Magic in the Measures: Tools, Types and Techniques

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Annual Dialysis Conference March 2019

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UMKC School of Medicine

BEST CHILDREN'S HOSPITALS U.S.News RANKED IN 10 SPECIALTIES 2018-19

MAGNET RECOGNIZED

Disclosures

- Nothing to disclose

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Anthropometry Puzzle

Case Report: 5 yr old male MR

- Vent dependent,
- ESRD on HD
- Liver disease s/p transplant
- Bowel perforations/enteric fistulas
- Ileostomy
- SEVERE rickets with wrist/ankle deformities
- Hx TPN dependence, now on IL + enteral feeds
- Impaired mobility
- Developmental and Speech/Language delay

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MR

- Need to monitor adequacy of:
  - Current feeding regimen
  - Growth
  - Nutritional status

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Objectives

- Review various uses of anthropometry in pediatric renal patients
- Review types of direct, indirect, and body composition measures
- Discuss the pediatric renal considerations of various anthropometric measures

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Anthropometry in Pediatric Renal

Nutrition Implications	Medical Implications	Outcomes
• Nutrition Status • Obesity • Malnutrition	• Medication dosing • Medical treatment interventions • Growth hormone	• Growth failure association with mortality • Time to transplant

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Frequency of Assessment

Table 1. Recommended Parameters and Frequency of Nutritional Assessment for Children with CKD Stages 2 to 5 and ID

	Minimum Interval (mo)								
	Age 0 to <1 y			Age 1-3 y			Age >3 y		
Measure	CKD 2-3	CKD 4-5	CKD ID	CKD 2-3	CKD 4-5	CKD ID	CKD 2	CKD 3	CKD 4-5	CKD ID
Dietary intake	0.5-3	0.5-3	0.5-2	1-3	1-3	1-3	6-12	6	3-4	3-4
Height or length-for-age percentile or SDS	0.5-1.5	0.5-1.5	0.5-1	1-3	1-2	1	3-6	3-6	1-3	1-3
Height or length velocity-for-age percentile or CDS	0.5-2	0.5-2	0.5-1	1-3	1-3	1-2	6	6	6	6
Estimated dry weight and weight-for-age percentile or SDS	0.5-1.5	0.5-1.5	0.25-1	1-3	1-2	0.5-1	3-6	3-6	1-3	1-3
BMI-for-height-age percentile or SDS	0.5-1.5	0.5-1.5	0.5-1	1-3	1-2	1	3-6	3-6	1-3	1-3
Head circumference-for-age percentile or SDS	0.5-1.5	0.5-1.5	0.5-1	1-3	1-2	1-2	N/A	N/A	N/A	N/A
nPCR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1*

Abbreviation: N/A, not applicable.
*Only applies to adolescents receiving HD.

S16 *American Journal of Kidney Diseases*, Vol 53, No 3, Suppl 2 (March), 2009: pp S16-S26

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Training

Calibration of scale:
Was standard weight used and was result within 10 grams?
Was calibration done twice?
Calibration of length board
Was the standard length used and was result within 0.2 cm?
Was calibration done twice?
Technique for weighing baby
Was baby naked?
Was weight done twice?
Were the two weights within 100 grams of each other?
Technique for length measurement
Was a helper present?
Was the head held in the proper position?
Were socks removed?
Was at least one leg extended fully?
Was length measured twice?
Were the length measurements within 0.7 cm of each other?
Technique for head circumference measurement:
Was the proper tape used (i.e., not a paper tape)?
Were headbands and barrettes removed?
Was the tape placed in the proper position?
Was the measurement done twice?
Were the head circumference measurements within 0.5 cm of each other?
Were appropriate infection control policies used or described?

