Effects of Chair Armrest Design on Wrist Posture

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Paper presented at the 43rd Annual Conference of the Human Factors and Ergonomics Society, Houston, TX, September 27-October 1, 1999

Published in the Proceedings of the Human Factors and Ergonomics Society 43rd Annual Conference, Vol. 1, pp. 584-588.

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Acknowledgements

We would like to thank the Steelcase Corporation for their support with this study.

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Background

- Armrests on ergonomic chairs were not common 10 years ago (reserved for executive/specialty models).
- Today, it is thought that sitting on a chair with armrests while typing provides countless benefits.
- Proliferation of general-use ergonomic chairs with different armrest designs

Research

- Working while sitting with the arms supported reduces strain to the body:
  - Minimizes upper limb muscle loads (Wells *et al*., 1997)
  - Minimizes shoulder loads (Feng *et al*., 1997)
  - Reduces spinal loads (Aaras *et al*., 1995)
  - Reduces loads on the hips and thighs while rising and sitting (Arborlius *et al*., 1992)
  - Reduces keying forces during typing (Rose, 1991)

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Focus of Study

- When typing with no armrests, the arms naturally hang to the sides of the body and the elbows stay close to the body.
  - This encourages ulnar deviation of the wrists while typing on a traditional keyboard.
- Therefore, would typing with armrest-supported arms minimize deviated hand posture?

⇒ Focus of study:
To test the effects of four different chair armrest designs on overall wrist posture while typing on a traditional keyboard

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Subjects

- 24 subjects (12 females, 12 males) were selected from a larger pool of subjects based on stature.
- Subjects were assigned to groups of either men or women at the 5th percentile, 50th percentile, or 95th percentile in stature for their gender.
  - ⇒ 6 groups (4 Ss/group) : Female 5th %ile, Female 50th %ile, Female 95th %ile, Male 5th %ile, Male 50th %ile, Male 95th %ile
- Average age: 20.6 ± 0.4 years (range: 18-29)
- Average weight: 61.3 ± 2.18 kg (range: 47.6-83.9)
- All right-handed, competent typists

Apparatus

- 4 different armrest designs (4 different chairs) with varying degrees of adjustability:
  - All height adjustable
  - Chair A: Rotation
  - Chair B: Pivot angle, width
  - Chair C: Pivot angle
  - Chair D: Pivot angle, width, depth

Chair A

- “Flipper” arms rotate 360°
- Gel-filled
- Vinyl-covered
- Broad, contoured shape

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Chair B

- Arms angle from 14° inward to 21° outward.
- Width-adjustable by 3” per pad
- Padded, vinyl-covered arms
- Curved shape

Chair C

- Arms angle from 17.5° inward to 15° outward
- Slightly tapered to the rear
- Angled 5° from rear to front
- Padded and cloth covered
- 2 chair sizes

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Chair D

- Arms rotate 21° inward and 21° outward in fixed increments
- Slide forward and backward through a 1.5” range
- Width-adjustable by 1.5” per pad
- Level, water-fall front arms
- Firmly padded
- Vinyl-covered

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Apparatus

- Traditional keyboard was set on an adjustable level articulating tray attached to a freestanding office worksurface.
- Dynamic wrist posture (-flexion/+extension and -ulnar/+radial deviation) was measured using gloves instrumented with electrogoniometers.
- Testing was conducted at Cornell University's Human Factors Laboratory.

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Procedure

- Ss were tested individually by the same experimenter.
- Ss were given information on ergonomic keyboarding posture.
- Ss were given instruction and allowed to adjust every feature on each chair in order to feel comfortable.
- Ss were instructed to make use of chair armrests while typing.
- Ss' left and right upper extremities were measured for:
  - Shoulder/elbow length (SEL)
  - Elbow/wrist length (EWL)
  - Hand width (HD)
  - Hand length (HL)

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Procedure

- Ss were randomly assigned to each condition.
- The order of administration of chair armrest and typing task was counterbalanced.
- Each 10-minute typing task was of comparable length and reading level (Typing Tutor software).
  - All were similar in requiring the left hand to perform 56-59% of the keystrokes.

Data Analysis

- Mean extension/flexion and ulnar/radial deviation angles were computed for each subject X condition X hand combination
  - Analyzed using a repeated measures analysis of variance.

- Anthropometric data was correlated with wrist posture using Pearson correlations (2-tailed).

