Ergonomics and Children:
How to prevent Injury in the Classroom

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With thanks to Kathryn Laeser, Shawn Oates, Prof. Gary Evans & Prof. Lorraine Maxwell.

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Presentation Content

- Computer use in schools
- Children and computer use - issues + research evidence
- Implications and future action

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Conceptual Framework

- Latency
  - Mass computerization of the office in the 1980s is associated with the increase in WMSDs in the 1990's
  - Mass computerization of the schools in the 1990's …?
- Lifelong habits
  - Learning good posture and work habits requires the same effort as learning poor posture and work habits.
- Children as small adults (biomechanically)

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Computers in Schools

- Computer use in schools inevitably is increasing
- Computer ergonomics is a lifelong skill (Larson, 1999).
- Tomorrow's workers are in today's schools

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Computers in Schools

(Coley, Policy Information Center, ETS, 1999)

- 98% of all schools own computers
- 4.4 million computers in classrooms
- Current average student-to-computer ratio:
  - 10:1 (range 6:1 – Florida, Wyoming, Alaska, North Dakota to 16:1 – Louisiana), down from 125:1 in 1984.
  - 11:1 – Elementary schools
  - 9.7:1 – Junior High
  - 8.4:1 – Senior High

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Computers in Schools

(Coley, Policy Information Center, ETS, 1999)

- 85% of schools have multi-media computers (MMC) [Keyboard + mouse]
- Current average student-to-MMC ratio is 24:1 (range 9:1 – Florida to 63:1 – Louisiana).
- US Dept. Education currently recommends a ratio of 5:1

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School Computers use by Children

(Coley, Policy Information Center, ETS, 1999)

- Daily computer use in schools:
  - 4th grade – 9%
  - 8th grade – 10%
  - 12th grade – 19%
- Computer integration into the curriculum (work, games)
- Internet access
  - 1998- 51% schools
  - 1999 - 89% schools
- One computer per desk policies

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Computers use by Children

(AOL & Roper Starch, 1999)

- Computers in schools and homes
- 1-3 hours per day computer use and growing
- 63% of 9-17 year olds prefer web surfing to watching TV

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Computers use by Children

(AOL & Roper Starch, 1999)

- Average on-line days per week:
  - 9-11 years old - 3 days/week
  - 15-17 years old - 5 days/week
- Internet:
  - Rookies average 6.6 hours/week
  - Experienced users (> 3 years) average 10.5 hours/week

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Computer Use by Children

(AOL Canada, 1999)

- ~ 5 million children <12 years old use the Internet
- By 2002, ~20 million children <12 years old will be using the Internet

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Lifelong Computer Use

(Berenter, Greenhouse & Webster, + Fortino Group, 1999)

- Survey of 162 children 9-12 years, 6,000 children 10-17 years old
- Children who use the Internet > 3 times/week spend only 66% time reading compared with non-users.
- Internet savvy kids score more 'As' in school, but do worse in spelling, punctuation and grammar.

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Lifelong Computer Use

(Berenter, Greenhouse & Webster, + Fortino Group, 1999)

- At present rates, during their lives children will spend >2 years on e-mail
- At present rates, during their lives children will spend at least 23 years on the Internet

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Technology Integration In Schools

- School Technology integration plans typically do not address ergonomic workstation design issues
  - Typical Technology Plan (e.g. ICSD, 1995)
    - Teacher training
    - Updating building infrastructure (power, network)
    - Hardware and software acquisition
  - United States Congressional Study (1995)
    - "America's Schools not designed or equipped for the 21st Century"

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School Technology Plans

- Plans focus on the technology
- Plans do not incorporate consideration of ergonomic issues.

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Ergonomic Design Issues

- Environmental conditions for computers:
  - Lighting
  - Ventilation (heat, IAQ)
  - Cable management/electrical fields
- Furniture for computer work
  - Worksurface
  - Monitor height
  - Keyboard tray
  - Mouse platform
  - Document holder
  - Chair
- Layout for computer work
  - Workstation layout
  - Classroom layout

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Ergonomic Design Questions

- How should computer workstation design be addressed in school technology integration plans?
  - What is the impact of computer workstation design on a student's physical well-being
  - What is the impact of workstation design on the effectiveness of computer use

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Research Studies

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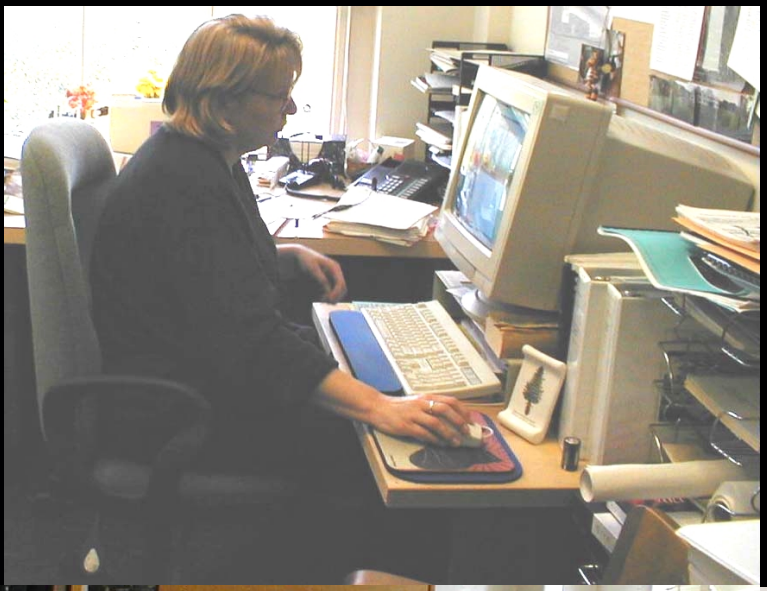
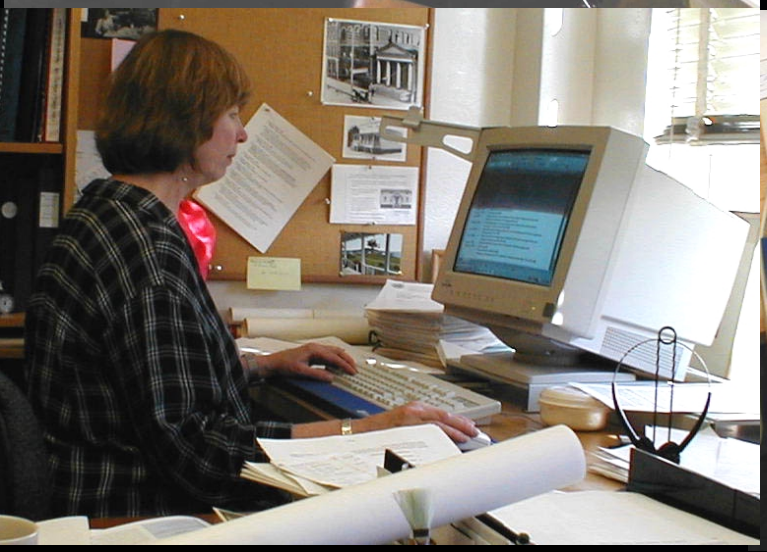
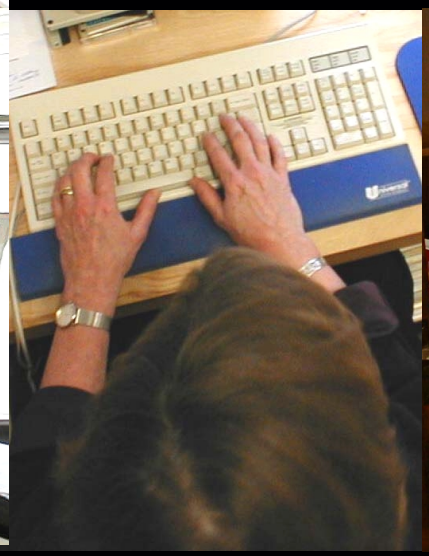
"At Risk" Postures



