

Hydration in infants and children

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Homeostasis – the key to adequate hydration

In healthy children:

- Large variations in daily intake of water
- Tolerance due to body's homeostatic mechanisms
- Kidney adjusts
absorption & excretion of water
→ maintain plasma osmolality 275-290mOsm/kg
plasma sodium 135-145mmol/l
- No need for exact precision in determining requirements for water

Getting the right balance

Water in (+ve balance)

- Drinking
- Produced by body in oxidative metabolism

Water out (-ve balance)

- Urine – 60%
- Skin and lungs – 35%
- Stool – 5%

Water balance maintained within $\pm 0.2\%$ (Grandjean et al, 2003)

Fluid requirements

Young infants ~150ml/kg

Toddler ~100ml/kg

Adult ~50ml/kg

Water depletion more likely in children

Why do infants and children have higher fluid requirements?

1. Body composition

Larger Total Body Water content

Foetus >90% total body mass

Term infant ~ 75%

↓ during 1st year of life

Remains stable until puberty

Adult 60% males

50% females

Why do infants and children have higher fluid requirements?

2. Higher surface to mass ratio

↑ water losses through the skin

More susceptible to changes in temperature

3. Higher respiratory & metabolic rate

↑ water lost via lungs

Dramatic growth in 1st year of life

(3 x weight gain; 50% ↑ in length)

Continuing growth to adolescence

Why do infants and children have higher fluid requirements?

4. Immature renal function

Foetus produces urine from ~ 10th week of gestation

At birth glomerular & tubular function deficient

Glomerular Filtration Rate is low

Impacts water & electrolyte homeostasis & excretion of waste products

Low concentrating capacity

∴ if water depleted

→ the kidney still produces dilute urine

Immature renal function

	2 weeks	8 weeks	1 year
Maximum urine osmolality (mOsm/kg H ₂ O)	700-800	1000-1200	1200-1400
GFR (ml/min/1.73m ²)	35-45	75-80	90-110

(from Guignard & Drukker in *Clinical Paediatric Nephrology*, eds Webb & Postlethwaite, 2003)

Other risks for water depletion

5. Thirst sensitivity

Learned behaviour *dryness* → *drinking*

↑ 1-2% in plasma osmolality → thirst reflex

Children don't display this thirst sensitivity

→ long periods without drinking (Box & Landman, 1994)

→ may not drink enough after exercise (Bar-Or et al, 1980)

Other risks for water depletion

6. Body cooling mechanisms & heat tolerance

↓ sweat rates (Meyer et al, 1992)

↓ acclimatisation to heat (Falk & Dotan, 2008; Bytowski & Squire, 2003)

↑ risk when exercising (AAP, 2000)

Lack of recognition of need to replace lost fluids

Infants & children are at greater risk for dehydration because of their age

Physiological

- Body composition
- Higher surface to mass ratio
- Higher metabolic rate
- Immature renal function
- Less heat tolerant
- Decreased thirst sensitivity

Developmental and social

- Dependency on caregivers

Dependency on care givers

- **Infants & toddlers cannot *ask* for drinks**
Must be given regular fluids
Rely on caregivers to pick up on cues
hunger vs thirst
Lack of awareness of insensible water losses
- **Inadequate *spontaneous* intake**
Lack of thirst response

Signs of dehydration

Only ~ 2/3 parents can identify > 1 sign of dehydration

(Gittelman et al, 2004)

Degree of dehydration	Infant	Older child
Mild <5% infant <3% child	Thirsty, alert, restless, ↓urine	
Moderate 5-10% infant 3-6% child	Lethargic, drowsy, sunken eyed, ↓ urine	Alert, postural dizziness, sunken eyed, ↓ urine
Severe >10% infant >6% child	Limp, cold, °urine ↓ consciousness	Apprehensive, cold, °urine, cramps

Water requirements for infants and children

Need for water highly individual & multifactorial:
age, gender, body mass, environment, activity

Difficult to define *universal recommendation* for populations

- **European Food Safety Authority 2008***
- **Institute of Medicine 2005****
- **World Health Organization 2003, 2005***

*includes water from beverages and food

**includes water from beverages, food and water absorbed during cooking

Based on water intakes & urine osmolality, not hydration status

Comparison of recommendations – infants

Age months	EFSA 2008 Draft Dietary Reference Values	Institute of Medicine 2005 Adequate Intakes	WHO 2003, 2005 Requirements
0-4			750 ml/d
0-6	100-190 ml/kg/d	700 ml/d	
6-12	800-1000ml/d		
7-12		800 ml/d	
8-12			1000 ml/d

Fluid requirements for infants

Young infant (0-6m)

Fluid = nutrition

- **Breast fed**

Demand breast feeding provides fluid & nutritional requirements

-150ml/kg

-100kcal/kg

-130ml water/kg

No extra fluid needed



Fluid requirements for infants

Young infant (0-6m)

Fluid = nutrition

- **Formula fed**

- 150ml/kg
- 100kcal/kg
- 130ml water/kg

May require extra cooled boiled water



Fluid requirements for infants

Older infant (6-12m)