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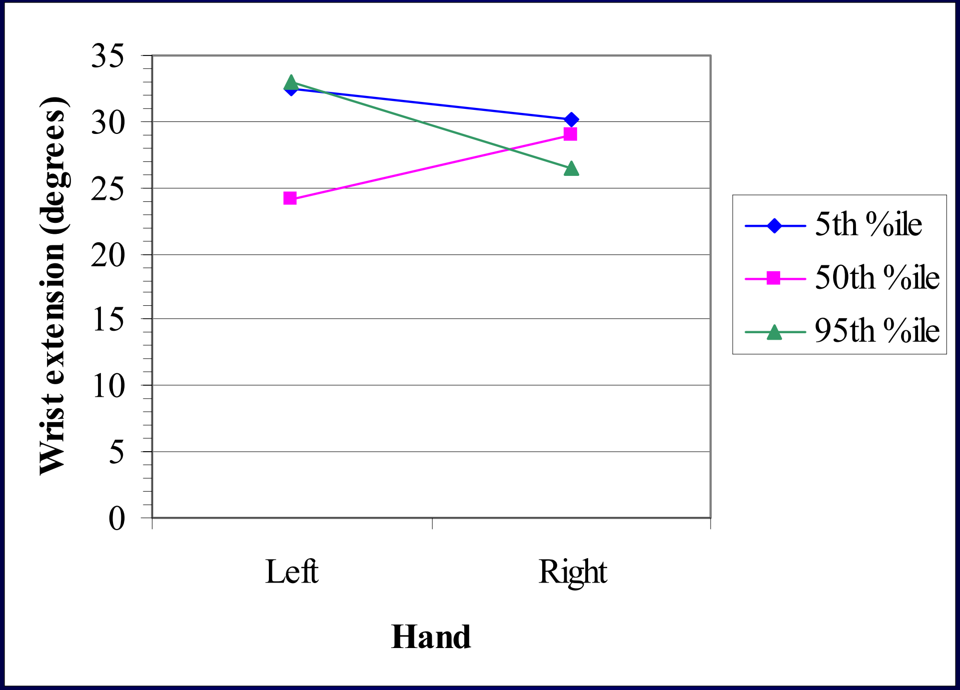
Results: Wrist Extension

- No significant main effects of gender, stature, hand, and chair armrest on mean wrist extension.

- Overall, wrist extension for each armrest design was as follows:
  - Chair A = 28.9° ± 1.7°
  - Chair B = 28.6° ± 1.6°
  - Chair C = 28.1° ± 1.4°
  - Chair D = 31.1° ± 1.7°

Results: Wrist Extension

- Significant interaction of hand X stature ($F_{2,54} = 3.770$, $p = 0.043$)
- Wrist extension:
  - L>R for 95th and 5th %ile stature groups
  - R>L for 50th %ile stature group



Results: Ulnar Deviation

- No significant main effects of gender, stature, hand, and chair armrest on mean ulnar deviation.

- Overall, ulnar deviation for each armrest design was as follows:
  - Chair A = 18.7° ± 1.4°
  - Chair B = 20.3° ± 1.3°
  - Chair C = 18.8° ± 1.3°
  - Chair D = 18.2° ± 1.4°

