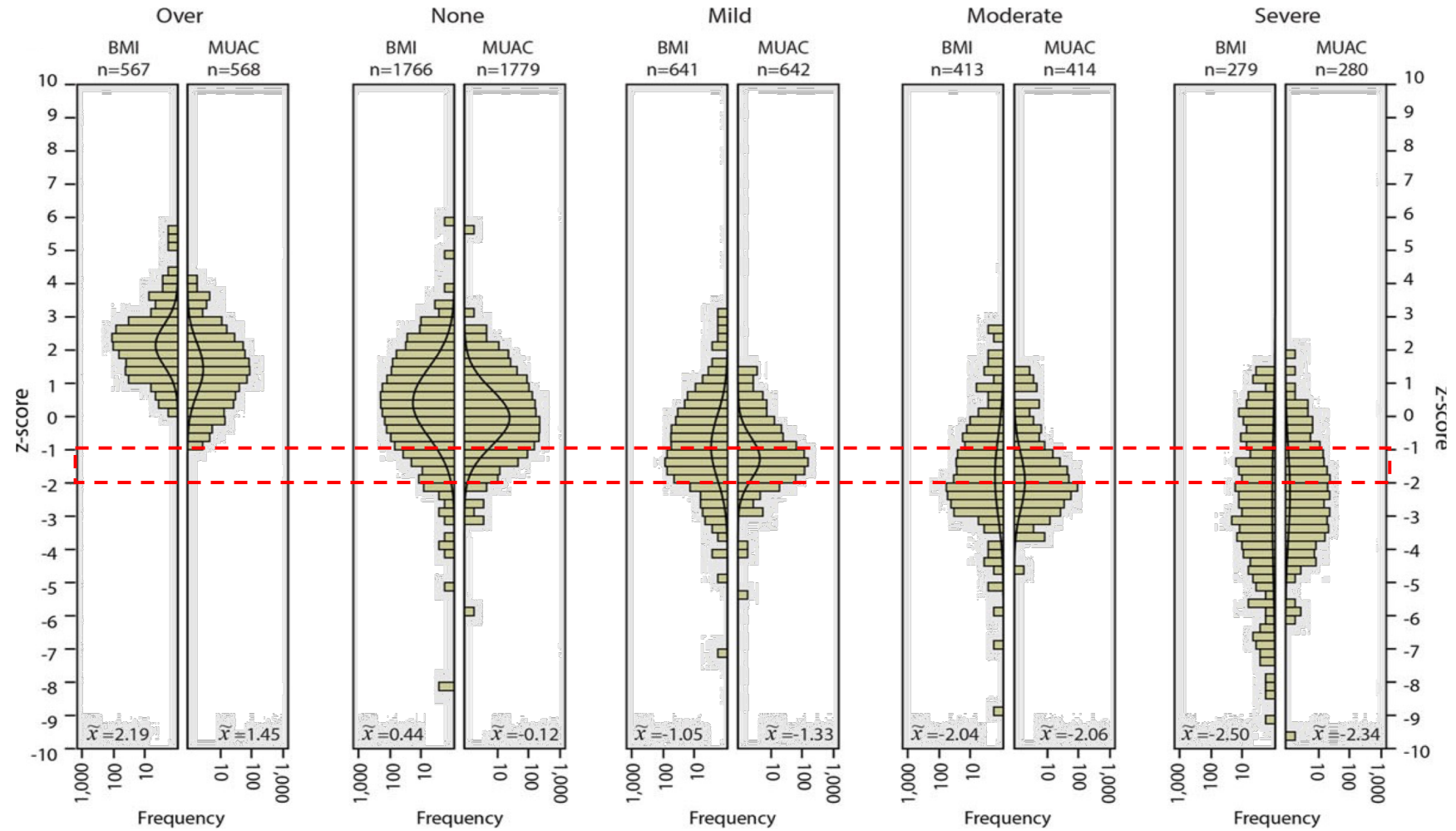
U.S. cohort  
(n=10,401)



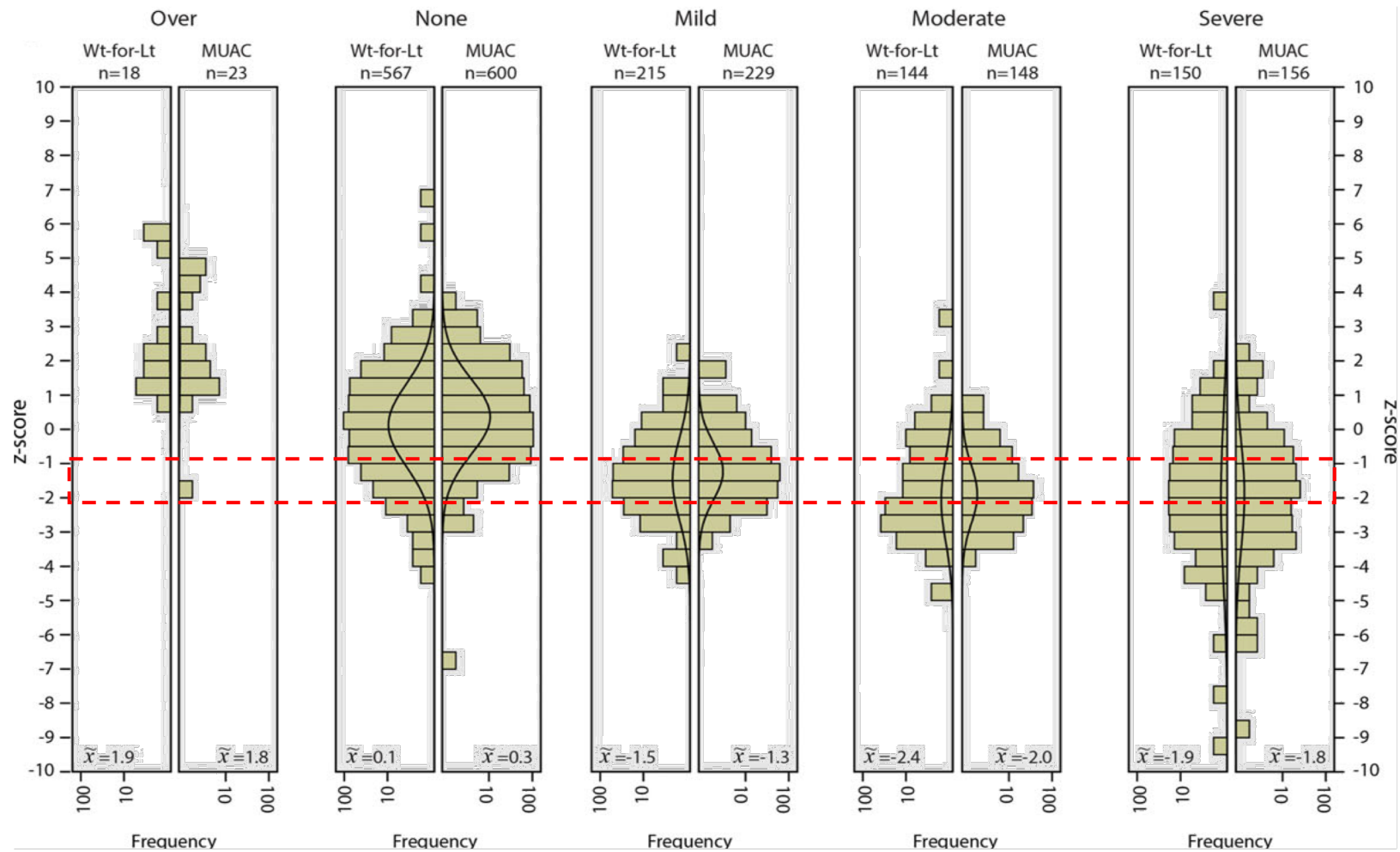
Adapted from Stephens K, et al. *Nutr Clin Pract.* 2018;33(1):124-132.



# BMI<sub>z</sub> vs. MUAC<sub>z</sub>



# W4Lz vs. MUACz



**Cystic Fibrosis**  
(n=262)

<b>Dietitian Classification</b>	<b>BMI z-score</b>	<b>MUAC z-score</b>
Overweight/Obese	100%	13%
Normal	85%	80%
Mild Malnutrition	24%	79%
Moderate Malnutrition	20%	58%
Severe Malnutrition	73%	81%
<b>Overall</b>	<b>55%</b>	<b>73%</b>

Cleft Lip and Palate  
(n=211)

Dietitian Classification	BMI z-score	MUAC z-score
Overweight/Obese	88%	65%
Normal	84%	79%
Mild Malnutrition	40%	72%
Moderate Malnutrition	67%	67%
Severe Malnutrition	0%	0%
<b>Overall</b>	<b>75%</b>	<b>75%</b>

## Ketogenic Diet

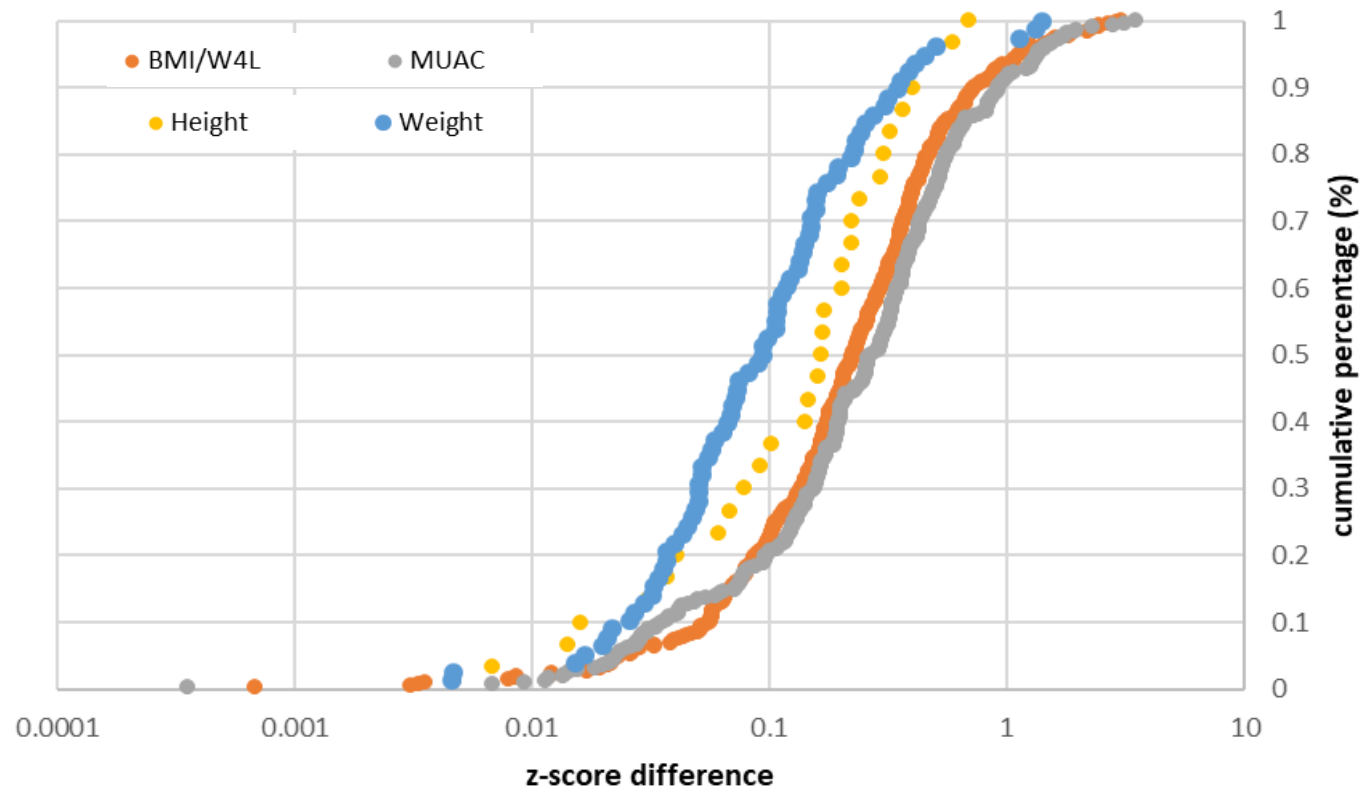
(n=266)

<b>Dietitian Classification</b>	<b>BMI z-score</b>	<b>MUAC z-score</b>
Overweight/Obese	100%	100%
Normal	63%	80%
Mild Malnutrition	17%	67%
Moderate Malnutrition	16%	42%
Severe Malnutrition	24%	6%
<b>Overall</b>	<b>48%</b>	<b>69%</b>

Renal Transplant  
(n=137)

<b>Dietitian Classification</b>	<b>BMI z-score</b>	<b>MUAC z-score</b>
Overweight/Obese	88%	88%
Normal	64%	72%
Mild Malnutrition	33%	67%
Moderate Malnutrition	29%	14%
Severe Malnutrition	0%	0%
<b>Overall</b>	<b>61%</b>	<b>70%</b>

