Evolution of the Computer Mouse
Prevention of Pain & Discomfort

Anatomy shows more than seen only from an Ergonomic Aspect

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Reference Study Fit for Work

Musculoskeletal Disorders in the European Workforce*

- 40 million workers in Europe are affected
- Repetitive Strain Injury (RSI) costs, €2.1 billion per annum in The Netherlands alone

* An increase in incidence of RSI is noted
* Fit for Work Musculoskeletal Disorders in the European Workforce, September 2009

www.fitforworkeurope.eu
Fundamental and Field Research shows

Relaxation in neck, shoulders, arms, hands and fingers

can be realized
Possible Sources of Irritation of Muscles

- not supporting forearm hand and fingers
- moving from the wrist (sideways)
- over extension of the wrist (hovering with the hand)
- excessive pronation and supination (hand shake position)
- gripping and pinching
A Step by Step Journey via the Anatomical Roadmap

1. Trapezius and Deltoid Muscles activity
2. Little Finger (Ulnar) sided Wrist pain
3. Hand Palm support
4. Position of Forearm and Wrist
5. Ulnar sided Dermatological (skin) effects
6. Proprioceptive Reflexes (neural excitation)
7. Summary and Conclusion
1. Trapezius and Deltoid Muscles activity

**Hand activities**
- influence the descending part of the Trapezius muscle
- but only partially influence the Deltoid muscle
- Deltoid muscle shows fatigue when holding the upper limb in position

Even activities of fingers only can influence muscles of arm and shoulder.
Trapezius and Deltoid Muscles activity

Points of attention

- Trapezius muscle supports the upper extremity posture
- Deltoid muscle is one of the main shoulder joint drivers
- Higher precision of tasks results in higher muscle tension
- Emotional stress as well as difficulty and complexity of tasks

Studies show precision influences tension of:

- Trapezius muscle
- But not of Deltoid muscle
Trapezius and Deltoid Muscles activity

**Prevent unnecessary muscle loads**
- support forearm, hand and fingers
- use desktop and or armrest
- height adjustable desks facilitate arm support

**Result;** minimal exertion of Trapezius muscles (lower EMG* values)

Note, wrist supports do not reduce muscle activation.

* EMG values show the level of muscle activity
Trapezius and Deltoid Muscles activity

Desktop contact of Ulna (little finger side) is prevented

- slight supination ($\sim 25^\circ$ ulnar side) hand palm facing downwards
- fine muscle tonus results in firmer forearm muscles (coapting)
- coapting due to positioning activity while handling an object

Ref. Leonardo da Vinci (1452-1519), study of Arms, Louvre, Paris, France
Trapezius and Deltoid Muscles activity

Relaxed and supported forearm hand and fingers

Do not reach
2. Little Finger (Ulnar) sided Wrist pain

Muscle action
- Extensor Carpi Ulnaris muscle
- Flexor Carpi Ulnaris muscle
- these muscles acting together can cause “wrist snap”

Note, reaching can also cause wrist pain

Wrist snap

Reaching
Ulnar sided Wrist pain

A random case history of moving the wrist sideward

- Extensor Digitorum muscle (A)
- Extensor Carpi Ulnaris muscle (B)
- Extensor Carpi Radialis muscles (ECR longus and brevis)

Extensor Carpi Ulnaris
Ulnar sided Wrist pain

**Muscle action**
- muscles acting together can cause “wrist snap”
- affecting wrist flexor muscles at the elbow
- frequent contractions lead to “pumping up”

Repetitive hand motions, moving the wrist sideways, may lead to some detrimental effects due to “compression neuropathy”.
Ulnar sided Wrist pain

Possible solutions

- change forearm position to reduce contact pressure
- increase portion of forearm resting on desktop or armrest
- pivot forearm around Flexor muscle belly
- prevent wrist snap
3. Hand Palm Support

Hand Palm Fascia

- a supporting triangle of great strength and density
- central portion occupies the middle of the hand palm
- fatty tissue surrounds this triangle
Hand Palm Support

Fundamental and field research results show

A hand supporting spherical (ball shape) body realizes minimal EMG values and thus lower MVC* values.

* Minimal Voluntary Contraction (MVC)
No Hand Palm Support

Resulting Grip Forces

Conventional mouse
- no hand palm support
- grip and pinch forces in fingers and thumb
- resulting reaction force and moments of force in joints
Grip Forces

What are we looking at

Reaction forces in the dominant functional (PIP*) joint

- reaction force $F_r$ due to grip force
- moments $F_r \times L_1$ and $x L_2$

* Proximal Inter Phalangeal (PIP) Joint
Grip Forces

What are we looking at

Handshake position, vertical mouse
- grip and pinch forces in fingers and thumb
- critical moment and force in (CMC*) joint of thumb

* Carpometacarpal (CMC) Joint
4. Position of Forearm and Wrist

Behaviour of Ulna and Radius

Motion of Forearm and Wrist

Behaviour of Ulna and Radius

**Handshake position**
- increased flexion and extension of wrist
- forearm in an unnatural position, supination more than 25°
- Interosseous Membrane (IOM*) taut

* Interosseous Membrane (IOM)
Forces on Interosseous Membrane

Mouse use in handshake position

- thumb and finger muscles connect to IOM
- possible muscular damage (microlesions) due to longstanding repetitive movements of thumb and fingers
5. Ulnar sided Dermatological (skin) effects

**Sources of complaints**
- friction, pressure and sweating
- wrist pivots on desktop

Note, hard plastics used in PC mice (ABS), rarely cause contact allergy.
Ulnar sided Dermatological (skin) effects

Unavoidable skin contact
6. Proprioceptive Reflexes (neural excitation)

Receptors provide information (proprioception)
- perception of stimuli relating to e.g. posture and position
- connective tissue is stretched or loaded and thus signals tension
- ligaments may function as proprioceptors

Note adhesion of tendons and ligaments is ensured by Sharpey’s fibers.
Proprioceptive Reflexes (neural excitation)

**Sharpey’s fibers**
- are an integral part of the bone structure
- provide tissue anchorage
- traverse the Periosteum* (see grey circumference)
- integrate directly with the muscles, ligaments, and tendons

Act contrary to for example sellotape when peel forces are exerted.

* Periosteum, bone covering membrane
7. Summary

What happens when we move from A to B to C

- **Pronated position (A)**
  - grip and pinch forces, excessive loads in PIP joint
  - skin contact

- **Supinated position of more than 25° (B)**
  - pinch forces instigate excessive loads in e.g. CMC joint
  - proprioceptive reflexes indicate temporary relief
  - skin contact

- **forearm and palm position of around 25° and supported fingers (C)**
  - IOM relaxed, reduced stress and positive (proprioceptive) reflexes
  - no grip and pinch forces
  - no skin contact
7. Conclusion

Evidence Based Results

A lightly slanted palm and finger supporting computer mouse requires least muscle activity and results in reduced neural excitation.
Reactions and Questions

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