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Virtual reality based kinematics for assessment of post-stroke upper limb function

Netha Hussain

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i Hörsal Arvid Carlsson, Academicum, Medicinaregatan 3

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Fakultetsopponent: Docent Påvel Lindberg, Kliniska vetenskaper, Danderyds sjukhus, Karolinska Institutet, Stockholm, Sverige

Avhandlingen baseras på följande delarbeten

I. Hussain N, Alt Murphy M, Sunnerhagen KS. Upper limb kinematics in stroke and healthy controls using target-to-target task in virtual reality. *Frontiers in Neurology*. 2018;9:300

II. Hussain N, Sunnerhagen KS, Alt Murphy M. End-point kinematics using virtual reality explaining upper limb impairment and activity capacity in stroke. *Journal of Neuroengineering and Rehabilitation*. 2019;16(1):82.

III. Hussain N, Sunnerhagen KS, Alt Murphy M. Recovery of arm function from acute to chronic stage of stroke quantified by kinematics. (Submitted manuscript)

IV. Hussain N, Alt Murphy M, Lundgren-Nilsson Å. Sunnerhagen KS. Relationship between self-reported and objectively measured manual ability varies during the first year post-stroke. *Scientific Reports*. 2020;10(1):5093

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Abstract

The main scope of this thesis was to develop a method for assessing the upper limb sensorimotor function following stroke using virtual reality-based technique. The studies reported in this thesis included 67 individuals extracted from the SALGOT (Stroke Arm Longitudinal Study at the University of Gothenburg) cohort and 43 healthy controls. They performed the target-to-target pointing task in a virtual environment using a haptic stylus that captured kinematic parameters.

The kinematic variables of movement time, mean velocity, peak velocity and number of velocity peaks were found to be discriminative for groups with moderate to mild stroke impairment, as well as healthy controls. Mean velocity and number of velocity peaks together explained 16% of the Fugl-Meyer Assessment of Upper Extremity score, while movement time and number of velocity peaks explained 13% and 10% of Action Research Arm Test score respectively. Movement time, mean velocity and number of velocity peaks showed improvement over time and were affected positively by younger age, less severe stroke and ischemic compared to hemorrhagic stroke. Except for the measurement at 6 months, movement time and number of velocity peaks differed significantly from that of healthy controls within one year after stroke. The correlation between self-reported manual ability and kinematic variables were low or very low early after stroke, which became moderate to high after 6 months for movement time and number of velocity peaks, but remained low to moderate for mean velocity and low for peak velocity.

The end-point kinematic variables, particularly movement time and number of velocity peaks, were demonstrated to be most effective in characterizing the upper extremity function and for capturing the improvement over time after stroke. This knowledge is useful in movement analysis research, especially in the development of new VR-devices. As there is a discrepancy between self-reported and objectively assessed arm function especially in the acute stage of stroke, a combination of self-reported and objective assessments of the upper limb should be used as outcome measures for gathering full understanding of the individual's functional level and for setting achievable rehabilitation goals.

Keywords: stroke, virtual reality, kinematics, upper extremity

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