- Use of standard training process and standard operating procedure (SOP)
  - Standardized staff training
  - Post test
  - Regular follow up monitoring (annually?)
- Trained staff complete measurements regularly
- Include importance of accuracy and impact it has on patient care

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(Coburn-Miller 2015)
https://wicworks.fns.usda.gov/wicworks/Sharing_Center/PA/Anthro/lib/pdf/Anthropometric_Training_Manual.pdf

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Aiming for Accuracy

- Equipment ready
  - Cleaned
  - Calibrated
- Patient readiness
  - Understands what will happen
  - In correct position
- Recording measure
  - Read at correct location
  - Avoid Parallax – observer error due to reading measuring tape at an angle
- Clinical considerations
  - Correction for prematurity
  - Considering medical/diagnosis related needs

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Types of Measures

- Direct
  - using a system or tool to directly read the height, length or any other aspect of an object to determine its measurement
- Indirect
  - take the measurement of one unit/object and convert it so that it matches the characteristics of something else

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https://www.mtiinstruments.com/knowledge-center/what-is-measurement-measurement-definition-all-you-need-to-know/

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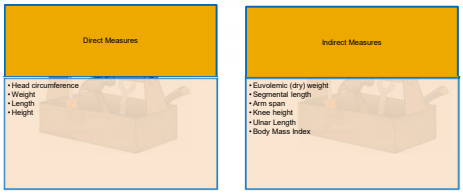
Anthropometry tool box



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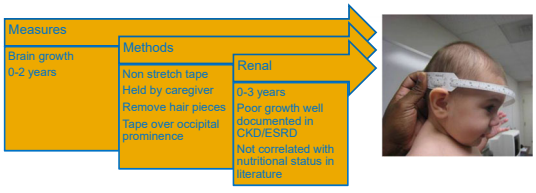
Head Circumference



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https://www.cdc.gov/nchs/data/nhanes/2015-2016/manuals/2016_Anthropometry_Procedures_Manual.pdf
KDOQI 2009

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Weight

Measures
- Any age
- Growth
- Adequacy of nutrition

Method
- Digital Scale
  - calibrate weekly
  - Balance to zero
- Infants dry diaper only
- Children no shoes
- HD: mid-week post dialysis weight
- PD: monthly clinic visit subtract PD fluid of last fill

Renal
- Medical diagnosis
- Dietary intake
- Rate of weight change
- NFPE: edema, dehydration, cramping
- Blood pressure and change in blood pressure with fluid removal
- Laboratory values & calculations: sodium, albumin, GFCR, PNA



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(KDOQI 2009)
http://www.who.int/childgrowth/training/module_b_measuring_growth.pdf
https://wwwn.cdc.gov/nchs/data/nhanes/2015-2016/manuals/2016_Anthropometry_Procedures_Manual.pdf

Recumbent Length

Measures
- 0-2 yrs supine
- 2-3 years unable to stand
- Subtract 0.7 to obtain standing height

Methods
- Infantometer
- 2 people required
- Knees firmly down
- Feet flat, toes point up
- Record 0.1cm
- Repeat 2x

Renal considerations
- Short stature well documented in CKD/ESRD
- Dietary
- Metabolic acidosis
- Salt wasting
- Secondary hyperparathyroidism
- Inadequate dialysis
- Short stature associated with increased morbidity



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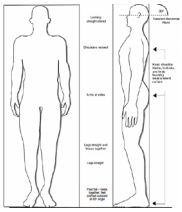
https://wwwn.cdc.gov/nchs/data/nhanes/2015-2016/manuals/2016_Anthropometry_Procedures_Manual.pdf
KDOQI 2009

Height

Measures
- >2 yr able to stand
- >30cm

Methods
- Stadiometer
- Calibrate weekly w/ 80 cm metal calibration rod
- Measure to 0.1cm
- Repeat 2x

Renal
- Short stature well documented in CKD/ESRD
- Dietary intake
- Metabolic Acidosis
- Secondary Hyperparathyroidism
- Dialysis prescription
- Salt wasting



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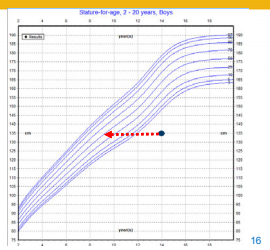
https://wwwn.cdc.gov/nchs/data/nhanes/2015-2016/manuals/2016_Anthropometry_Procedures_Manual.pdf
(KDOQI 2009, Foster 2004)

Height age

- Age at which the child's height would be on the 50th percentile
- Growth and maturation delay common in CKD
- Height age can be a surrogate for maturation stage
- Used to calculate BMI in renal patients in pubertal and peripubertal stages (Tanner stage 2-4)



