Effects of a Vertical Split-Keyboard on Posture, Comfort, and Performance

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Research Goal

To determine the effects of an alternative keyboard design, a vertical split-keyboard (VK) with attached, width-adjustable palm supports on

- dynamic wrist posture
- self-reports of fatigue and discomfort
- typing performance

Results were compared to a traditional keyboard (TK).

The Prototype

Frank DiMeo / Cornell University Photography

The “Vertical” Features:

- QWERTY keypads:
  - 90° inclination, 0° rotation
- Attached, fixed side-mirrors
- Adjustable width (33-40 cm)

Hypotheses

The keyboard designers claim this design will

- Reduce ulnar deviation
- Reduce forearm pronation

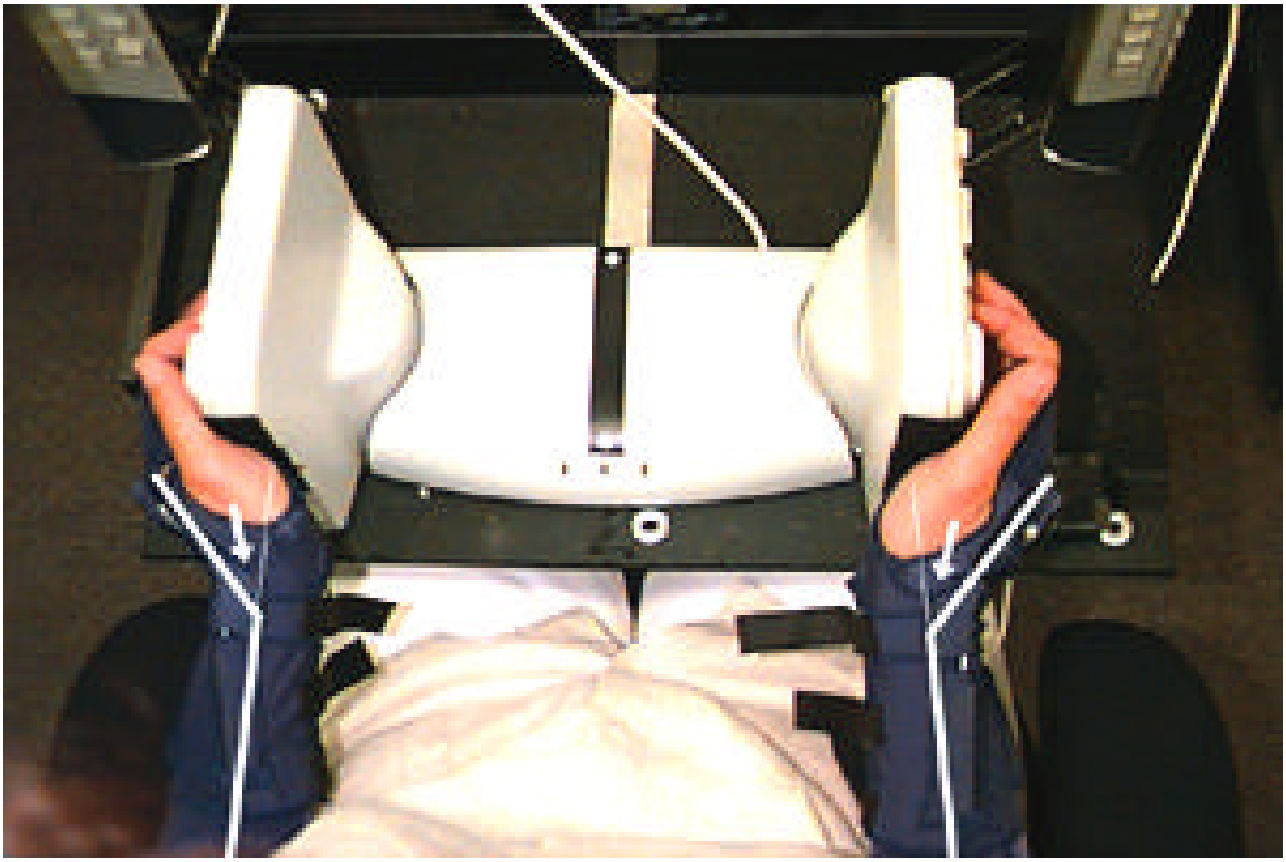
with minimal effects on

- typing performance
- reports of comfort

Cornell Pilot Study

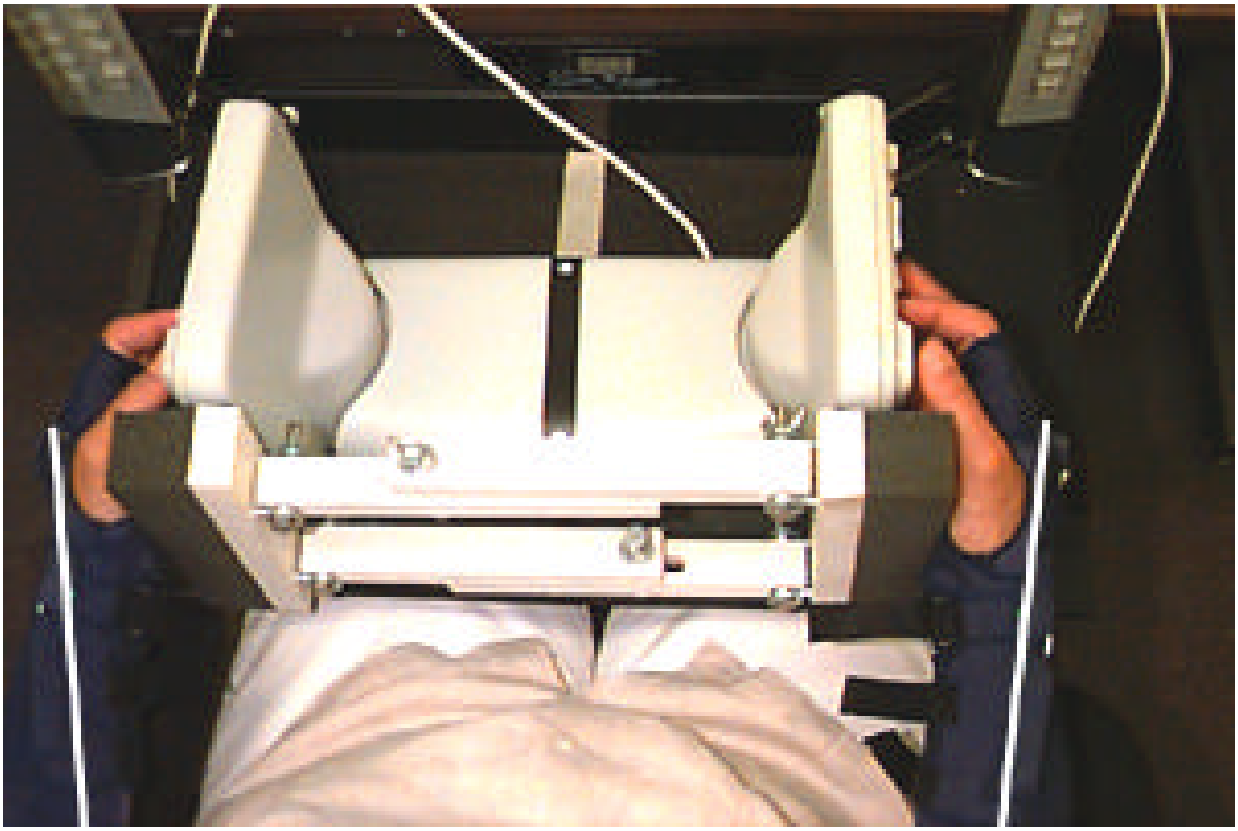
Pilot study suggested

- The “Vertical” prototype may encourage extreme wrist extension



Design Modification

