

## Ergonomics for Children

### ... Rethinking assumptions

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<http://childergo.com>

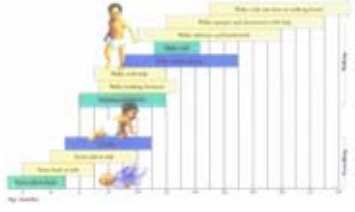
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## "Child Ergo" Challenges

- Range of body sizes
- Rate of growth
- Strength capabilities
- Cognitive & functional characteristics

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## Developmental stages



Developmental stages are predictable, but the timing varies between children


Cole & Cole (1997) The Development of Children

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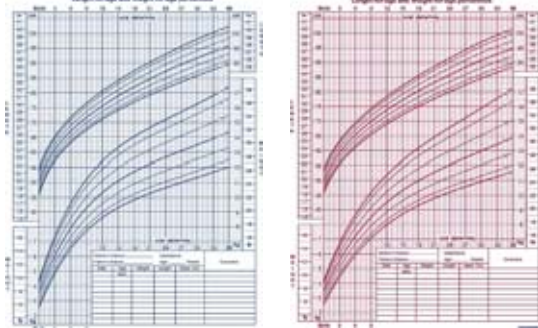
## Child Anthropometrics

- Infants, Children & Youths to 18  
(US Consumer Product Safety Commission, 1977)
- CHILData: Handbook of child measurements  
(Wilson & Norris, U. Nottingham for Dept. Trade & Industry, 2001)

[www.humanics-es.com/recc-child.htm](http://www.humanics-es.com/recc-child.htm)

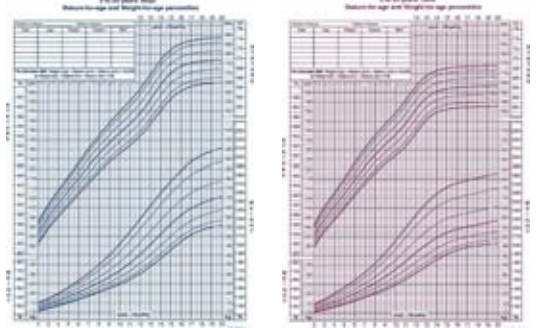


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**CDC's growth charts by age (birth to 36 months)**  
[www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts)

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**CDC's growth charts by age (2 to 20 years)**  
[www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts)

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### Children's bone growth

- By 7, girls' bone size = 80% peak
- Bone Mineral Content (BMC) = 40%

(Bass et al, J Clin. Invest, 1999)

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**Body Mass Index, by age (boys, 2 to 20 years)**  
[www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts)

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**Body Mass Index, by age (girls, 2 to 20 years)**  
[www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts)

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**Trends in overweight (BMI ≥ 95th percentile): United States**  
 SOURCE: CDC/NCHS; NHES I/II (1963-70); NHANES I (1971-74); NHANES II (1976-80); NHANES III (1988-94); NHANES 1999

Obesity in children by age, sex & decade  
[www.cdc.gov/nchs/nhanes.htm](http://www.cdc.gov/nchs/nhanes.htm)

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### Obesity among children

Child obesity tripled 1960's → 1990s

- Among children, aged 6-11
  - Increased from 4% in 1965 to 13% in 1999
- Among adolescents, aged 12-19
  - Increased from 5% in 1970 to 14% in 1999
- Similar increase among boys and girls

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### Child strength


- Boys & girls 2-15 years did not differ sig. (150 subjects - Peebles & Norris, I EA 2000)
- Boys stronger than girls by the age of 10 (530 Swedish children - Häger-Ross & Rösblad, Acta Paediatr 2002)
- By the 16th year, males much stronger
- Max. strength does not increase after 16.

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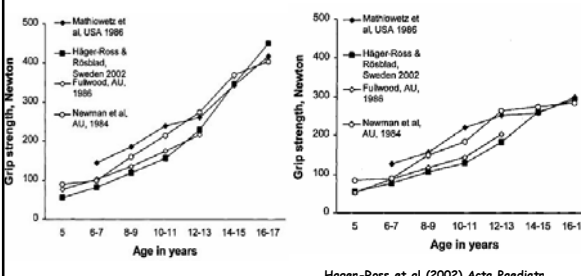
## Child strength

- Poor correlation between types of grip (finger push / hand push / twist / pinch etc.)

(150 subjects - Peebles & Norris, IEA 2000)



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Grip strength in boys & girls, 5 - 17 years

Hager-Ross et al (2002) Acta Paediatr

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## Child Physical Abilities

- Children's abilities are often over-estimated.
- Exceed limits → increase risk

North American Guidelines for Agricultural tasks

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## Children & MSDs

- Children experience MSDs.
- Child MSDs differ from adults.
- These affect...
  - Product designs
  - Design of the built environment
  - Task design



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## Muscle dynamics change with age...