- In adults, sustained work in a deviated posture can increase injury risks to the upper body.
- What happens in children?





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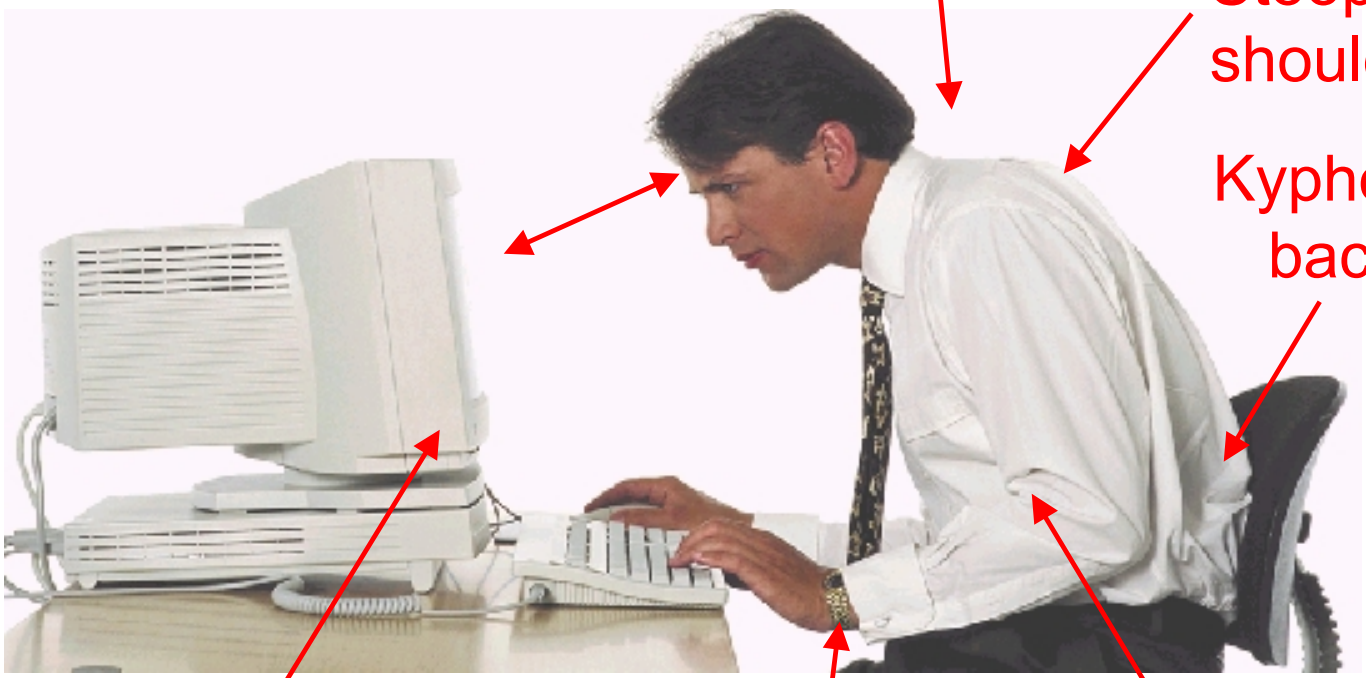
"At Risk" Typing Posture in Adults
('Yuppie hunch')



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"At Risk" Mouse Use Posture in Adults

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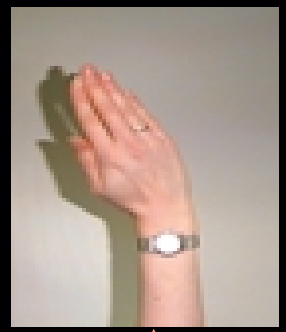
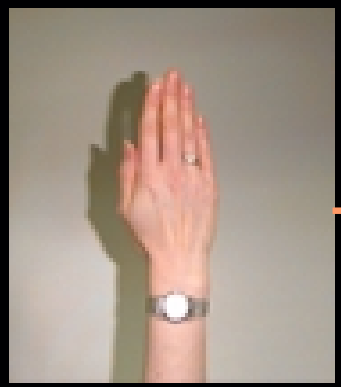
Hand posture: Lateral deviations

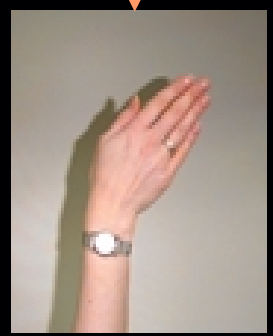
Radial Deviation
Deviated posture causes wrist strain.



Neutral Posture
Relaxed wrist with the hand in a neutral posture.



Ulnar Deviation
Deviated posture causes wrist strain.



