COMPLEXITY OF GAIT POST STROKE

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INTRODUCTION

Determining how individuals will respond to therapeutic interventions focused on improving gait function after stroke is challenging. Some individuals demonstrate improvements in walking speed via the recovery of pre-stroke gait patterns, while others may increase speed through the strengthening of compensatory movement patterns [1]. Traditional measures of gait function derived from spatio-temporal parameters, such as gait speed, do not delineate between recovery of pre-stroke patterns or compensation, and thus, do not provide information about a patient’s ability to adapt their gait to different tasks and environmental constraints. There is a critical need to develop methods that differentiate among capacities for adapting movement patterns in individuals with stroke.

One approach to understanding the health and adaptability of biological systems is through the measurement of complexity. Since complexity represents the adaptability of the biological system in question, the assessment of complexity of movement parameters is particularly attractive when attempting to better understand the recovery processes after events such as stroke.

Therefore, the primary purpose of this study was to determine whether the complexity of gait in persons with hemiparesis due to stroke is different to that of individuals without disability during a gait task. Based on the previous work documenting the decrease in complexity [2, 3] of biological signals with age and disease, our hypothesis was that the complexity would be significantly lower in the group with stroke compared to the group without disability.

METHODS

Participants with chronic stroke and participants without disability were enrolled in this case-control study. Participants with stroke had to meet the following inclusion criteria: 1) minimum of 6 months post stroke, 2) able to walk for at least 10 meters on level surfaces without physical assistance or use of an assistive device and/or lower extremity orthosis, 3) continue to experience residual deficits from the stroke that affects walking ability. Participants without disability were included if they were able to walk without physical assistance or use of an assistive device or orthosis during all home and community activities. Exclusionary criteria for the participants without disability included: 1) known neurological condition or any neurological deficits such as prior stroke, 2) current musculoskeletal condition outside typical age-related changes, and 3) complications from health conditions that influence walking.

All participants completed a 2-minute walk at their preferred pace around a level, tiled indoor walking track. During the walking tasks, three dimensional accelerometer data from wireless inertial measurement units (IMUs) (InterSense Inertia Cube BT) worn on each lower extremity segment [foot, shank, thigh] and pelvis were collected (60 Hz) using MotionMonitor software (Innovative Sports Training, Inc.).

These data were used to determine the complexity of the gait patterns using the multivariate, multiscale entropy (MMSE) algorithm developed by Ahmed and colleagues [4]. The calculation of MMSE results in a measure of complexity across multiple time scales and provides a means for comparing the movement complexity across groups.
and/or conditions. The complexity index was calculated from the MMSE results and represents the area under the MMSE curve and provides a way of comparing the physiological complexity of gait across multiple time scales.

Two-tailed, independent t-tests with a significance level of \( p < .05 \) were used to test the hypothesis that the complexity index for each limb segment would be lower in the participants with stroke compared to that of the healthy participants.

RESULTS AND DISCUSSION

A total of 22 participants were enrolled in this case-control study (11 with chronic stroke and 11 participants without disability). Participants with chronic stroke had significantly (\( p < 0.05 \)) lower complexity at every lower limb segment and the pelvis compared to healthy controls during overground walking, see Table 1.

The results of this study support the hypothesis that in individuals with stroke would exhibit lower levels of gait complexity compared to that of healthy participants and are consistent with previous studies of the temporal variability of upper extremity movement in individuals with stroke [5].

Greater complexity is thought to signify the overall health of a system and its underlying physiological capacity to adapt to everyday stresses. Healthy biological systems exhibit complex behaviors while age and disease reduce this complexity [2, 3]. The results of this study support this paradigm.

CONCLUSIONS

The reduced complexity of gait after stroke represents a decrease in the adaptability in the neuromotor system. This information may discern between those patients who are more likely to respond to therapeutic interventions and those who will not. Ultimately this information could allow therapists to tailor interventions in such a way to optimize function.

REFERENCES


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<th>Complexity Index</th>
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<tbody>
<tr>
<td></td>
<td>Paretic Foot</td>
</tr>
<tr>
<td>Stroke</td>
<td>3.59 ± 0.58</td>
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<tr>
<td>Healthy</td>
<td>4.71 ± 1.06</td>
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