Designers agreed to include a keyboard-mounted, vertical palm support in the evaluation.



Experimental Design

- Repeated measures
- Randomized block design
- 12 female, experienced touch-typists (>45WPM)
- 15-minute typing tasks
- Five counterbalanced conditions

Independent Variables

1. Keyboard

- VK with palm support
- TK with wrist rest

2. Chair

- Standard adjustable
- Specialized adjustable

Dependent Variables

1. Dynamic wrist posture

- measured in degrees with electrogoniometer affixed gloves

2. Comfort

- Self-reports of discomfort and fatigue for 18 body segments.

3. Typing performance

- WPM and percent accuracy with Typing Tutor software

Experimental Conditions

Compare effects of keyboard and chair

- Standard office chair with TK and VK
- Specialized office chair with TK and VK

Compare the effects of with and without forearm supports

- Specialized office chair with chair-mounted forearm supports and VK

Experimental Conditions

Example 1:

Standard office chair with TK

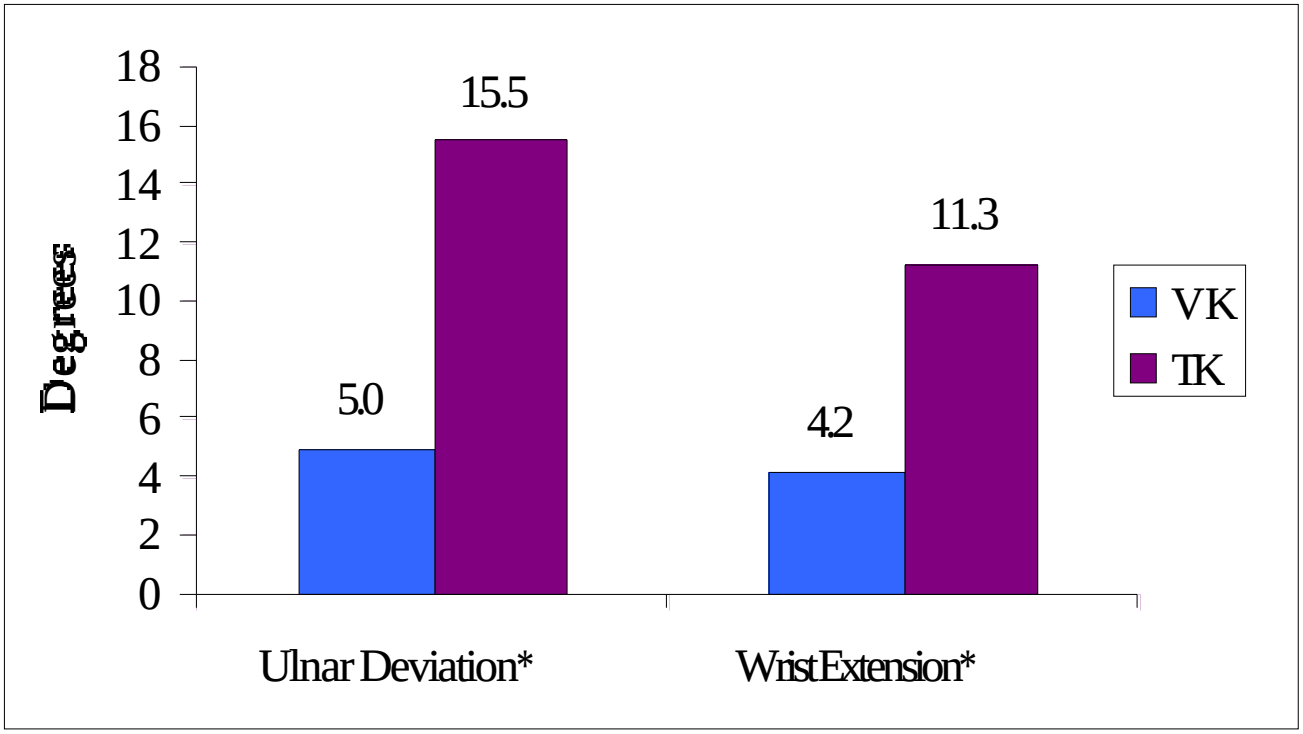
Experimental Conditions

Example 2:

