Effects of the use of a special computer mouse

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EMG measurements executed by IDEE University of Maastricht

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Publications


- Computer mouse use in two different hand positions: exposure, comfort, exertion and productivity, Applied Ergonomics, volume 34, issue 2, March 2003, Ewa Gustafsson, Mats Hagberg


- A new computer mouse called Horse, C.J. Snijders and P.C. Helder in Europhysicsnews, issue 35/6 2004


- The build up of unnecessary tensions by the current computer mouse. Submitted to Clinical Biomechanics, August 2006, C.J. Snijders, M. van den Bergh, J. Storm J, J.J.M. Pel

Note, publications are either in draft, submitted and/or published
Neck- shoulder- arm- en hand complaints

Neck- shoulder- arm- en hand complaints also referred to as Repetitive Strain Injury (RSI) or Upper Extremity Cumulative Trauma Disorders (UECTD).

This is not a diagnosis but a general description.

These complaints are a serious source of discomfort and stress and may result in absence from work.
Increasing incidence of RSI is noted

Contributing factors to upper-extremity complaints are:

- repetitive movements
- awkward postures
- static force

Furthermore, a working environment which is a source of stress increases the risk of these complaints.
Fundamentals

Reduction of day to day productivity due to complaints in:
- neck and shoulders, 11%
- elbow, wrist and hand, 5%

Fundamental disadvantage of current input devices:
- User is susceptible to stress and strain
Neck-shoulder-arm-en hand complaints ranked by age

Percentage RSI among the working population of the Netherlands in 2000 (CBS, 2002)
Background and theory

Research with Erasmus University Medical Center (Erasmus MC) Rotterdam, The Netherlands has shown that relaxation in neck, shoulders, arms and hands can be realized by means of:

- relaxation of hand and fingers (Extensor Digitorum Communis)
- a reduction of force when pinching and gripping (Extensor Carpi Radialis Longus and Brevis)
Model I gripping and pinching

wrist flexes: flexor activity

gripping: flexor and extensor activity

Publication March 1987 in Medicine and Science in Sports and Exercise, Volume 19, No 5 “Provocation of epicondylalgia lateralis (tennis elbow) by power grip or pinching”.

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Model II bloodflow in arms and hands

Compression of arteries, veins and nerves results in:

- tingling
- pain
- numbness
- obstruction of flow

in arms and hands.
Anatomy

Superficial neck muscles:
- realize movement of the head
- connect vertebrae with first rib
Anatomy

Deep neck muscles

- stabilize head on torso
- postural muscles are continuously active
Anatomy

Deep neck muscles

Increased tension due to stress or activities results in:

- contraction of these muscles
- reduction of mobility of the head
- increase in pressure on vertebrae
- risk of pressure on nerves

The first rib is slightly elevated.
Anatomy

Excessive muscle tension

Increased tension results in:
- reduced space between first rib and clavicular bone

Compression of:
- arteries (red) reduction of flow
- veins
- nerves
Anatomy

Excessive muscle tension

Increased tension results in:
- reduced space between first rib and clavicular bone

Compression of:
- nerves (yellow) results in tingling
- arteries
- veins
Fully relaxed hand after 3 days
Types of physical load

- extensor muscle load, hand & fingers hover above the mouse
- gripping and pinching
- Cinderella effect, exertion of unnecessary static forces
- too large supination angle
- excessive ulnar deviation of the wrist, “hand shake position”
- excessive extension of the wrist
- hand and lower arm hover above an object
Physical load type I

With the existing computer mouse fingers have to remain elevated in between switching to prevent inadvertant switching. This results in *extensor* load.
Extensor load

Fingers and hand hover above the mouse
EMG data from fundamental research

EMG values show the level of muscle activity

visible moments of rest

no moments of rest

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Fundamentals of Extensor Relaxation

Conventional concept

New concept
Relaxed hand
Extensor muscles active
Comparison of regular mouse and new design

Rotation of vector $Fd$ reduces the “cantilever” from $a$ to $a'$ resulting in a reduction of required muscle force to switch.
Fundamentals of Extensor Relaxation
Angles with relaxed hand

approx 45 degrees

approx 45 degrees
Angles of relaxed hand on new design
Overview of angles

max 165 degrees
forearm

desktop = support

approx 15 degrees

approx 75 degrees

proximal surface

45 degrees

middle surface

45 degrees

distal surface

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Extensor Relaxation

Theory and practice of extensor relaxation

- prevent or reduce extensor use
- instigate relaxation response

Result

- lower tension of the (postural) muscles
- reduction of constriction of subclavicular artery and vein
Physical load type II