# Failure to Thrive (n=240)

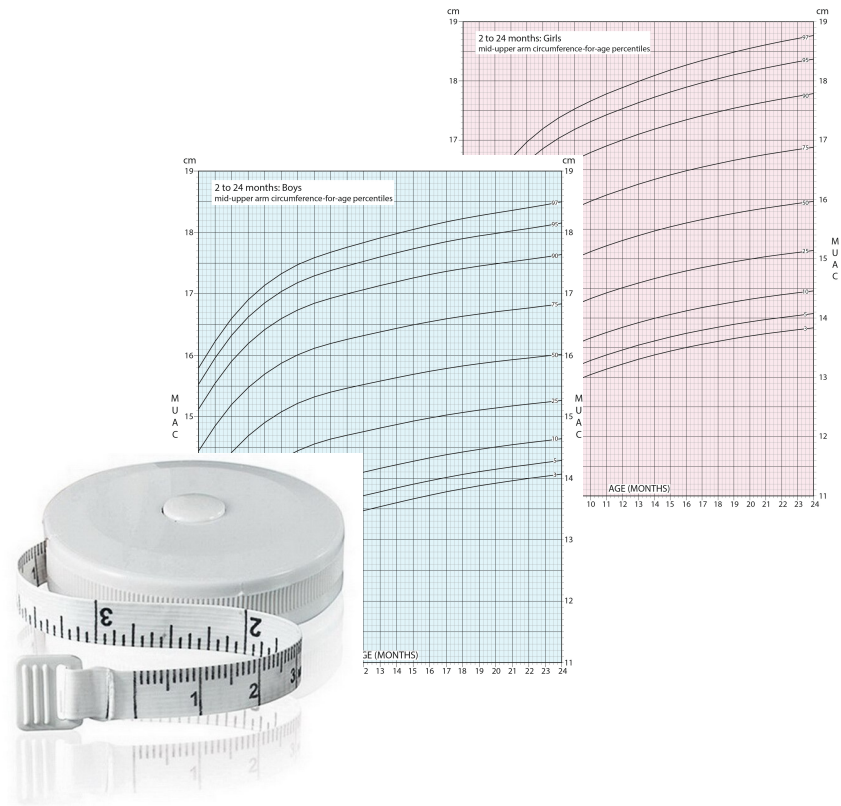


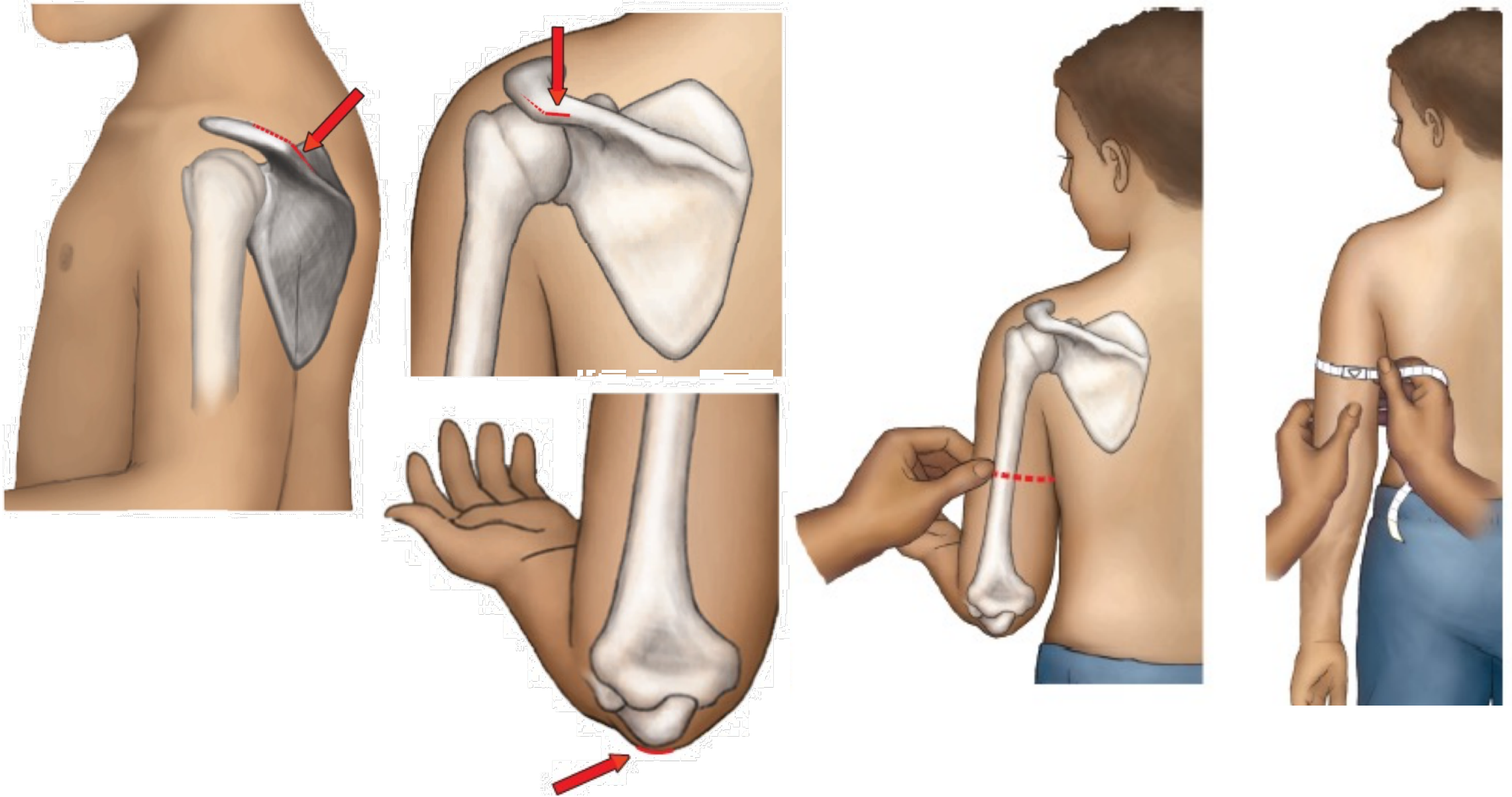
# Clinician Usability

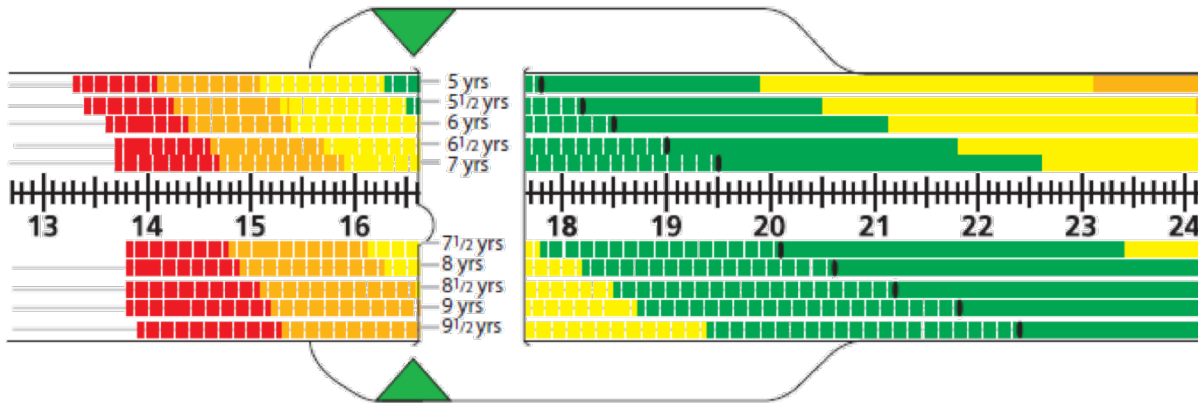
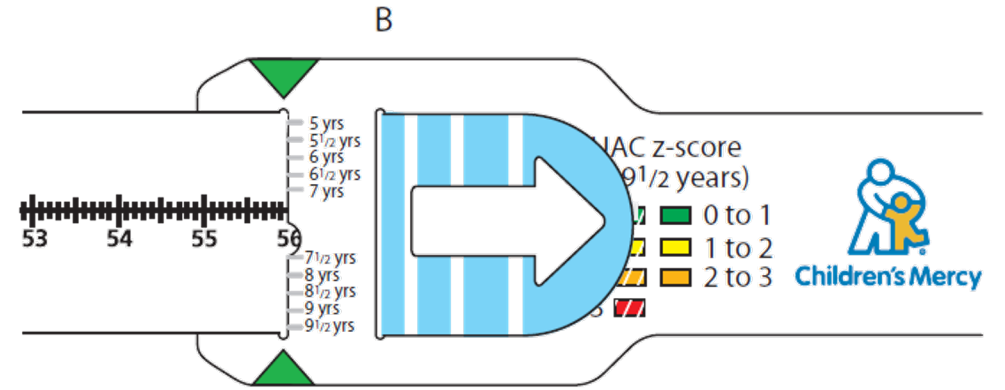
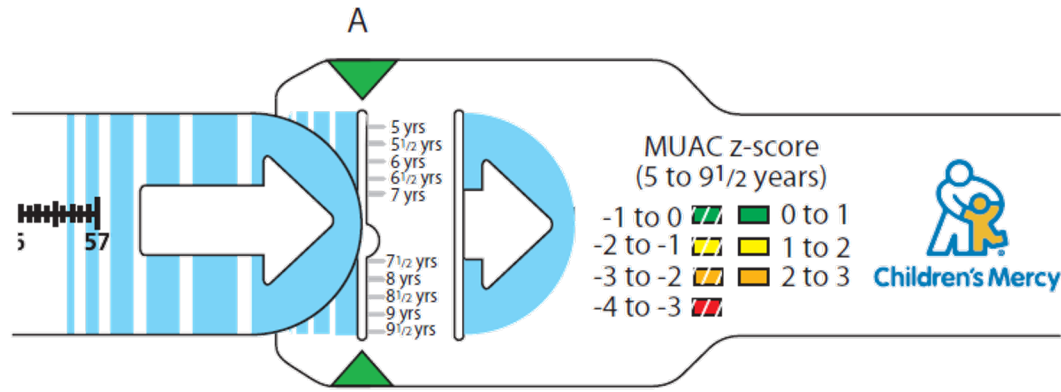
Task (% easy/very easy)	<10 uses	>50 uses	p-value
using the tape to identify the midpoint of the upper arm	53%	88%	<0.001
threading the tape through the openings to construct the loop	73%	78%	0.287
positioning the tape at the midpoint of the upper arm	77%	84%	<0.001
identifying the correct position at which to read the tape	53%	90%	<0.001
reading the MUAC value in millimeters	70%	96%	<0.001
reading the MUAC z-score range	43%	82%	<0.001
<b>Overall preferences for the device</b>	<b>23%</b>	<b>74%</b>	<b>&lt;0.001</b>



# Rapid Screening







**Reference table for z-score ranges on tape:**

Color/Pattern Key	MUAC z-score range	Risk classification
Solid orange	2 to 3	Moderate overnutrition
Solid yellow	1 to 2	Mild overnutrition
Solid green	0 to 1	Normal
Hashed green	-1 to 0	Normal
Hashed yellow	-2 to -1	Mild undernutrition
Hashed orange	-3 to -2	Moderate undernutrition
Hashed red	-4 to -3	Severe undernutrition

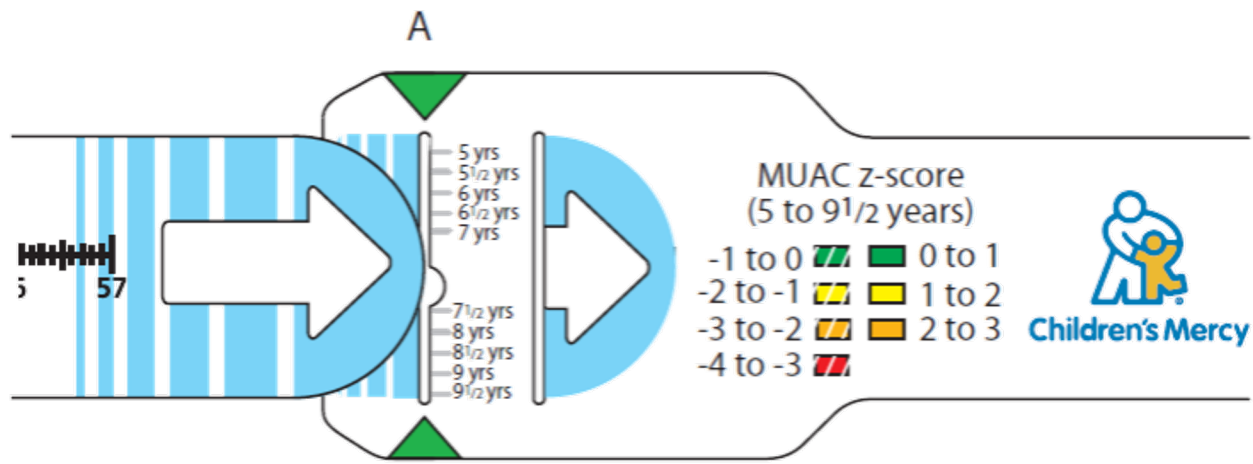
# Decentralization of MUAC Assessment

- Raises awareness
- Improves early detection and treatment
- Reduces late-stage complication/hospitalizations
- Increases program coverage
- Permits rapid implementation
- Provides continuity during pandemic

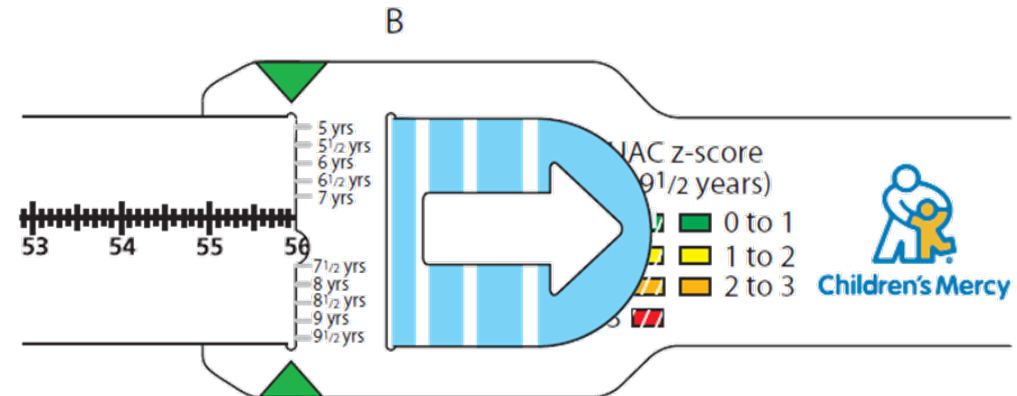
\*\* Adequate training, support, supervision

# Key Takeaways

- MUAC has been used to examine nutritional status for more than 60 years
- MUAC offers clinical and operational advantages over other measures
- MUAC z-scores permit broader application compared with single cut-off values
- MUACz is easy to implement



# THANK YOU!





# Measuring Mid-Upper Arm Circumference: A PICU Perspective

Bridget Little, BSc, PGDipDiet, NZRD

Advanced Clinician, Paediatric Intensive Care Dietitian

Starship Child Health, New Zealand



# Disclosure

- This educational event is supported by the Abbott Nutrition Health Institute
- I have received a lecture honorarium from Abbott Nutrition International



# Key Learning Objectives

- Describe key indicators that should be included as part of the nutritional assessment of paediatric critically ill patients
- Review the factors that can affect the interpretation of anthropometric measurements in paediatric critically ill patients
- Discuss the role of measuring mid-upper arm circumference (MUAC) in the paediatric critical care setting

# Nutrition in the PICU

---

- Lower body fat and muscle mass
- Higher calorie per kilogram resting energy expenditure
- Malnutrition and overfeeding associated with:
  - ↑ Time on ventilation
  - ↑ Risk infection
  - ↑ Length of stay
  - ↑ Mortality

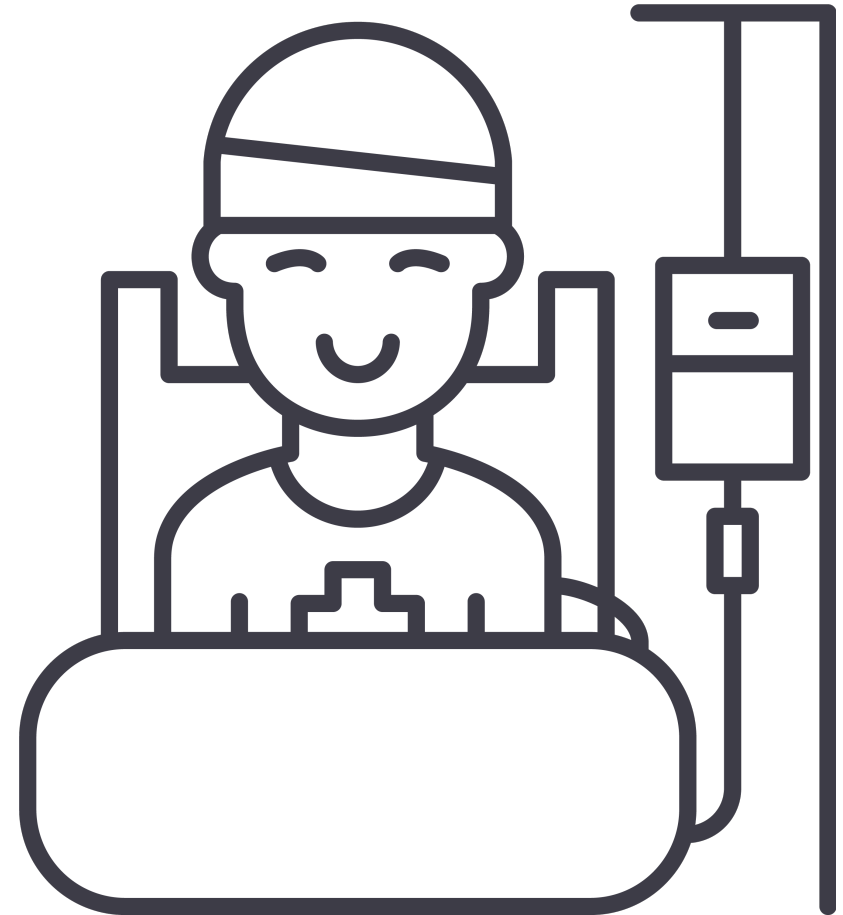


Image: VectorStock

# ANZ Paediatric Critical Care Nutrition Support Guideline

---

Australasian Society of Parenteral  
and Enteral Nutrition

## **Australian and New Zealand Paediatric Critical Care Nutrition Support Guideline**

November 2021



admin@auspen.org.au

1300 560 299 (within AUS) or +613 5975 5266 (outside AUS)

21, 33 Milgate Drive, Mornington, Vic, 3931

ww.auspen.org.au

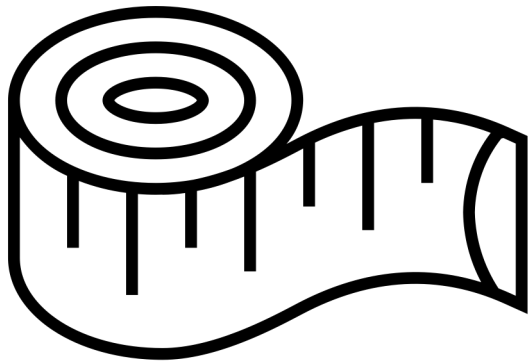
AuSPEN. Australian and New Zealand Paediatric Critical Care Nutrition Support Guideline.

