Evaluation of 8 ergonomic computer mice

a regular mouse and

the computer mouse called The Horse

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EMG measurements executed by IDEE University of Maastricht

Publications

- Provocation of epicondylalgia lateralis (tennis elbow) by power grip or pinching. Publication March 1987 in Medicine and Science in Sports and Exercise, Volume 19, No 5, C.J. Snijders, A.C.W. Volkers, K. Mechelse, A. Vleeming
- 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
- Understanding work related upper extremity disorders: clinical findings in 485 computer users, musicians and others. Journal of Occupational Rehabilitation 2001;11(1):1-17, E.F. Pascarelli EF, Y. Hsu
- A new computer mouse called Horse, C.J. Snijders and P.C. Helder in Europhysicsnews, issue 35/6 2004
- Resultaat gebruik handondersteunende computermuis door patiënten met nek-schouderklachten. Publicatie Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde, jaargang 14, juli 2006, nr 6, P.C. Helder, C.J. Snijders en R.L. Krullaards
- Blood flow changes in RSI subjects: an introduction of a pen with biofeedback, Marijke C. Dekker, Gert-Jan Kleinrensink, Rob L. Krullaards, Chris J. Snijders.
- 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

Introduction

Subjects to be discussed:

- the risk of neck-, shoulder-, arm- and hand complaints
- background, 2 models plus anatomy
- 7 types of physical load resulting from the use of a mouse
- Solutions and background to solutions
- 9 ergonomic computer mice and a regular mouse compared

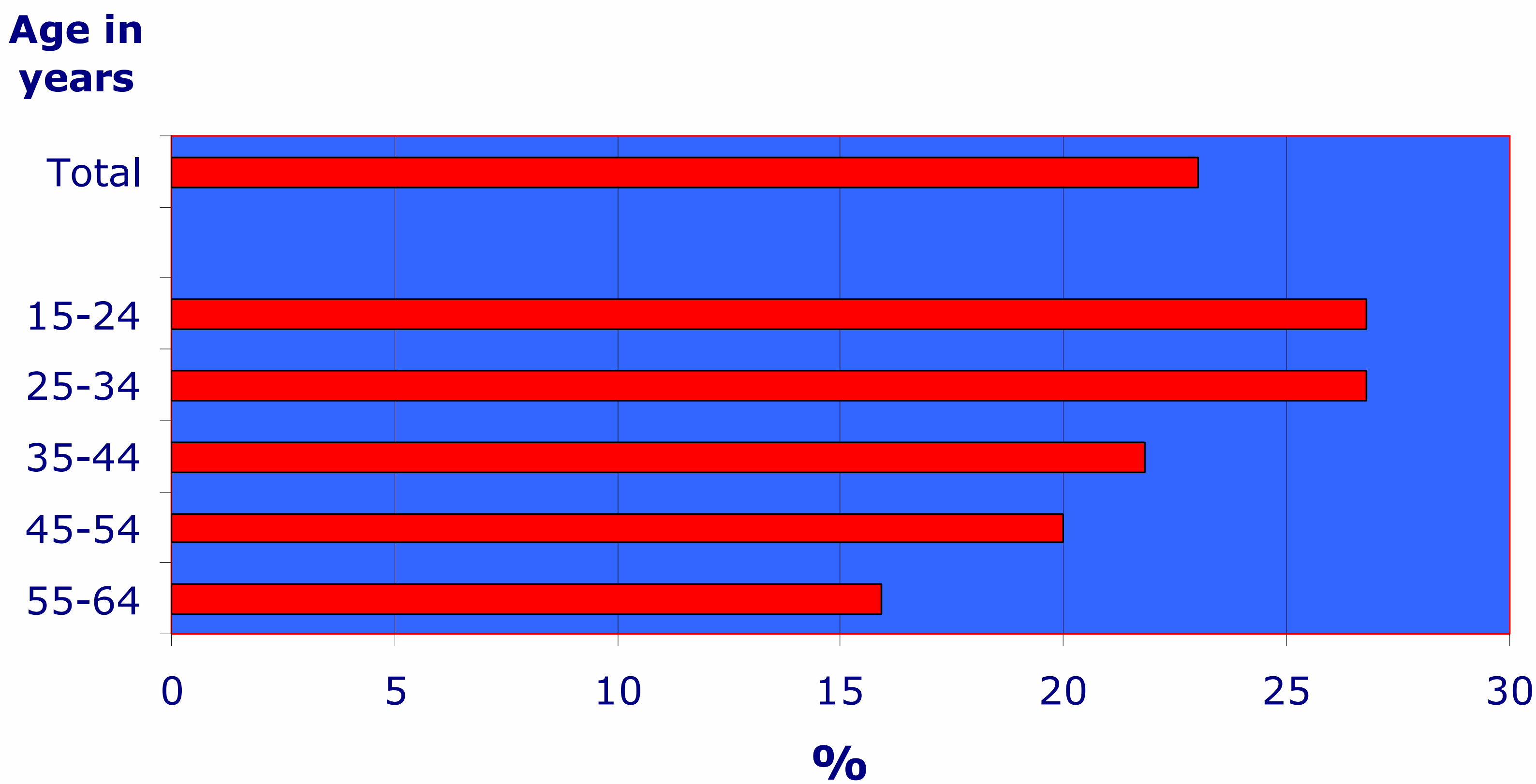
Neck-, shoulder-, arm- and hand complaints

Risk factors are:

- excessive use of force
- work in uncomfortable positions
- prolonged repetitive work in the same position
- repetitive movements

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

Neck-, shoulder-, arm- and hand complaints



RSI percentage of working population in The Netherlands in 2000 (CBS, 2002)

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Scientific research procedure

Steps:

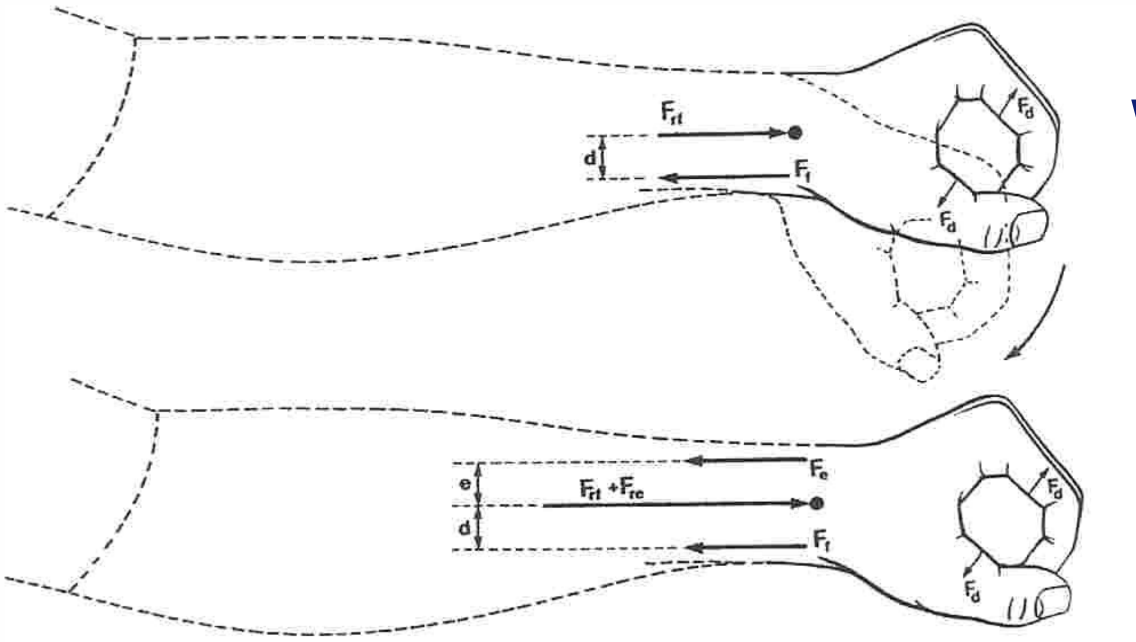
- problem definition
- development of fitting model both fundamental and field based
- definition of physical loads
- evaluation and adaptation of the model
- synthesis of model and practical application
- review after 1 year

Objective, synthesis of theory and practice.

Models I and II

Recearch by Erasmus MC university hospital Rotterdam has shown that relaxation in neck, shoulders, arms and hands can be realized by means of a reduction of force when gripping and pinching.

Model I gripping and pinching

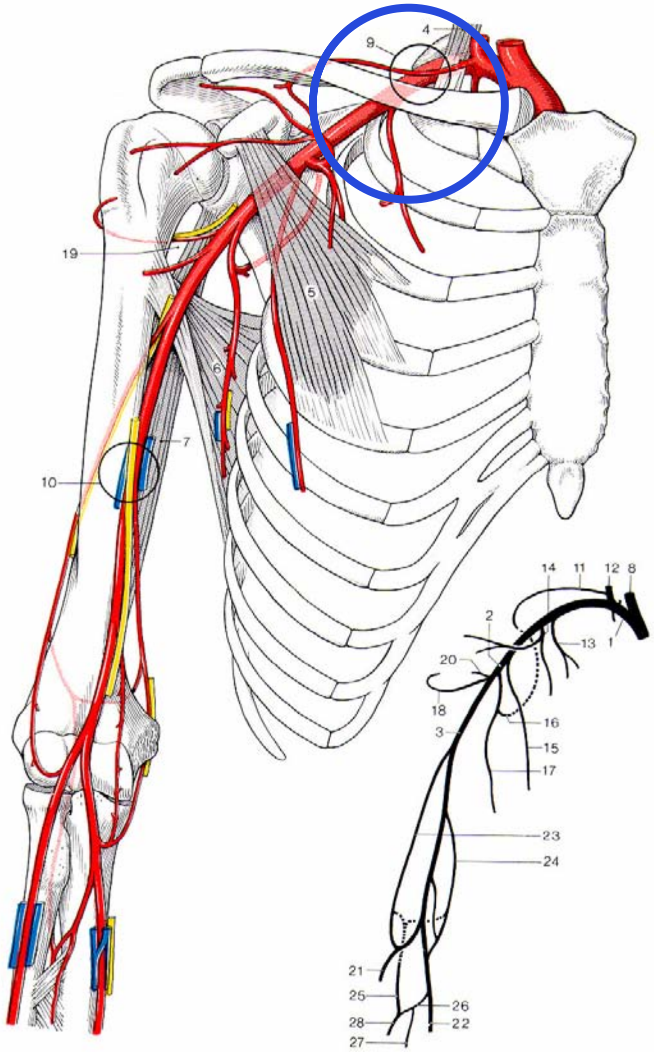


wrist flexes: flexor activity

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”.