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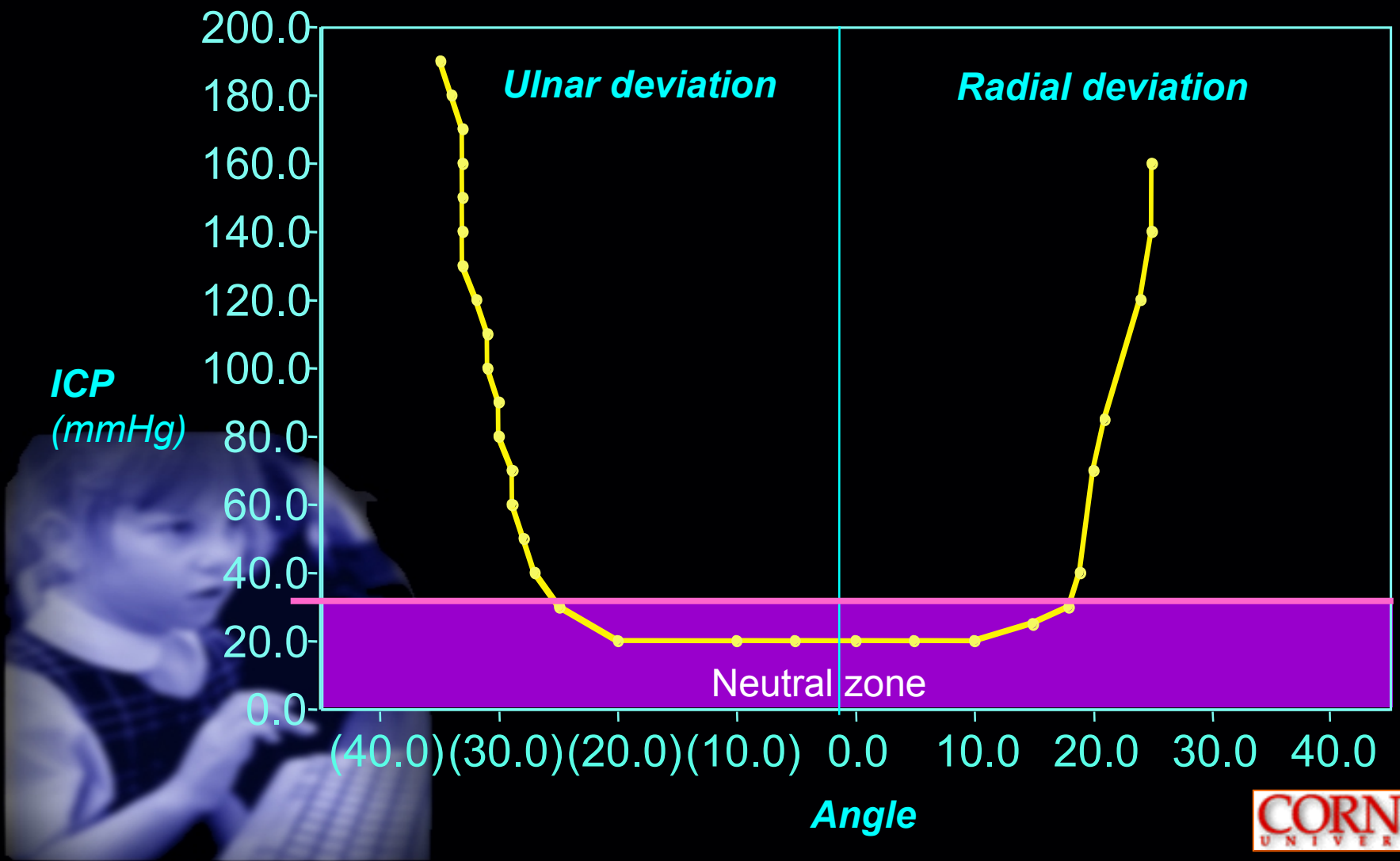
Lateral Deviation and ICP

(Rempel, 1992)



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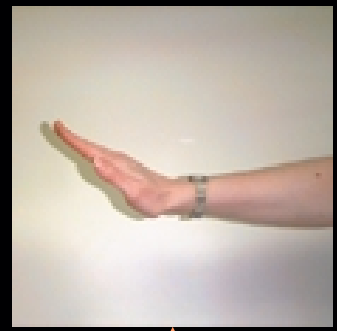
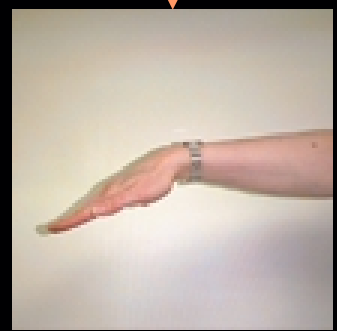
Hand posture: Vertical deviations

Wrist Extension
Deviated posture causes wrist strain.



Neutral Posture
Relaxed wrist with the hand in a neutral posture.

Wrist Flexion
Deviated posture causes wrist strain.



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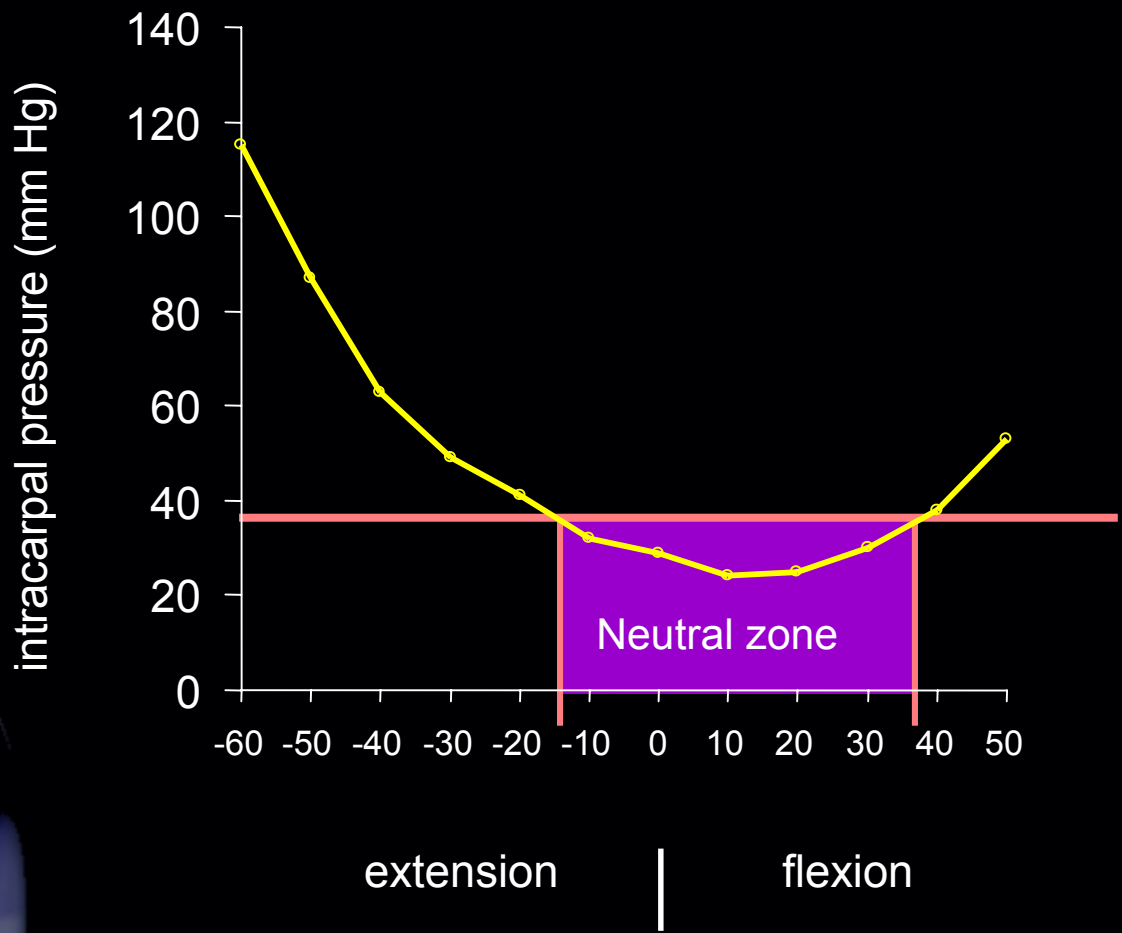
Vertical Deviation and ICP

