Effects of the use of a special computer mouse
The HandShoe Mouse

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Introduction - problems and observations

Based on fundamental biomechanical research it was noted that the level of forearm muscle activity varies depending on the type of computer mouse used.
EMG values showed that a supporting contour can realize significant reduction of activity in between muscle actions like switching and scrolling or moving the mouse over the desktop.
Next to the contour of the supporting surface, the plane angle variation from fully pronated to 90^0 supination, “handshake position” has a significant effect on muscle activity.

With a conventional mouse a combination of thumb, ring- and little finger is required to realize optimal control in the horizontal (X-Y) plane. By providing a supporting contour for hand palm and fingers, it was noted that gripping and pinching of thumb and fingers (m. extensor carpi radialis longus and brevis) to control the mouse in the X-Y plane was no longer necessary (1).

The supporting contour enables a near to fully relaxed flexor and extensor muscle position which is reflected by a significant reduction of the EMG signal. This contrary to the hovering finger position

required with a conventional mouse where the hand is fully pronated. This contour arch stabilizes the freely moving finger guaranteeing the joint's (PIP) movements in static and dynamic situations (2).
Fingers (tips, close to the desktop) rest on the switches which follow the contour of the mouse.
To switch only a light flexing action of the fingers is required whereby the majority of the switch action is at the finger tips.

A fully pronated hand and forearm (hand flat on the desk top) as well as a supination angle near to vertical (handshake position) forces hand and forearm in a strained position.
Moving the hand sideways in a pronated position may lead to hypertrophy of the wrist flexor muscles (e.g. m. flexor carpi ulnaris). In some cases this may even lead to nerve compression (neuropathy) (3).
In studies with respect to Chronic Compartment Syndrome (CCS) with keyboard operators, the arm pain was invariably worse in the mouse operating hand (4).

Vertical "handshake" type computer mice, generally assumed to provide a neutral hand position, have been re-evaluated in view of observed Interosseous Membrane (IOM) tautness. Anatomical *in vitro* studies suggest negative effects of such an assumed "neutral" forearm position.

Note, the IOM connects both forearm bones (Ulna and Radius) of which the Radius has an arched curvature, contrary to the Ulna. This results in the IOM being more or less stretched or relaxed depending on hand and forearm position. For example, in the "handshake" position the most stretched position of the IOM occurs, distance between the forearm bones is at its maximum. A slanted position of forearm and hand reduces this distance and relaxes the IOM (5).

Because most of thumb and index finger (long) muscles originate from the IOM, the assumption is justified that opposing muscles (antagonists) in using vertical mice may cause muscle disorders *in vivo* (6). Contrary to this, with a lightly slanted mouse position (around 25^{0} - 30^{0}), wrist and forearm at a natural angle, minimal forearm muscle activity is needed (7) (8) (9).

Results due to posture

As mentioned, a conventional mouse instigates gripping and pinching (m. extensor carpi radialis longus and brevis) next to hovering of the fingers above the switch buttons (m. extensor digitorum).
Based on in vivo tests during field research, it is assumed muscle spasms in the deep neck muscles (mm. scaleni) may occur. This may result in a reduction of the space between first rib and Collar (Clavicle) bone, Costo-Clavicular space and lead to compression of nerves (brachial plexus) and blood vessels (subclavian artery and vein) (10) (11).

Exertion of (unnecessary) static forces like gripping, pinching and hovering (extensor loads) result in muscles acting continuously. The special motor units (type I muscle fibers) control these lesser forces and are continuously active resulting in irritation, also called Cinderella effect (12). Furthermore, studies compared the muscle energy metabolism of the finger extensor muscle assuming alterations due to impaired blood flow (energy metabolism). It is assumed that a deficit in energy production by oxidative pathways may exist in the affected muscles. Two possible explanations for this would be the partial and/or local reduction of blood supply and the reduction of the muscle oxidative capacity itself. Work-related pain in the finger extensor muscles may be associated with intracellular pH compartmentation during exercise, a build-up of metabolic wastes (13).

In general symptoms are:

- pain, numbness, and tingling in the pinky and ring fingers, and the inner forearm
- pain in the neck and shoulders
- signs of poor circulation in the hand or forearm
- weakness of the muscles in the hand

Conclusion

Based on the aforementioned, we may conclude that working in physically uncomfortable conditions, as well as the resulting metabolic waste due to working in such circumstances, may cause detrimental effects. According to us such effects can be avoided by means of providing fitting support, thus preventing the mentioned muscle overload.