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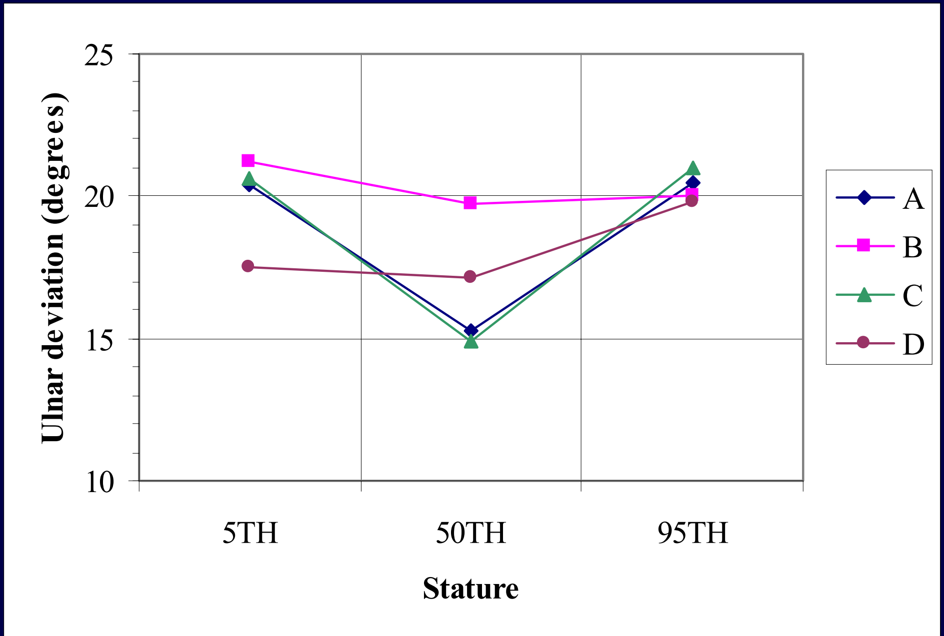
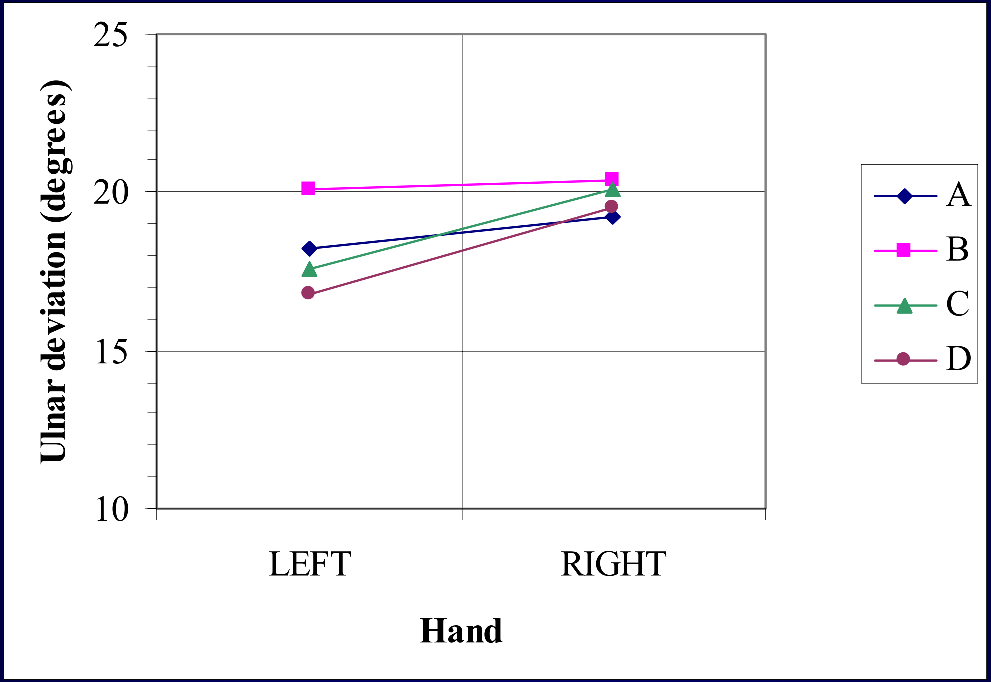
Results: Ulnar Deviation

- Significant interaction of stature X chair
  ($F_{6,54} = 2.526$, $p = 0.031$)
- For all chairs, 50th %ile group is lowest for ulnar deviation.
- Chairs A and C are lowest for ulnar deviation for the 50th %ile group.



Results: Ulnar Deviation

- Significant interaction of hand X chair ($F_{3,54} = 5.562$, $p = 0.002$)
- For all chairs, R > L for ulnar deviation



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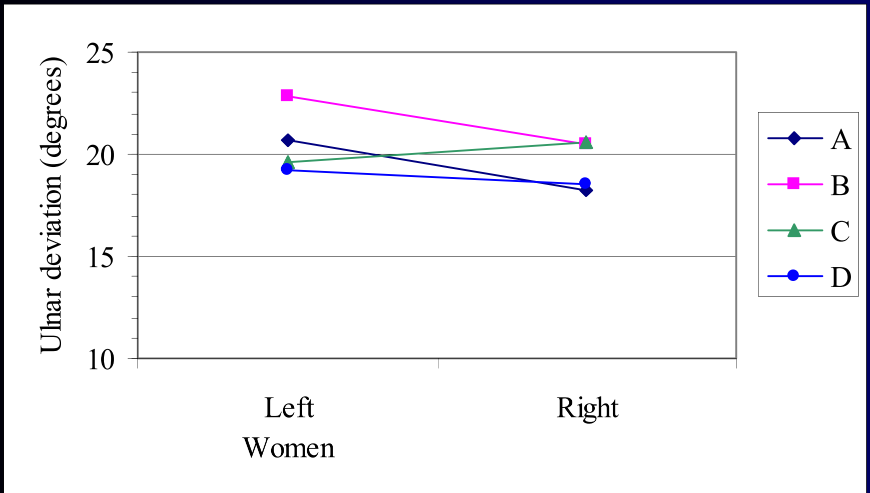
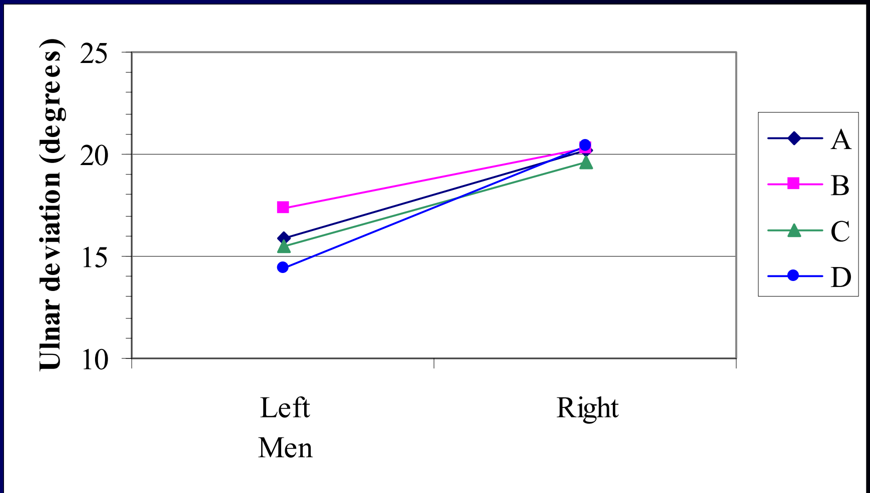
Results: Ulnar Deviation