(Honan *et al.*, 1995)



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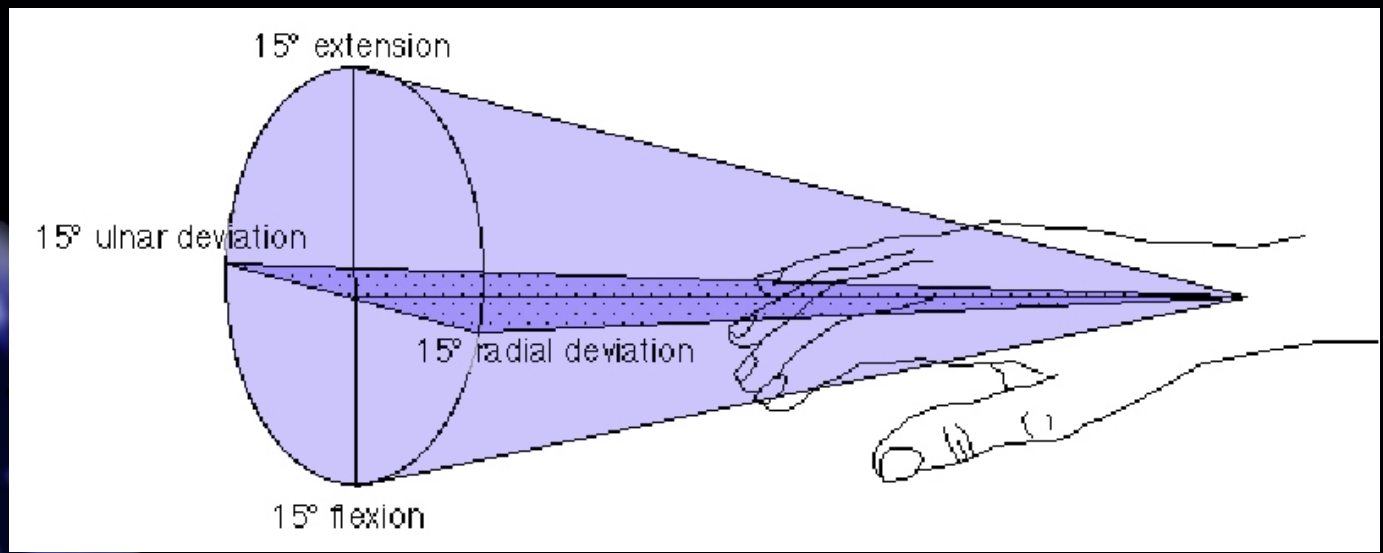
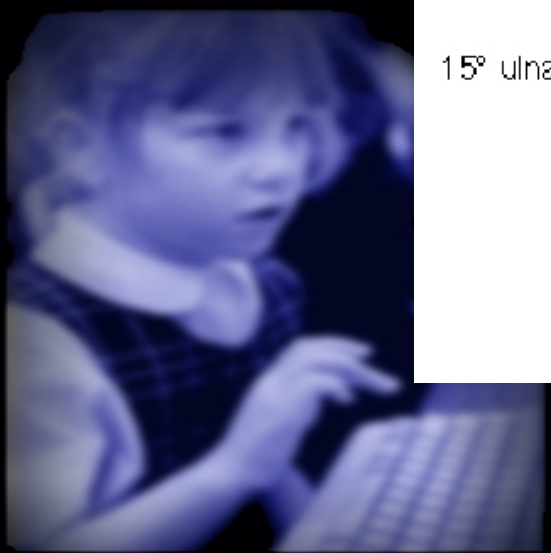
Neutral Zone of Hand Movement

(Hedge, 1998)

- Hand movements within a neutral range should be encouraged
- Is this how children work on computers?





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Neutral Work Posture

- Upper body posture
  - Back supported by chair
  - Feet firmly on surface
  - Head balanced on neck
  - Popliteal angle >90°
  - Upper arms close to body
  - Elbow angle >90°
  - Wrist neutral (<15°)

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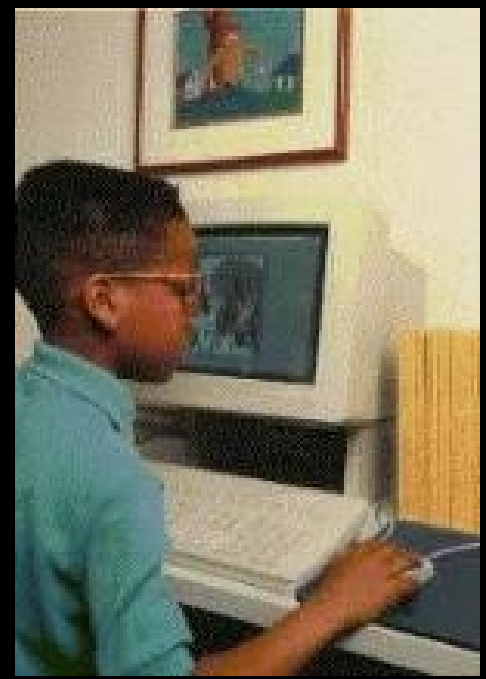
How are children working at computers?



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Children's Posture at Computers

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)

- 95 elementary school children (46 boys, 49 girls)
- Grades 3 through 5 studied
- Ages 8.5 – 11.5 years
- Approx. equal numbers at the 5th, 50th and 95th %iles for stature
- Urban, suburban and rural schools studied

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Research Procedure

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)

- Children evaluated in their typical computer work area
- Children evaluated while working on a novel text-writing task
- Workspace dimensions and layout recorded
- Posture evaluated using the Rapid Upper Limb Assessment (RULA) method
- RULA measures taken after 5 minutes of work

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Workstation Dimensions

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)

Dimension	Recommended	Observed
Keyboard height	21.5 – 24”	25.6 –39.4”
Monitor height	31.5 – 38”	37.4 – 51.2”
Backrest height	26 – 30”	23.6 – 31.5”
Seat pan width	13 – 15”	11.8 – 17.7”
Back rest angle	90 ° - 120°	90 ° - 108°

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Interpretation of RULA Scores

- (1-2) Posture is acceptable if it is not repeated for long periods of time.
- (3-4) Further investigation is needed and changes are required.
- (5-6) Further investigation and changes are required very soon.
- (7) Further investigation and changes are required immediately.

