

Wearable sensors for monitoring Epilepsy and Parkinson's disease

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademien, Göteborgs universitet kommer att offentlig försvaras i Hörsal Arvid Carlsson, Academicum, Medicinargatan 3.

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av

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Avhandlingen baseras på följande delarbeten

- I. Ozanne A*, Johansson D*, Hällgren Graneheim U, Malmgren K, Bergquist F, Alt Murphy M. Wearables in epilepsy and Parkinson's disease – A focus group study. *Acta Neurologica Scandinavica* 2018; **137(2)**:188-194.
- II. Johansson D*, Ohlsson F*, Krýsl D, Rydenhag B, Czarnecki M, Gustafsson N, Wipenmyr J, McKelvey T, Malmgren K. Tonic-clonic seizure detection using accelerometry-based wearable sensors – A prospective, video-EEG controlled study. *Seizure* 2019; **65**: 48-54.
- III. Johansson D*, Thomas I*, Ericsson A, Johansson A, Medvedev A, Memedi M, Nyholm D, Ohlsson F, Senek M, Spira J, Westin J, Bergquist F. Evaluation of a sensor algorithm for motor state rating in Parkinson's disease. *Parkinsonism & Related Disorders* 2019; Epub March 26.
doi.org/10.1016/j.parkreldis.2019.03.022.
- IV. Johansson D, Ericsson A, Johansson A, Medvedev A, Nyholm D, Ohlsson F, Senek M, Spira J, Thomas I, Westin J, Bergquist F. Individualization of levodopa treatment using a microtablet dispenser and ambulatory accelerometry. *CNS Neuroscience & Therapeutics* 2018; **24(5)**:439-447.

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ABSTRACT

Introduction: Epilepsy and Parkinson's disease (PD) are conditions where management would benefit greatly from monitoring symptoms over longer time periods in natural everyday environments instead of only intermittent assessments at clinics. Wearable technology with built-in sensors such as accelerometers and gyroscopes, could allow continuous and objective long-term monitoring of movement patterns.

The overall aim of this thesis was to explore and evaluate how wearable sensors can be used in clinical applications with continuously monitored movement related variables in epilepsy and PD.

Methods: The studies in the thesis involved both qualitative and quantitative research methods. Perceptions regarding the use of wearable technology in disease monitoring and management as reported by individuals with epilepsy and PD as well as health professionals working with these patient groups were explored using focus group discussions (Paper I). Wrist-worn sensors were used to detect tonic-clonic seizures in epilepsy (Paper II) and to quantify motor levodopa responses in PD (Paper III). The effects of individual dose adjustment based on information derived from wearable sensors were further investigated (Paper IV). The performance of sensor-based algorithms for seizure detection and motor state recognition was evaluated against clinical standard evaluations including video-EEG in epilepsy and clinical assessment scales for PD motor and non-motor symptoms. Adherence and missing data were examined to explore feasibility of using wearables (Paper II-IV).

Results: End users saw possible benefits for improved treatment effects with the use of wearable sensors and valued this benefit more than the possible inconvenience of wearing the sensors (Paper I). However, they were concerned about unclear information and inconclusive recordings and some fears about personal integrity were at odds with the expectations on interactivity (Paper I). Wearable sensors showed a high sensitivity and a low false positive rate in detecting tonic-clonic seizures in epilepsy (Paper II). Wearable sensors are useful for automated quantification of PD motor states using instrumental testing as well as passive monitoring (Paper III-IV). The PD motor and non-motor symptoms, disease-specific quality of life and wearing-off symptoms improved after dose titration based on the information provided by a wrist-worn sensor (Paper IV). Adherence to using wearables was high across the studies and missing data was mainly attributed to sensor malfunction.

Conclusions and clinical implications: The use of wearable sensors for detecting seizures or quantifying PD motor states showed clinical utility as tools for ascertaining tonic-clonic seizure frequency and monitoring treatment effects in PD outside of hospital. The information provided by sensor monitoring was effective for supporting clinical decision making in PD, indicating that treatment individualization based on wearable sensors is feasible.

Keywords: Epilepsy, Parkinson's disease, wearable sensors, continuous and objective monitoring, end users' perceptions, qualitative content analysis, machine learning algorithms, tonic-clonic seizure detection, dose titration, motor state recognition