**Cinderella effect**, exertion of unnecessary static forces:
- extensor load, tonic muscles act continuously
- special motor units (type I muscle fibres) control lesser forces, are continuously active resulting in irritation and aggravation
Physical load type III

Objects that induce *gripping and pinching* due to shape:

- the regular mouse, too small for the average hand, held between thumb, ring finger and little finger
- thin, pen like objects, held between thumb, ring finger and little finger
- handle shape objects, gripped by the entire hand
Physical load type IV

A too large supination angle: objects force hand and lower arm in a strained position:

relaxed hand
supination angle of around 15°
Physical load type V

“Hand shake position”, a too large supination angle combined with an excessive ulnar deviation:

The hand is forced in a position resulting in an ulnar deviation of the wrist outside the regular functional area.
Physical load type VI

A **too large extension angle** of the wrist:
Corresponding with load type V the hand and wrist are forced outside the functional area.
Physical load type VII

Hover the hand and arm above an object:

For example the use of a pen in combination with a tablet forces hand and possibly lower arm in a hovering position to allow for a free motion over the tablet.
Summary

Over exertion of muscles results in discomfort, even aggravation. The objective should therefore be a low EMG/MVC value.

Relaxation results in:
- improved blood flow in arms and hands
- enhances comfort and health
Results field research

- at intake all participants expressed complaints
- with 53% of the study population complaints were continuous
- after 6 months no participant suffered from continuous complaints
- 22% expressed no complaints at all
- mean blood flow velocity radial artery increase, 14 cm/s to 16 cm/s
- proportion of participants with an average blood flow velocity in the radial artery of ≤ 3 cm/s decreased from 23% to 10%
- average Circular Range Of Motion (CROM) improved from $133^0$ to $155^0$

Note, a positive appreciation of the special mouse was expressed with respect to shape (84%) and weight (86%).
Interventions and treatments

Overview applies to the period prior to field research

1. General Practitioner (GP)
2. Physiotherapist
3. Occupational Health Physician (OHP)
4. Other therapists
5. Rehabilitation programme
6. Psychologist
7. Neurologist
8. Orthopaedic Surgeon
**Recommendations**

- repetitive movements result in discomfort and aggravation, one should therefore aim at low EMG values

Prevent the Cinderella effect, exertion of unnecessary static forces:

- tonic muscles act continuously to exert these static forces
- special motor units (type I muscle fibres) control the lesser forces (5-10% MVC) and are continuously active resulting in irritation and aggravation
Reactions and questions
Evaluation of 8 ergonomic computer mice

a regular mouse and

the computer mouse by Hippus
Evaluation of ergonomic computer mice

IDEE University Maastricht, the Netherlands, has performed the necessary EMG measurements.

The protocol consisted of:
10 sec. rest,
10 sec. motion,
10 sec. rest
10 sec motion, however with the left button active.
Evaluation of ergonomic computer mice

EMG-measurement set-up:
EMG signal of extensor muscles

extensor carpi radialis longus

extensor carpi radialis brevis
Evaluation of ergonomic computer mice

A number of ergonomic computer mice were made available for the evaluation programme. The use of these mice resulted in complaints with the users. The source of these complaints could in general be attributed to the aforementioned 7 types of physical load factors.

Muscle exertion has been measured by means of EMG
Source of physical load

Regular mouse
In general the regular mouse is too small for the average hand resulting in a grip like action of thumb, ring finger and little finger and thus excessive loads on metacarpal bones and ligaments.

- excessive extensor load
- excessive thumb load
- instigates working from the wrist
- instigates gripping and pinching
EMG signal of a regular mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Vertical mouse
Forces the hand in an almost vertical position. The hand rests on its side. This generates excessive friction between hand and table top while working.