Younger children have...

- Slower muscle relaxation
- Slower rapid alternating movements  
Muscle relax time: 90 ms at age 3 → 40 ms at 10 (half-times)
- Smaller muscle fiber diameters  
Significant increase in muscle fiber diameters at 10

Lin & Walsh (1994) Physiological maturation muscles in childhood. *The Lancet*.

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## MSDs

- Stretches & exercise promote slow-twitch
- Disuse → fast-twitch & muscle spasticity
- This can → to dynamic muscle imbalance
- Hinders recovery from muscle tension

Lin & Walsh (1994) Physiological maturation muscles in childhood. *The Lancet*.

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## Children & MSDs

- 10-15% of over-use patients  
(Markison interview, 2002).
- Highly correlated with repetition & prolonged, awkward postures.

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## MSDs in children

- Sub-maximal Repetition
  1. Micro-trauma
  2. Inflammation
  3. Tissue fatigue & damage
  4. Loss of flexibility
  5. Weakness, discomfort & pain

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## Soft-tissue Injuries

- Ligament & tendon injuries uncommon in children with immature bone growth plates.
- Ligaments 2-3 X stronger than child's bones.
- Tendons: high water content, collagen turnover.
- Fibroblasts (connective tissue) → flexibility.

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## Child Postures


- Patterns begin at around 7
- Wide range postures & movements
- Conscious control of posture  
→ over-correction, over-control & tension.



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## Child Over-use

- Sports
- Web-surfing
- Video games ("Nintendo thumb")
- Musical instruments
- Handwriting



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## Computers & Over-use

- 40% 3<sup>rd</sup>-5<sup>th</sup> graders in high-risk postures (Findings from 11 schools - Hedge, Johns Hopkins pres, 2000)
- 40-50% 6<sup>th</sup>-8<sup>th</sup> graders report over-use discomfort (Williams, I SOES 2002)
- 40% 6<sup>th</sup> graders report current symptoms (Most reported discomfort in the last year) (321 6<sup>th</sup> graders - Jacobs, Work 2002)

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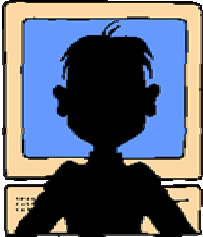
### Computer Over-use

- 64% 6<sup>th</sup> grade laptop users report neck discomfort (Fraser, I SOES 2002).
- 60% discomfort rate among laptop users (Harris & Straker, Intl J Ind. Erg., 2000).
- 51% neck & 44% back pain in the last month (Murphy & Buckle, I EA 2000).

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### Computer Over-use

- 152 6<sup>th</sup> graders: MS discomfort increases with hrs on computer & if can't touch type (Jacobs & Baker, Work 2002).



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### Video games & TV

- 2/3 U.S. homes have video games.
- 60% children watch TV > 2 hours → pain.

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### Changes in Vision

- 80% farsighted at birth
- Farsightedness ↓ w/age and normalizes by 7-8.
- As farsightedness ↓, nearsightedness ↑ w/age.

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### Children and Vision

- Complex visual skills not fully developed.
- Hand-eye coordination develops by 11-12.



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### Children & Vision


- 25% K-6 grades have refractive errors. (APHA (2002))
- Correlation between:
  - Heavy reading (< 10 yrs) & myopia.
  - Computer use (> 3 hr) & premature myopia.

Hoening (2002)  
Unpublished research at UC Berkeley  
Described in Ophthalmology Times, 2002

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## Children & Eyestrain: Incidence

- 218 elementary students - 56% (Williams et al, HFES Proc, 2000).
- 191 undergraduate students - 60% (Ladrihan et al, 1999).
- Rates similar to adults.



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## Recommendations

- Adaptable furniture & equipment.
- Child-sized stations & equipment.
  - Back support.
  - Ability to move/change position.
  - Knee clearance and foot support.
- Sit/stand.

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## Recommendations

- Monitor at least 2-3 feet from child eyes.
- Large fonts (14 - 16 point, bold)
- Monitor directly in front.
- Top of screen no higher than eye level (at the highest).

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## Recommendations

- Touch typing.
- Replace mousing with keying.
- Mouse with non-dominant hand.
- Keyboard & mouse below elbow height. (if child can touch-type and keyboard tilts back).