Model II blood flow in arms and hands



Compression of arteries, veins and nerves results in:

- tingling
- pain
- numbness
- obstruction of flow

in arms and hands.

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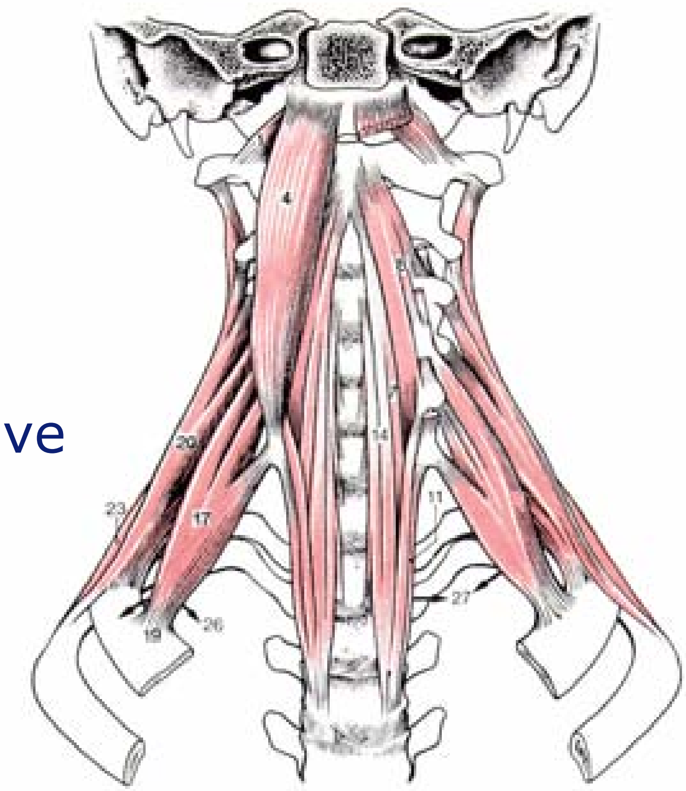
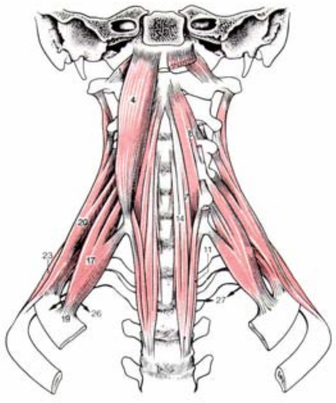
Anatomy

Deep neck muscles



- stabilize head on torso
- postural muscles are continuously active

Anatomy



Deep neck muscles

Increased tension due to stress or activities result 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.

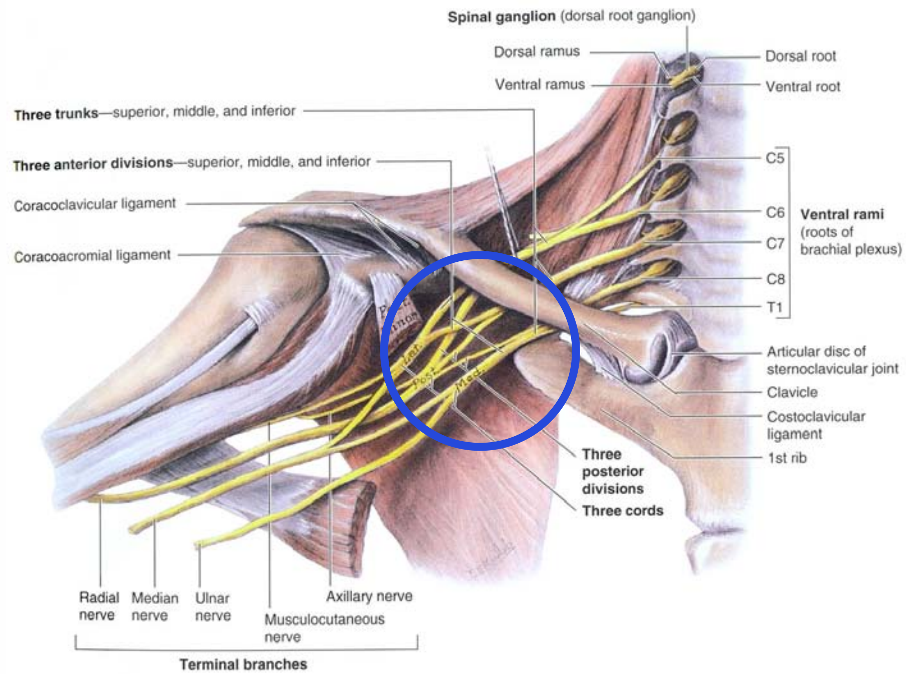
Anatomy

Excessive muscle tension

Increased tension results in:

- reduced space between:

  first rib and clavicular bone



Compression of:

nerves (yellow) results in tingling

arteries

veins

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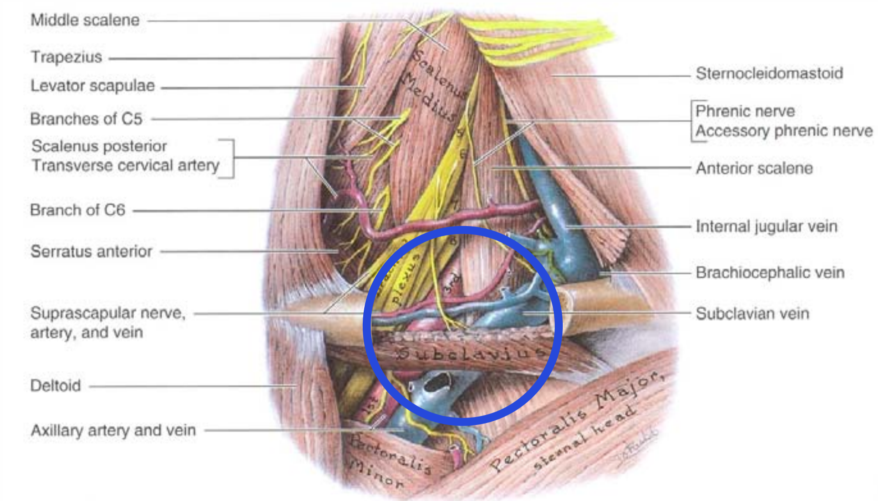
Conclusion based on anatomy



The area around the neck is of vital importance; function and disfunction are defined by various anatomical factors.

Function and disfunction are, among other aspects, influenced by excessive tension in the deep neck muscles.

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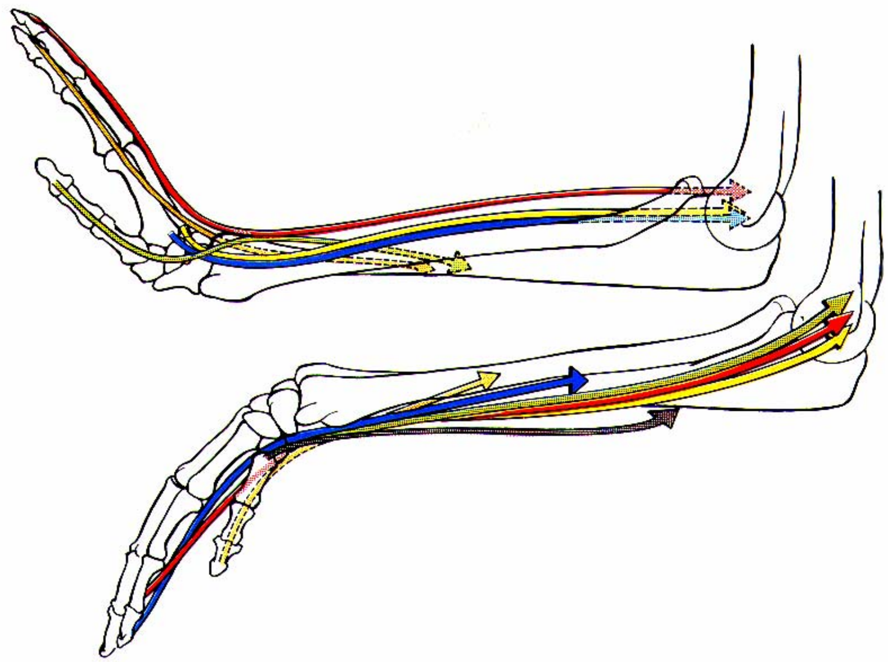
Types of physical load

- extensor muscle load, hand & fingers hover above the mouse
- Cynderella effect, exertion of unnecessary static forces
- gripping and pinching
- 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.