Ref. publication prof. Han Min Chen “The effect on forearm and shoulder muscle activity in using different slanted computer mice”

- a too large supination angle
- hand rests on its side
- mouse is gripped between palm of the hand, fingers and thumb
- this position instigates gripping and pinching
- metacarpal bones and ligaments are stressed
- excessive tension in muscles of the lower arm
EMG signal of vertical mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

A-symmetrical ball mouse
The ball acts counter productive. The XY coordinates provided by the desk top are no longer used.

Operating the ball by means of the thumb carries an additional risk when the arterial flow is restricted. Synovia production can be inhibited resulting in calcitic deposits on the tendon. 
(referte Morbus de Quervain)

- excessive extensor loads (fingers)
- no arm movement, risk of restricted arterial flow
- ball leads to excessive thumb load
EMG signal of a-symmetrical ball mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Symmetrical ball mouse
The ball acts counter productive. The XY coordinates provided by the desk top are no longer used.

Too little support is provided for the hand, this instigates switching with the thumb.

- excessive extensor loads (fingers)
- no arm movement, risk of restricted arterial flow
- ball inhibits the support of the hand, no rest possible
EMG signal of symmetrical ball mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Hand forced in a pre-set vertical position
The weight of the hand rests on the side. The wrist is forced in an elevated position. This strained position results in awkward movements.

Ref. publication prof. Han Min Chen “The effect on forearm and shoulder muscle activity in using different slanted computer mice”

- a too large supination angle
- an excessive ulnar deviation “hand shake” position
EMG signal of fixed vertical mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Pen mouse
A thin pen-like object, does not provide support for the hand. Extensor muscles are continuously active.

- too thin
- shape instigates gripping and pinching
- no support provided
- instigates motions from the wrist
- no stability, no rest for the hand
EMG signal pen mouse

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Pen and tablet
The pen is too thin and thus cumbersome, instigates gripping and pinching.

Hovering hand (and arm) above a tablet causes unnecessary stresses and strains in lower (extensor) and upper arm muscles

- too thin
- shape instigates gripping and pinching
- no support provided
- instigates motions from the wrist
- extensor muscles are continuously active
EMG signal pen and tablet

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Mouse with horizontal buttons
Fingers hover in a horizontal position above the buttons and have to be continuously lifted to avoid inadvertent switching. The hand slides from the body due to lack of support. The application of a “scroll wheel” at the side while no support is provided, generates a risk for the thumb joint.

(refere Morbus de Quervain)

- excessive extensor load
- scroll wheel at the side
- no thumb rest
- shape instigates gripping and pinching
EMG signal of mouse with horizontal buttons

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
Source of physical load

Joystick, mouse with handle
This mouse instigates gripping and pinching. As a result muscles are excessively strained and arm movement is restricted.

Ref. publications in Clinical Biomechanics by prof. Han Min Chen “The effect on forearm and shoulder muscle activity in using different slanted computer mice” and Gustafsson and Hagberg “computer mouse use in two different hand positions: exposure, comfort, exertion and productivity”

- a too large supination angle
- hand is positioned on its side
- one grips the handle
- position instigates excessive gripping and pinching
EMG signal joystick, mouse with handle

1. extensor carpi radialis longus (red line)
2. extensor carpi radialis brevis (yellow line)
EMG signal joystick, mouse with handle

flexor carpi radialis (red line)
Minimal physical loads with the Hippus mouse

The shape is based on the hand in a relaxed position. Fingers and thumb rest supported. A light contraction of flexor muscles suffices to switch. The scroll wheel is positioned close to the finger tips to allow for minimal movements.

- hand, wrist and thumb are fully supported
- extensor muscles are relaxed
- shape prevents gripping and pinching
- scroll wheel positioned between index and middle finger
- to stimulate arterial flow large movements are possible

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EMG signal of the Hippus mouse

1. m. extensor carpi radialis longus (red line)
2. m. extensor carpi radialis brevis (yellow line)
Pressure points

Pressure points of hand on mouse
EMG signal of the Hippus mouse

flexor carpi radialis (red line)
Conclusion

- mice investigated show on average high EMG values
- EMG values of extensor muscles indicate high level of activity
- a number of mice show continuous high flexor loads
- with a number of mice hand and/or arm are forced into positions which cause unnecessary stresses and strains

Hippus mouse:

- design based on natural relaxed position of hand and arm
- shape and weight realize reduction of muscle load
- supports hand continuously, during action as well as in rest

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Reactions and questions