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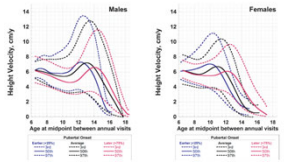
Height Velocity



(Kelly, 2014)

- Change in height per unit time
- Use serial measurements at 6-12 month intervals to assess adequacy of linear growth
- Children < 2 years may use smaller intervals to assess height velocity
- Correct cause of poor linear growth (acidosis, hyperparathyroidism, salt wasting, etc)
- Used to determine eligibility for growth hormone

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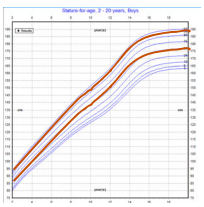
Mid-Parental Height

- Measures genetic potential
- Mid parental height
  - Girls: [(Dad's ht (cm) -13cm) + Mom ht (cm)] / 2
  - Boys: [(Mom's ht + 13 cm) + Dads ht (cm)] / 2
- To obtain 5-95%ile patient specific height
  - 5%ile= Mid parental height –8.5cm
  - 95%ile =Mid parental height + 8.5cm



(Secker 2012)

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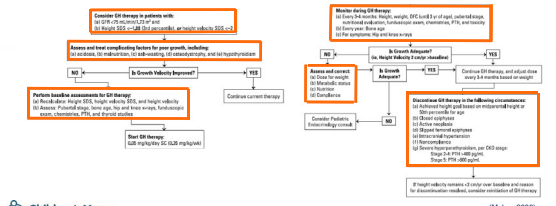
Growth Hormone



(Mahan 2006)

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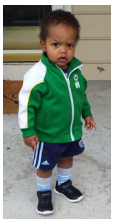
Can't get a height?



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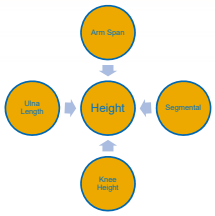
Indirect height measures

- Segmental
- Arm span
- Knee height
- Ulna length



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OL1

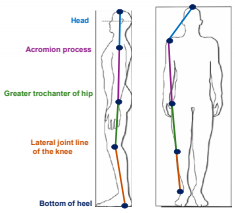
Total Body Segmental Length

Measures

Severe contractures
Unable to lie flat
Spina bifida
Cerebral palsy

Methods

Non-stretch tape
2 people
Measure in 4 segments in supine position
Repeat x 2
High inter-rater reliability
~4 min to complete
Overestimates by ~7cm



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(Haapala 2015)
www.spinabifidaassociation.org

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Arm Span

Measures

>2 years
CP
Spinal cord injuries
Spina bifida
•BMI
•Mid lumbar lesion x 0.95
•High lumbar lesion x 0.9

Methods

Metal ruler c welded right angle at "0"
Patient flat against wall or floor
Arms 90 degree angle
Measure tip of 3rd finger to tip of 3rd finger
Strong correlation standing height 0-6 years
High interrater reliability
Not suitable for contracture/poor muscle tone

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(Dosa 2009)
www.spinabifidaassociation.org

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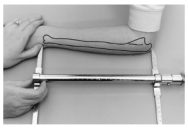
Ulna Length

Measures

Any age (more difficulty in young children)
Duschenne Muscular Dystrophy(DMD)
Spinal Muscular Atropy (SMA)
CP

Methods

Caliper, tape, or grid
Pt sitting, arm 90-110 degrees
Palpate proximal end of ulna and tip of styloid process
High intra & interrater reliability
Positive bias (overestimates)
Caution use individuals for clinical assessment



Harpenden caliper

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(Gauld 2004, Haapala 2015))
www.spinabifidaassociation.org

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Slide 22

OL1 Oladitan, Leah,, 03/12/2019

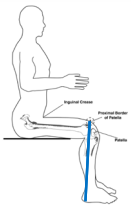
Knee Height

Measures

Bedridden
CP

Methods

Caliper
Heel to anterior surface of femoral condyles
Parallel to tibia
Blade of caliper under heel
High inter-rater reliability
CP children was more closely related to actual height at younger ages/less severe CP



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(Haapala 2015) 25

Height predictive equations

Height prediction equations (using segmental lengths)