- Fluid derived from weaning foods
- High water content: fruits & veg 90-95%

6 month old

wt 7kg

120ml/kg formula = 840ml = 80kcal/kg

2 x 120g fruit/veg = 220ml = 20kcal/kg

Total fluid = 150ml/kg

Once weaning is established

- Foods have lower water content
 - Rice & pasta 65-80%
 - Fish 70-80%
 - Meat 45-65%
 - Bread 30-45% (Grandjean & Campbell, 2004)
- Water with meals (from a clean cup or beaker)
 - Tap water or bottled water (NB Na < 200mg/l)
 - Does not need to be boiled
 - Do not need fruit juices or baby juices

Comparison of recommendations – children

Age (y)	EFSA 2008 Draft DRV	IoM 2005 Adequate Intakes	WHO 2003, 2005 Requirements
12-24 m	1.1-1.2 l/d		
1-3		1.3 l/d	1.0 l/d
2-3	1.3 l/d		
4-8	1.6 l/d	1.7 l/d	
9-13 (boys)	2.1 l/d	2.4 l/d	
9-13 (girls)	1.9 l/d	2.1 l/d	
14-18 (boys)		3.3 l/d	
14-18 (girls)		2.3 l/d	

How much do children actually drink?

National Diet and Nutrition Survey 2008/09

Doesn't include fluid from food

Fluid	1½ - 3 y	4 - 10 y	11 - 18 y
Milk whole, skimmed semi-skimmed,	278	187	141
Beverages fruit juice, soft drinks, tea, coffee, water	527	668	1025
Total	805	855	1166

Are our children chronically dehydrated?

Age (y)	NDNS 2008/09		EFSA 2008	IoM 2005	WHO 2003, 05
	Recorded	Total			
1 - 3	805ml (+ 400ml)	1205ml		1300ml	1000ml
4 - 8	855ml (+ 500ml)	1355ml	1600ml	1700ml	
14 - 18 boys	1264ml (+ 600ml)	1864ml		3300ml	
14 - 18 girls	1060ml (+ 500ml)	1560ml		2300ml	

Risks of having too much water

Neonate cannot efficiently excrete water load

Infants and toddlers

- Small stomach volume
- Decreased appetite
- Inadequate energy and nutrients
- Faltering growth

Case study

1 year old girl

At birth weight, length on 25th centile
HC on 9th centile

At 1 year dramatic faltering growth

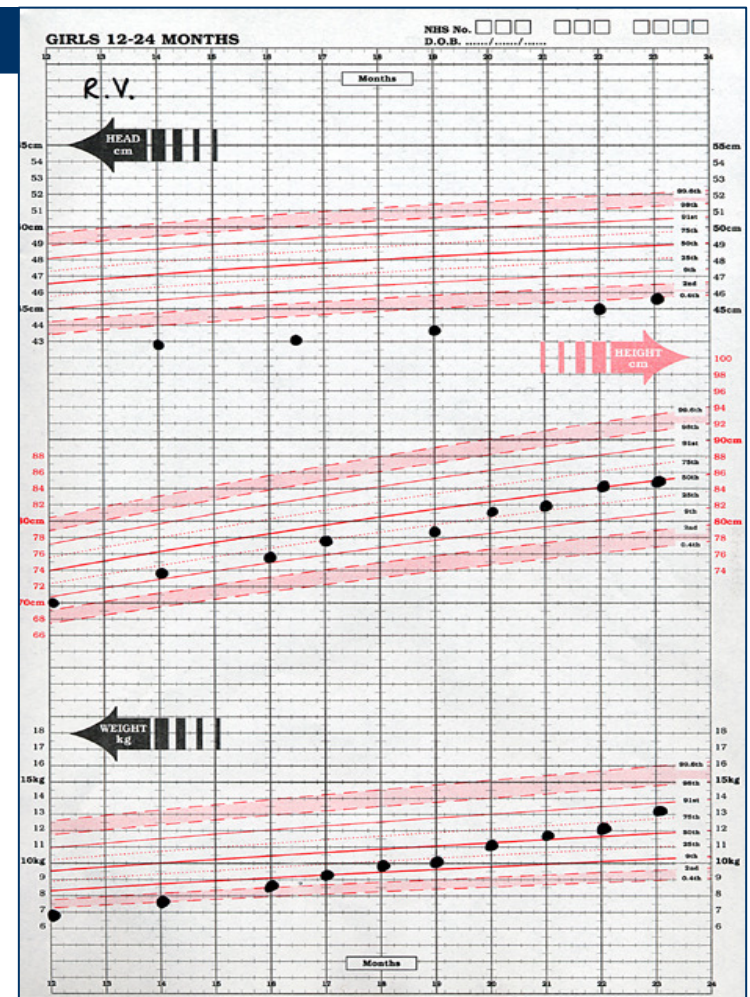
Diet history: fluid intake 190ml/kg
1000ml water daily

300ml formula = 30kcal/kg

3 small meals = 35kcal/kg

Energy intake = 65kcal/kg

normal req = 95kcal/kg



Risks of having too little water

Excessive milk drinking in toddlers

- Decreased appetite for foods
- Iron deficiency anaemia associated with milk intake > 500ml/d (Cowin et al, 2001; Gunnarsson et al, 2004)
- Increased saturated fat intake