<https://custom.cvent.com/FE8ADE3646EB4896BCEA8239F12DC577/files/13e4990105cc4e5e80abcc9553f18763.pdf>

Published 2021. Accessed March 4, 2022.

# Nutrition Risk Screening

---



Anthropometric measures have been recommended as a means of nutrition risk screening in the paediatric critical care setting

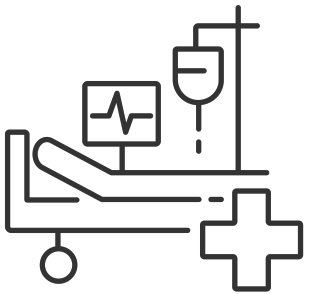
# Nutrition Assessment

---

**≤ 48  
hours**



Nutritional status should be assessed within 48-hours of admission



Multiple indicators should be used to assess nutritional status

Image: VectorStock

# Defining Nutritional Status

- 15 – 25% of children admitted to the PICU are malnourished<sup>1-3</sup>
- Almost ⅓ experience further deterioration during their stay<sup>1-3</sup>
- Anthropometric measures can facilitate malnutrition diagnosis<sup>4-6</sup>
- Several measurements ideal
- A single accurate measurement can identify the need for further assessment<sup>4</sup>

1. Prince NJ, et al. *ICM*. 2014;40(8):1132-9..
2. van Puffelen E, et al. *Clin Nutr*. 2020;39(1):104-9.
3. Beer SS, et al. *Nutr Clin Pract*. 2015;30(5):609-24.
4. van Puffelen E, et al. *JAMA Network Open*. 2018;1(5):e182668
5. Becker P, et al. *Nutr Clin Pract*. 2015;30(1):147-61.
6. Bouma S, et al. *Nutr Clin Pract*. 2017;32(1):52-67.

# Defining Malnutrition with a Single Data Point

Indicator	Mild Malnutrition	Moderate Malnutrition	Severe Malnutrition
Weight-for-length z-score ( $< 2$ years age)	-1 to -1.9	-2 to -2.9	$\geq -3$
BMI-for-age z-score ( $> 2$ years age)	-1 to -1.9	-2 to -2.9	$\geq -3$
Length/height-for-age z-score	No data	No data	$\geq -3$
MUAC z-score	-1 to -1.9	-2 to -2.9	$\geq -3$

# Confounding Factors

---



Image: Canva Pro



Weight measures should be interpreted with caution  
Obtaining accurate lengths/heights not always possible or practical



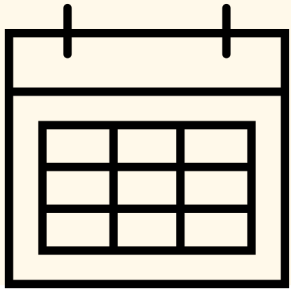
Biochemical markers may be affected by critical illness and  
fluctuating fluid balances  
Diet histories can be difficult to obtain



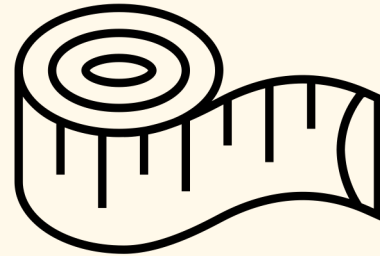
# Defining Malnutrition with a Single Data Point

Indicator	Mild Malnutrition	Moderate Malnutrition	Severe Malnutrition
Weight-for-length z-score (< 2 years age)	-1 to -1.9	-2 to -2.9	$\geq -3$
BMI-for-age z-score (> 2 years age)	-1 to -1.9	-2 to -2.9	$\geq -3$
Length/height-for-age z-score	No data	No data	$\geq -3$
MUAC z-score	-1 to -1.9	-2 to -2.9	$\geq -3$

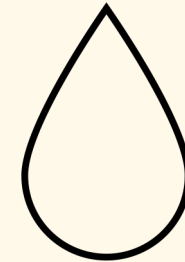
# Mid-Upper Arm Circumference



Consider in length of  
stay > one week



Relatively easy with  
appropriate expertise  
and equipment



Less affected by fluid  
changes than weight  
measures

# Measuring MUAC

---

- Assess changes within an individual over time
- Or for comparison to appropriate references/standards:
  - CDC 2017: 2 months to 18 years<sup>1</sup>
  - WHO 2007: 3 months to 5 years<sup>2</sup>
  - WHO 2017: 5 to 9 years<sup>3</sup>

1. Addo OY, et al, *Am J Clin Nutr.* 2017;105(1):111-20.

2. WHO. Child growth standards. [www.who.int/tools/child-growth-standards](http://www.who.int/tools/child-growth-standards)

3. Mramba L, et al. *BMJ.* 2017;358:j3423.

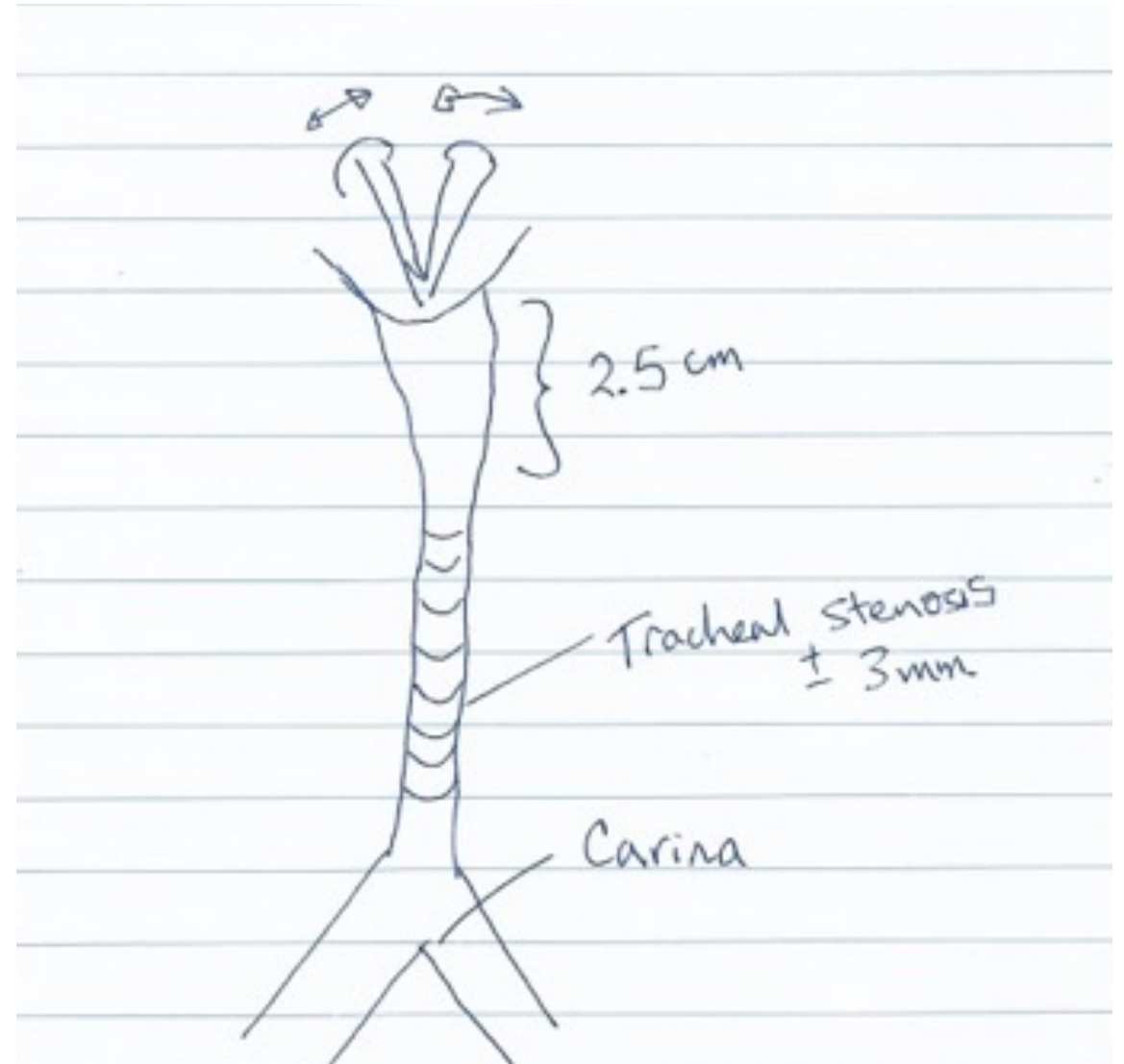
A pair of black-rimmed glasses is resting on a stack of books. A red bookmark is visible in the foreground. The background is blurred, showing more books and a wooden surface.

# Case Study

Anthropometry in a patient with a critical airway

# Jeremiah

- Term baby
- Birth anthropometry ~ 75<sup>th</sup> percentile
- Multiple congenital anomalies including:
  - Tetralogy of fallot
  - Tracheal stenosis
  - Complete tracheal rings



# Admitted to PICU

- 2 months age: sliding tracheoplasty + VSD closure + LPA sling repair
- Pre-op growing on 1 kcal/ml ready-to-feed infant formula via NGT
  - Provides: 110 ml/kg, 110 kcal/kg, 2.8 g protein/kg
- Unstable airway: tracheomalacia, recurrent formation granulation tissue → tracheostomy
- Unable to weigh between 2.5 and 4 months of age
- Surgeons keen to ensure good nutrition and growth



What methods for anthropometric assessment could you consider?  
(Select all that apply)

---

- A. Length
- B. Head circumference
- C. MUAC
- D. Weight-for-length

What factors impact your decisions around this patient's nutritional management?

- A. Anthropometric measurements
- B. Ventilation settings
- C. Pre-op nutritional requirements
- D. All the above





# In Practice

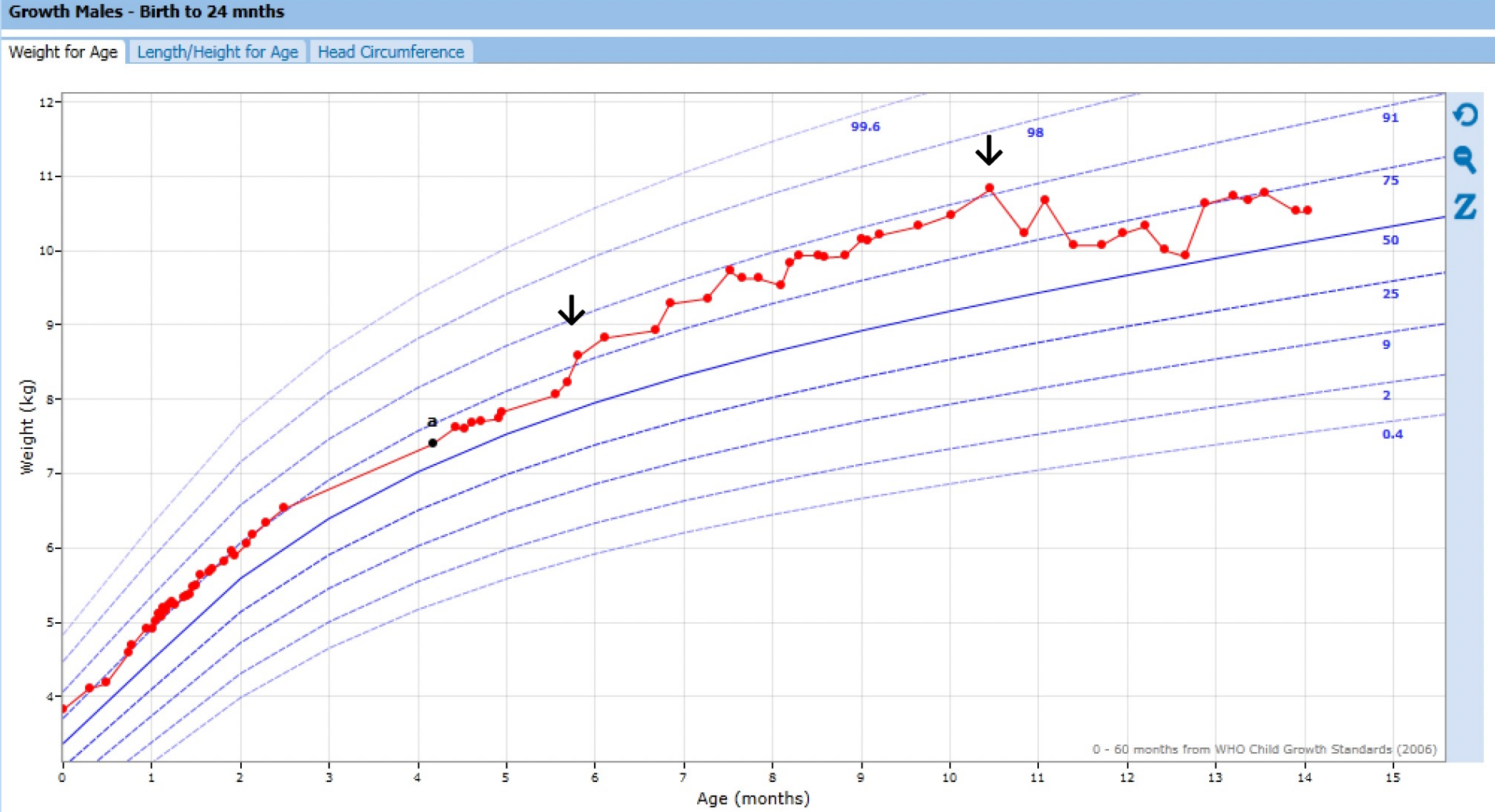
- MUAC z-score: 1 to 2
- End-of-the-bed-o-gram
- Fluctuating ventilatory support
- Pre-op nutritional requirements
- Clinical experience informed decision making
- Feeding ~70% pre-op nutrition (80 kcal/kg + 2.1 g protein/kg)