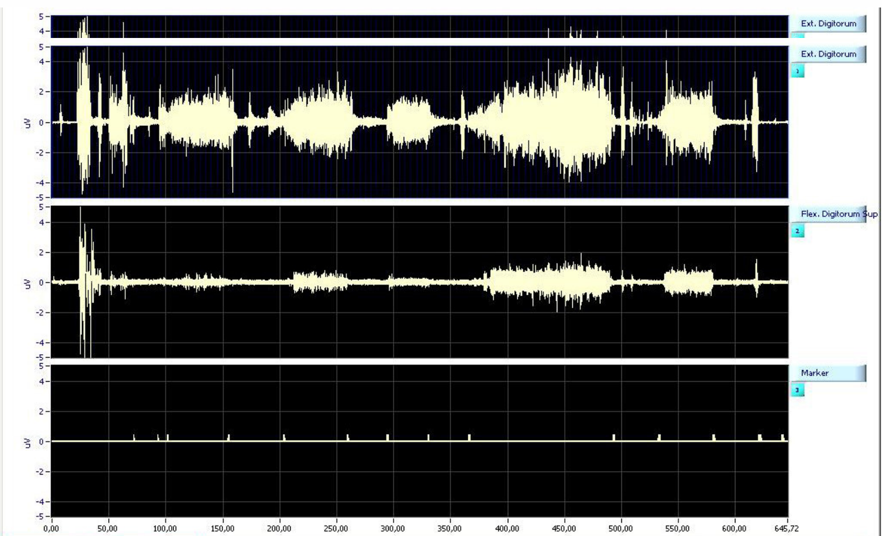


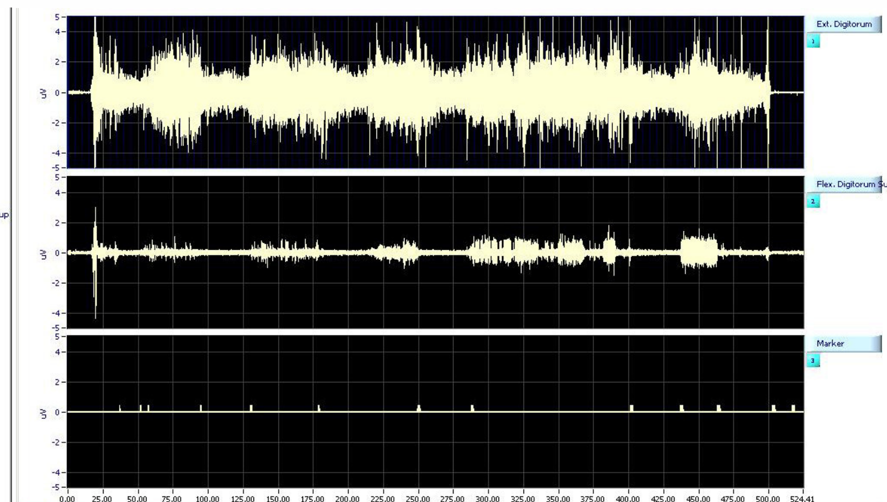
Extensor load

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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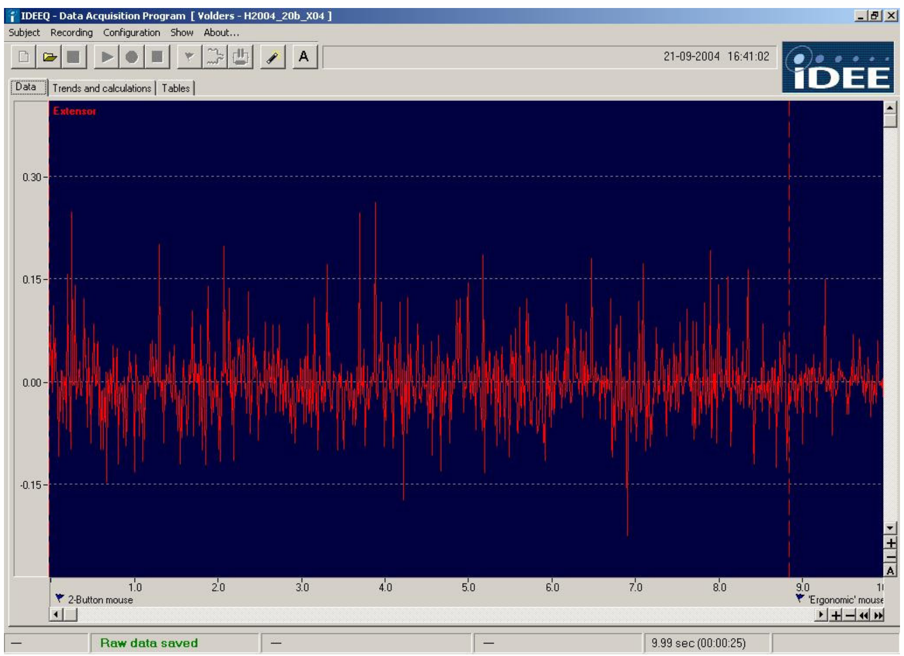
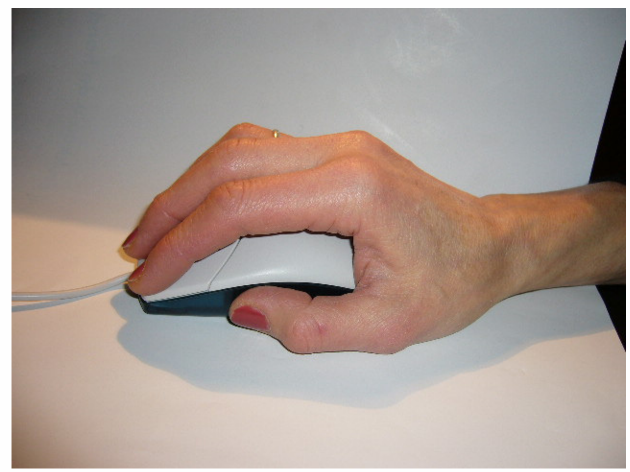
Physical load type II

Cynderella 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





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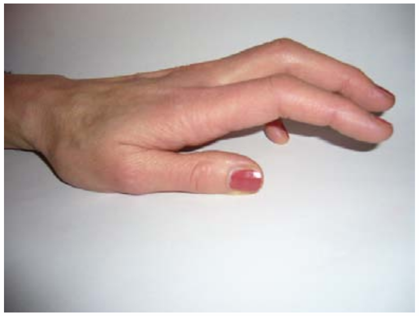
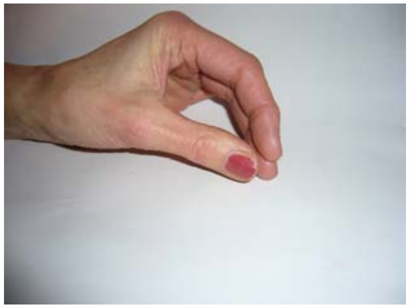
Physical load type III

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





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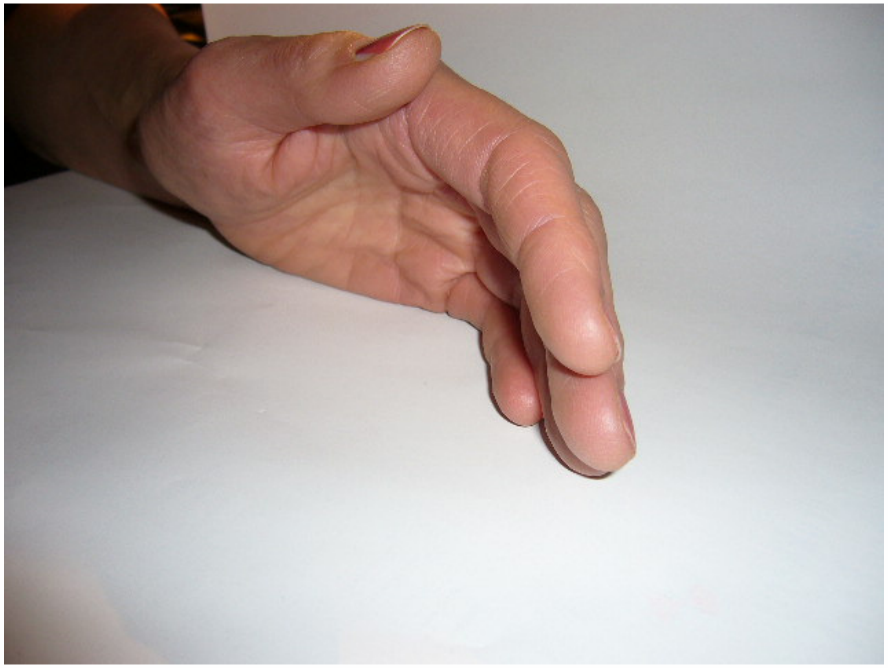
Physical load type IV

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



relaxed hand
supination angle of around 15^0

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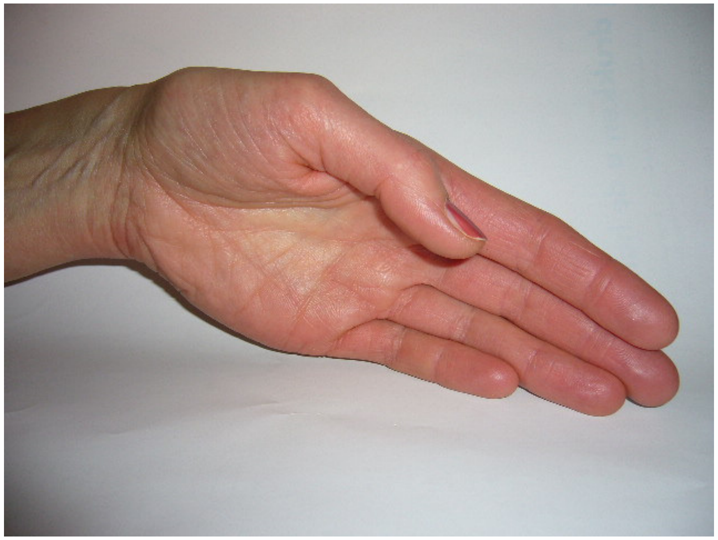
Physical load type V

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

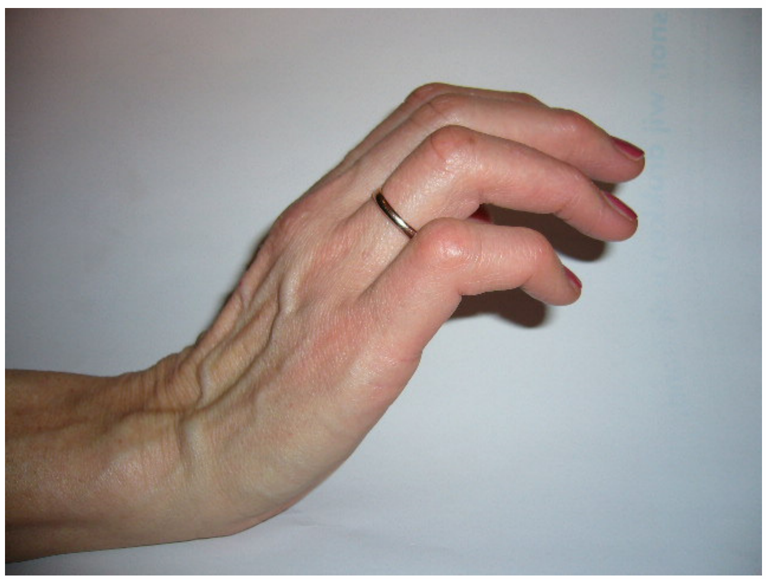
The hand is forced in a position resulting in an ulnar deviation of the wrist outside the regular functional area.