Specialized office chair with chair-mounted forearm supports and VK

Results

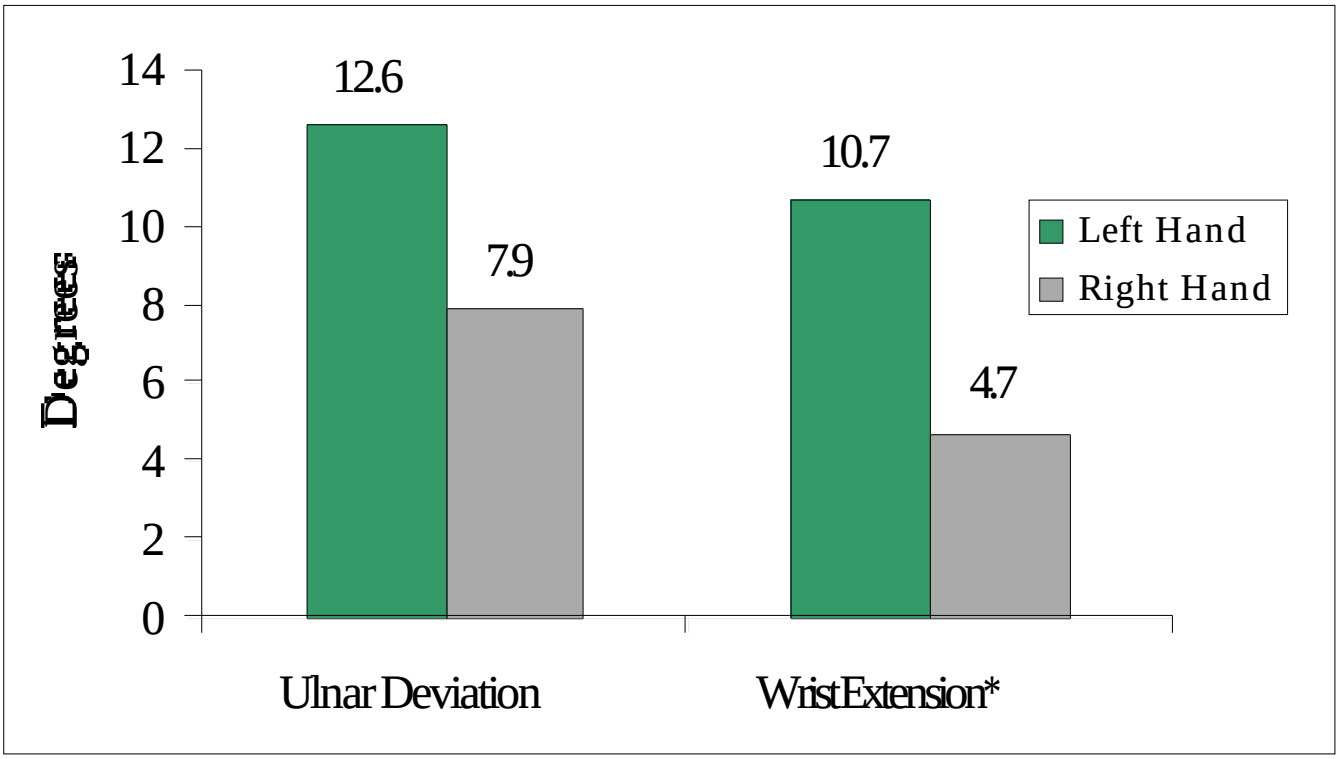
- Mean wrist angles by keyboard



Significant main effect of KEYBOARD on:
*Ulnar Deviation ($F_{1,11}$=160.74, p=.000)
**Wrist Extension ($F_{1,11}$=19.28, p=.001)