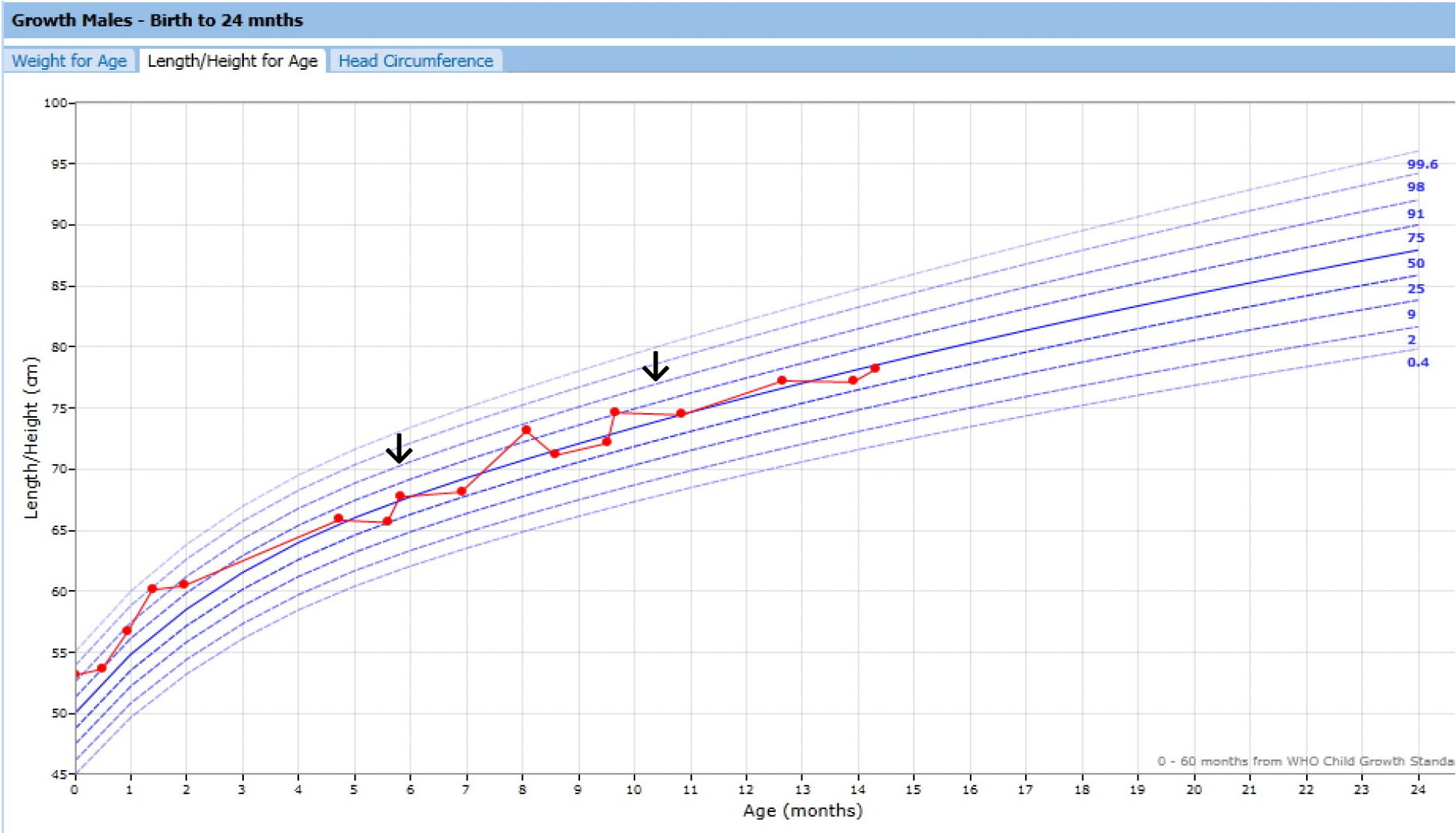
# Weight and Feed Journey

- ~ 4 months able to weigh, tracking ~75th centile
  - MUAC z-score tracking 1 to 2
  - ~ 6 months ongoing rapid weight gain
  - Lowered energy density: 1 kcal/ml → 0.8 kcal/ml → 0.65 kcal/ml
  - Also adjusted feed volumes
  - Nutrition transition: 80 kcal/kg → 60 kcal/kg + 1.3 g protein/kg
  - Became concerned about nutritional adequacy
-

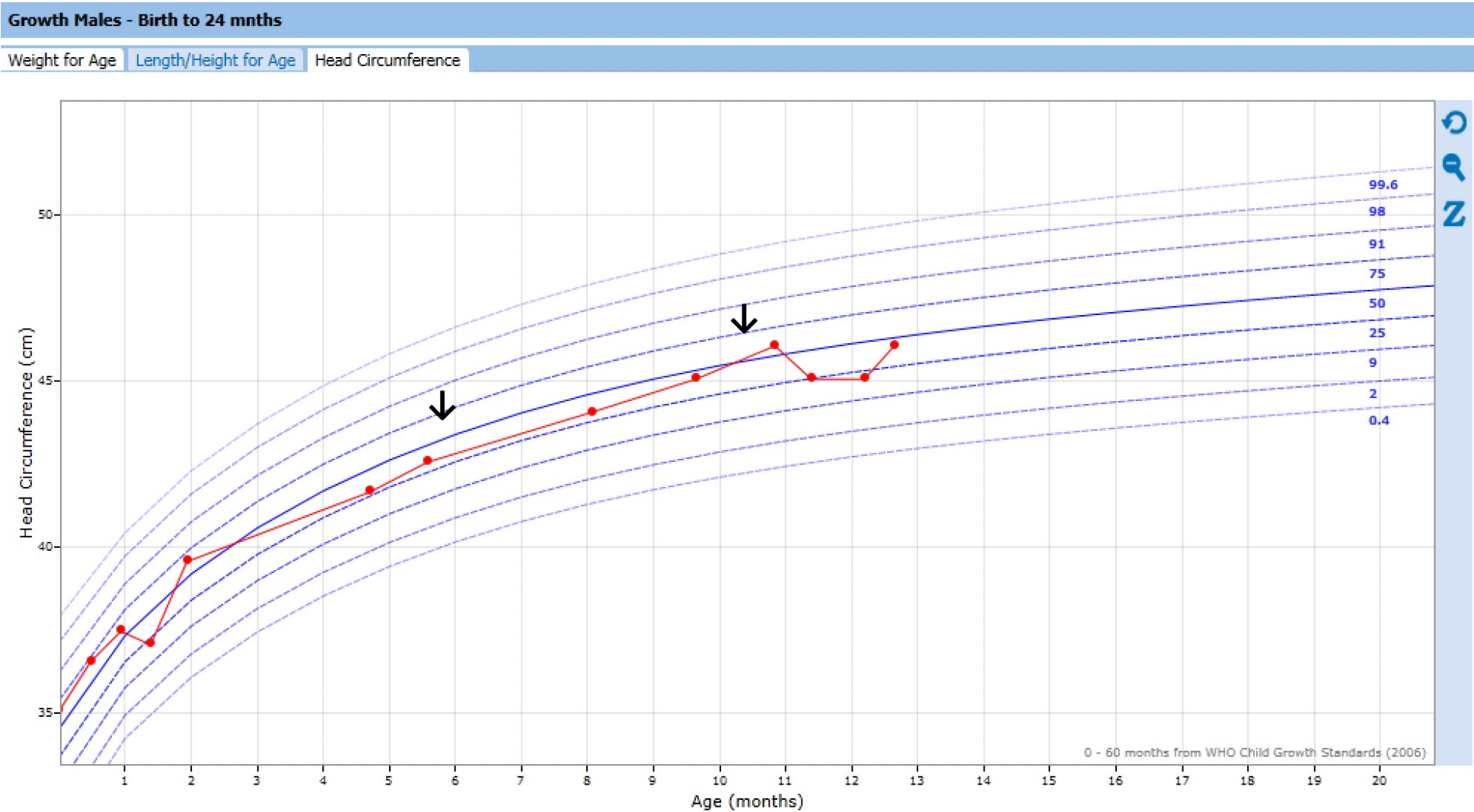
# Jeremiah - Weight



# Jeremiah - Length



# Jeremiah - Head Circumference



# Why?

---

- Repeated debridement of granulation tissue
- Steroids in theatre
- Cushingoid appearance
- Limiting handling
- ↓ Development opportunity

<u>Theatre Date</u>	<u>Surgery Duration</u>	<u>Primary Procedure</u>
16/08 13:40	45 mins	Fibreoptic bronchoscopy
12/08 09:28	44 mins	Laryngoscopy
08/08 19:30	64 mins	Laryngoscopy
05/08 08:35	51 mins	Laryngoscopy
01/08 16:02	41 mins	Laryngoscopy
29/07 09:54	76 mins	Laryngoscopy
27/07 11:27	45 mins	Laryngoscopy
22/07 08:46	52 mins	Laryngoscopy
19/07 13:29	47 mins	Laryngoscopy
15/07 09:41	49 mins	Laryngoscopy
13/07 00:59	59 mins	Excision of lesion of trachea
08/07 08:46	51 mins	Laryngoscopy
01/07 08:42	32 mins	Laryngoscopy
27/06 14:47	33 mins	Laryngoscopy
24/06 15:38	39 mins	Rigid bronchoscopy
21/06 08:32	26 mins	Laryngoscopy
17/06 08:29	44 mins	Laryngoscopy
15/06 09:44	39 mins	Laryngoscopy
13/06 11:15	41 mins	Laryngoscopy
09/06 09:10	45 mins	Laryngoscopy



What are some of the barriers to getting accurate information?

---

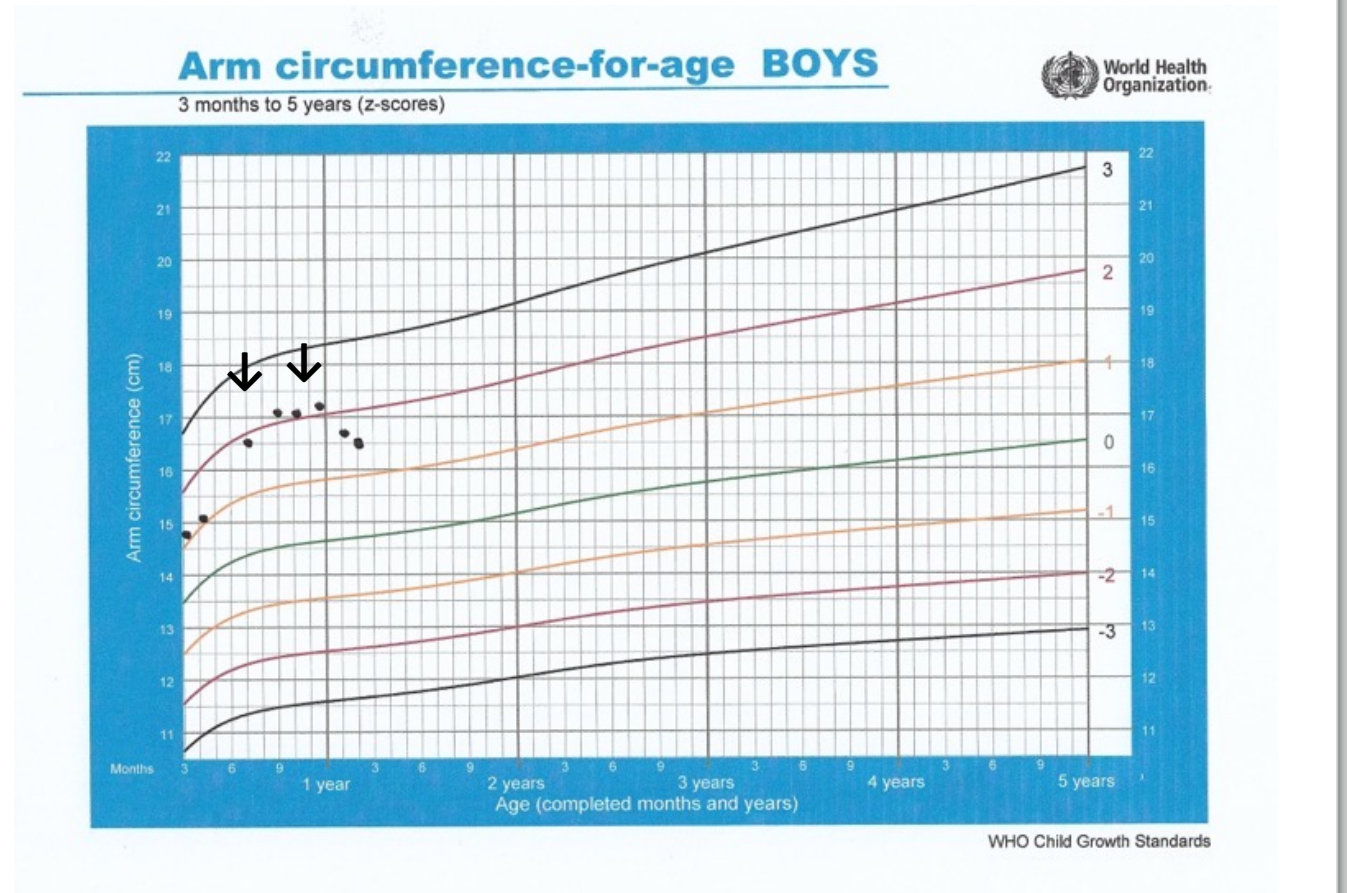
- A. Fluid retention
- B. Limited handling
- C. Lean mass vs. fat mass
- D. All the above

# Jeremiah MUAC + Triceps Skinfold Thickness (TSF)

## Triceps skinfold thickness

6 months: 85<sup>th</sup>C

10 months: 85 - 97<sup>th</sup>C





# Nutrition Analysis

<b>Nutrient</b>	<b>Recommended Daily Intake (RDI)</b>
Energy (kcal)	75%
Protein (g)	75%
Sodium (mmol)	83%
Potassium (mmol)	93%
Phosphorus (mmol)	92%
Magnesium (mmol)	59%
Iron (mg)	72%
Selenium ( $\mu\text{g}$ )	72%
All other nutrients	$\geq 100\%$

# Nutrition Analysis

<b>Nutrient</b>	<b>Recommended Daily Intake (RDI)</b>	<b>Lower Reference Nutrient Intake (LNRI)</b>
Energy (kcal)	75%	N/A
Protein (g)	75%	N/A
Sodium (mmol)	83%	100%
Potassium (mmol)	93%	100%
Phosphorus (mmol)	92%	100%
Magnesium (mmol)	59%	100%
Iron (mg)	72%	100%
Selenium (µg)	72%	100%
All other nutrients	≥ 100%	N/A