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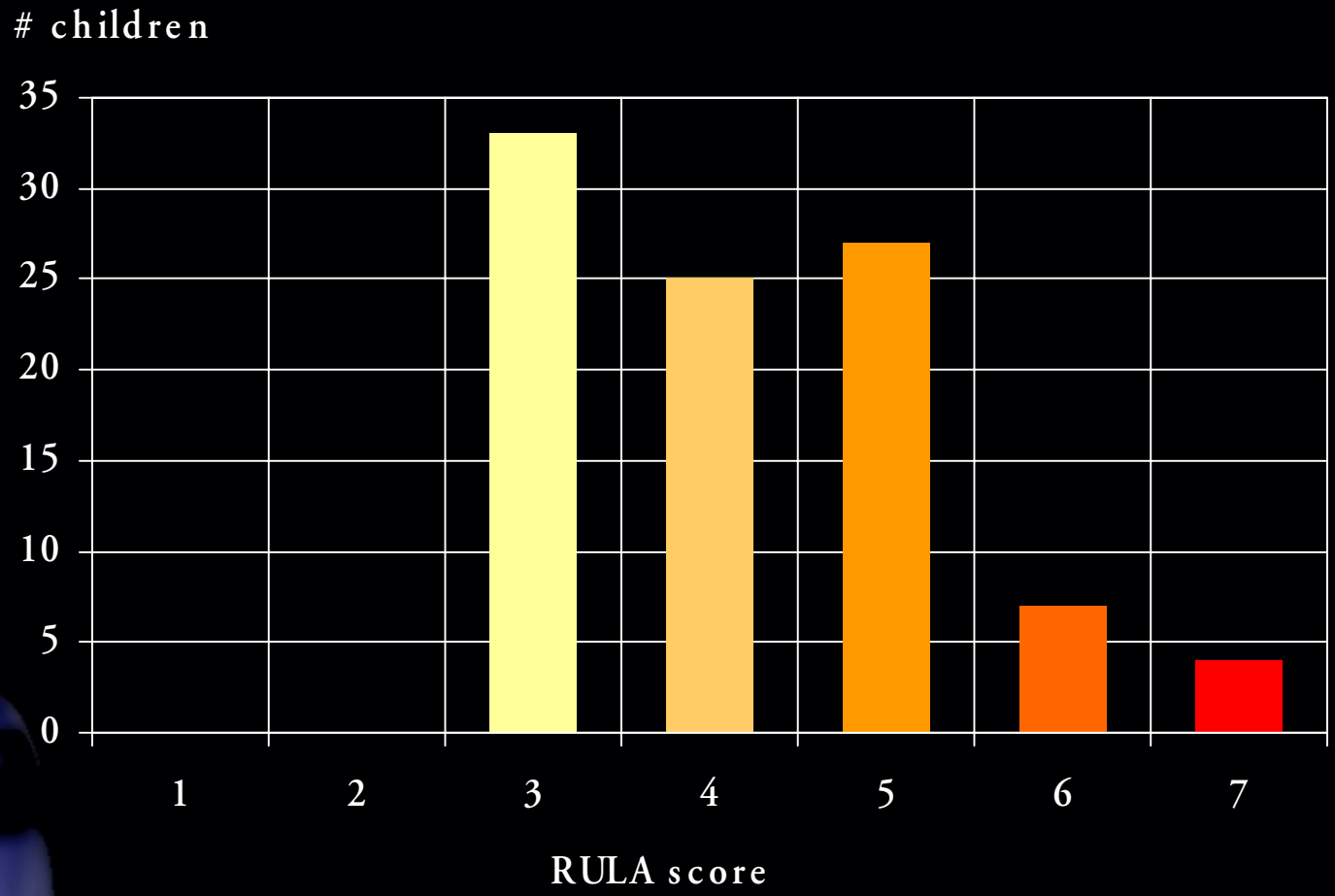
Overall RULA Results

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)



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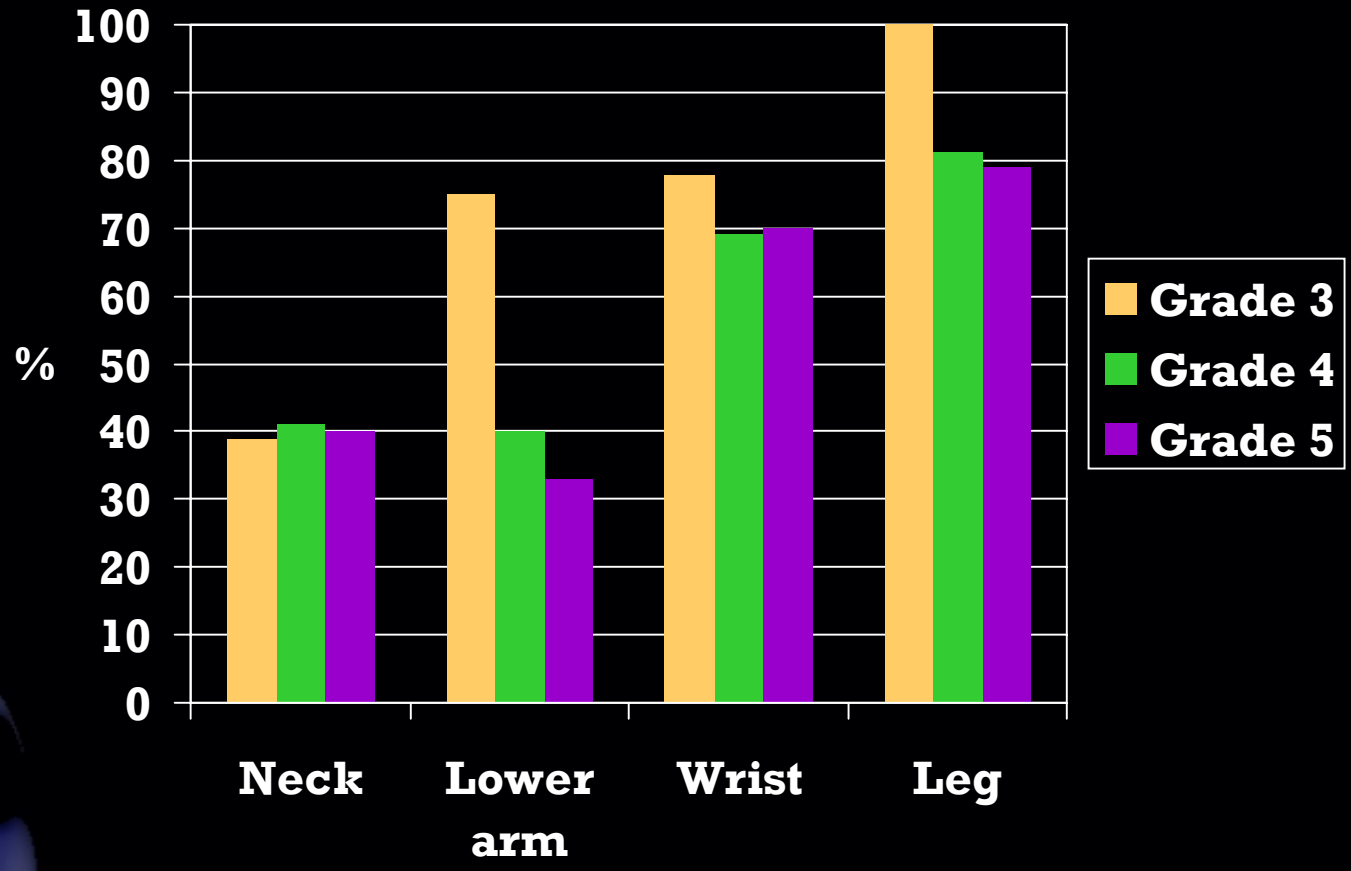
RULA: ‘At Risk’ Body Segments

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)



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Research Conclusions

(Oates, Evans and Hedge, Computers in Schools, 14, 55-63, 1998)

- Children working in 'at risk' postures:
  - Keyboards too high
  - Incorrect keyboard angle
  - Monitors too high
  - Legs dangling
- Short duration of computer work
- Marked lack of attention and commitment to consideration of ergonomic issues in schools

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Ergonomic Solutions for Better Posture?