Stevenson (Age 0–12)	
Knee height	H = (2.68 × KH) + 24.2
Tibia length	H = (3.26 × TL) + 30.8
Gould	
Males	
Ulna length	H = 4.8052 × 1.308A + 28.003
Knee height	H = 2.423KH + 1.327A + 21.818
Tibia length	H = 2.702T + 1.717A + 36.509
Females	
Ulna length	H = 4.4892 × 1.315A + 31.485
Knee height	H = 2.473KH + 1.187A + 21.151
Tibia length	H = 2.777T + 1.457A + 37.745
Chumlea (Age 6–18)	
White male	H = (2.32 × KH) + 40.54
Black male	H = (2.18 × KH) + 39.60
White female	H = (2.15 × KH) + 43.21
Black female	H = (2.02 × KH) + 46.59

H=estimated height, KH=knee height, A=age, T= tibia length, U=ulna length

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(Haapala 2015)

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Growth Charts

Fenton – until 50 weeks post menstrual age (PMA)

WHO growth charts 0-2 years
- Adjust for prematurity

CDC growth charts 2-18 years

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Alternative growth charts

Growth Chart	Study Sample Information	Ages	Parameters	Limitations	Use With CDC
Achondroplasia	189 males 214 females	0-18 years	• height/age • height velocity/age • upper, lower segment lengths/ age • OFC/age	Small sample size, especially children over 10 years	Compare to CDC weight/ age, length or height/ age; use with CDC for weight/ length or height or BMI/ age
Cerebral palsy*†	360 children (males and females), 0-120 months with spastic quadriplegia	0-10 years	• length/age • weight/age	Both longitudinal and cross-sectional data, small sample size, for spastic quadriplegia only	Use with CDC weight/age, length or height/age, weight/ length or height or BMI/age
Down syndrome	Longitudinal data; 400 males, 300 females; 1960-1986	1-36 mo 2-18 years	• weight/age • length or height/ age	Included children with congenital heart disease, reflects tendency to be overweight	Use with CDC weight/ age, length or height/ age, weight/ length or height, BMI/age
Noonan syndrome	64 males, 48 females	0-20 years	• height/age	Small sample size	Compare to CDC; use CDC for weight/age, length or height/ age, weight/length or height or BMI/age
Prader Willi syndrome	56 males, 36 femalesNote – sample did not receive growth hormone	3-24 years	• height/age	Longitudinal and cross-sectional data, small sample size, do not use if individual received growth hormone	Compare to CDC; use CDC for weight/ age, weight/ height, BMI/age
Turner syndrome	366 females; pooled data; no hormone treatment	2-19 years	• height/age	Small sample size, unequal age distribution	Use with CDC for weight/age, height/ age, weight/height, BMI/age
Williams syndrome	61 females, 47 males	0 to 18 years	• weight/age • height/age • OFC/age	Retrospective and croos	Use with CDC for weight/length or height, BMI/age

*All charts have sex-specific versions for male and female children (except for Turner syndrome charts).
†These growth charts should be used only with children who have cerebral palsy with spastic quadriplegia and may underestimate the growth for a child with mild cerebral palsy or without spastic quadriplegia. More information about growth and children with cerebral palsy can be found at the North American Growth in Cerebral Palsy Project website: http://www.healthsystem.virginia.edu/internet/nagcepp/

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https://www.doh.wa.gov/Portals/1/Documents/8100/961-158-CSHCN-NI-en-L.pdf

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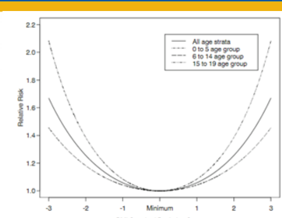
BMI



(Srivaths 2009)

Useful in monitoring nutritional status when calculated with dry weight

Consider height age vs height for those with delayed maturation.

