

# EPIDEMIOLOGY OF MUSCULOSKELETAL DISORDERS AMONG COMPUTER USERS: LESSON LEARNED FROM THE ROLES OF POSTURE AND KEYBOARD USE

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# INTRODUCTION

More than half of US adults now use a computer at work

Widespread concern that computer users are at increased risk of upper-extremity musculoskeletal disorders

Prevention requires characterization of risk

Early studies compared keyboard users to non-users

Attention is focused on characteristics of computer work that might lead to increased risk

# INTRODUCTION

Is computer use associated with musculoskeletal outcomes?

Is the association causal or non-causal?

Review epidemiological evidence of associations between MSD outcomes and:

- computer user posture
- keyboard use intensity (hours/day or hours/week).

# INTRODUCTION

## CAUSAL vs NON-CAUSAL ASSOCIATION (HILL, 1965)

- Strength**
- Consistency**
- Specificity
- Temporality**
- Biologic gradient
- Plausibility
- Coherence
- Experimental evidence
- Analogy

“None of my nine viewpoints can bring indisputable evidence for or against the cause and effect hypothesis...”

AB HILL, 1965

# POSTURE AND MUSCULOSKELETAL OUTCOMES AMONG COMPUTER USERS

## LITERATURE REVIEW:

Six field-based, observational epidemiologic studies in which measures of operator posture were used as exposure variables in analyses relating computer use to UEMSDs.

Only one study followed a cohort prospectively; the remaining five were of cross-sectional design.

# Hunting et al., 1981

**Subjects:** 162 workers using VDTs and 133 comparison subjects

**Exposure:** VDT user posture assessed by direct measurement

**Health outcome:** Discomfort, upper extremity physical examination

## **Results:**

Ulnar deviation  $>20^\circ$  was significantly associated with physical examination abnormalities for some categories of VDT work

Negative association between keyboard height and musculoskeletal discomfort of neck, shoulder, and arms (higher keyboard = discomfort)

head rotation angle and head inclination angle discomfort and clinical abnorm.

Ability to work with hands and forearms supported neck, shoulder and arm pain

# Starr et al., 1985

Subjects: 100 video display terminal operators

Exposure: VDT operator posture estimated from photographs taken while participants were keying

Health outcome: Musculoskeletal discomfort questionnaire

Results: Increasingly downward monitor viewing angle    discomfort

# Sauter et al., 1991

Subjects: 40 VDT users

Exposure: Direct measurement while the participant was working at his/her VDT workstation

Health Outcomes: Musculoskeletal discomfort rating scale

## Results:

Right arm discomfort was associated with:

Shoulder flexion (flexion discomfort)

Relative keyboard height (keyboard height wrt elbow discomfort)

Right hand ulnar deviation

Left arm discomfort was associated with:

Relative keyboard height

Relative document distance (document distance discomfort)

# Faucett and Rempel, 1994

**Subjects:** 70 newspaper workers

**Exposure:** Direct measurement of VDT workstation configuration and operator posture

**Health outcome:** MSD outcomes were assessed with a questionnaire

## **Results**

Upper torso:

Head rotation and keyboard height above elbow height were associated with pain and stiffness severity

Significant interactions were observed between posture and some psychosocial work factors and some upper torso MSD outcomes

Upper extremity:

Significant interactions were observed between posture and some psychosocial work factors and some UE MSD outcomes

# Bergqvist, et al., 1995

Subjects: 260 VDT users

Exposure measures: “extreme hand positions” and keyboard-elbow height difference

Health outcomes: MSD symptoms and clinical examination

## Results:

N/S outcomes were significantly associated with “too highly placed keyboard”

Arm/hand symptoms were non-significantly associated with low keyboard placement

Arm/hand symptoms (but not diagnoses) were significantly associated with “non-neutral position” of the wrists

Odds ratios below 1.0 for associations between table “inadjustability” and shoulder disorders and between frequent overtime and neck diagnoses

# Marcus et al., 2002

Subjects: 632 newly hired computer users

Exposure measures: direct measurement at time of enrollment

Health outcomes: symptoms and examination confirmed disorders

## Results:

Neck/Shoulder outcomes: Lower risk associated with (significant or near significant):

- Inner elbow angle  $>121^\circ$

- greater downward head tilt

- placement of the keyboard  $>17$  cm from the edge of the desk

- presence of armrests on the participants chair

- J key below elbow height

- Absence of telephone shoulder rest

Hand/Arm outcomes: Lower risk associated with:

- Horizontal location of the "J" key  $>12.5$  cm from the edge of the desk

- Use of a keyboard with the "J" key  $<3.5$ cm above the table surface

- Radial wrist deviation of  $<5^\circ$  while using a mouse

## POSTURE AND NECK/SHOULDER MSD OUTCOMES

Study	N	Postural variable			
		keyboard ht. below elbow ht.	armrest or ability to rest arms	downward head tilt	head rotation
Hunting et al., 1981	295				
Starr et al., 1985	100	-	n.a.		-
Sauter et al., 1991	40	n.a.	n.a.	-	
Faucett & Rempel, '94	70		n.a.	-	
Bergqvist et al., 1995	260		n.a.	n.a.	n.a.
Marcus et al., 2002	632				-