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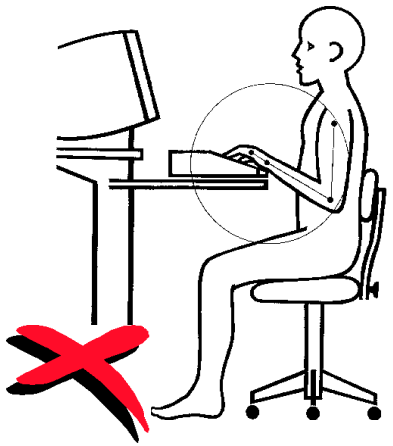
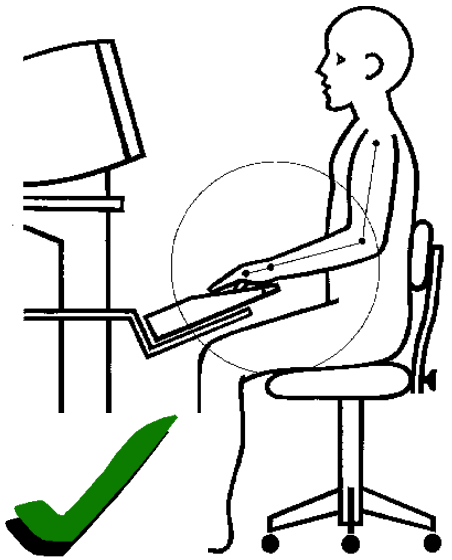
It's not what you use it's the way that you use it...

Desk



Tray

Tiltdown system



(Stack, 1988)

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Improving Workstation Ergonomics

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Tested effects of computer workstation design on:
  - Posture
  - Task performance
  - Engaged behavior
  - Preferences
- Studied keyboard and mouse use
- Compared conventional and tiltdown keyboard arrangements

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Research Design

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 58 middle school children tested:
  - 30 6th grade students
  - 28 8th grade students

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Research Design

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Keyboarding and mousing tasks performed under two conditions:
  - desktop arrangement
  - tiltdown keyboard system

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  - tiltdown keyboard system

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Experimental Measures

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Posture
  - RULA method
- Performance
  - computer program for each task
- Engaged Behavior
  - video tapes
- Preferences
  - interview

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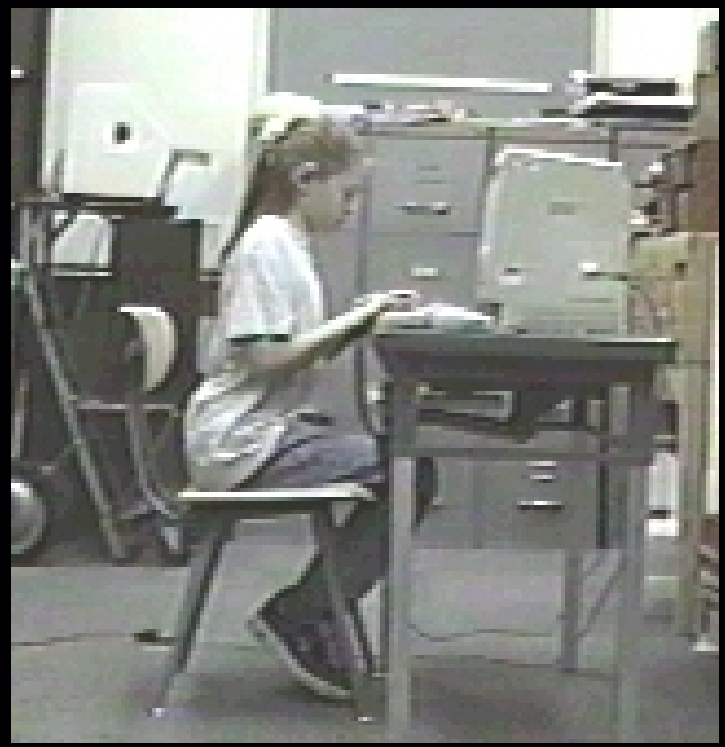
6th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 6th grader using the keyboard on the table top set at the height of the school computer surfaces.



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6th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 6th grader using the keyboard on a tiltdown tray system.

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6th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 6th grader using the mouse on the table top set at the height of the school computer surfaces.

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6th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 6th grader using the mouse on a lowered platform.

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8th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 8th grader using the keyboard on the table top set at the height of the school computer surfaces.

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8th Grade: keyboard and mouse use

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 8th grader using the keyboard on a tiltdown tray system.

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Posture

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Results confirmed that seated posture improved when the workstation had the adjustable tiltdown system:
  - keyboarding ($p<.001$)
  - mousing ($p<.001$)