Results

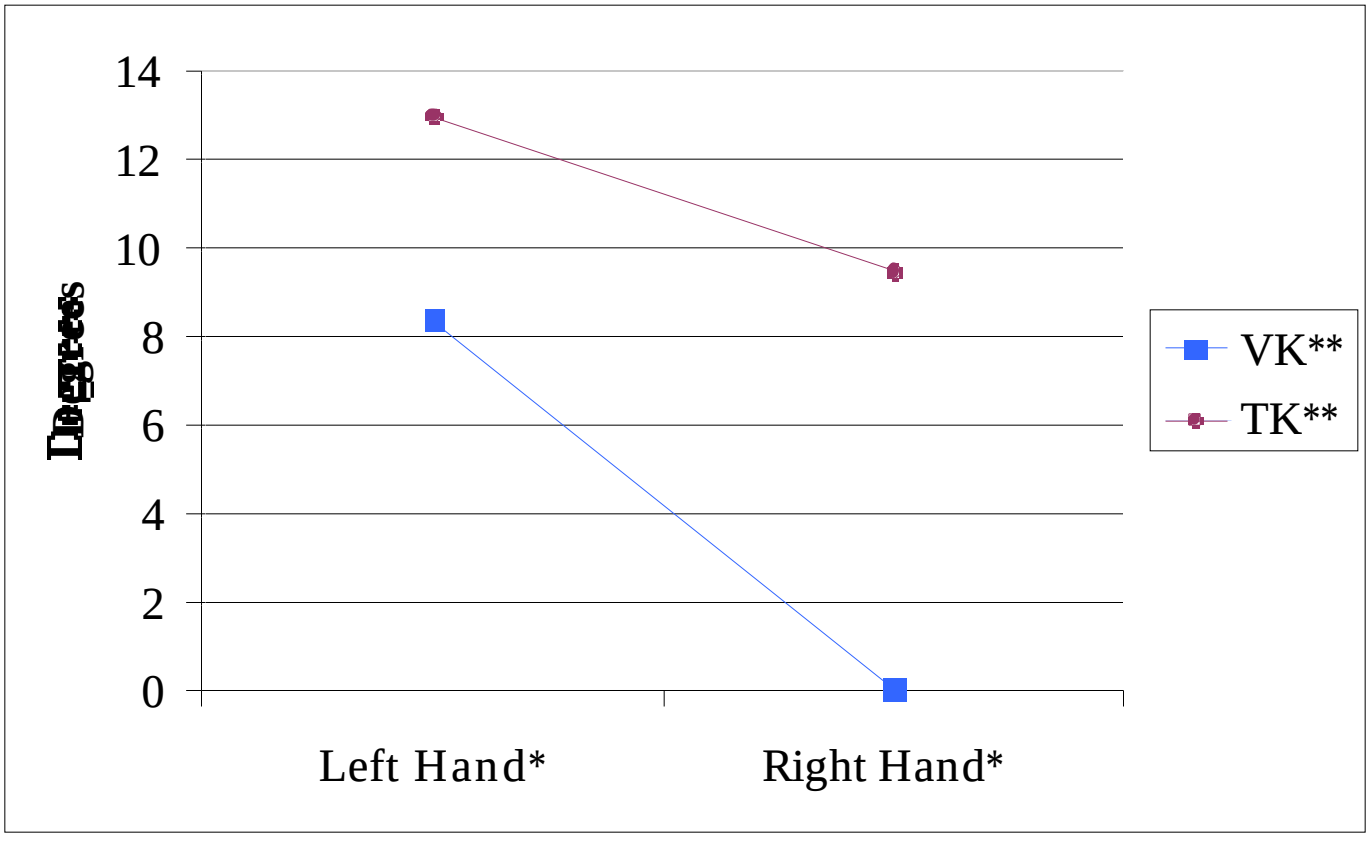
- Mean wrist angles by hand



*Significant main effect of HAND on Wrist Extension ($F_{1,11}$=11.43, p=.006)

Results

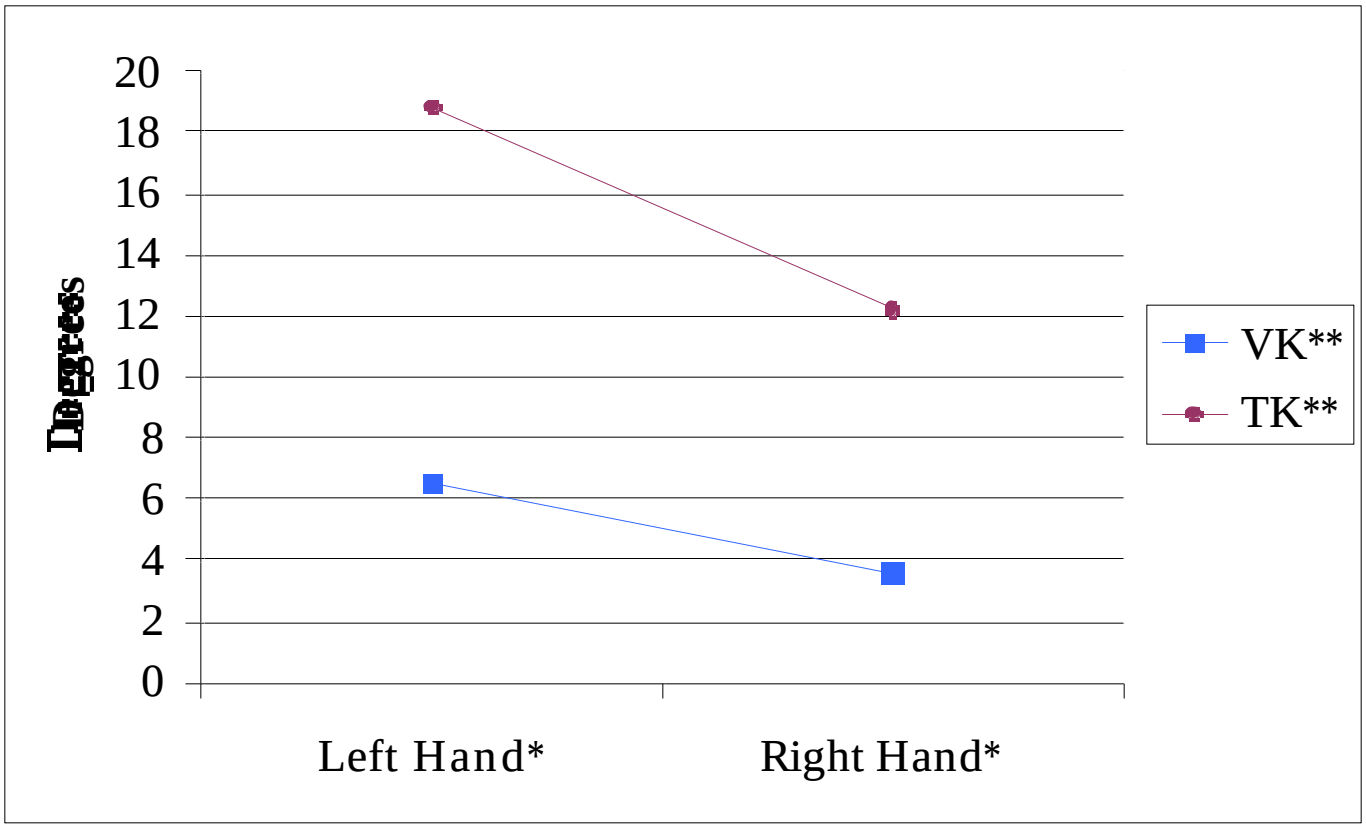
- Flexion/Extension
  - wrist angles for hand by keyboard interaction