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.



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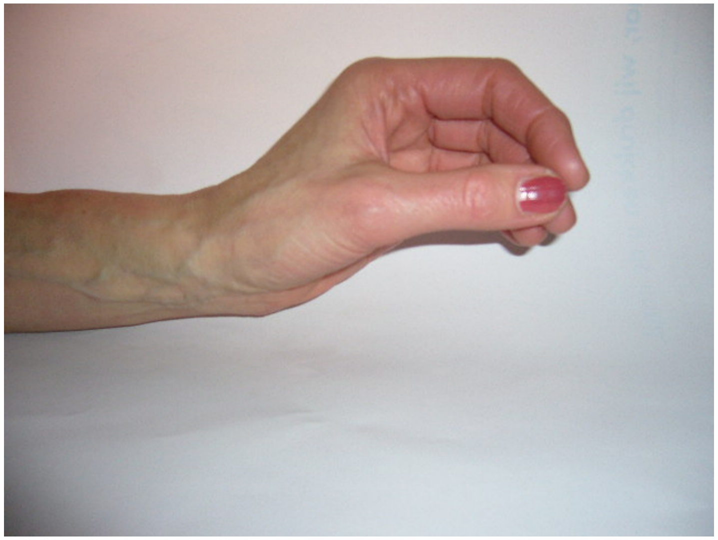
Physical load type VII

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.



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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

Evaluation of ergonomic computer mice

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

The protocol consisted of:

10 sec. rest,

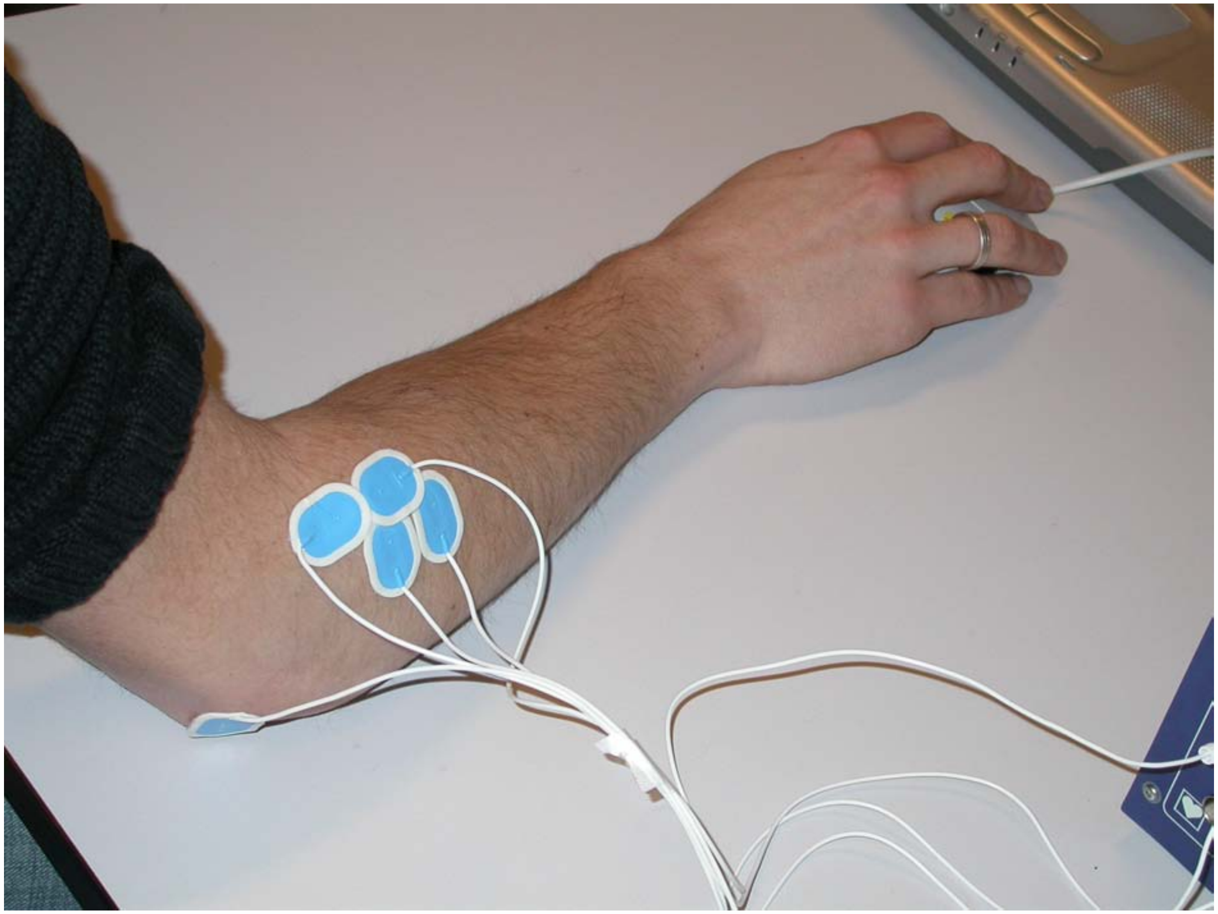
10 sec. motion,

10 sec. rest

10 sec motion, however with the left button active.

Evaluation of ergonomic computer mice

EMG-measurement set-up:



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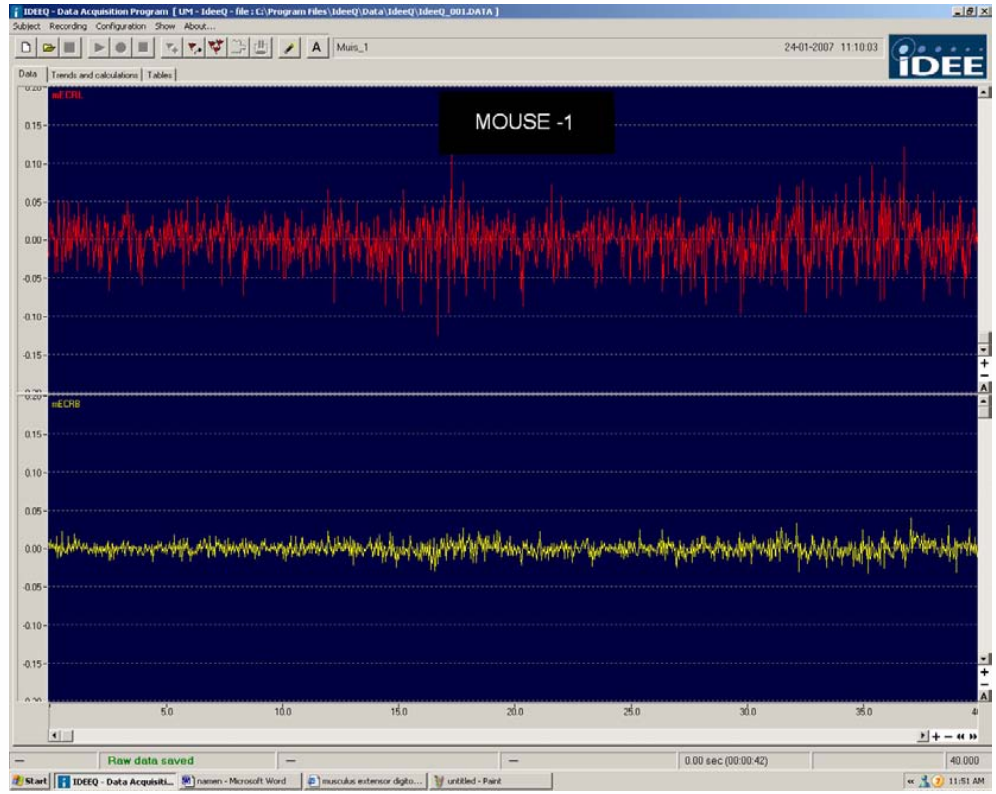
EMG signal of extensor muscles

extensor carpi radialis longus

extensor carpi radialis brevis



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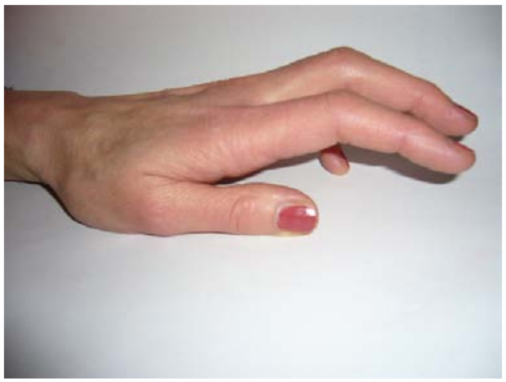
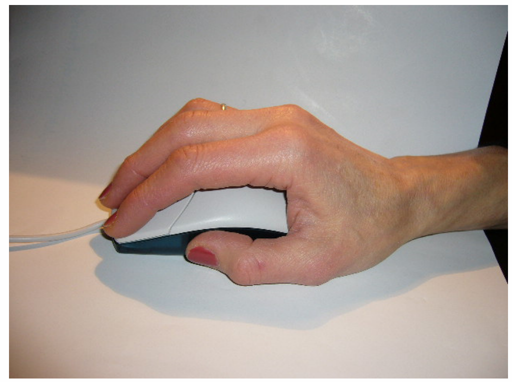
Evaluation of ergonomic computer mice

9 computer mice and The Horse were measured by means of EMG while the various physical load factors were analyzed.