- Significant interaction of gender X hand X chair armrest
  ($F_{3,54} = 2.973$, $p = 0.040$)
- Women: L tends to be > R for ulnar deviation
- Men: R > L for ulnar deviation





Anthropometric Correlations

- Correlations were computed between age, weight, the measured anthropometric dimensions for R and L arms (SEL, EWL, HW, HL), and wrist extension and ulnar deviation for each chair.

- Age was not significantly correlated with any variable.

- Weight was significantly correlated with several anthopometric dimensions.

- Several significant correlations between these dimensions
  ⇒ especially for R arm

Left Hand

	SEL	*EWL*	*HW*	*HL*
Weight	.60**	.58**	.47*	.74***
SEL		.55**	.06	.76***
EWL			.15	.67***
HW				.18

* P <0.05; ** P <0.01; *** P <0.001

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Right Hand

	SEL	EWL	HW	HL
Weight	.63***	.66***	.66***	.70***
SEL		.68***	.54**	.72***
EWL			.71***	.84***
HW				.61***

* P <0.05; ** P <0.01; *** P <0.001

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Right Hand

- R Hand: Significant correlations among:
  - wrist extension for each chair armrest condition
  - ulnar deviation for each chair armrest condition
- R Hand: Significant negative correlations between:
  - wrist extension and ulnar deviation for each chair armrest condition

Right Hand: Wrist Extension

	B	C	D
A	.93***	.86***	.84***
B		.83***	.75***
C			.84***

* P <0.05; ** P <0.01; *** P <0.001

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Right Hand: Ulnar Deviation

	B	***C***	***D***
A	.83***	.90***	.82***
B		.79***	.82***
C			.76***

* P <0.05; ** P <0.01; *** P <0.001

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Right Hand

	Ulnar D.			
Ext.	A	B	C	D
A	-.41*	-.43*	-.54**	-.44*
B	-.32	-.46*	-.49*	-.38
C	-.34	-.35	-.48*	-.39
D	-.40*	-.35	-.46*	-.51*

* P <0.05; ** P <0.01; *** P <0.001

Left Hand

- L Hand: Significant correlations among:
  - wrist extension for each chair armrest condition
  - ulnar deviation for each chair armrest condition

- No significant correlations between wrist extension and ulnar deviation for any condition.

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Left Hand: Wrist Extension

	B	C	D
A	.76***	.75***	.72***
B		.82***	.69***
C			.77***

* P <0.05; ** P <0.01; *** P <0.001

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Left Hand: Ulnar Deviation

	B	C	D
A	.93***	.94***	.90***
B		.90***	.88***
C			.90***

* P <0.05; ** P <0.01; *** P <0.001

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Weight

- Chair B: Significant negative correlation between weight and R hand ulnar deviation

  (r = -0.42, n = 24, p = 0.039)

- No correlations between weight and any L hand wrist measures.

Summary of Results

- Wrist posture (extension, ulnar deviation) was comparable for the four chair armrest designs.
  - $\Rightarrow$ Armrests may not exert a significant effect on typing wrist posture.
- Some effects of gender, stature, and hand on wrist posture
- Evidence of asymmetry effects: Wrist posture measures were intercorrelated for R hand but not L hand.

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Limitations/Future Research

- Chair armrests compared in this study are among the best available.
- Typing tasks were only 10 minutes long.
- Confounding variables exist within overall chair designs.
  - $\Rightarrow$ 1 chair with 4 armrests v. 4 chairs with 4 armrests
- Subjects adjusted their chairs and workstations to optimal positions, which may have reduced postural variability.

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Limitations/Future Research

- *Caution:*

  On average, wrist postures were high and well outside of a neutral zone of movement.

  ⇒ Good typing posture cannot be simply achieved with a good chair with good armrests.

Conclusion

- All chair armrests tested in this study were equal in terms of wrist posture.
- There is a need for a field study.
- Chairs need to be taken into the context of furniture.

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