*Significant interaction of KEYBOARD X HAND ($F_{1,11}$=6.94, p=.023)

Results

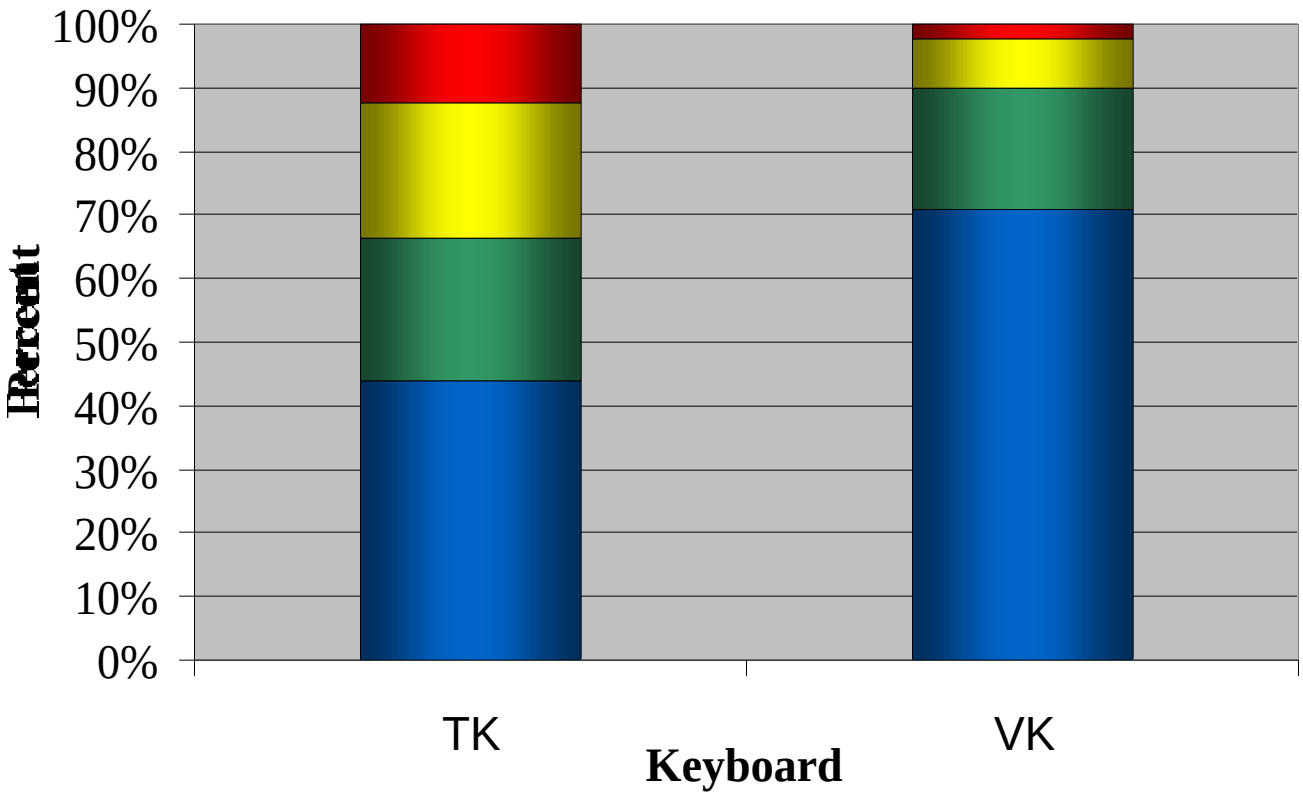
- Radial/Ulnar Deviation
  - wrist angles for hand by keyboard interaction



* Significant interaction of KEYBOARD X HAND ($F_{1,11}$=6.63, p=.026)