Source of physical load

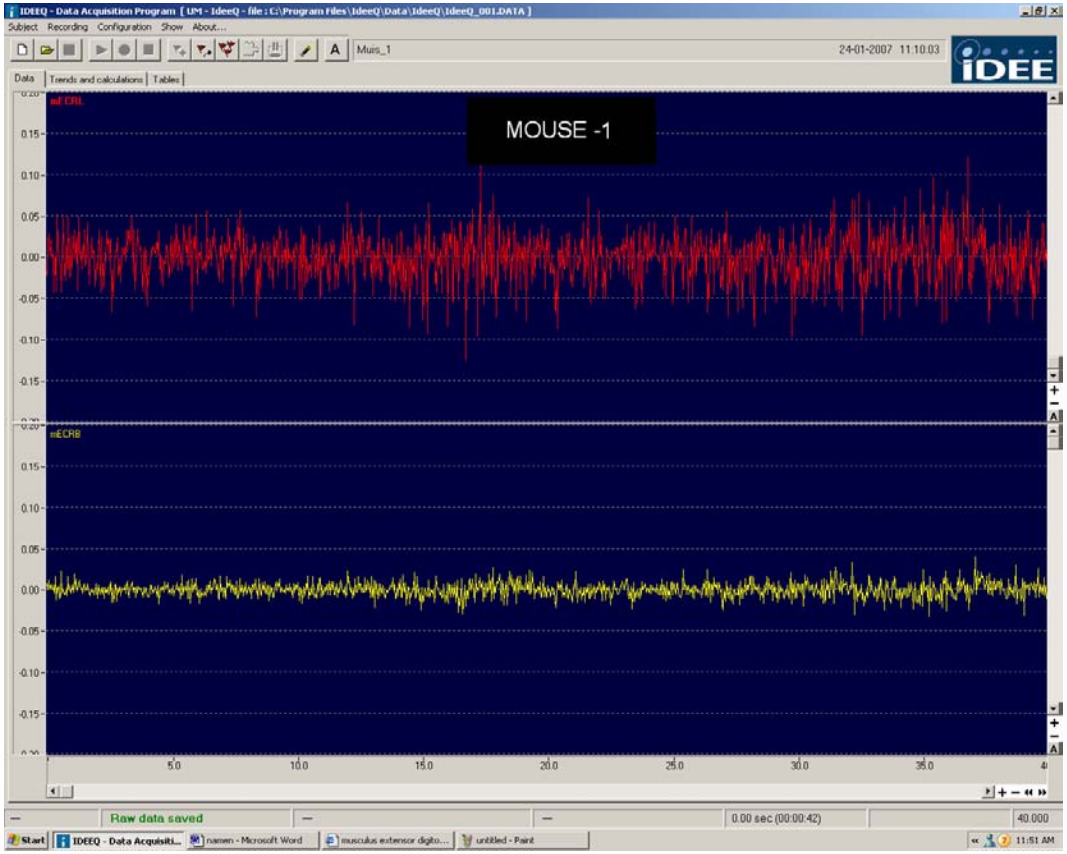
Regular mouse
In general the regular mouse is too small for the average hand resulting in a grip like action of thumb, ring finger and little finger and thus excessive loads on metacarpal bones and ligaments.

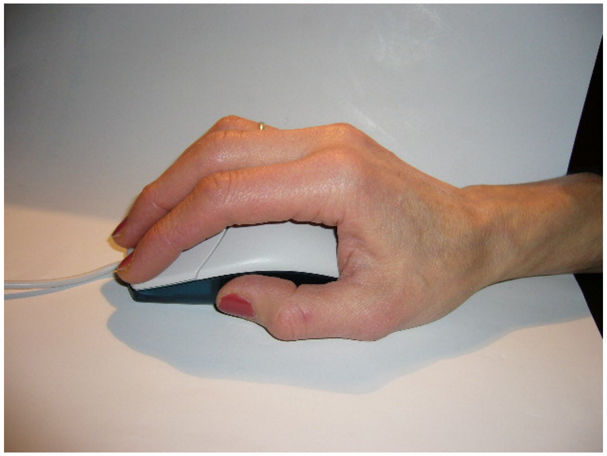


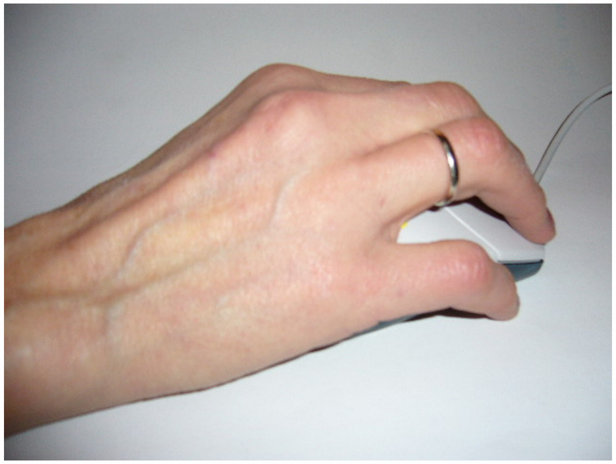


- excessive extensor load
- excessive thumb load
- instigates working from the wrist
- instigates gripping and pinching

EMG signal of a regular mouse







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

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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.

- 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

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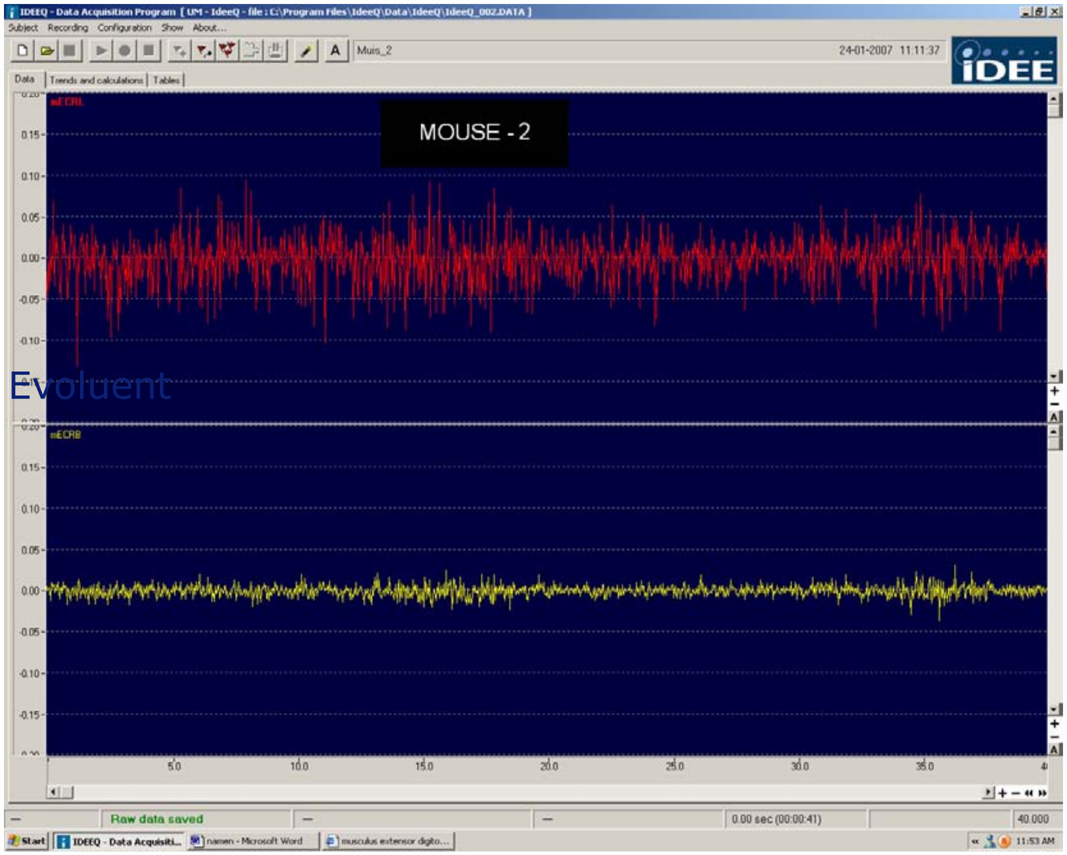
EMG signal of vertical mouse



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

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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