References

1) A new computer mouse called Horse
   C.J. Snijders, P.C. Helder, Euro Physics News, 2004, 35, 6, p. 208-209
   http://www.europhysicsnews.org or http://dx.doi.org/10.1051/epn:2004610
2) Functions of some finger joints while handling the PC mouse, and their possible relevance for computer aided learning
   K.J.van Zwieten et al.
   Published in: Auer, Michael E. & Schreurs, Jeanne (Ed.) Academic and Corporate E-Learning In a Global Context, 2010, p. 1098-1101.
   Kassel University Press, International Association of Online Engineering.
   http://www.handshoemouse.com/dnld/Functions-of-finger-joints.pdf
3) Hand Positions in scrolling, as related to PC-workers' dystonia and treatment of dystonia by means of vibrostimulation and external shock waves therapy
   K.J. van Zwieten et al. Department of Anatomy, BioMed, University of Hasselt, transnational University Limburg, Diepenbeek, Belgium.
   Published by State Polytechnical University, Saint - Petersburg, Russia
   http://uhdspace.uhasselt.be/dspace/handle/1942/10335
4) Chronic compartment syndrome, an important cause of work-related upper limb disorder
   M.H. Pritchard et al. Department of Rheumatology, University Hospital of Wales, Cardiff, UK.
   Published by Oxford Journals, Rheumatology, 2005, Volume 44, Issue 11, p. 1442-1446
   http://rheumatology.oxfordjournals.org/content/44/11/1442.full
5) The Physiology of the Joints Vol. I (Upper Extremities) by I.A. Kapandji
   Published by Churchill Livingstone, New York, USA
   ISBN 10 / ASIN: B001KTCTK4
   http://med-ebook.blogspot.com/2009/11/physiology-of-joints-kapandji-volume-1.html
6) Bony characteristics determine the behaviour of the interosseous membrane (IOM) during supination, neutral position, and pronation of the forearm
   F.H.M. Narain et al. Department of Anatomy, Anton de Kom University of Suriname, Paramaribo, Suriname
   Published by Technical University of Liberec, Studentska 2, 46117, Liberec, Czech Republic
   http://doclib.uhasselt.be/dspace/handle/1942/11240

7) Interosseous membrane (IOM) extreme tautness in forearm neutral position, evident from in vitro anatomical observations, strongly suggests unwished effects on fingers and thumb long muscles, during repetitive tasks in vivo
K.J. van Zwieten et al. Department of Anatomy, BioMed, University of Hasselt, transnational University Limburg, Diepenbeek, Belgium.
Published by State Polytechnical University, Saint - Petersburg, Russia
http://doclib.uhasselt.be/dspace/handle/1942/11371
8) The effect on forearm and shoulder muscle activity in using different slanted computer mice
Han-Ming Chen et al, Department of Mechanical Engineering, National Taiwan University, Taipei 106, Taiwan, ROC
Published by Clinical Biomechanics 22, 2007, 518-523
http://www.handshoemouse.com/dnld/prof-Han-Min-Chen.pdf
9) Lower arm muscle activities in handling a slanted computer mouse, in order to prevent repetitive strain injuries - the role of the pronator teres muscle
K.J. van Zwieten et al. Department of Anatomy, BioMed, University of Hasselt, transnational University Limburg, Diepenbeek, Belgium.
Citation Biomedica 2010 Life Science Summit Proceedings. p. 217-218
http://doclib.uhasselt.be/dspace/handle/1942/10816
10) Measurement of subclavicular pressure on the subclavian artery and brachial plexus in the costoclavicular space during provocative positioning for thoracic outlet syndrome
Y. Tanaky et al. Department of Orthopaedic Surgery, Japan Self Defense Force, Sapporo General Hospital, Toyohira-ku, Sapporo, Japan.
Published by Journal of Orthopaedic Science 2010 Jan.,15, 1, p. 118-124
http://www.ncbi.nlm.nih.gov/pubmed/20151261
11) The results of using of a hand supporting computer mouse by patients with neck-shoulder disorders
P.C. Helder et al. Erasmus MC, Rotterdam, The Netherlands.
Published by Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde, 2006, 14, 06, July 2006, p. 257 - 264
http://www.handshoemouse.com/dnld/TBV.pdf
English summary: http://www.handshoemouse.com/research-2.html
12) Pathophysiology of upper extremity muscle disorders
B. Visser et al. Institute for Fundamental and Clinical Human Movement Sciences, Faculty of Human Movement Sciences, Vrije Universiteit Amsterdam, The Netherlands
Published by Journal of Electromyography and Kinesiology, 2006, 16, 1-16
http://www.ncbi.nlm.nih.gov/pubmed/16099676
13) Work-Related Pain in Extrinsic Finger Extensor Musculature of Instrumentalists Is Associated with Intracellular pH Compartmentation during Exercise
A. Moreno-Torres et al. Research Department, Centre Diagnòstic Pedralbes, Esplugues de Llobregat, Spain
Published by PLoS One. 2010 Feb 9, 5, 2:e9091.
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0009091