Poor indicator of body composition

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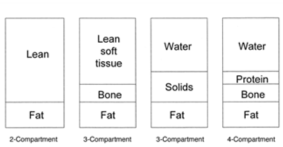
Body Composition



(Foster 2004)

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Body Composition Measures

- Mid upper arm circumference(MUAC)
- Triceps skinfold thickness (TSF)
- Bioelectic Impedance Analysis (BIA)
- Hand Grip Strength (HGS)

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Mid upper arm circumference (MUAC)

Measures

Any age
Marker of malnutrition
Used to calculate arm muscle area (AMA) and arm fat area(AFA)

Methods

Non-stretch flexible tape
Remove clothing on arm
Identify & mark midpoint
Pull snug to 0.1cm
Same arm for serial measurements
Easy,quick

Renal

Consider adjustment height age
Fluid sensitive, obtain post dialysis
Good to monitor trend over time
Pilot study: strong correlation with clinical assessment & BMI related malnutrition/obesity
Lower MUAC z-scores in dialysis vs kidney transplant

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(Payal Modi 2015)

Triceps Skin Fold (TSF)

Measures

Any age
Estimate of regional body fat
Used with MUAC to estimate arm muscle area and arm fat area

Methods

Flexible, non-stretch tape
Harpenden skinfold or Holtain caliper
Identify midpoint
Fold of fat lifted away from underlying Triceps muscle
Read dial to 0.1mm
Requires experience for accuracy

Renal

Consider height age
Difficult to obtain in young children accurately
Inaccurate
- subcutaneous edema
- obesity

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https://www.doh.wa.gov/Portals/1/Documents/8100/961-158-CSMCN-NI-om4.pdf
https://nutritionalassessment.mumc.nl/en/skinfold-measurements

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Bioelectric Impedance Analysis (BIA)

Measures
- >2 years
- Measure of total body water to estimate fat mass & fat free mass
- Phase angle, measure of water distribution between intra & extracellular spaces
- Vector length indicator of hydration status

Methods
- Whole body – 5 segments
- Single frequency
- Multiple frequency or Bioimpedance spectroscopy(BIS)
- Non-invasive, well tolerated, inexpensive, easy to perform
- https://vimeo.com/152199550

Renal
- Can be used to monitor fluid status change over time in pediatric HD
- Tanner stage important in assessment
- Less sensitive indicator of FM in overweight & malnourished

Omronhealthcare.com


https://learn.inbodyusa.com

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(Dasgupta 2018 Wong Vega 2017)
https://www.cdc.gov/nchs/data/nhanes/lbc.pdf

Hand Grip Strength (HGS)

Measures
- Hi years
- Muscle function

Methods
- Hand dynamometer
- Calibrate before each use with hanging weights.
- Pre-test patient
- Non-fistula hand
- Adjust grip
- Patient standing for test
- Rapid, inexpensive, objective, non-invasive

Renal
- One pediatric study (Egypt): ~70% CKD/ESRD had HGS <10%ile
- Median HGS significantly lower in non-glomerular cases vs. glomerular(P<0.001)
- No muscle wasting classification system yet determined.
- Cannot use if surgery within the past 3 months (fistula placement)

dynamometer

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(Abd El Basset Bakr, 2018)
https://wwwn.cdc.gov/nchs/data/nhanes/2011-2012/manuals/muscle_strength_proc_manual.pdf

Measure	Potential problem with CKD	Effect on Nutrition Assessment
Head circumference	Severe edema in infants	Overestimation of nutrition
Length/Height	Growth failure due to gH, acidosis, delayed puberty hyperparathyroidism	Underestimates nutrition
Euvolemic weight	Fluid overload increases weight	Overestimates nutrition
MUAC	Altered distribution of fat & muscle mass	Overestimates nutrition
Skinfold thickness	Fluid overload increases subcutaneous tissue Altered regional distribution of fat mass	Overestimates or underestimates nutrition status
BIA	Fluid overload with abnormal fluid distribution	Unpredictable effect on FFM from TBW

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Adapted from Foster 2004

Anthropometry Puzzle

Case Report: 5 yr old male MR

- Vent dependent,
- ESRD on HD
- Liver disease s/p transplant
- Bowel perforations/enteric fistulas
- Ileostomy
- SEVERE rickets with wrist/ankle deformities
- Hx TPN Dependence, now on IL + enteral feeds
- Impaired mobility
- Developmental and Speech/Language delay

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Take Away

- All anthropometric measures have limitations
- Training and practice are required for proficiency
- Use of multiple measures needed to obtain best overall picture
- Serial measures likely most beneficial to monitor nutritional status
- Need more studies in peds renal....anyone?

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Thank you

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