# Interpretation

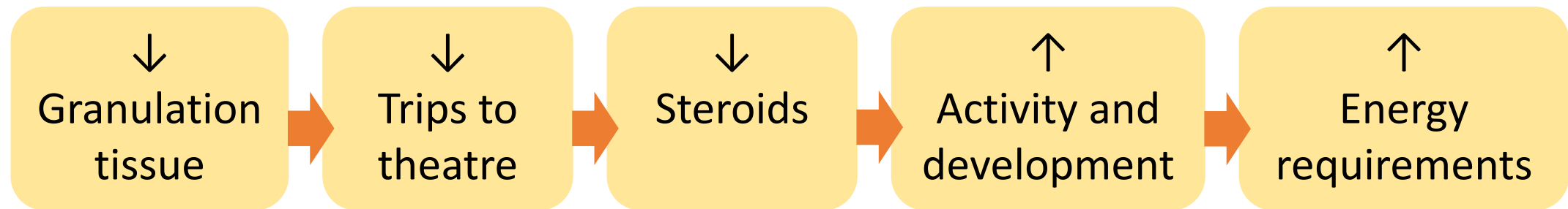
---

- ✓ Energy intake appropriate as maintaining linear growth
- ✓ Normal serum biochemistry
- ✓ Continue to monitor:
  - Weight, length and head circumference
  - MUAC, TSF
  - Biochemistry – including serum urea for protein adequacy

# Jeremiah – Follow Up

---

- 1 year old: changed to low-energy ready-to-feed (0.76 kcal/ml)  
Provides: ~60 kcal/kg (consistent), 1.6 g protein/kg (achieves RDI)

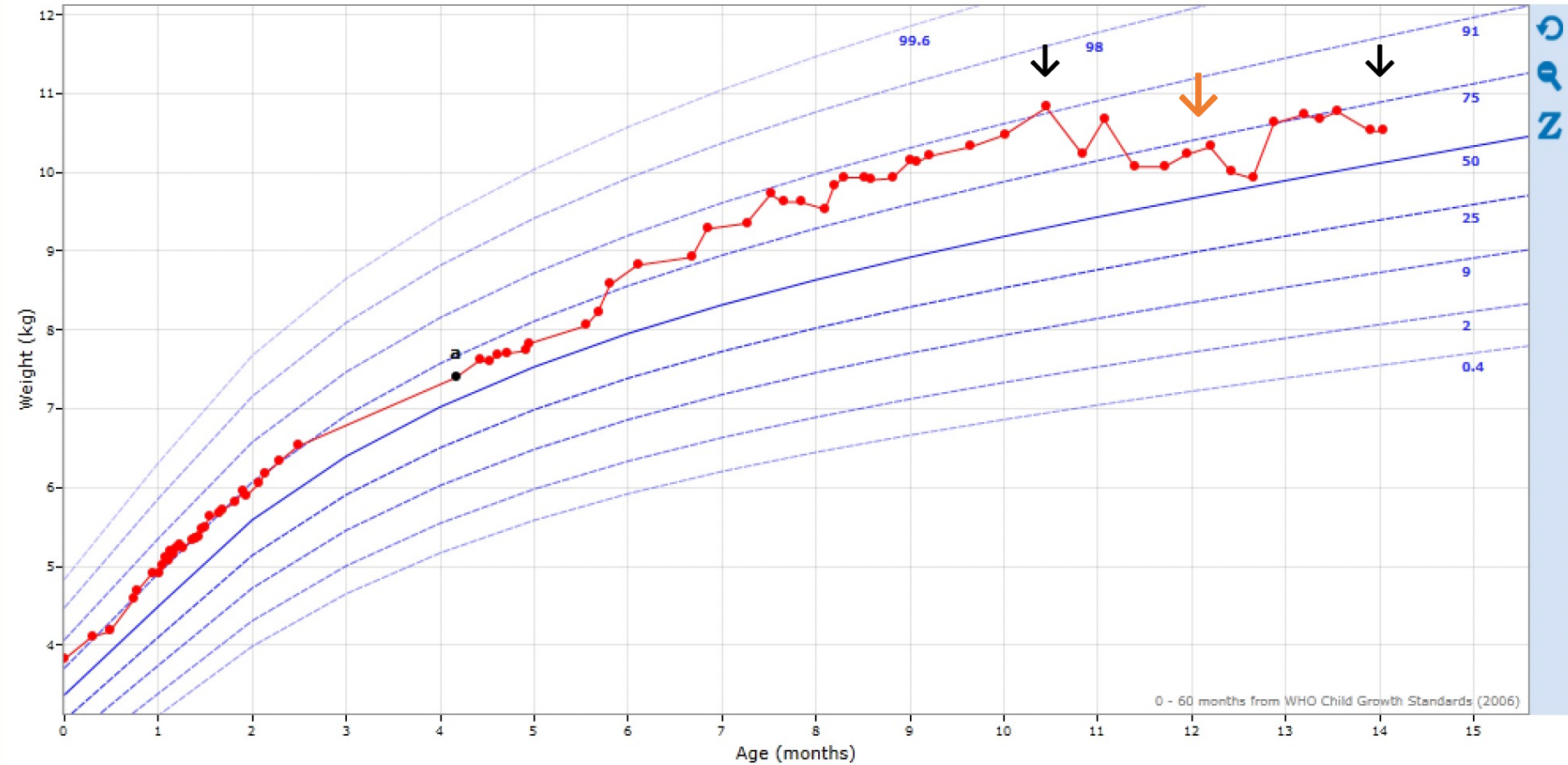


- Feeds gradually increased to provide: 75 kcal/kg, 2.1 g protein/kg

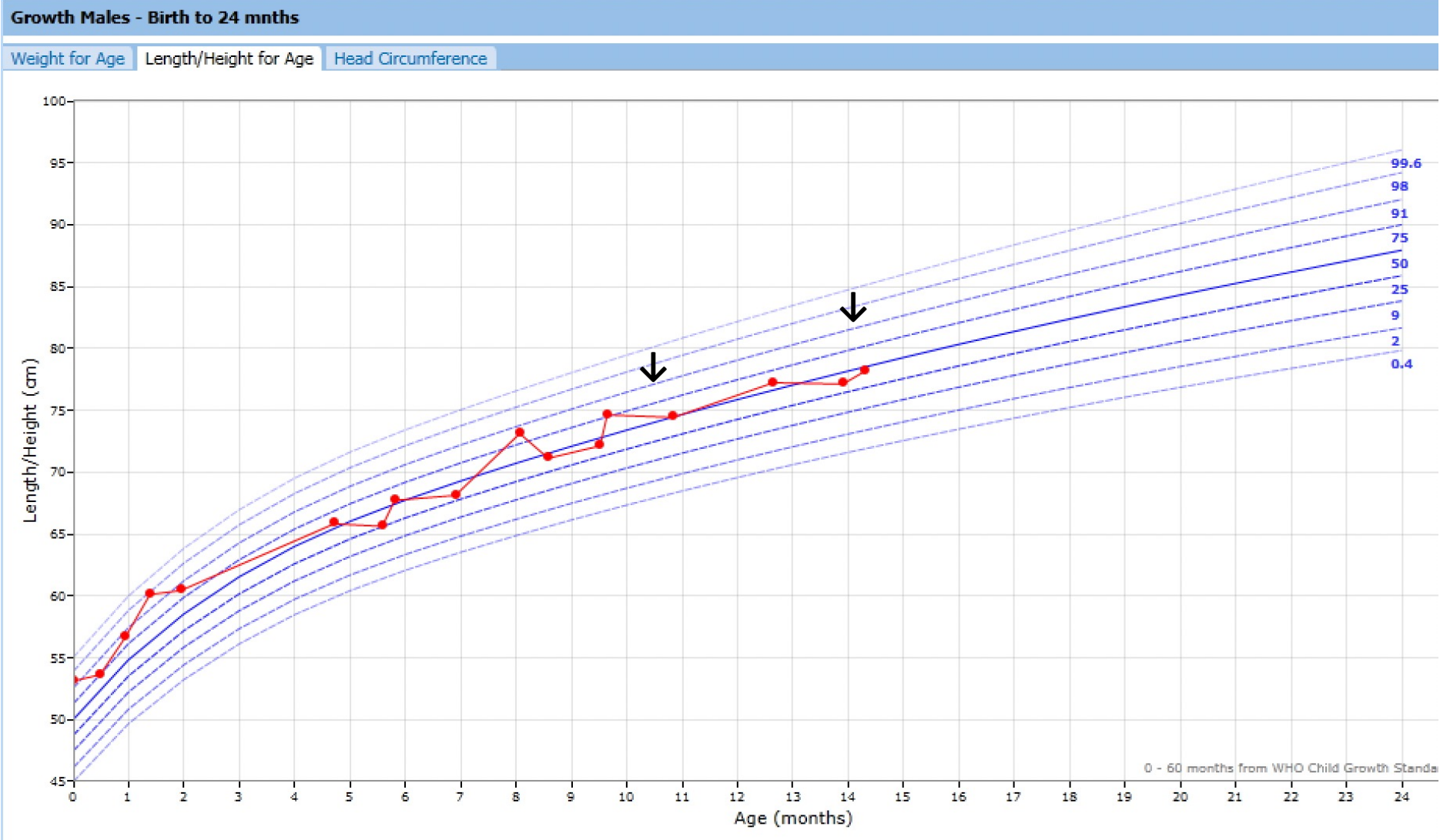
# Jeremiah Weight – Follow Up

Growth Males - Birth to 24 mnths

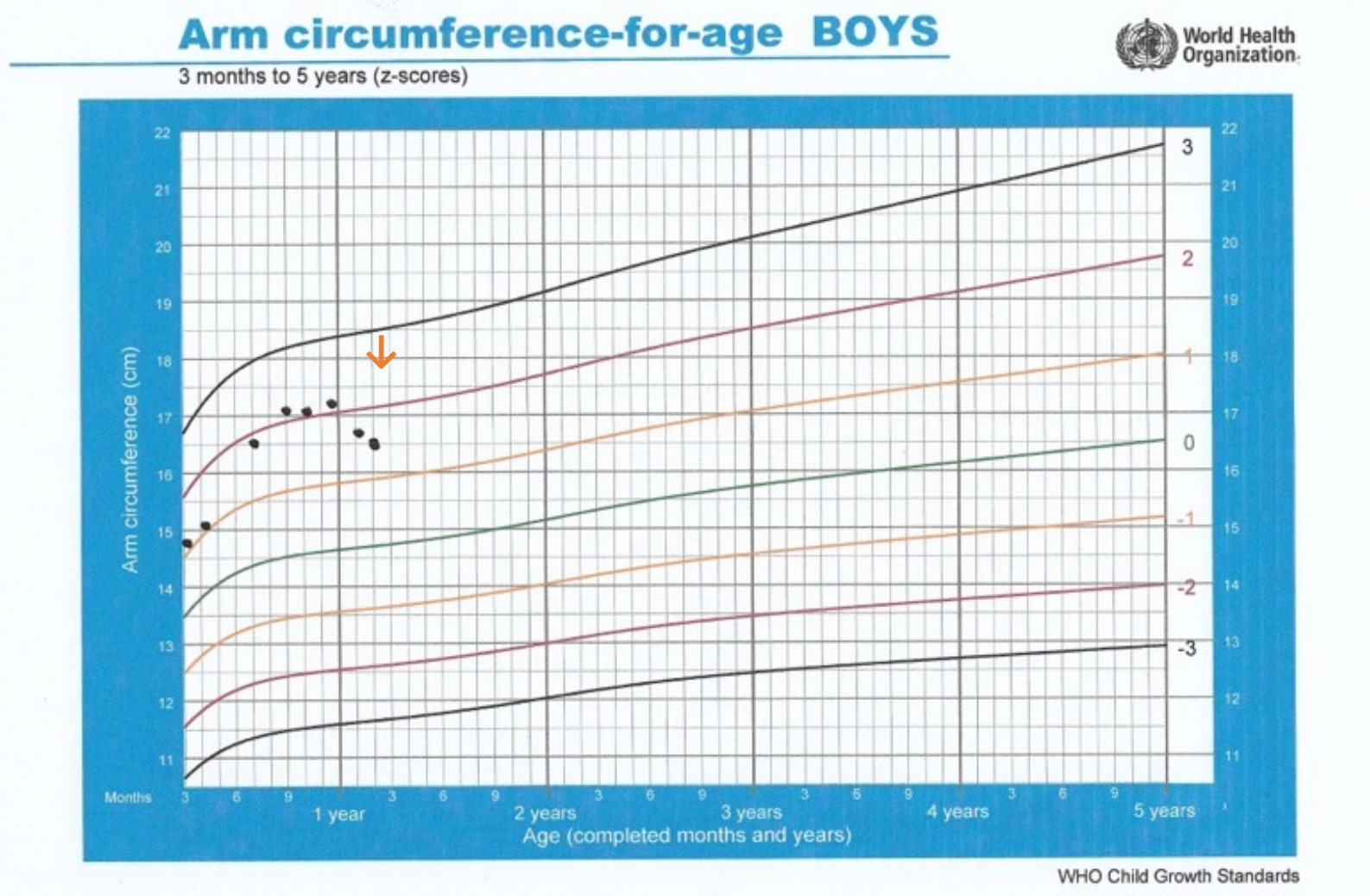
Weight for Age Length/Height for Age Head Circumference



# Jeremiah Length – Follow Up



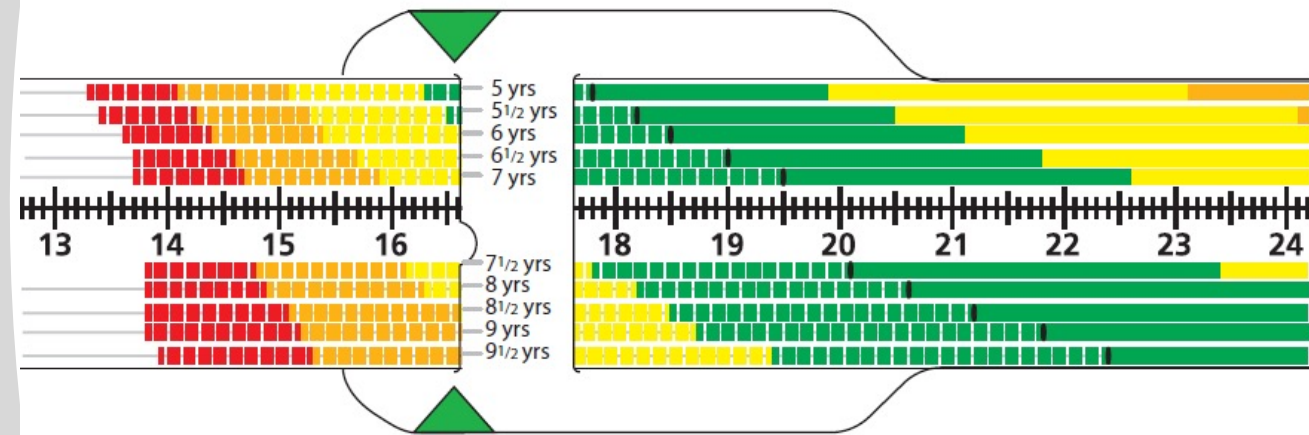
# Jeremiah MUAC + TSF – Follow Up



**Triceps skinfold thickness**  
After steroids stop:  
50 – 85<sup>th</sup>C

# MUAC Z-Score Tape

- Easy to use and read
- All-in-one
- Re-usable
- Interpretable on the spot
  - Age ranges
  - Z-scores
  - Colour coding
- Based on CDC data