Case study

2½ year old girl

Drinking 1000ml full fat cows milk daily

Energy req	1230kcal
Iron req	6.9mg

DRV saturated fat = 11% total dietary energy

1000ml milk	
	= 650kcal
	= 24g SFA (18% energy)
	= 0.6mg iron



Risks of having too little water

Excessive intake of high sugar drinks

- **Obesity**

- school children given water ↑ consumption by 1.1 glasses/day with ↓ risk of overweight of 31% (Muckelbauer et al, 2009)

- **Poor appetite, poor weight gain, loose stools**

- ‘squash drinking syndrome’ - on reducing sugary drinks toddlers showed improvement in all symptoms (Hourihane & Rolles, 1995)

- **Dental caries**

- in young children consuming regular soda pop, regular powdered beverages (& 100% fruit juice) had ↑ risk of caries (Marshall et al, 2003)

A practical recommendation for fluid intake in healthy children

6 – 8 drinks a day

- 100-120ml toddlers
- 160-180ml 5 yr old
- 200-220ml 10 yr old
- 280-300ml 15 yr old

Subject to:

age, gender, environment,
activity, water from food

Suitable drinks

- Water preferred
- Some milk (350-500ml)
- Fruit juice, smoothies
- ? Fizzy pop, squashes
- ? Artificial sweeteners
- ? Tea, coffee

72.5% preschool children
50% infant school children
never drank water

(Petter et al, 1995)

Clinical scenarios – fluid balance critical to maintain hydration

Too much fluid going out

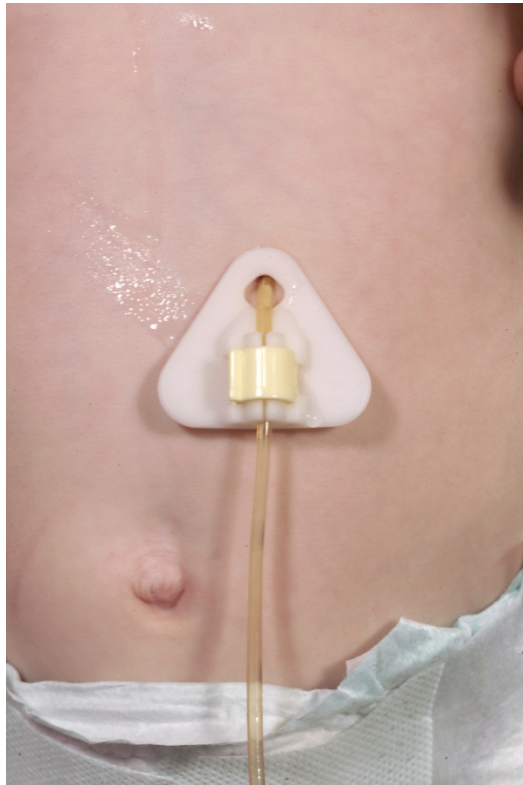
- **Gut**
acute gastroenteritis, enteropathy, stomas
- **Lungs**
cardiorespiratory diseases, congenital heart disease, cystic fibrosis, tracheostomy
- **Skin**
pyrexia, eczema, burns, CF, phototherapy
- **Kidney**
renal dysplasia, nephrogenic diabetes insipidus, renal tubular diseases

Clinical scenarios – fluid balance critical to maintain hydration

Not enough fluid coming in

- Dysphagia – cerebral palsy, neurodisability
- Vomiting – chemotherapy, GORD
- Behavioural – fussy feeders and eaters
- Carer – child neglect or abuse

Alternative methods of feeding



Are there added benefits of adequate hydration in the well child?

Cognitive function in young adults

- mild dehydration (2% loss of body weight)
→ significant impairment of cognitive function

(Gopinathan et al, 1988; Cian et al, 2000)

- Water restriction/consumption following 12 hr water restriction → did not affect cognitive performance; however self-reported arousal as a result of water ingestion

(Neave et al, 2001)

Cognitive function in children

- **infants**

dehydration → confusion, irritability and lethargy

- **young children**

dehydration → decrements cognitive performance?

- **10 – 12 year olds**

dehydrated group → significantly worse auditory digit span, poorer performance in semantic flexibility & pattern identification

(Bar-David et al, 2005)

Cognitive function in children

Children given drink or no drink 20-45 minutes before cognitive tests. Voluntary water intake 57-250ml

- Improvement in visual attention
no effect on visual memory in **6 – 7 year olds**
(Edmonds & Jeffes, 2009)
- Improvement in visual attention
& visual memory in **7 – 9 year olds**
(Edmonds & Burford, 2009)

Children (8y 7m) given 300ml or no water before cognitive tests

- Memory performance improved
sustained attention not altered
(Benton & Burgess, 2009)

Summary

- Fluid balance is critical in the child with extra losses or insufficient intake due to disease
- It is not fully understood how hydration affects health & well-being in children
- Water is beneficial if in deficit, but does additional water confer any benefit in children who are seemingly well hydrated?
- More knowledge is needed to assess the impact of water and hydration in promoting health in children