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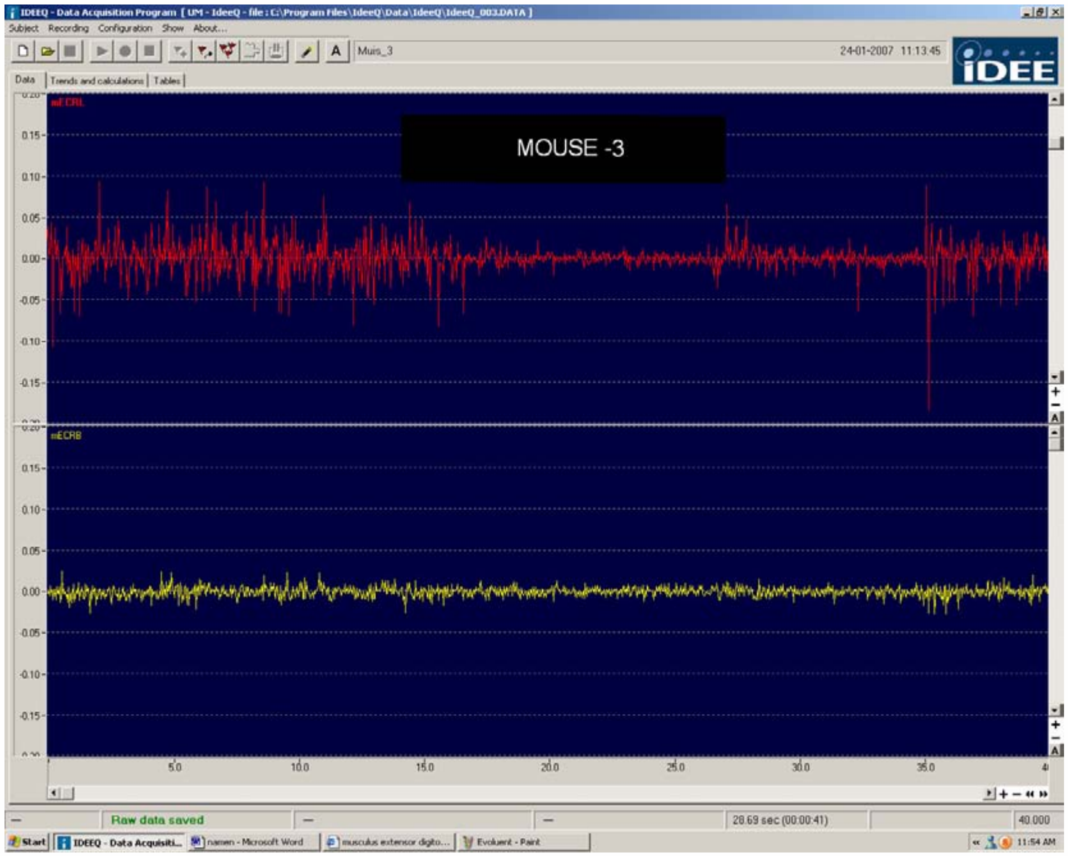
EMG signal of a-symmetrical ball mouse



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

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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

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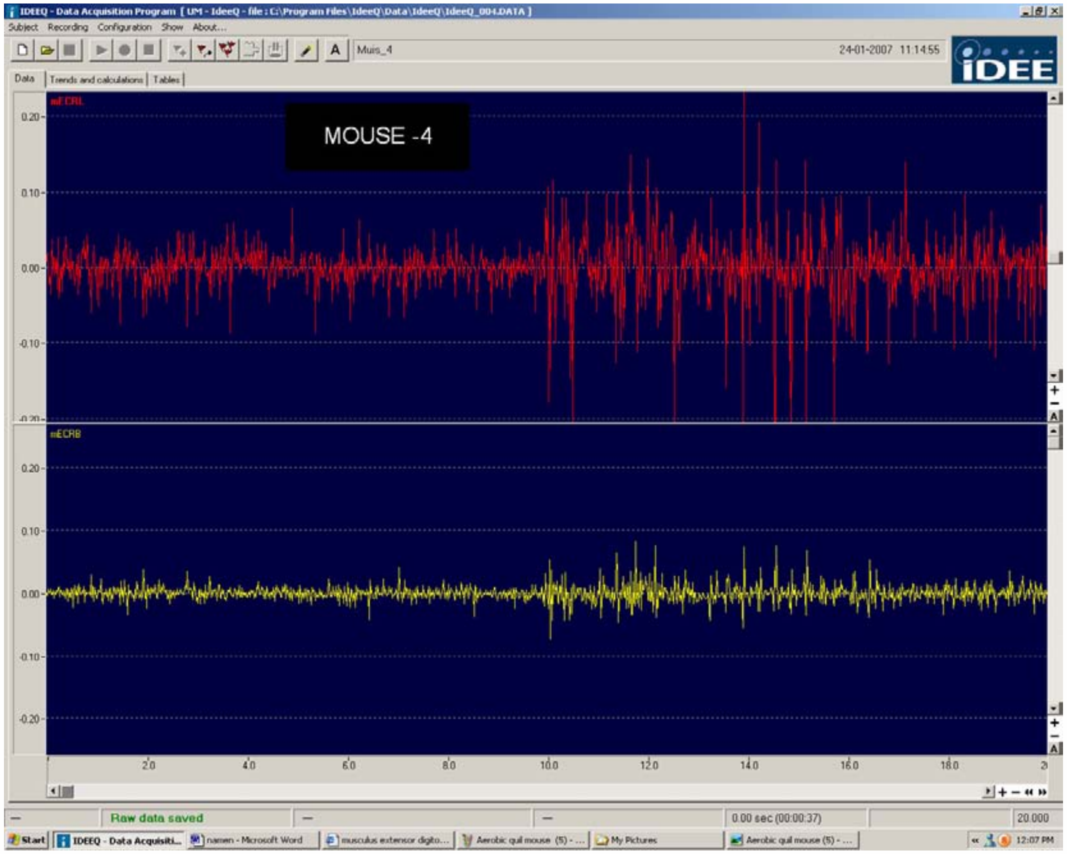
EMG signal of symmetrical ball mouse



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

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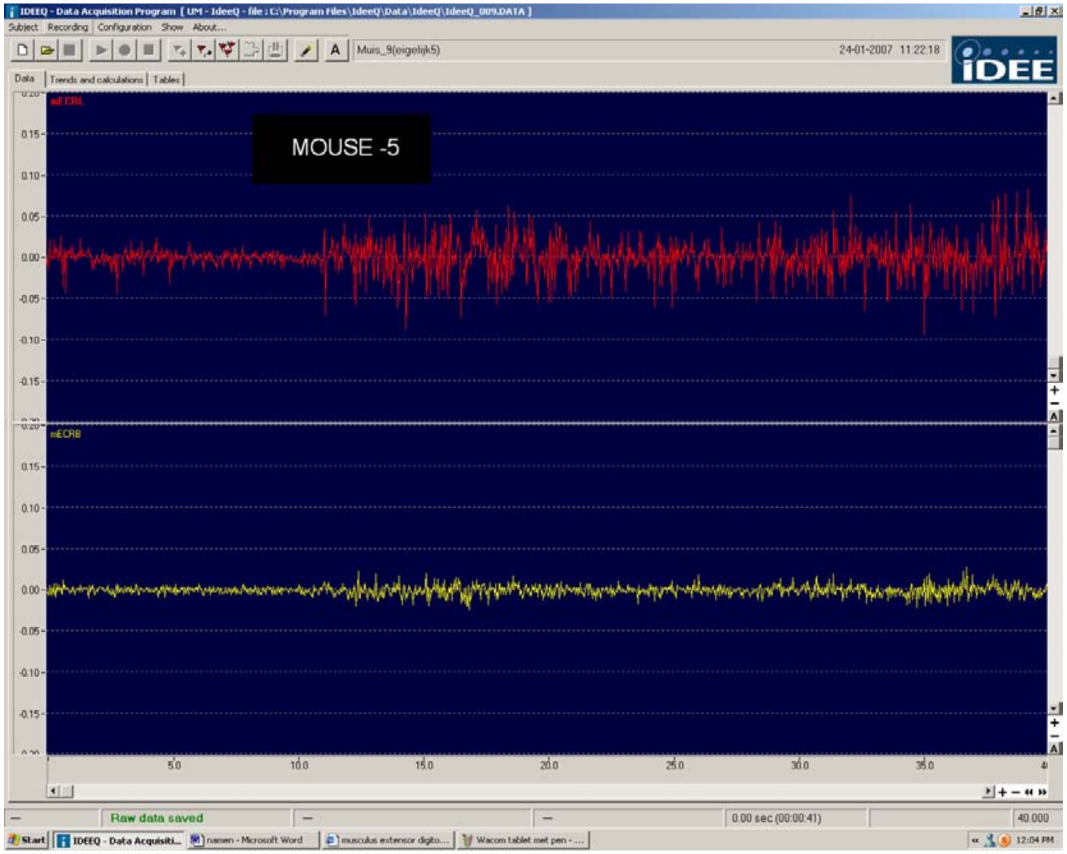
Source of physical load

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.

- 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)

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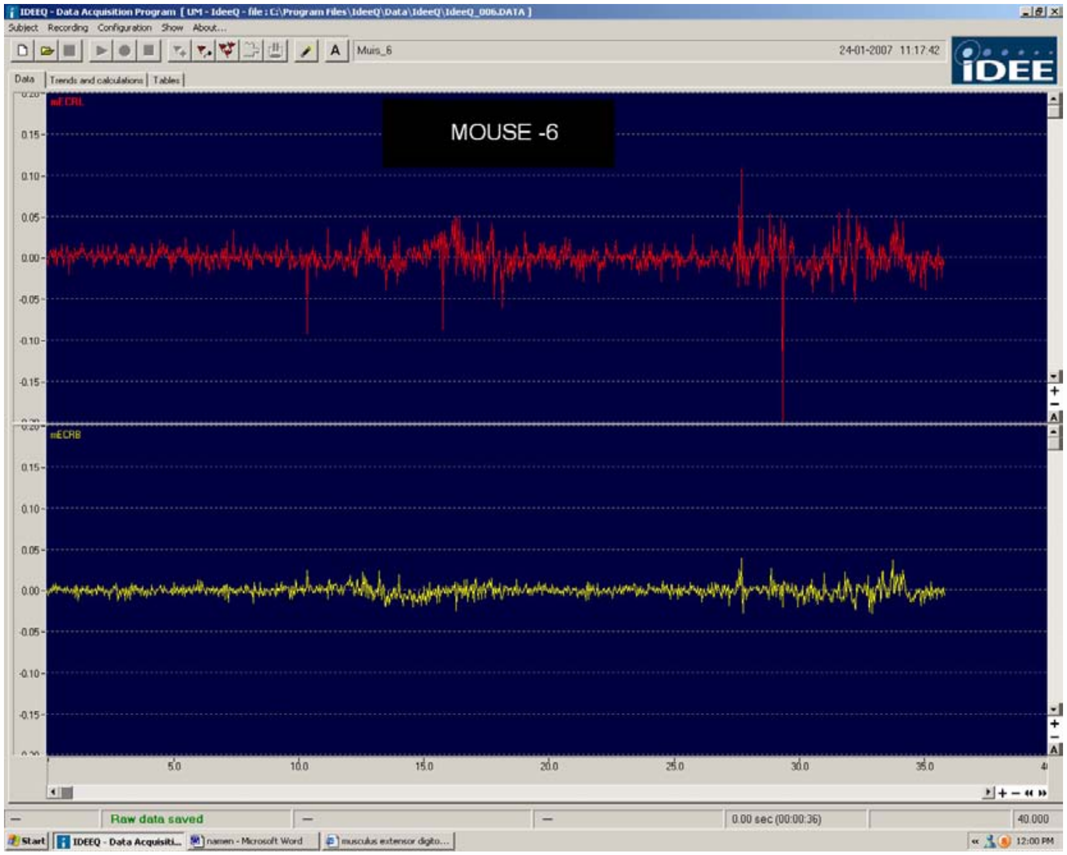
Source of physical load