<u>Color/Pattern Key</u>	<u>MUAC z-score range</u>	<u>Risk classification</u>
Solid orange	2 to 3	Moderate overnutrition
Solid yellow	1 to 2	Mild overnutrition
Solid green	0 to 1	Normal
Hashed green	-1 to 0	Normal
Hashed yellow	-2 to -1	Mild undernutrition
Hashed orange	-3 to -2	Moderate undernutrition
Hashed red	-4 to -3	Severe undernutrition



# Summary

---

- Nutrition is integral to the management of PICU patients
- Nutrition assessment is key to determining patients' nutritional requirements
- Accurate anthropometric measurements can be difficult to obtain in the PICU setting
- Measuring MUAC is minimally invasive and requires minimal patient handling
- MUAC can be a useful tool in assessment and monitoring of nutritional status
- The MUAC z-score tape can help define both under and over nutrition



**THANK YOU!**



**Aim High**  
THERAPY SERVICES

# Potential Application of MUAC as an Alternative Growth Measurement in Children With Disabilities

Paediatric Nutrition Symposium:  
Assessing Anthropometry in Dietetic Practice

**Aimee McLeod**  
**Accredited Practising Dietitian**  
**B Nutr. Diet. (Hons I)**

# DISCLOSURES

- This educational event is supported by Abbott Nutrition Health Institute and Abbott Nutrition

# LEARNING OBJECTIVES

1

Review methods and challenges of anthropometry in disability practice

2

Recognise the potential application of MUAC measurements as a tool for nutrition assessment

3

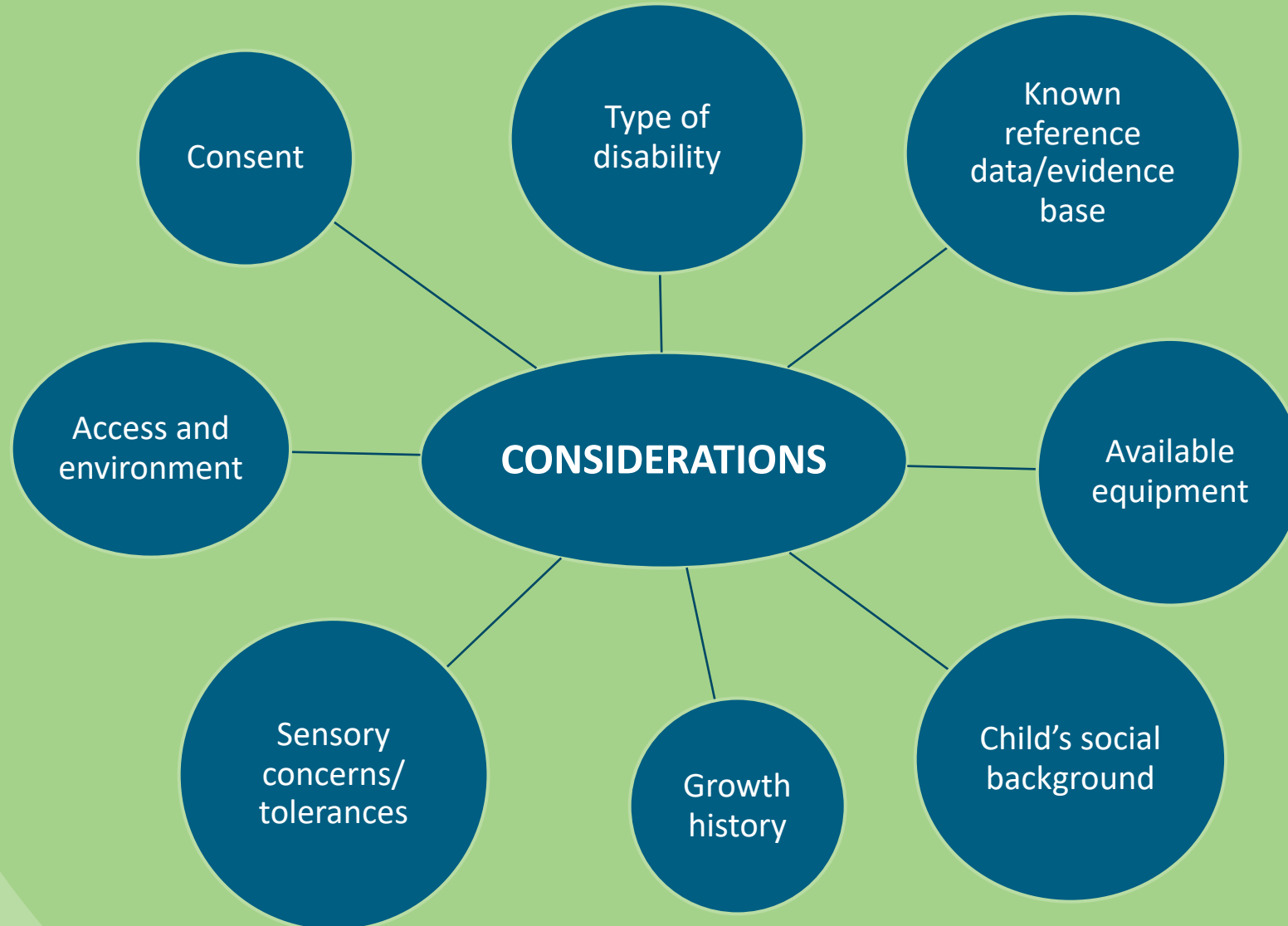
Apply this knowledge to a case study in community dietetics practice



## SERVICE DESCRIPTION

- A private practice dietetics service
- Specialising in disabilities: intellectual, physical, neurological and acquired
- Primarily funded by our National Disability Insurance Scheme (NDIS)
- Clients across the lifespan in group home and private residence
- Client issues include: feeding tubes, dysphagia, weight and gastrointestinal issues

# ANTHROPOMETRY IN DISABILITY PRACTICE



# EVIDENCE BASE

- Evidence for growth expectations in disability populations is generally poor, particularly for more rare conditions
- Slightly more evidence for Cerebral Palsy (CP) population with some guidelines developed in Australia specific for anthropometric assessment



# WHAT WE KNOW

- Reliable serial measurements are critical
- Alternative measures besides weight and height are frequently needed
- BMI is not recommended
- Body composition is often altered
- Specialised CP growth charts are not recommended
- Skinfold measurements are recommended

## MANAGEMENT OF CEREBRAL PALSY IN CHILDREN

A guide for allied health professionals

# BARRIERS WE FACE

**Accuracy and  
reliability**

**Past bad experiences  
(either child or  
parent)**

**Medical  
trauma/PTSD**

**Sensory aversions**

**Environmental/safety  
constraints**

**Time constraints**

**Availability of  
equipment**

**Lack of evidence base**

# ANTHROPOMETRY IN PRACTICE

For weight: wheelchair scales, standing scales, hoist scales, baby scales

For height/length: fixed stadiometer, baby measuring mat, knee-height segmometer or flexible measuring tape

For skinfolds, specifically tricep skinfold: skinfold callipers

For MUAC, waist or hip circumference: flexible measuring tape



# MID-UPPER ARM CIRCUMFERENCE

---

- Relatively easy compared to other methods
- Quick to complete
- Only a measuring tape required
- Non-invasive and requires minimal physical contact
- Comfortable for the client – can be carried out standing, sitting or laying
- Less affected by peripheral oedema which is common in wheelchair users



# CASE STUDY - SOPHIE

---

- 13yo referred for assessment and management
- Diagnosis: GMFCS V spastic quadriplegic CP, premature birth (27 weeks), chronic lung disease
- Reported by paediatrician to be underweight at 24.5 kg and no weight gain in 12 months
- Speech pathologist concerned about dysphagia and aspiration risk, recommended thickened fluids
- Family not concerned about weight
- Difficult history of engagement with health services

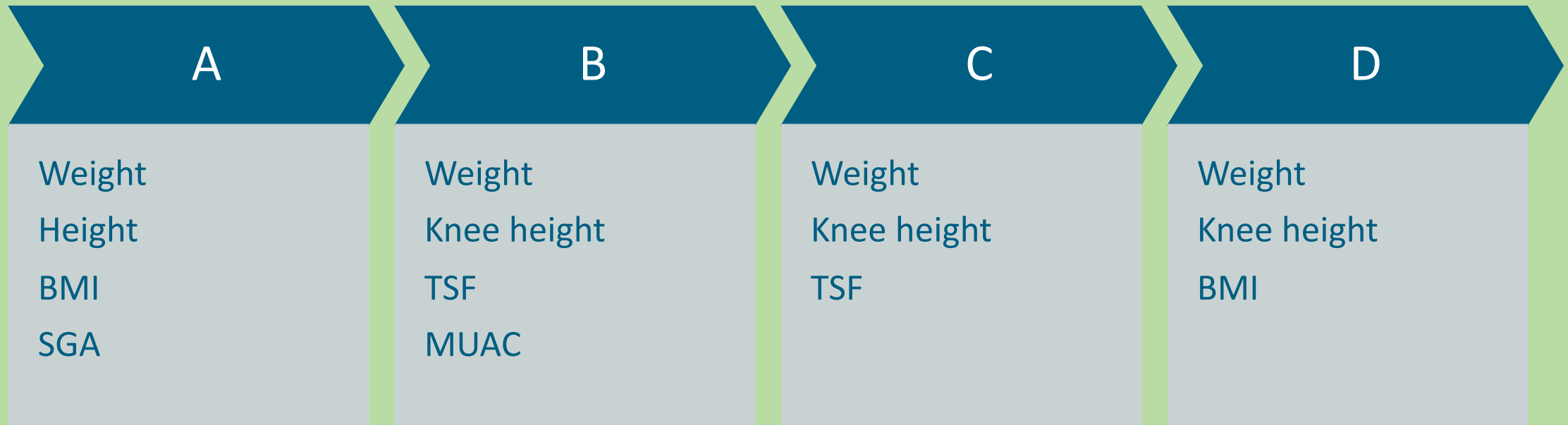


# INITIAL APPOINTMENT

---

- Home visit after school – limited space, no firm flat floors
- Manual wheelchair with lateral supports
- Spasms/distress
- Only a fixed hoist in the bedroom
- Unable to stand or lay flat
- Equipment available: portable wheelchair scale, skinfold callipers, measuring tape

# WHAT METHODS FOR ANTHROPOMETRIC ASSESSMENT COULD YOU CONSIDER?



# WHAT ARE SOME OF THE BARRIERS TO GETTING MORE ACCURATE INFORMATION?

---

A. Possible accessibility issues

B. Family's understanding of concerns and past issues with engagement

C. Lack of medical data

D. Possible Work, Health & Safety (WHS) issues

E. A, B, C, and D



# WHAT DID I DO?

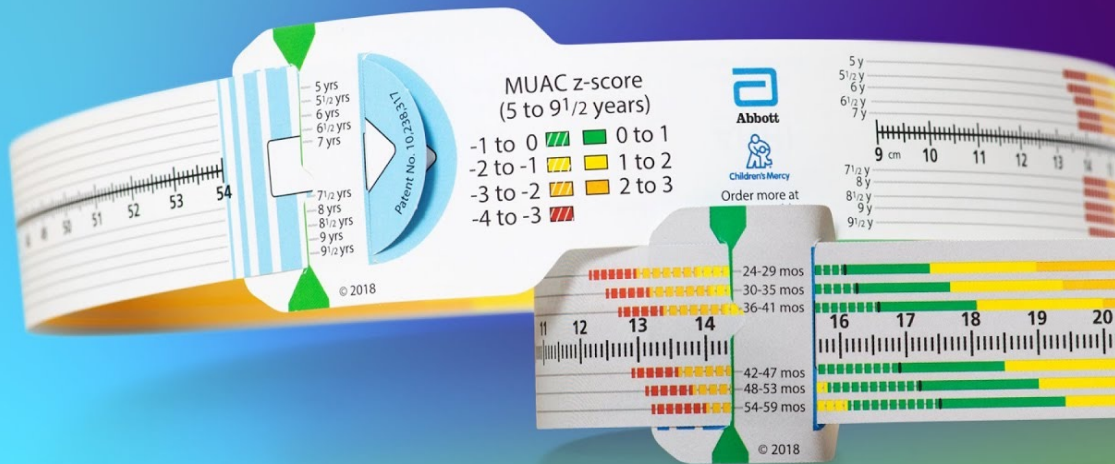
WEIGHT	At initial consult using wheelchair scales	24.4kg <<3 <sup>rd</sup> percentile
	Reported by Mum using home bathroom scales	28.4kg
	Recent hospital appointment	26kg
HEIGHT	Knee height	38cm = estimated height of 127cm (using halfway point of Chumlea (Chumlea W, et al. <i>J Gerontol</i> 1992;47(6):M197-203) and Gauld equations (Gauld LM, et al. <i>Dev Med Child Neurol</i> 2004;46(7):475–480) <<< 3 <sup>rd</sup> percentile on CDC charts for girls
MUAC	Using a measuring tape	Left 19cm 25 <sup>th</sup> – 50 <sup>th</sup> percentile (Frisancho A. <i>AJCN</i> . 1981;34:2540-2545)
TSF	Using skinfold callipers	Left TSF: 4.6mm <<3 <sup>rd</sup> percentile (Addo O, et al. <i>AJCN</i> . 2010;91:634-42)  Right TSF: 6.2mm <3 <sup>rd</sup> percentile (Addo O, et al. <i>AJCN</i> . 2010;91:634-42)

# 2 year follow up

- Gastrostomy fed for last 12 months
- Weight: 32.8kg (<3<sup>rd</sup> percentile)
- MUAC:

Method	Measurement	Interpretation
Tape	24.0cm – left 23.2cm - right	>95 <sup>th</sup> percentile (Frisancho A. <i>AJCN</i> . 1981;34:2540-2545) 90 <sup>th</sup> -95 <sup>th</sup> percentile (Frisancho A. <i>AJCN</i> . 1981;34:2540-2545)
MUAC z-score tape	24.0cm – left 23.2cm - right	Mild undernutrition Mild to moderate undernutrition

# USING THE MUAC Z-SCORE TAPE



Easily carried out with minimal effort

Traffic light system allows parents/caregivers to easily understand risk

Families or other health professionals such as GPs or community nurses in rural and remote locations could be trained to use the MUAC z-score tape

Allows for tracking over time with serial measurements – better for disability population esp. rare conditions

Very well tolerated by children with trauma backgrounds

Can be performed with the person in a standing, sitting or recumbent position – more practical with physical limitations

Generally, requires one person to take the measurement, with exception of those who experience limb spasticity where a second person may be required to support keeping the limb still

# SUMMARY

- MUAC offers a useful alternative measurement in children with disabilities
- MUAC z-score tape helps overcome some of the barriers to anthropometry assessment in paediatric disability
- Valuable for practices who cannot afford expensive equipment (e.g. skinfold callipers and wheelchair scales or mobile practices)
- Families or other health professionals in rural and remote locations could be trained to use the MUAC z-score tape for self-monitoring, saving on travel costs and time
- Use in conjunction with other anthropometry data and clinical judgement

## Contact information

E: [aimee@aimhightherapy.com.au](mailto:aimee@aimhightherapy.com.au)


W: [aimhightherapy.com.au](http://aimhightherapy.com.au)

Facebook: [Aim High Therapy Services](#)

THANK YOU



**Aim High**  
THERAPY SERVICES



# **BEYOND HEIGHT AND WEIGHT: CLINICAL IMPLICATIONS OF MID- UPPER ARM CIRCUMFERENCE**

**KAREN STEPHENS, MS, RD, CSP, LD**

# DISCLOSURES

This educational event is supported by the Abbott Nutrition Health Institute

No conflicts of interest



# OBJECTIVES

Discuss why and how MUAC measurements were initiated in clinical practice

Describe best practice strategies for dietitians and others utilizing MUAC in assessments

Evaluate case examples of implementation of MUAC in pediatric practice

# POLLING QUESTION

How many times have you used MUAC measurements in your practice in the past 6 months?