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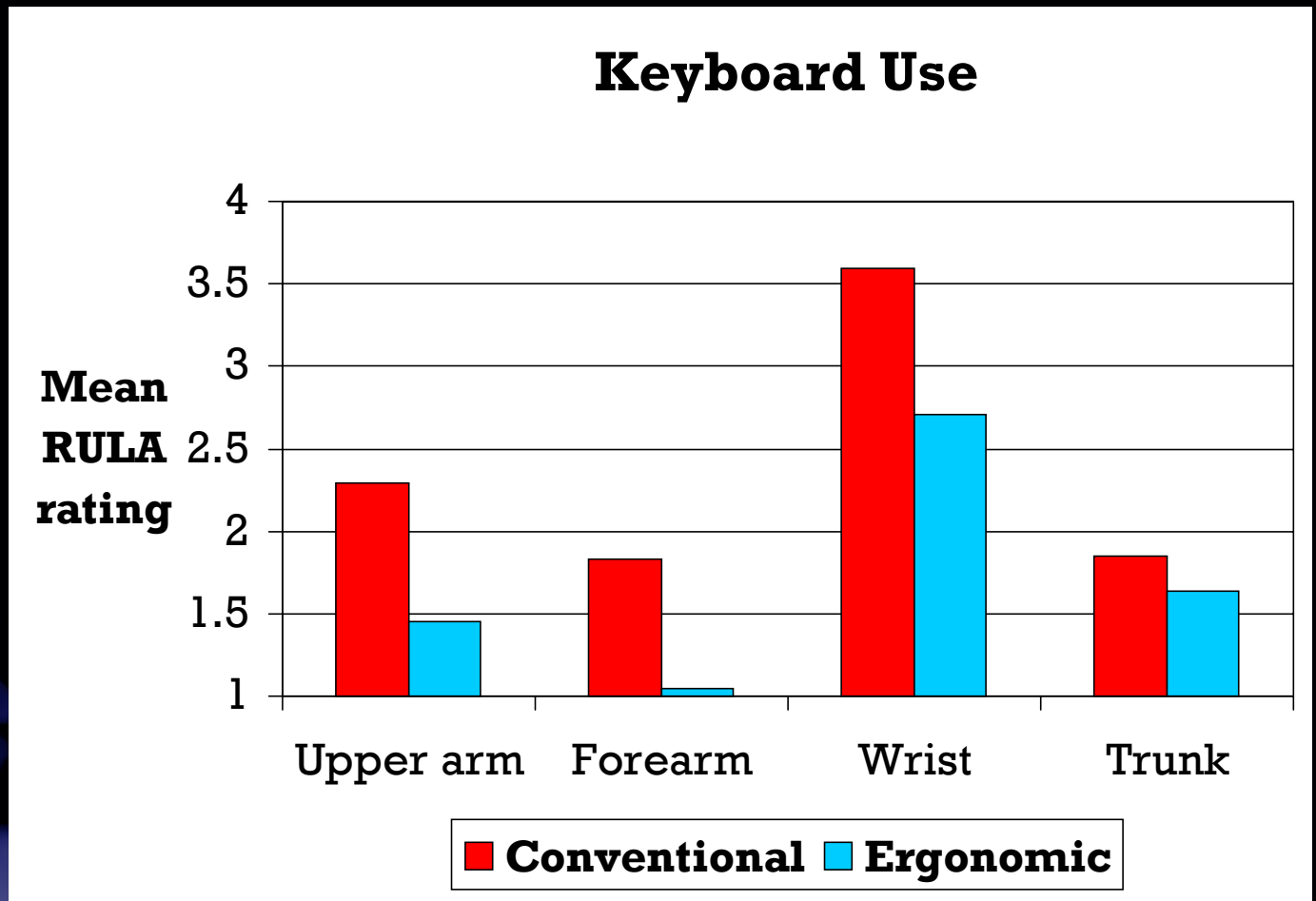
Posture Improvements

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)



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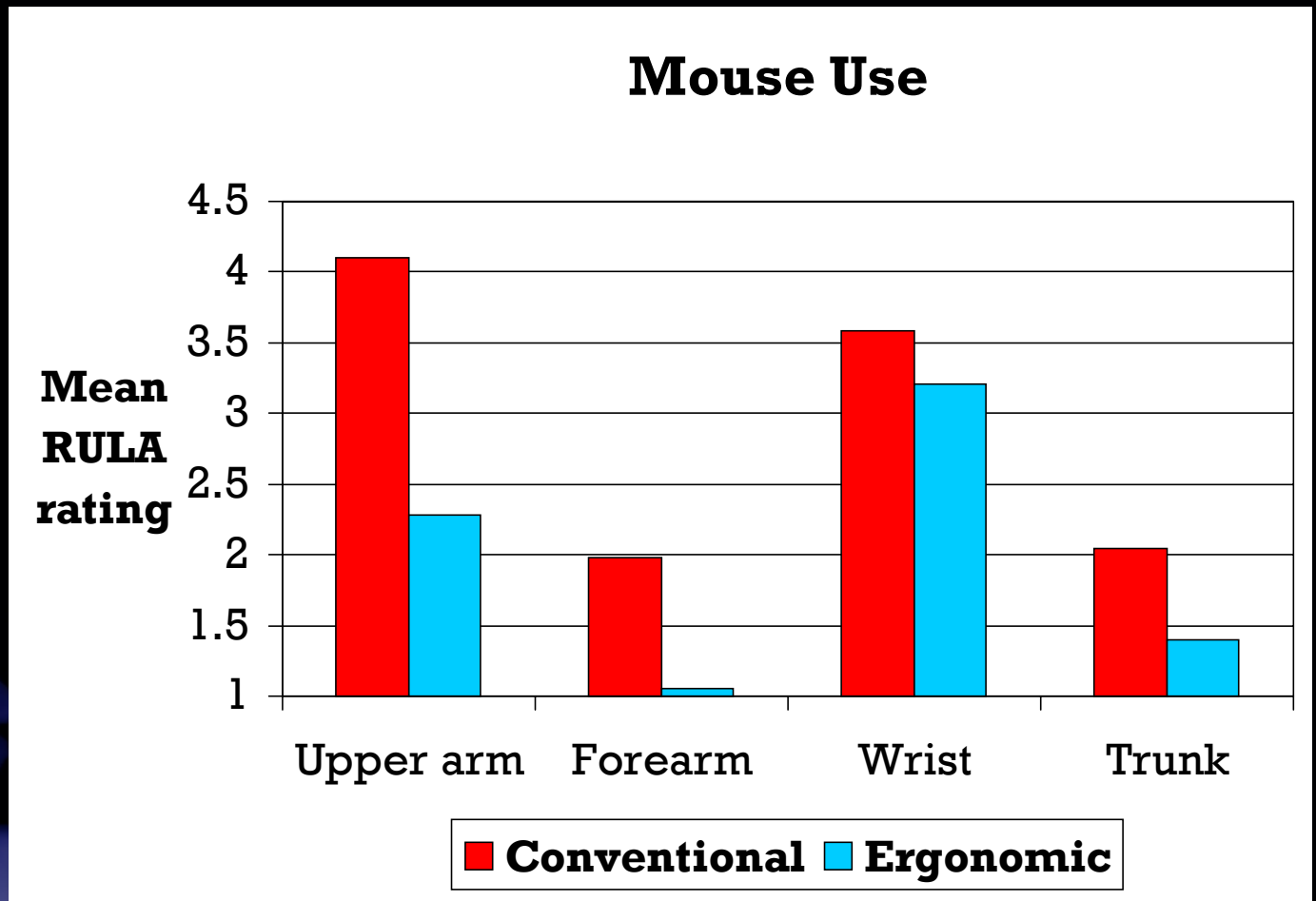

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Performance

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Typing performance
  - small but significant decrease with Ergonomic arrangement (<1%: p<.001)
  - Likely can be overcome with practice
- Mousing performance
  - small but significant improvement with Ergonomic arrangement (3%: p=.018)
  - may be due to change in posture or possibly improved mouse pad surface

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Engaged Behavior

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Increased distractions and decreased on-task time occur with a mismatch between seating arrangement and the nature of the learning activity (Hastings & Schweiso, 1993).
- Differences in on-task time were not statistically significantly different in our study, but a longer duration testing period may be required to properly assess this.

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Student Preferences

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- 38% of students chose the tiltdown system as the workstation they would rather work at.
- 33% stated that the tiltdown system was more comfortable than the desktop arrangement
- 40% chose the tiltdown system as the workstation that was easier to work at.