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)

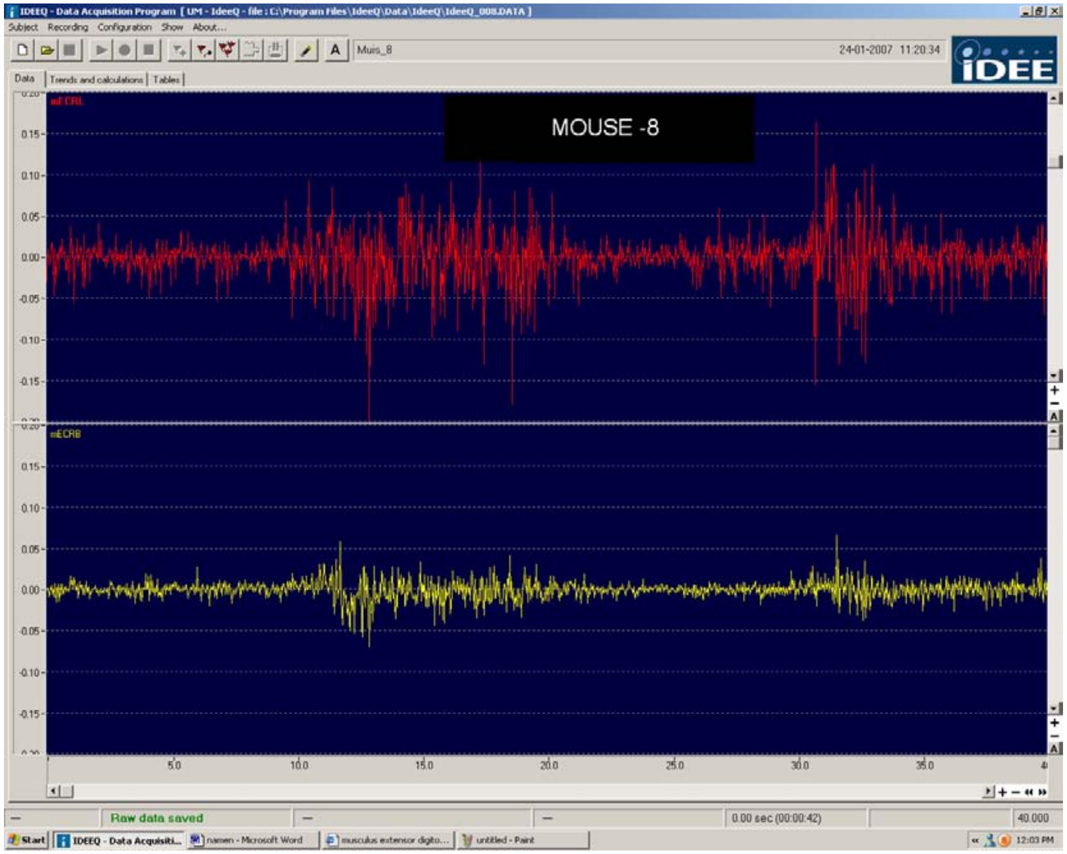
Source of physical load

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 inadvertant 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.

- excessive extensor load
- scroll wheel at the side
- no thumb rest
- shape instigates gripping and pinching

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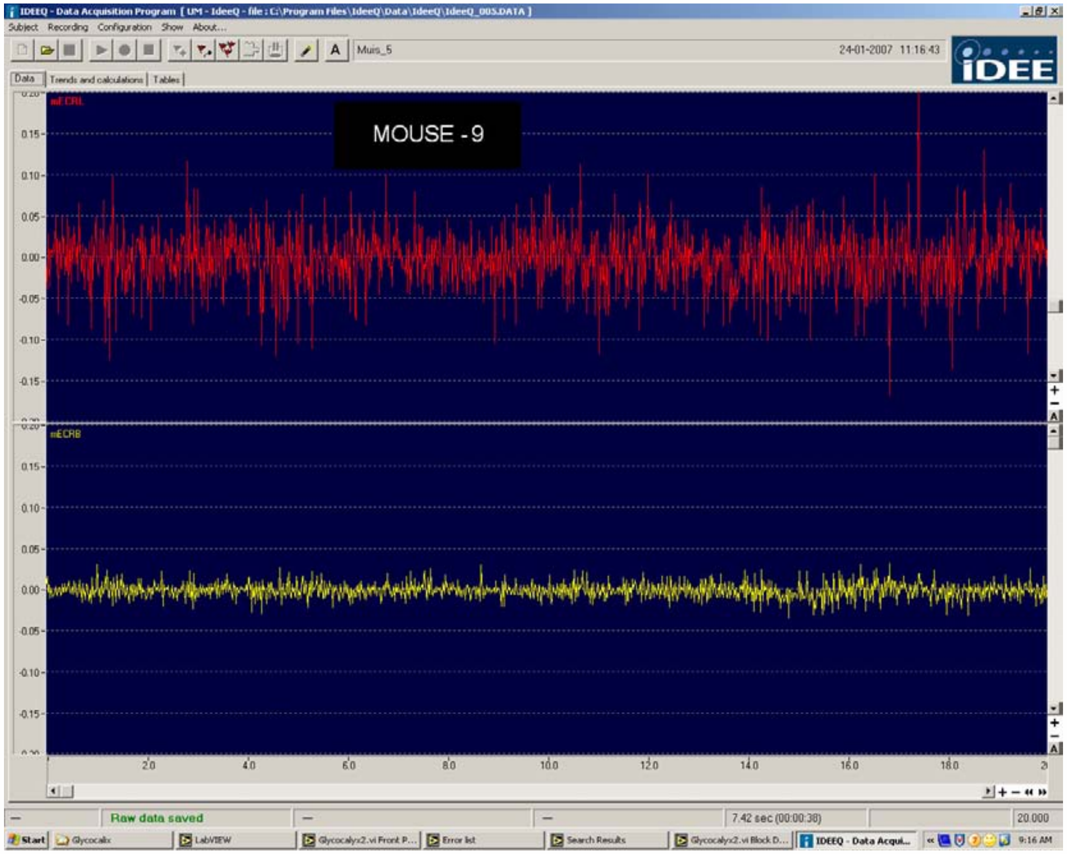
EMG signal of mouse with horizontal buttons



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

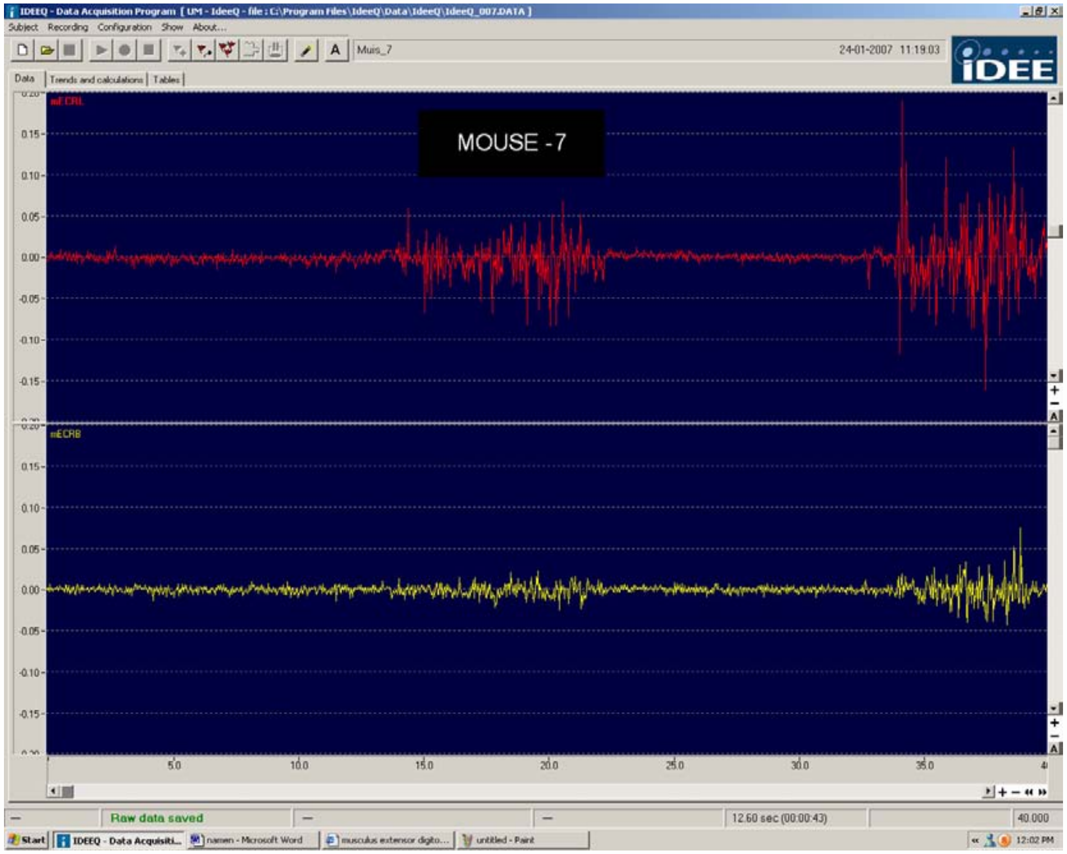
Source of physical load

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

Referte publicatie "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)