- a. 0
- b. 5-10 times
- c. 25-50 times
- d. >50 times

# MALNUTRITION IS EVERYWHERE

In developing and developed nations

Energy imbalance—deficiency and excess

- Underweight
- Obesity
- Acute/chronic diseases
- Micronutrient deficiencies
- Socioeconomic issues



Negative impacts of malnutrition

Improper growth and development

- Increased disease risk
- Negative psychological effects
- Increased medical demands & expense

Identification and intervention for malnutrition are critical

“How can we improve?”

# RECOMMENDED MALNUTRITION INDICATORS

**Table 2.** Primary indicators when only a single data point is available for use as a criterion for identification and diagnosis of malnutrition related to undernutrition: Academy of Nutrition and Dietetics/American Society of Parenteral and Enteral Nutrition 2014 Pediatric Malnutrition Consensus Statement.

Primary indicators	Mild malnutrition	Moderate malnutrition	Severe malnutrition
Weight for height z score	-1 to -1.9 z score	-2 to -2.9 z score	-3 or greater z score
BMI or age z score	-1 to -1.9 z score	-2 to -2.9 z score	-3 or greater z score
Length/height z score	No data	No data	-3 z score
Mid-upper arm circumference	Greater than or equal to -1 to -1.9 z score	Greater than or equal to -2 to -2.9 z score	Greater than or equal to -3 z score

# WHY MUAC?



MUAC

“An independent indicator for diagnosing pediatric malnutrition.”<sup>1</sup>

“MUAC should be part of the full anthropometric assessment in all patients.”<sup>2</sup>

“MUAC...a more sensitive prognostic indicator for mortality than weight-for-height parameters in malnourished pediatric patients.”<sup>3</sup>

<sup>1</sup> Mei Z, et al. *Bull World Health Organ.* 1997;75(4):333-341.

<sup>2</sup> Becker P, et al. *J Acad Nutr Diet.* 2014;114(12):1988.

<sup>3</sup> Briend A, et al. *Matern Child Nutr.* 2012;8(1):130-133.

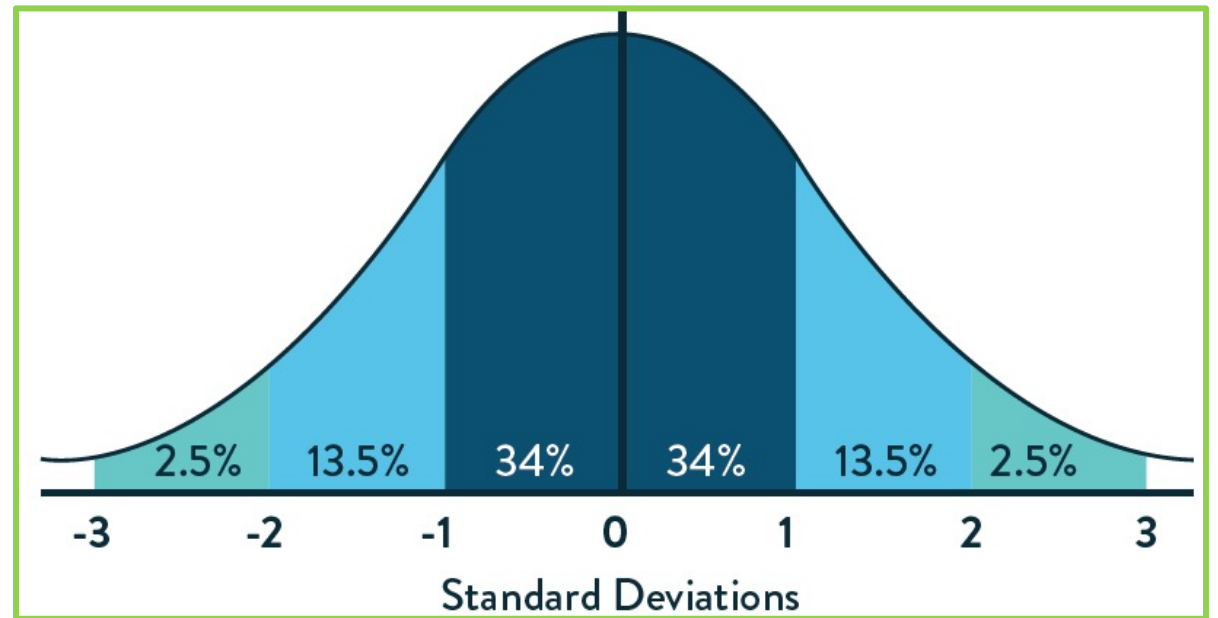
# PERCENTILES TO Z-SCORES

## Z-Score

- Measure of the distance from the mean, positive or negative
- Useful at the extremes
- Can be measured across measures and populations

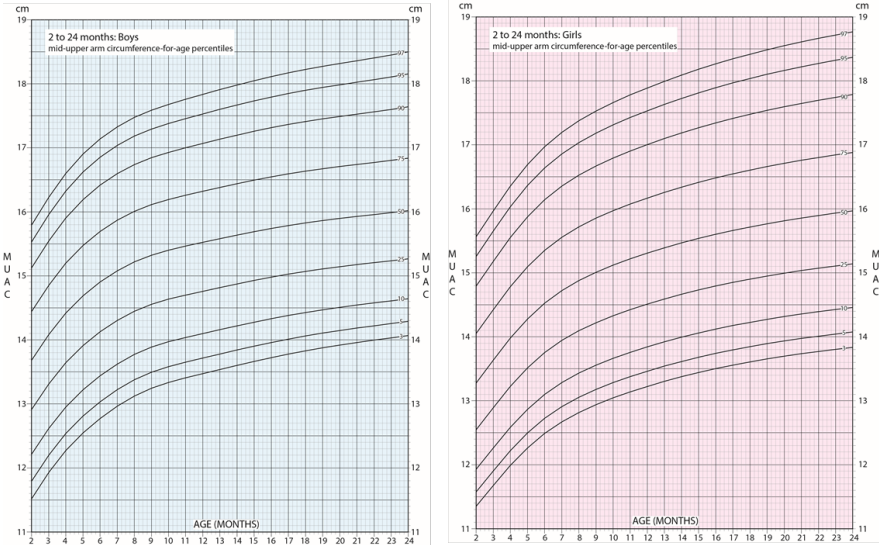
## Percentile

- Ranking in a population, positive only
- Limited at extremes
- Stepwise increase may reflect different absolute changes

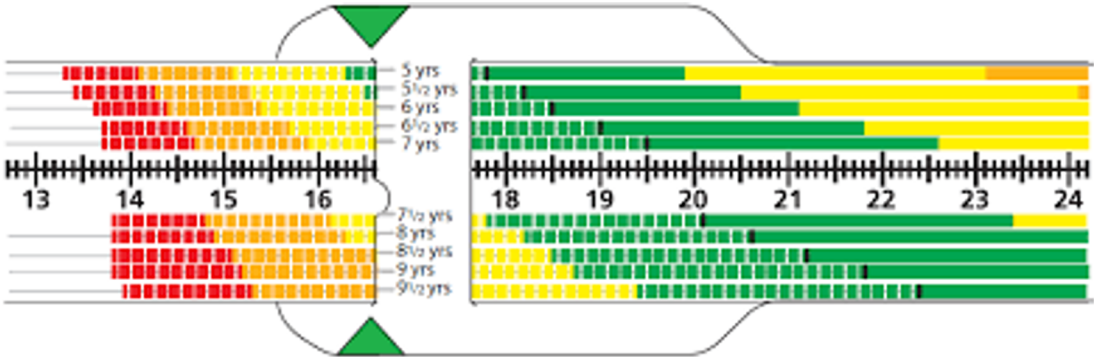


# MUAC GROWTH CHARTS VS Z-SCORE TAPES

MUAC Growth Charts



MUAC Z-Score Tapes

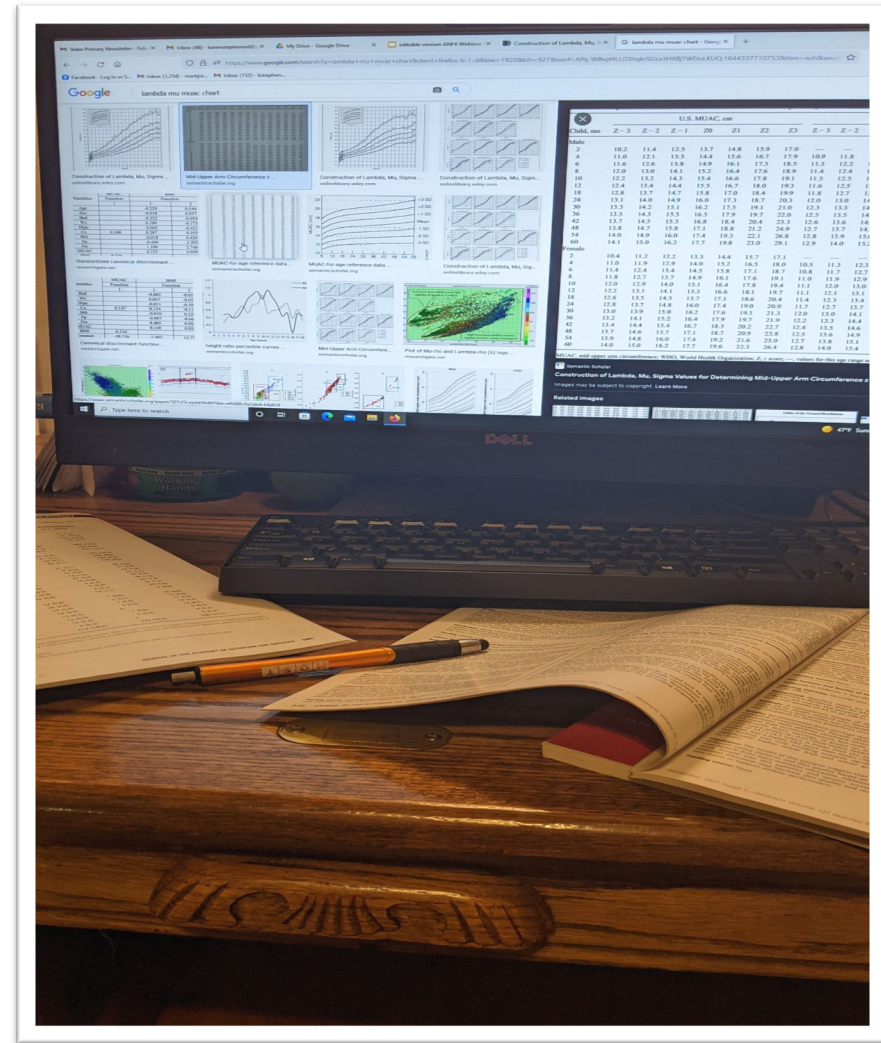


# HOW TO IMPLEMENT MUAC IN PRACTICE

Preliminary efforts:

Set up a Pediatric Malnutrition Committee

- Review new indicators; researched malnutrition
- Develop implementation plan, timeline





# ROLL-OUT PLANS

## Pediatric malnutrition competency training

- Written resource materials and MUAC z-score tapes provided
- Training on correct measuring MUAC
- Practice sessions, practice, practice
- Competency quiz

## All staff required to participate - 10 measurements per week

- Modified electronic health record (EHR) to allow entry for MUAC data and z-scores
- Managers monitoring and retraining
- Feedback from useability of MUAC z-score tape study<sup>1</sup>
- Collected data to compare MUAC and BMI<sup>2</sup>

<sup>1</sup>Thaete K, et al. *Glob Pediatr Health*. 2019;6:2333794X19861575.

<sup>2</sup>Stephens, K et al. *Nutr Clin Pract*. 2018;33(1):124-132.

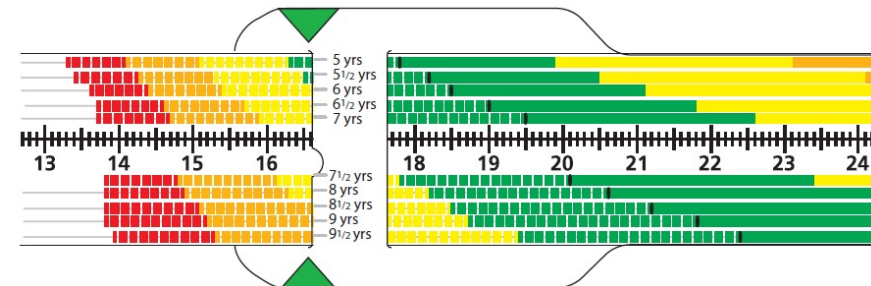
# RESPONSE TO USING MUAC MEASUREMENTS

## Initially:

- “Uncomfortable”, “different”
- New criteria—lots of questions
  - How do I use MUAC?
  - How do I use z-scores?
  - Are the indicators accurate?
- Confidence increased with use
- Identified malnutrition more frequently

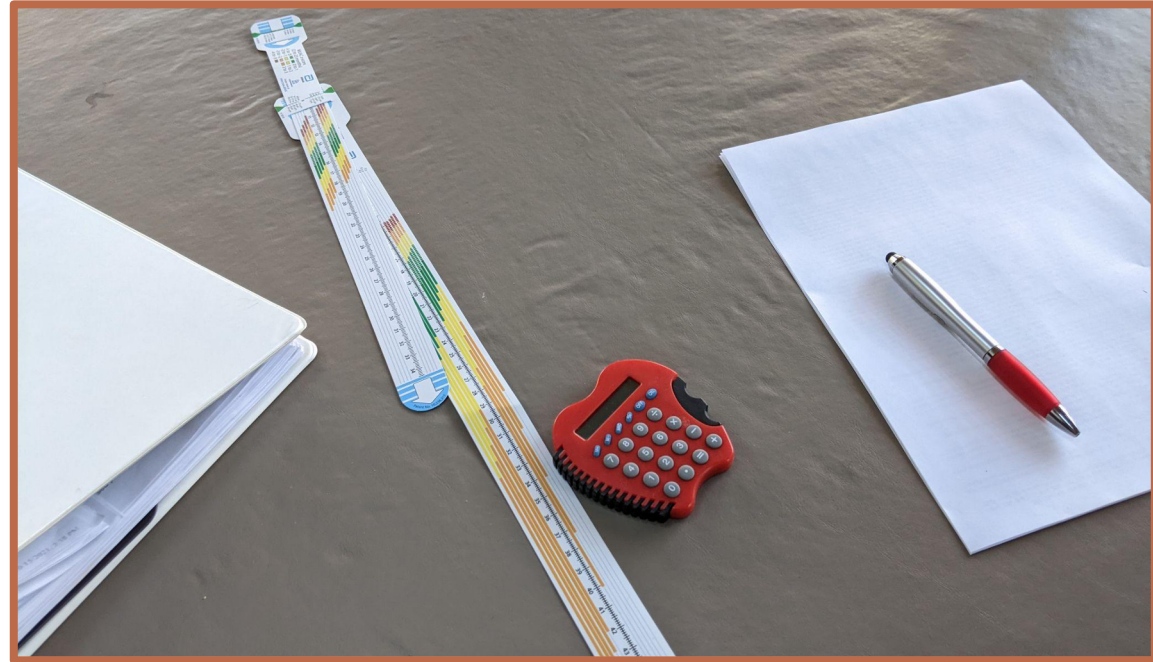
## After Use of MUAC:

- Easy, convenient, and portable
- Adds one more piece of information
- Can use when other measures are not available
- Requires limited equipment; inexpensive
- May be more sensitive to changes in muscle and fat mass than BMI
- We love them!