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Limitations of the Study

(Laeser, Maxwell & Hedge, J. Res. Comp. Ed., 31, 173-188, 1998)

- Implications limited to immediate effects of the workstation
- Students all from the same school
- Unequal number of males and females
- Self-selection – volunteer sample
- Normal ability children
- Desktop computer

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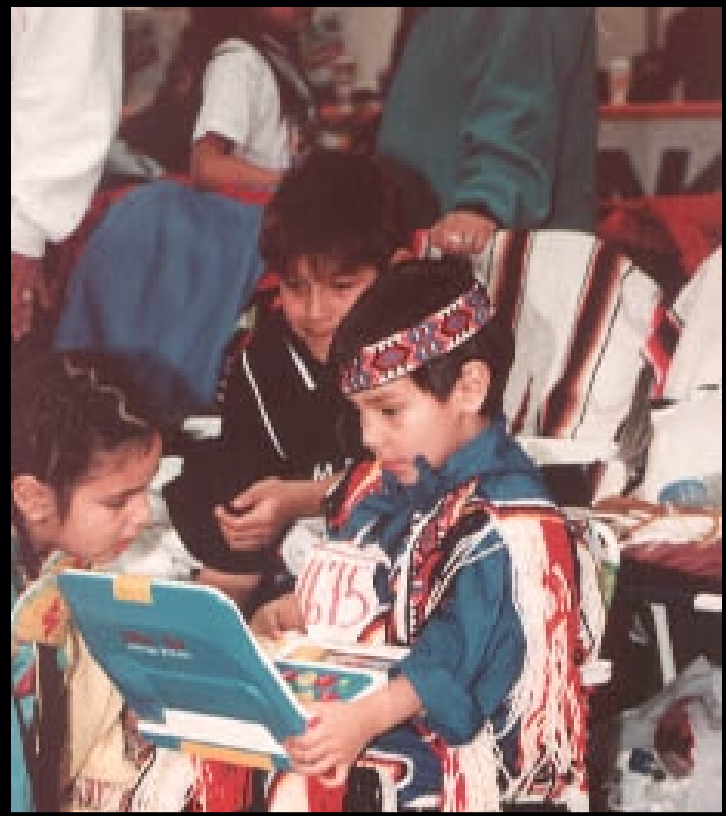
Laptop Computers in Schools



http://www.ammsa.com/sage/APRIL99.html

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Laptop Computers in Schools

- In 1995, the then House Speaker, Newt Gingrich, proposed putting a laptop computer in the hands of every schoolchild in America.
- In isolated pockets around the country, it's happening at a frenzied pace, in both private and public schools." (http://www.csmonitor.com/durable/1998/06/09/p51s1.htm)

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Laptop Computers in Schools

- In 1997 the chairman of the Texas Board of Education, proposed buying laptops for all 3.8 million public-school students in the state.

(http://www.csmonitor.com/durable/1998/06/09/p51s1.htm)

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Laptop Computers in Schools

- According to Microsoft Corp., in the last two years computer software and hardware companies have encouraged 250 middle and high schools to lease or loan the computers to about 40,000 students nationwide. They note that "the idea is so popular with parents that many districts have plans to double or even triple the number of participants by next fall."

(http://www.csmonitor.com/durable/1998/06/09/p5ls1.htm)

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Laptop Computers

(Harris & Straker, Int. J. Indust. Erg. 2000 in press)

- Surveyed 314 10-17 years old children
- Interviewed and observed 20 children
- Mean daily laptop use = 3.2 hrs
- Mean weekly laptop use = 16.9 hours
- 60% reported postural;l discomfort
- Discomfort correlated with time of use per session, not days of use

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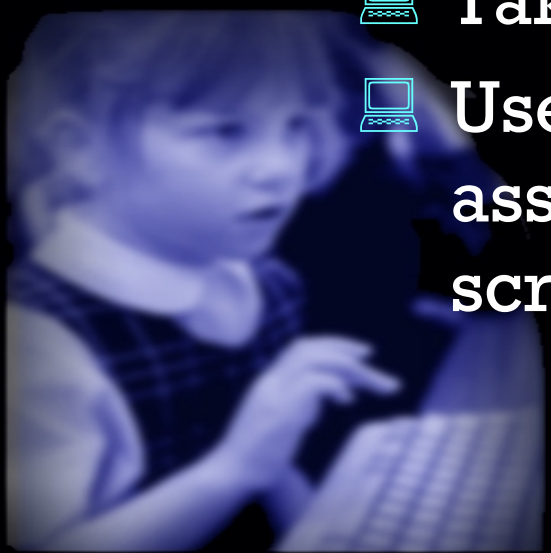
Laptop Recommendations

(Harris & Straker, Int. J. Indust. Erg. 2000 in press)

- Laptop use associated with poor posture and musculoskeletal discomfort
- Laptop design - need to separate keyboard and screen
- Encourage neutral, supported postures
- Take frequent breaks, stretch, move
- Use the lightest laptop (carrying also associated with discomfort) + best screen



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Conclusions

- Workstation design influences a child's posture and their computer task performance.
- Children often adopt 'at risk' postures when using computers.
- Postural risk can be reduced with task-appropriate and ergonomically designed workstations, and with ergonomic training.
- Exposure can be managed and minimized by monitoring use time + stretch breaks.

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Future Issues and Recommendations

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Research Needs

- Surveys of different grades, differently-abled children
- Students workstation redesign/retrofitting to facilitate healthier postures
- Durability of adjustable workstations in educational environments
- Teacher and student training in healthy computer work posture
- Other school ergonomic issues (backpacks, laptops, visual effects etc.)

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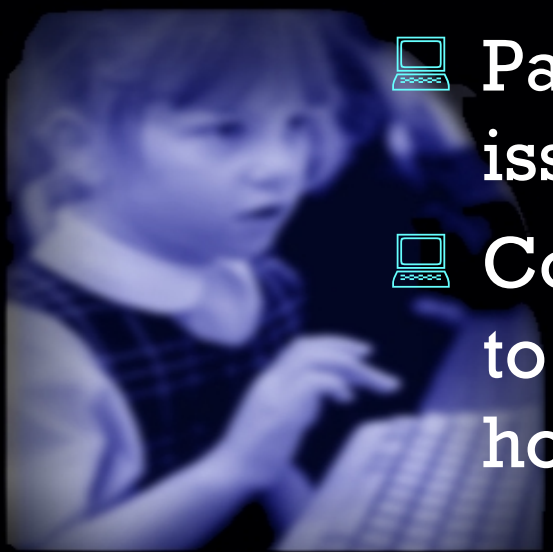
Recommended Actions

- Schools should consider the ergonomic implications of classroom computer use
- Schools should train students in good ergonomic practices and healthful postures
- Schools should budget for appropriate workstations to support computer use
- Parents should consider ergonomic issues with home computer use
- Computer use time should be managed to control exposures at school and home



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Protecting Our Future

- As Ergonomists, we have a responsibility to use our professional knowledge of ergonomic solutions to protect future generations against unnecessary exposures to musculoskeletal injury risks.

(Source:
Time Digital, 1998)

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