# Wrist and thumb joint postures and motions – measurements using electrogoniometry and EMG

Akademisk avhandling

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av
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The thesis is based on the following papers:

I Per Jonsson, Peter W. Johnson. Comparison of measurement accuracy between two types of wrist goniometer systems. *Applied Ergonomics*. 2001 Dec; 32(6):599-607.

II Peter W. Johnson, Per Jonsson and Mats Hagberg. Comparison of measurement accuracy between two wrist goniometer systems during pronation and supination. *Journal of Electromyography and Kinesiology*. 2002 Oct; 12/5: 413-420.

III Per Jonsson, Peter W. Johnson and Mats Hagberg. Accuracy and feasibility of using an electrogoniometer for measuring simple thumb movements. *Ergonomics.* 2007 50(5): 647-59.

IV Per Jonsson, Peter W. Johnson, Mats Hagberg and Mikael Forsman. Thumb joint movement and muscular activity during mobile phone texting – a methodological study. *Submitted for publication*.

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**Abstract**

Correct measurements of the joints' extreme postures, velocity and repetitiveness are important for studies of the origin of musculoskeletal disorders. Posture measurements of wrist and thumb joints may also provide insights into input device designs that may reduce effort and/or facilitate productivity. Electrogoniometry offers a relatively simple and objective way to measure joint postures and motions. The expectation is that electro-goniometric instruments will provide better measures of postures and movements than the more subjective methods such as self-reporting or observation.

In the first part of this thesis, two wrist goniometer systems were evaluated. The systems differed in how the goniometers were engineered and positioned over wrist and forearm. One system was integrated into a fingerless glove and floated over the forearm whereas the other system was mounted directly over the wrist. "True" wrist positions were established with the aid of a fixture that allowed the positioning of the wrist in known angles. The "Crosstalk" – when movement in one plane artificially causes movement to be measured in another movement plane, "offset" – where the measured movement axes differ or are offset from the actual movement axes, and "range of motion" – the difference between the actual and measured range of motion of the joint, were compared. The measurement errors were substantial with both systems for simple, standardized wrist postures. However, the system with the transducers built-in in the fingerless glove had considerably less crosstalk errors and proved to have less between-subject differences. The similarities and differences in the measurement errors could be attributed to differences in systems design and methods to improve the accuracy of wrist posture measurement were provided.

In the second part of this thesis, the accuracy and feasibility of measuring thumb postures and movements with a simple thumb-mounted electrogoniometer were evaluated. The "true" thumb positions were established and defined using a manual goniometer. The posture measurement error of the thumb-based electrogoniometer was small relative to the manual goniometer, and on average, less than 5 degrees. A follow-up study determined whether this simple thumb-mounted goniometer could provide meaningful information on thumb posture during mobile phone use. When measuring thumb posture during SMS messaging, thumb posture was shown to be affected by the size of the mobile phone and differences in movement speeds were seen between the two movement axes of the thumb. Thumb movements in abduction/adduction were almost twice as fast as those in flexion/extension. It was also established that the thumb worked near the extreme ranges of motion – which is known to contribute to musculoskeletal disorders.

Finally, this thesis determined whether measurements with a simple, thumb mounted electrogoniometer could be used in place of more complicated measures of muscle activity (EMG) for assessing musculoskeletal load during mobile phone use. Sophisticated correlation analyses of these different methods showed that only during very limited conditions could thumb goniometry be used in lieu of EMG measurements to assess musculoskeletal loads. Measurements indicated that the thumb's muscle activity most often complemented rather than replaced the simple goniometric measures of the thumb.

**Key words:** Accuracy, Electrogoniometry, Input device, Information and communication technology, Mobile phone, Muscle activity, Posture, Thumb, Wrist

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