# IN CLINICAL PRACTICE

Have tapes available—cannot measure without a tool



# MAKE IT CONVENIENT



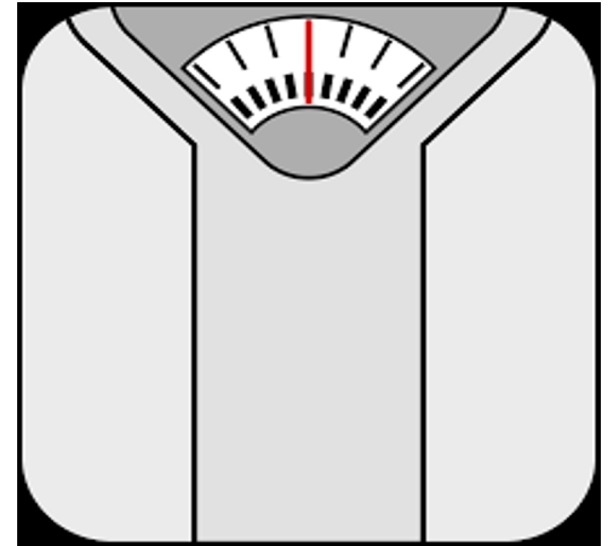
# WHEN TO MEASURE MUAC IN CLINICAL SETTINGS

As standard part of nutrition assessment

- When measuring height and weight, measure MUAC also
- May be someone other than RD

During nutrition-focused physical exam, measure MUAC

- Start at top of head and move down
- When examining shoulders and arms, ask “Is it okay if I measure your muscles?”



# TEACHING TOOL

## Parents:

- Ask about it
- Discuss growth in a non-threatening way
- Compare child's measurement to what is normal-for-age
- Shows progress when growth occurs
- Color-coded tapes (red, orange, green) are easy to understand

## Other Healthcare Professionals

- What are you measuring? Why?
- Helps them pay more attention to nutrition status of patients
- Another way to monitor how a child is doing



# MUAC MEASUREMENTS AS AN INDEPENDENT INDICATOR

When unable to  
obtain weight

When no scale  
available

## Patients:

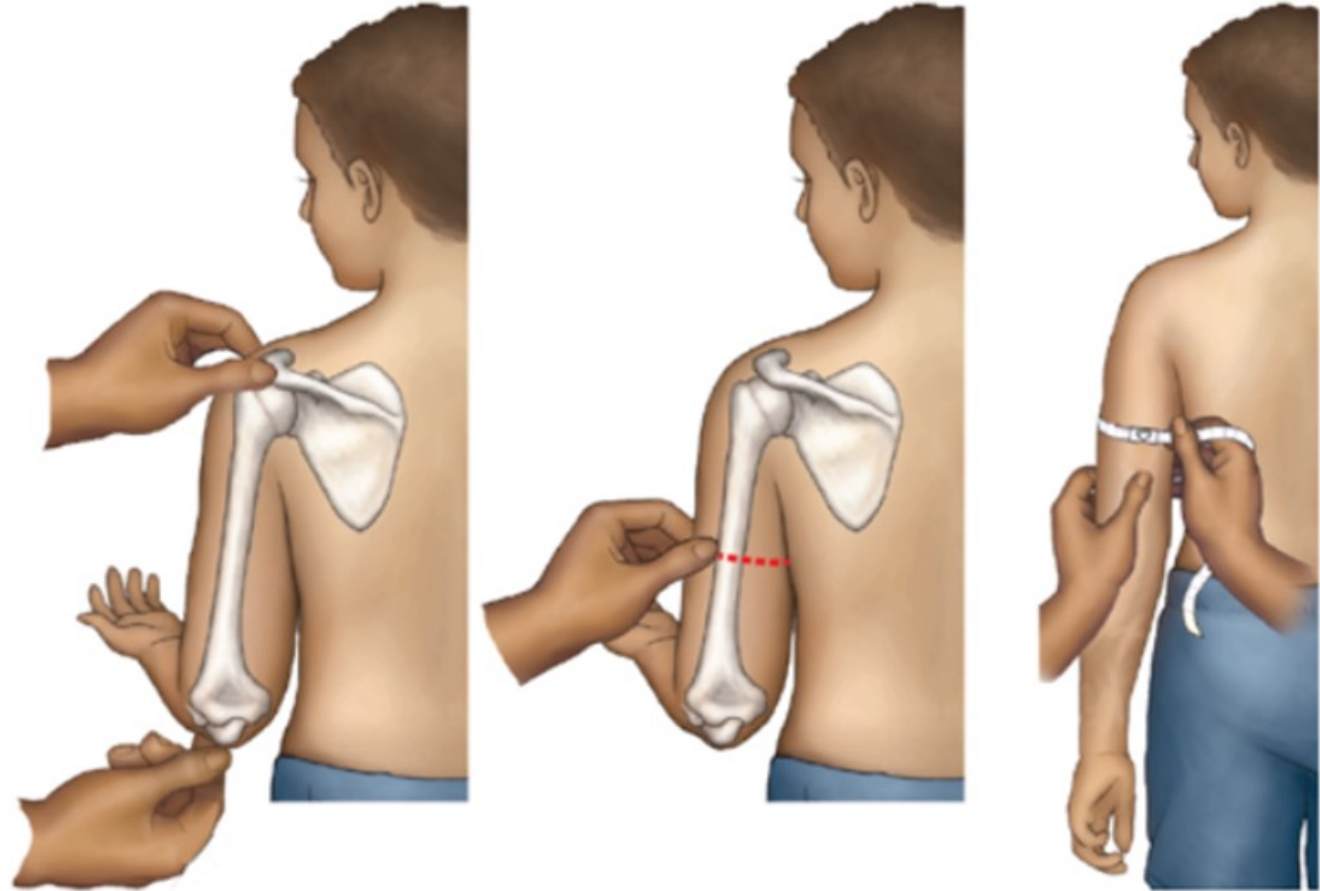
- Physical anomalies
- Edema
- Ascites
- Taking steroids

# TRAIN OTHERS TO MEASURE

Health professionals

- Medical assistants
- Nurses
- Home health workers

Parents/caregivers





# TELEHEALTH

RD is not in same location with patient

- Difficult to assess well without measurements
- Family may not have a scale

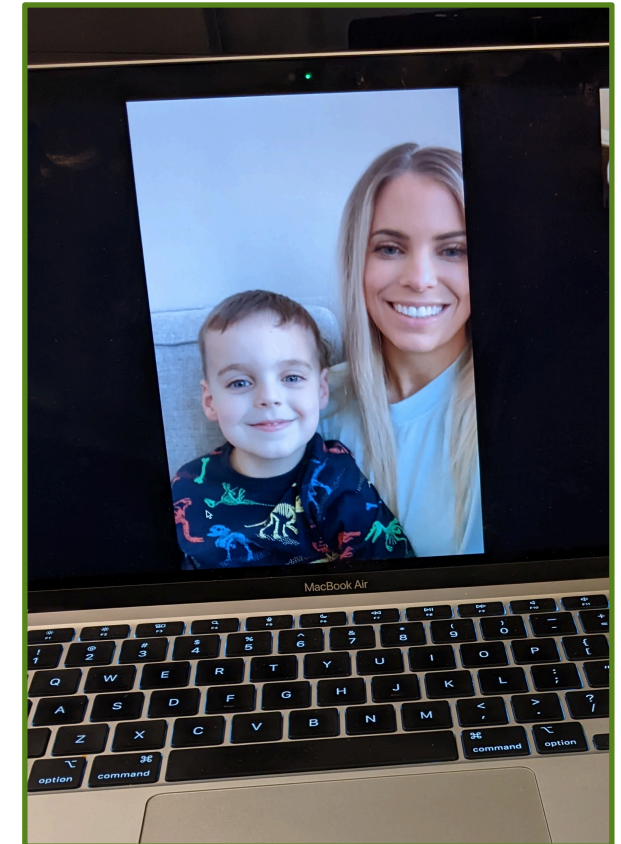
Gives baseline information

Child is his own control

Indicates increases or decreases in measurements

Shows in real time what is happening

Measurements taken at regular intervals—may be reported to RD



# USE FOR PATIENTS WHO ARE FAR FROM HOSPITAL OR CLINIC

Some patients cannot come to hospital or clinic

No accurate scales available

Train parents to measure MUAC while in clinic; provide a tape

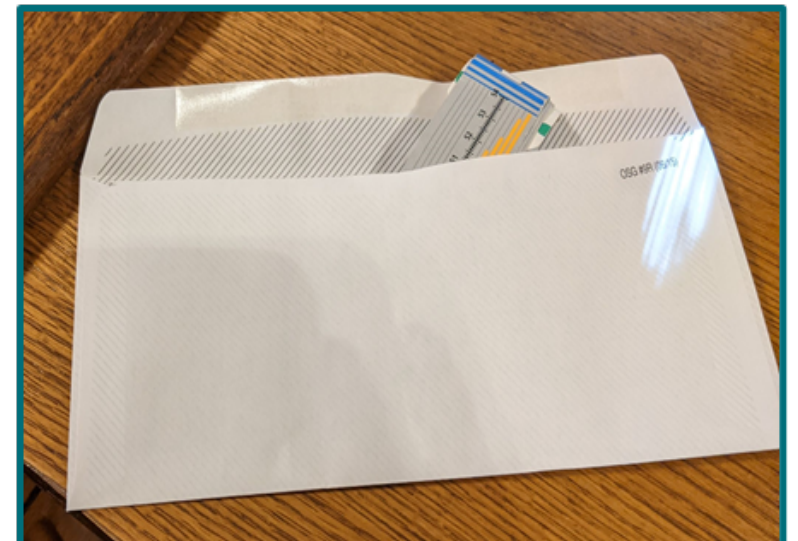
OR...

Mail MUAC tape along with instructions for measuring

Parents submit numbers to RD at set intervals

Patient portal

Secure email



# COMMUNITY HEALTH OR HOME VISITS

Scales not always available, especially for children or teens

MUAC measurements can provide point of reference for growth



# USE IN OBESITY AND EATING DISORDERS

## Benefits to using MUAC:

- Patient may be sensitive about size or have poor body image
- “Measuring muscle” may be less threatening than weight
- May help parents recognize health risk

## Limitations with obesity:

- Difficult to find acromion process on shoulder area due to excess tissue
- Tape does not always lie flat on upper arm

# VALUE IN SPECIAL POPULATIONS

Cerebral palsy

Cystic fibrosis

Renal patients

Orthopedics

Muscle & fat deposition are sometimes different

## MUAC AND CYSTIC FIBROSIS

Cystic Fibrosis (n=262)

Dietitian Classification	BMI z-score	MUAC z-score
Overweight/Obese	100%	13%
Normal	85%	80%
Mild Malnutrition	24%	79%
Moderate Malnutrition	20%	58%
Severe Malnutrition	73%	81%
Overall	55%	73%

# DATA COLLECTION

Valuable to contribute to overall pool of knowledge

Research done at Children's Mercy indicates that thresholds need to be refined

Need more data from more places



# BARRIERS TO USING MUAC MEASURES

1

## No available tapes

- Can use standard measuring tape and MUAC growth charts
- MUAC z-score tape is easier; provides detailed information as a snapshot

2

## Inexperience measuring

- Follow guidelines carefully; accuracy is important
- Practice

3

## Families are unfamiliar with MUAC

- Teaching tool about nutrition status
- Let them observe and practice measuring their child

# CASE EXAMPLE: 1

8-year-old had major spine surgery and is in a whole-body cast

Unknown weight of the cast and difficult to weigh child

Child has been eating very little. Parents concerned about child healing without good nutrition

Had MUAC measurement prior to surgery RD taking weekly MUAC measures

Noted 1 cm loss in MUAC measurement Increased nutrition supplementation to provide calories and nutrients until patient can resume prior intake





# CASE EXAMPLE: 2

Severely underweight baby brought to Nutrition Clinic

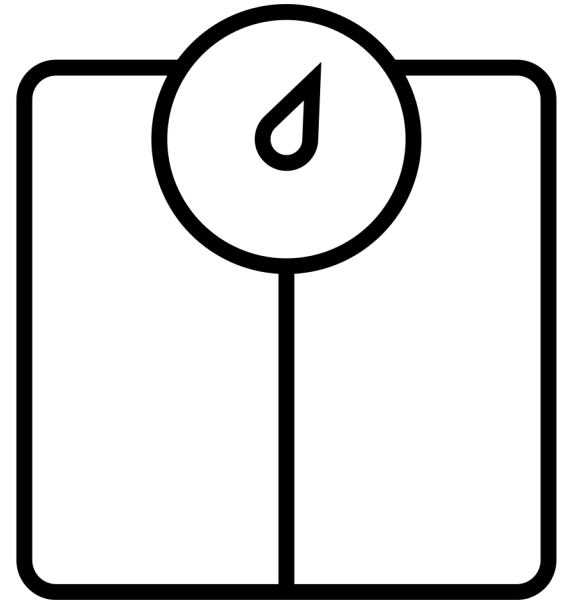
Parents state they are doing all they can to provide nutrition to him

RD and parents came up with plan to improve intake

Follow-up set for 6 weeks

Family returned; pt gained weight and had increase in MUAC measurement

Family stated they “could see that he had grown from the increase in his arm measurement”



# KEY TAKEAWAYS

Malnutrition is a problem in all areas of the world. MUAC is valuable as an additional tool to assess nutritional status

MUAC tapes are simple to use, convenient, and provide important screening data for quick assessment

Use of MUAC measurements may be particularly helpful when scales are not available, in special health populations such as cystic fibrosis and orthopedics, and by parents for at-home monitoring

# POLLING QUESTION

On a scale of 1 to 5 with 5 being the highest, how likely are you to utilize MUAC z-score measurements with your patients or clients in the next 3 months?

- a. 1
- b. 2
- c. 3
- d. 4
- e. 5

# Thank You!