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## Recommendations

- Smaller keyboards.
- Light touch keyboards.
- Child sized pointing devices.
- Pointer close to midline.
- Evaluate alternative input devices (e.g. trackballs)

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## Recommendations

- Limit exposure.
  - Avoid video games, e-mail, web search.
- Limit usage; 1 hour limits.
- 5-10 min. breaks per 20-30 min.

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### Recommendations

- Emphasize posture & body awareness
- Promote movement & changing posture.
- Daily exercise.

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### Recommendations

- Avoid laptops.
  - Hard to position screen & keyboard.
- Avoid carrying laptops in backpacks.
  - Limit backpack weight.
  - Wheeled carts.

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### More on ... child injury prevention

[humanics-es.com/recc-child.htm](http://humanics-es.com/recc-child.htm) (Rani's ChildErgo site)

[www.cdc.gov](http://www.cdc.gov) (Center for Disease Control)

[www.cpsc.gov](http://www.cpsc.gov) (Consumer Product Safety Commission)

[consumerreports.com](http://consumerreports.com) (Consumer Reports Magazine)

[cpsc.gov/neiss/query.asp?](http://cpsc.gov/neiss/query.asp?) (Nat'l Electronic Inj Surveillance)

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### For more on... Children and Vision


[www.aoa.org](http://www.aoa.org)

[www.nei.nih.gov](http://www.nei.nih.gov)

[www.opticalinternet.com](http://www.opticalinternet.com)

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### Children sitting



1400 BC, Egypt

1800's, England

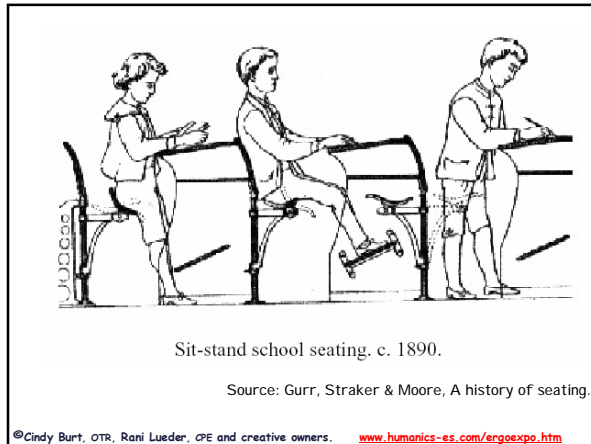
500 BC, Greece

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Problems continue, but in a new form

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### Recommendations

- Chair should fit & support.
- Turn off vibration.
- Hold controller loosely.
- Avoid high screens.
- Avoid glare & reflections.

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### Recommendations

- Limit concentrated stretches.
- Move frequently.
- Stretch (at least every 20-30 min).
- Avoid static gripping.
- Neutral hand postures.

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### For more on... School ergonomics

- [www.humanics-es.com/recc-child.htm](http://www.humanics-es.com/recc-child.htm)
- [ergo.human.cornell.edu](http://ergo.human.cornell.edu)
- [www.ergonomics4schools.com](http://www.ergonomics4schools.com)
- [www.designshare.com](http://www.designshare.com)
- [www.educationalevironments.org](http://www.educationalevironments.org)
- [www.tifaq.org/kids.html](http://www.tifaq.org/kids.html)

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### Handwriting



- Hand dexterity:
  - skill & grace
  - quickness, sureness, neatness
  - light touch.
- Hand patterns from childhood continue through adulthood.

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### Handwriting is affected by...

- Motor planning.
- Postural mechanism.
- Muscle strength & flexibility.
- Coordination.
- Visual system.

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### Hand Skill Development

- Supination.
- Stabilize forearm & wrist.
- Isolate thumb from fingers.
- Separate sides of hand.
- Stabilize thumb & index web space.
- Individualize digits.
- Palmar arching.
- Precise fingertip rotation.

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### Handwriting


- Pencil grip requires tri-pod grip.
- Tri-pod grip develops in kindergarten.
- Pre-mature start → poor writing patterns.
- Poor patterns damage thumb joint (metacarpal).

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### Handwriting

- Child can't write effectively on flat surfaces until they reach 7.
- Tabletop activities promote flexed postures & immature motor patterns.
- Inclined & vertical surfaces → upright sitting

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## Recommendations

- Don't encourage writing until child develops tri-pod grip.
- Pencil grips promote proper physiological position for writing.
- Relaxation techniques for handwriting.  
2 minute breaks per 20 - 30 min.

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## For more on... Handwriting for kids

[www.allthewritenews.com](http://www.allthewritenews.com)

[www.otideas.com](http://www.otideas.com)


[www.hwtears.com](http://www.hwtears.com)

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## Questions?

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## Thank you!

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