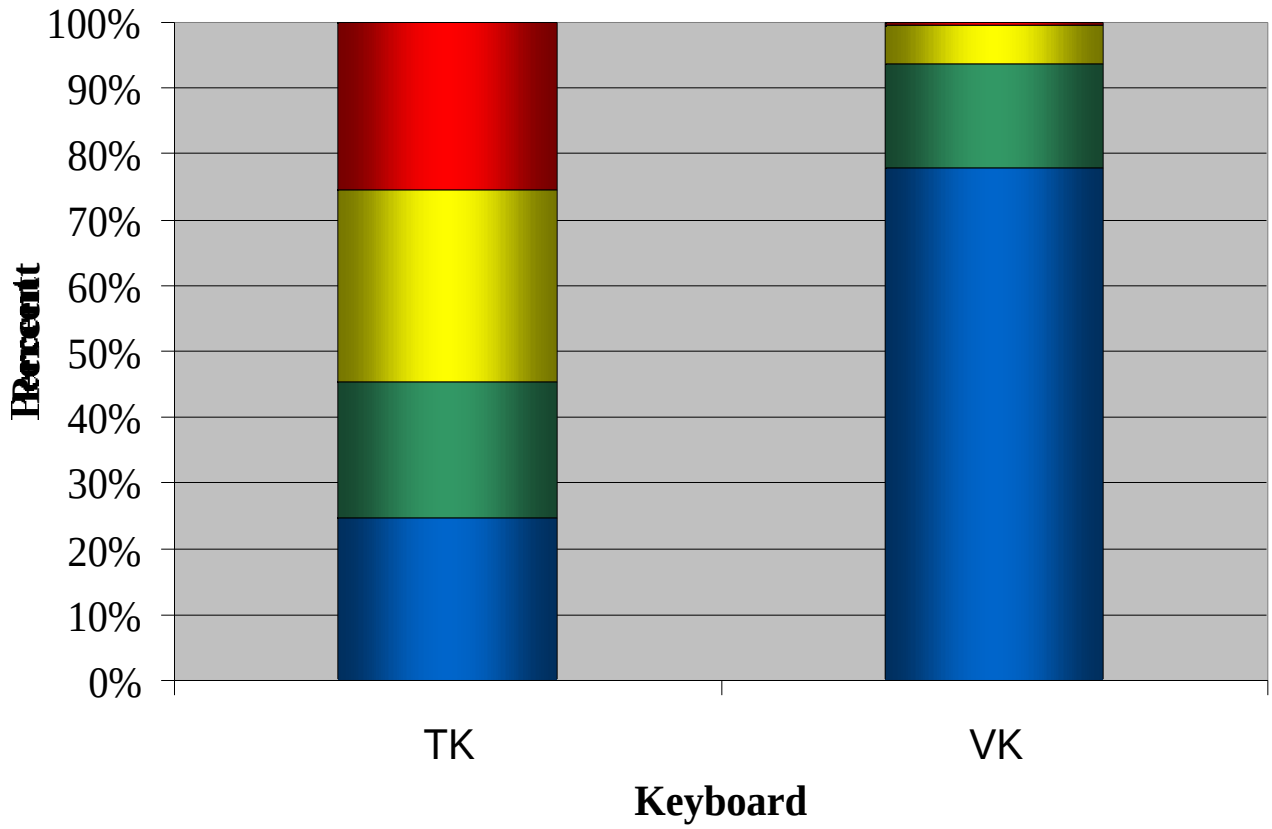
Potential Risk of Injury

- Flexion/Extension
  - % of movements in risk zones
  - HIGHEST (>20.6° flexion or extension)
    - TK: 12% vs. VK: 2% ($F_{1,11}$=12.23, p=.005)
  - LOWEST (<10.5° flexion or extension)
    - TK: 44% vs. VK: 80% ($F_{1,11}$=6.40, p=.028)



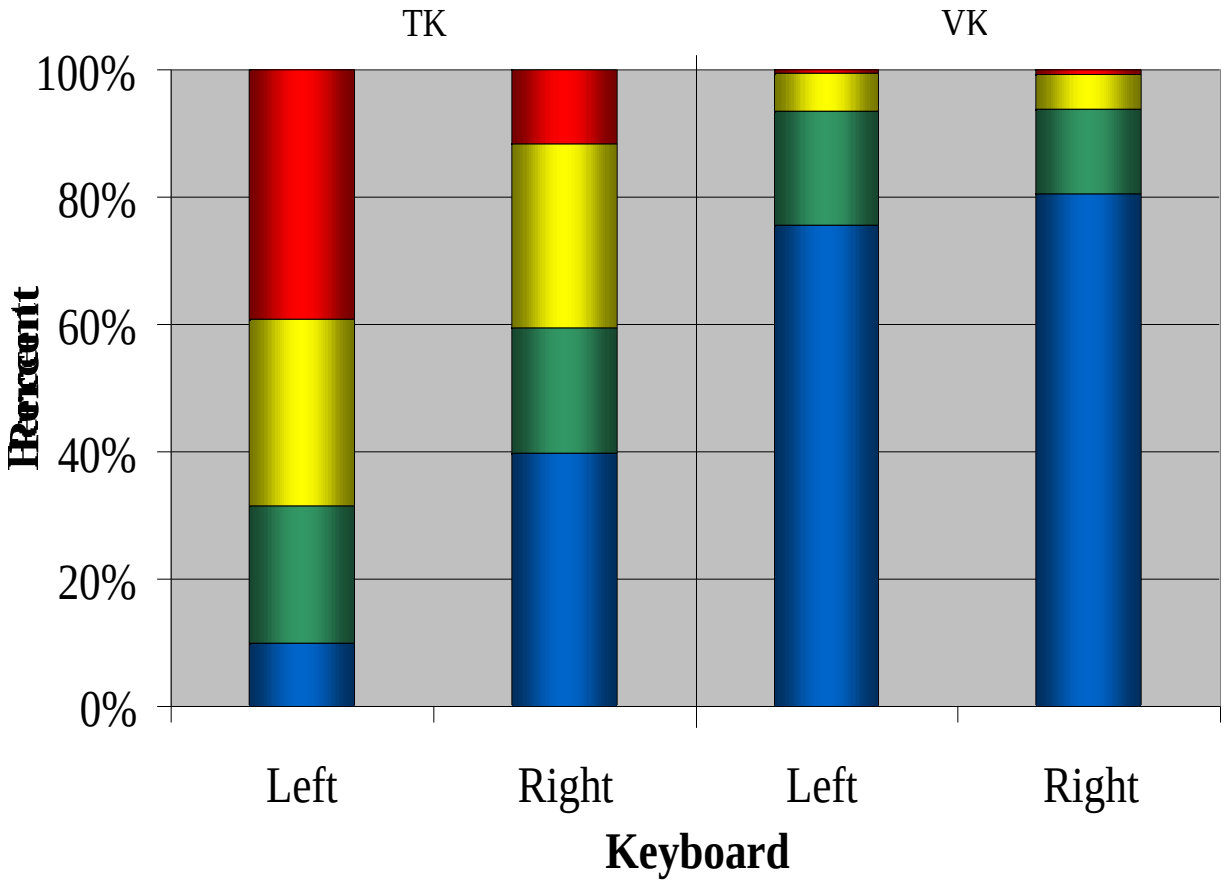
Potential Risk of Injury

- Radial/Ulnar Deviation
  - % of movements in risk zones
  - HIGHEST (>20.6° radial or ulnar deviation)
    - TK: 25% vs. VK: <1% ($F_{1,11}$=19.22, p=.001)
  - LOWEST (<10.5° radial or ulnar deviation)
    - TK: 25% vs. VK: 78% ($F_{1,11}$=75.63, p=.000)