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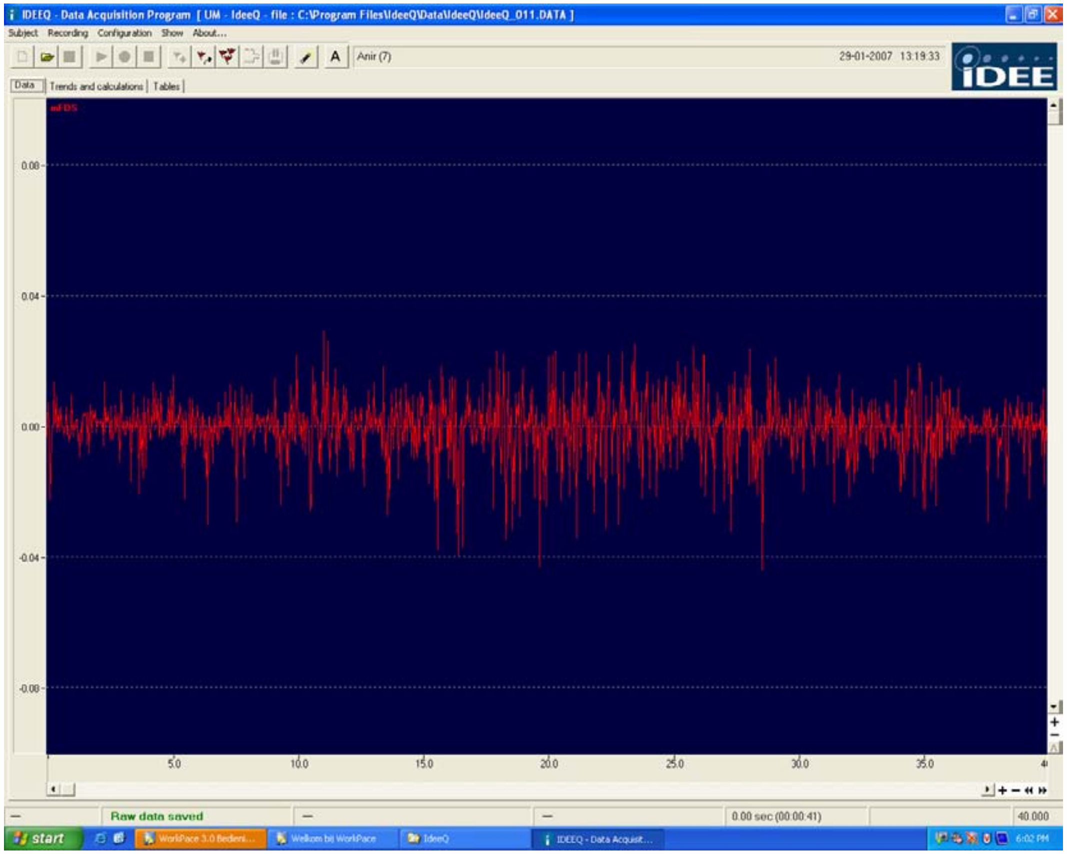
EMG signal joystick, mouse with handle



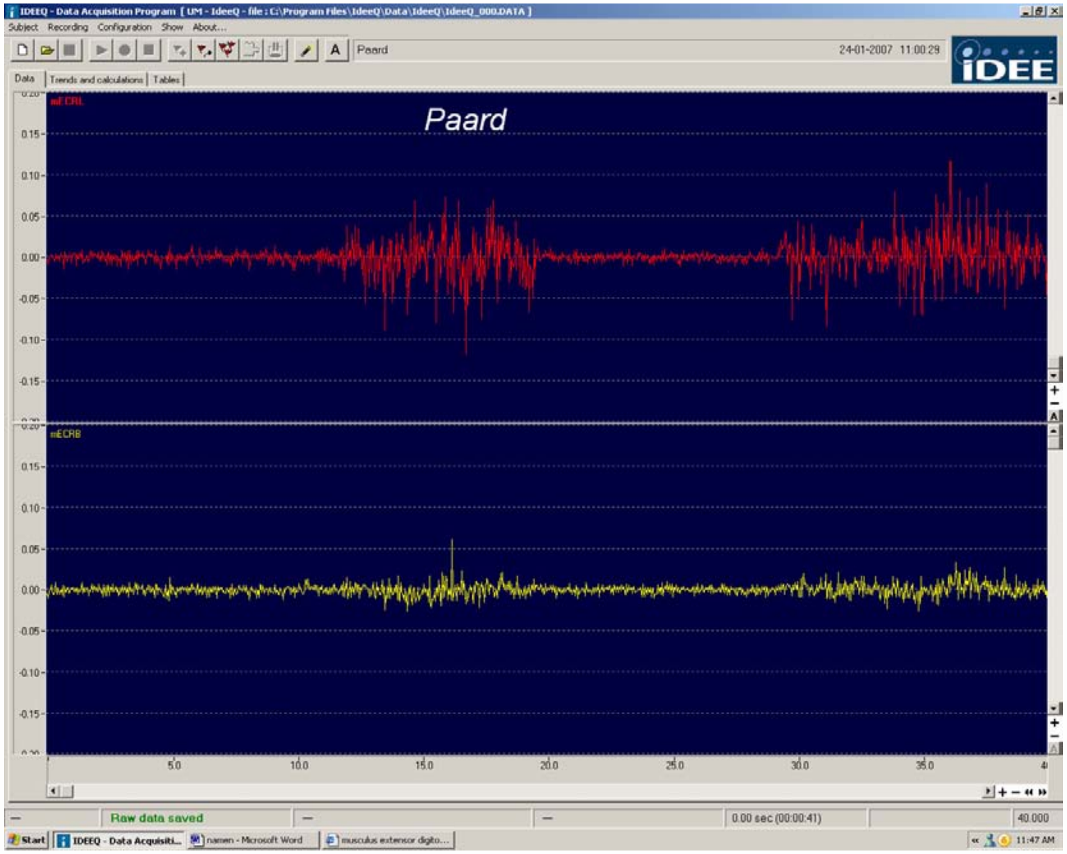
flexor carpi radialis (red line)

Minimal physical loads with The Horse

The Horse
The shape of The Horse 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

EMG signal of The Horse



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

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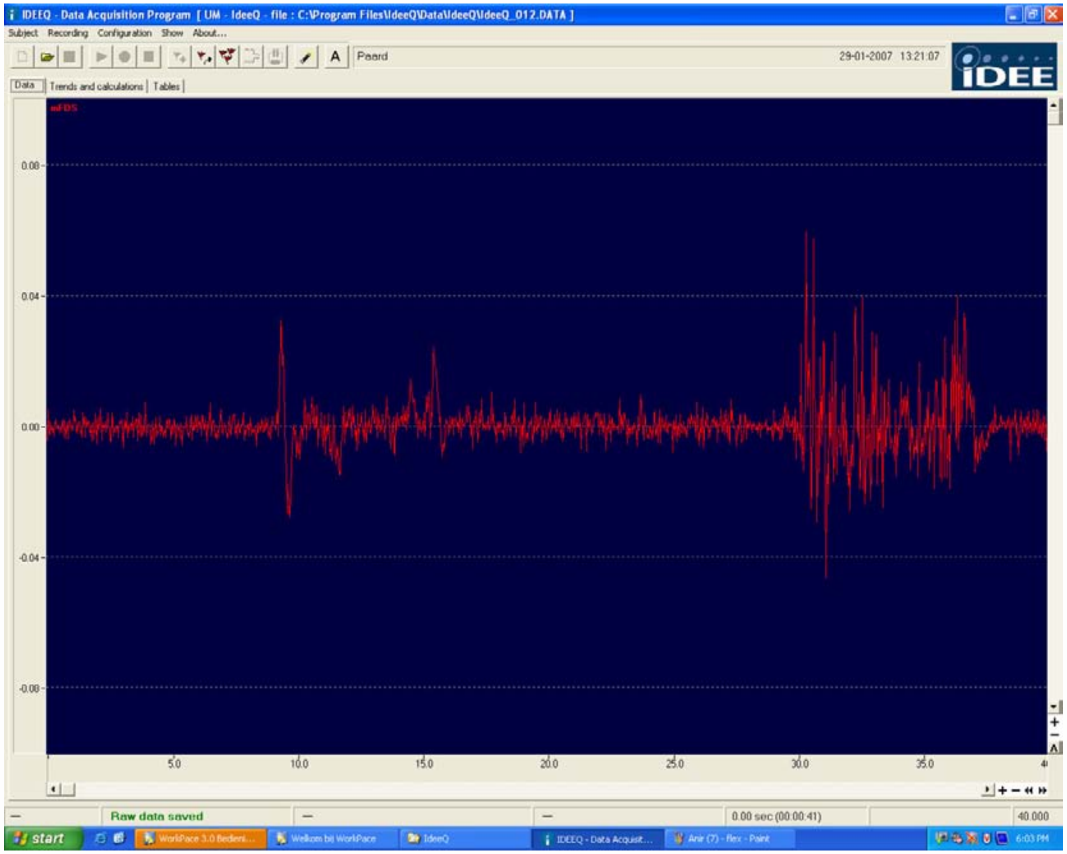
EMG signal of The Horse



flexor carpi radialis (red line)

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Fully relaxed hand after 3 days using The Horse

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
- The Horse is based on the natural relaxed position of hand and arm
- shape and weight of The Horse realize a reduction of muscle load and thus EMG values
- The Horse supports the hand continuously, during action as well as in rest

Reactions and questions

What we measured