# POSTURE AND HAND/ARM OUTCOMES

## Postural variable

Study	Sample size	Keyboard ht below elbow ht	Ulnar deviation	Radial deviation	Wrist extension	Wrist flexion	Keyboard thickness
Hunting et al., 1981	295			-	-	-	
Starr et al., 1985	100	n.a.	n.a.	n.a.	-	-	n.a.
Sauter et al., 1991	40			-	-	-	n.a.
Faucett & Rempel, 94	70	or **	-	-	-	-	n.a.
Bergqvist et al., 1995	260		?	?	?	?	n.a.
Marcus et al., 2002	632	n.a.	-	*	-	-	

\* while using mouse

\*\* depending on interaction term

# WHY AREN'T THE RESULTS CONSISTENT?

## CROSS SECTIONAL STUDY DESIGN

Associations may be observed between musculoskeletal illness and postures that were assumed after the illness onset (suggested by Bergqvist)

## HETEROGENEITY OF EXPOSURE ESTIMATION AND HEALTH OUTCOME ASSESSMENT

## INCOMPLETE CONTROL OF CONFOUNDING

e.g., psychosocial stress

# WHY AREN'T THE RESULTS CONSISTENT?

## LIMITED PRECISION OF POSTURE ESTIMATION

How representative is one measure of posture?

Ortiz et al. (1997) performed a repeated measures study of postural variability between and within computer users

For wrist, elbow, shoulder, and neck postures, variability was significantly greater between users than within users

Ortiz et al. concluded that a single measure of posture can distinguish postures between participants in an epidemiological study

***-however-***

Repeated measures would increase the precision of posture estimation and would improve power to detect posture effects

# WHY AREN'T THE RESULTS CONSISTENT?

## NON-INDEPENDENCE OF POSTURAL VARIABLES

Upper limb postures are clearly biologically related to each other

Multivariable analyses that include multiple related postural measures may have estimation problems

If postures and musculoskeletal outcomes are modeled individually, associations may be confounded by the effects of postures not included in the model

Principal components analysis of the posture exposure variables

# **EFFECTS OF DAILY OR WEEKLY COMPUTER USE INTENSITY ON MSD OUTCOMES AMONG COMPUTER USERS**

**15 studies identified in which daily or weekly hours of computer use was examined as a risk factor for MSD outcomes**

**One prospective, 14 cross sectional**

## KEYBOARD USE INTENSITY (HOURS/WEEK OR HOURS/DAY) AND MSD OUTCOMES

Study	N	Neck/ shoulder outcomes	Hand/ arm outcomes	Location not specified	Comments
Canadian Labour Congress, 82	1742		n.a.	n.a.	Lower risk in highest category
Sauter et al. 1983	333	n.a.	-	n.a.	
Knave et al., 1985	550	n.a.	n.a.		
Rossignol et al., 1987	1545	n.a.	n.a.		7 h/d vs 0 h/d
Fahrbach and Chapman, 1990	205		n.a.	n.a.	Possible confounding by gender
Sauter et al., 1991	539	n.a.	-	n.a.	
Bergqvist et al., 1992	134			n.a.	<5h/wk vs. <30h/wk vs. >30h/wk
Bernard et al., 1994	1000	-		n.a.	Possible threshold?
Faucett and Rempel, 1994	150			n.a.	
Bergqvist et al., 1995	353	-	-	n.a.	Sig. interaction with other expos.
Polanyi et al., 1997	1007	n.a.	n.a.		
Nelson and Silverstein, 1998	577	-		n.a.	
Evans and Patterson, 2000	170	-	n.a.	n.a.	
Katz et al., 2000	1544	n.a.		n.a.	College seniors
Marcus et al., 2002	632	-		n.a.	Prospective
<b>TOTAL</b>		<b>3</b>	<b>6</b>	<b>3</b>	
		<b>5-</b>	<b>3-</b>		
		<b>1</b>	<b>0</b>		

# CONCLUSIONS

## KEYBOARD USE AND MSD OUTCOMES

Greater consistency among studies

Hand/arm outcomes appear to be more consistently associated with keyboard use than neck/shoulder outcomes

# REASONS FOR REMAINING INCONSISTENCY

Selective survival bias in cross sectional studies (can even observe paradoxical associations)

Cause-effect reversal bias

Information bias – exposure self-reported by persons with and without symptoms

# AREAS WHERE KNOWLEDGE IS INCOMPLETE

Shape of the dose response relationship

Effect modification (interaction) with other exposure variables

# CONCLUSIONS

**CAUSAL ASSOCIATIONS BETWEEN COMPUTERS AND MSDs?**  
(STRENGTH, CONSISTENCY, TEMPORALITY)

## POSTURE

Appears to be an independent risk factor for MSDs among computer users

Most consistent for relative keyboard height, head rotation, (resting of arms?)

Effect magnitude is not large

## COMPUTER USE INTENSITY

Hours keying appears to be a risk factor for MSDs among computer users

Effect magnitude is at least moderate

Is effect greater for hand/arm than for neck/shoulder?