Potential Risk of Injury

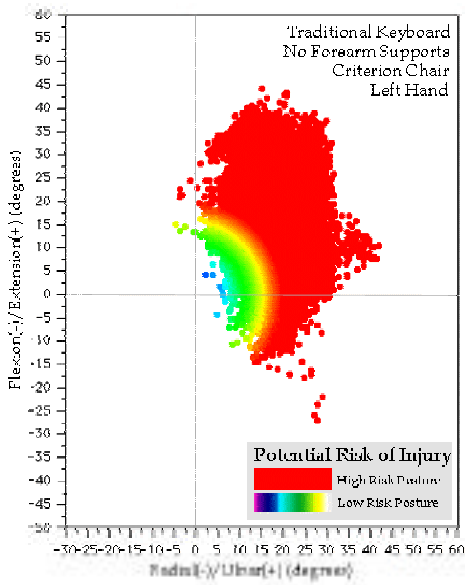
- Radial/Ulnar Deviation
  - % of movements in risk zones in HIGHEST risk zone:
    - HAND X KEYBOARD ($F_{1,11}$=5.97, p=.033)
      - **TK left: 39%, right: 12%**
      - **VK left and right: <1%**



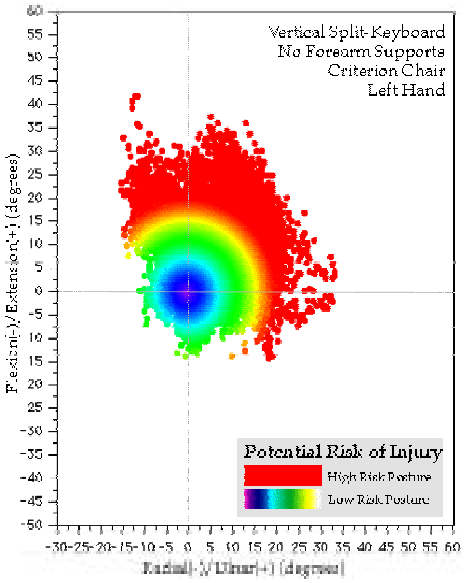
Wrist Movement Plots

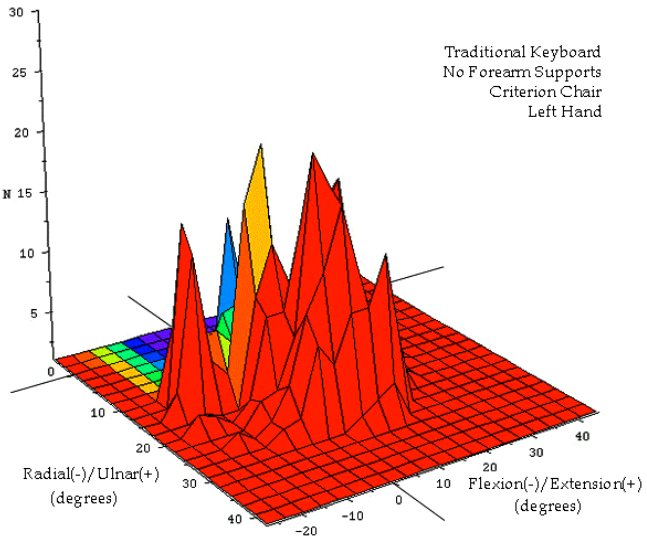
- Left hand

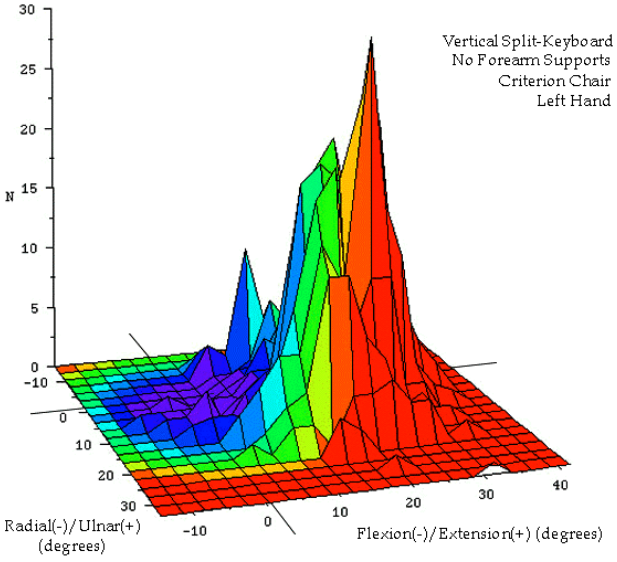
TK



VK



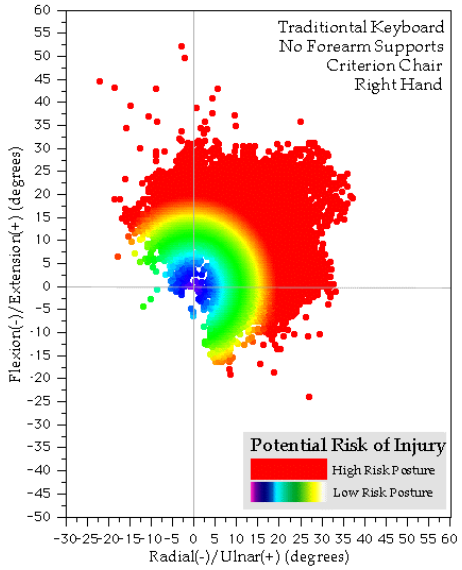




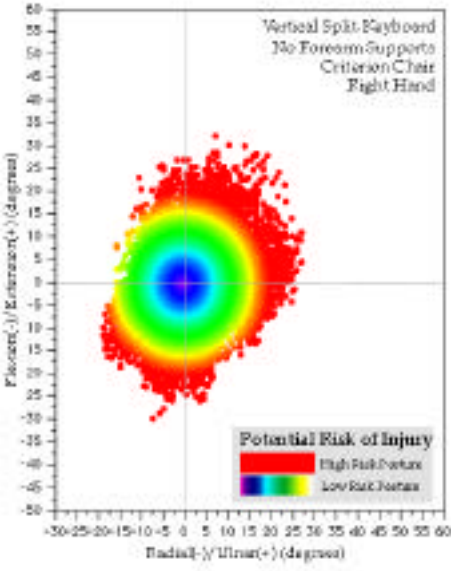
Wrist Movement Plots

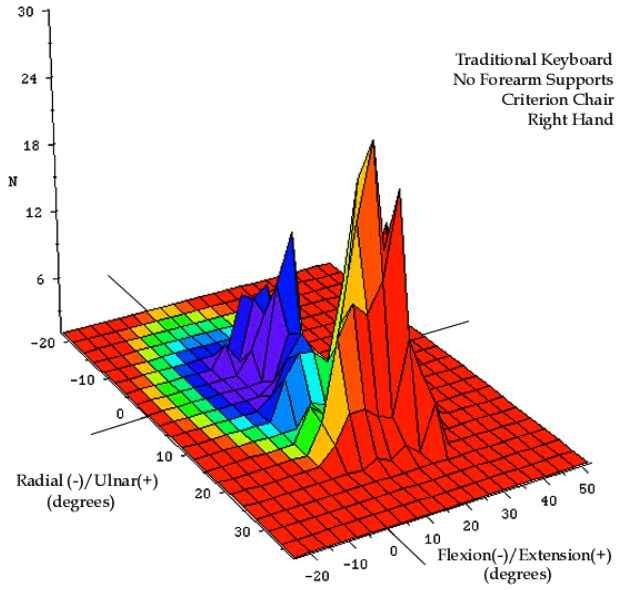
- Right hand

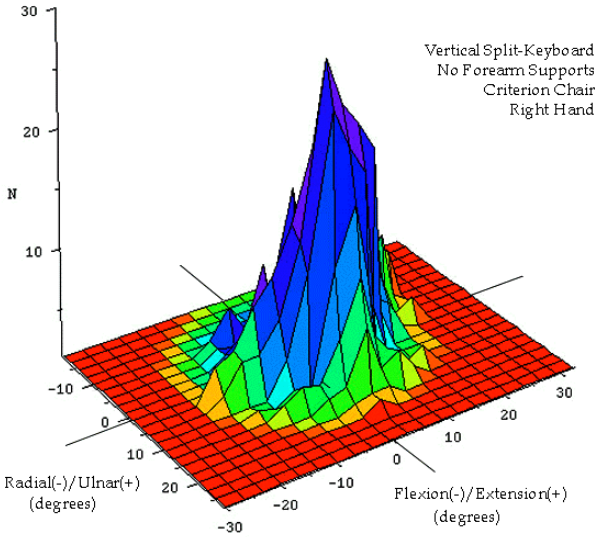
TK



VK







Results

- Self-reports of comfort
  - Mean number of moderate/severe responses per subject for the VK were significantly ***higher**** than for the TK.
    - Fatigue
      - Right forearm (p=.043)
      - Right back of shoulder (p=.022)
      - left back of shoulder (p=.043)
      - Upper back (p=.022)
    - Discomfort
      - Right back of shoulder (p=.043)
      - Upper back (p=.031)

* paired t-test, df=23

Results

- Typing performance
  - Performance for the VK was significantly ***less*** than for the TK.
    - Average WPM
    - ($F_{1,11}$=27.84, p=.000)
      - TK: 60 WPM vs. VK: 50 WPM
    - Average % accuracy
    - ($F_{1,11}$=7.47, p=.019)
      - TK: 92% vs. VK: 89%

Conclusions

- The VK design as tested **did** reduce ulnar deviation and wrist extension as compared to the TK.
  - ° May reduce the risk of injury for VK users
  - ° Differences between hands may be due to
    - – subjects were right-handed
    - – typing tasks required the left hand to perform 57-59% of the keystrokes.

Conclusions

- The VK design as tested **did** reduce forearm pronation as compared to the TK.
  - VK nearly eliminated forearm pronation and may reduce risk of injury.

Conclusions

- The VK as tested **did not** improve user comfort as compared to a TK.
  - 83% of the subjects reported that the TK was more comfortable than the VK.
    - familiarity with the TK
    - radically different posture for the VK
  - Reports of discomfort and fatigue decreased when the VK was used with forearm supports, but were still more frequent than with the TK.

Conclusions

- Comments of Comfort
  - Overall, the mean number of reports of moderate/severe discomfort and fatigue per subject were relatively few. (VK: 0.17-0.33 out of 18)
  - Duration of the keyboarding exercises may have been too short for subjects to accurately perceive discomfort and/or fatigue.

Conclusions

- The VK design as tested **did not** improve typing performance.
  - VK performance for both WPM and percent accuracy was significantly lower than for the TK
  - Subjects were not given a training period for the VK

Future Research

- A long-term field study may
  - Confirm the beneficial effects of more neutral wrist postures
  - Determine more accurately reports of comfort
  - Provide results applicable to a wider range of user groups (i.e. gender, handedness, musculoskeletal injury, anthropometry)

Summary

- Based on the findings of the present study
  - 12 female, touch-typists; five 15-min. typing tasks; laboratory setting

Keyboard	Wrist Posture	Comfort	Performance
Vertical Split-	●		
Traditional		●	●