INTRODUCTION

Parkinson’s disease (PD) is a progressive degenerative disorder of the central nervous system. Bradykinesia is one of the cardinal symptoms of PD and it is used to describe the slowness of movement. Patients with PD also exhibit impaired ability to adjust to movement. Previous reports indicate that the use of anti-PD medication by people with PD produces an increase in movement speed [1, 2] but the regularity of movement decreases. The decrease in regularity may reflect the person’s improved ability to selectively adjust the movement after medication [3].

Approximate entropy (ApEn) is one technique used to quantify the regularity of biological signals [4]. In this study, ApEn was used to quantify the regularity of the voluntary wrist movement. There has been no previous investigation of the association between bradykinesia and regularity of the movement pattern. The objective of this study was to examine the relationship between movement speed and regularity of the wrist movement.

METHODS

Seven patients (3 Males, 4 females; 63.42±8.25 years of age) with idiopathic PD participated in this study. The protocol was approved by the Institutional Review Board at Creighton University in Omaha, Nebraska and written informed consent was obtained from each subject prior to participation. Each subject was seated in an adjustable chair with the hand of the most affected side placed in a manipandum and the wrist centered over the axis of rotation. The manipandum was free to rotate horizontally approximately 180 degrees over a fixed base. The subjects’ elbow was positioned at 120° and the forearm in the neutral rotation [Figure 1]. The subject’s trunk was strapped to the chair to minimize movement during the course of experiment.

Figure 1: Experimental setup for measuring voluntary movement of the wrist flexion and extension

Subjects were first tested in the Off-medication state (OFF–MED) defined as 12 hours after the last dose of anti-PD medication. Each subject’s wrist was positioned at his or her maximum extended position. The subject then performed repetitive voluntary reciprocal wrist flexion and extension movements. Subjects were instructed to move his or her hand as quickly as possible through the maximum range of motion for a period of 10 sec. Two trials were collected. Each subject then resumed his or her usual dose of anti-PD medication, and the testing was repeated approximately one hour later in the On-Medication state (ON-MED). Joint position was recorded using...
an encoder (SC904 series, PacSci, CA, US). Joint torque was measured with a torque transducer (TRT-200, Transducer Tech, US). The position signal was sampled at 100 Hz.

ApEn was calculated based on the position signal. Typically, ApEn values range between zero and two [4, 5]. A more regular or consistent pattern of movement yields a lower ApEn value. Bradykinesia was quantified by measuring the number of cycles (NOC) of movement and the ability to adjust movement is quantified by measuring regularity. One cycle of movement was defined as the voluntary completion of one flexion and one extension movement. NOC of movement was calculated by counting the number of completed flexion/extension cycles. Pearson’s correlation coefficient was used to examine the relationship between number of cycles of movement and ApEn values.

RESULTS AND DISCUSSION

The NOC during Off-Med (9.44 ± 3.32) was smaller than the NOC during On-Med (10.44 ± 2.98). The ApEn value was lower during Off-Med (0.590 ± 0.188) than the On-Med (0.737 ± 0.279) state. Figure 2 illustrates the correlation between the ApEn and NOC of movement in the Off-Med and On-Med states, respectively. There was a strong correlation between NOC and ApEn during Off-Med (r = 0.962) and On-Med (r = 0.977) states.

Increased NOC during On-Med compared to OFF-Med showed that movement speed increased with anti-PD medication. Lower ApEn values during Off-Med confirm more regularity of wrist movement, while higher ApEn during On-Med state confirm more irregularity of wrist movement. The unique finding of this study was the strong correlation between NOC and ApEn, suggesting that regularity of wrist movement decreased as the speed of wrist movement increased.

CONCLUSION

The strong correlation between NOC and ApEn indicates that faster wrist movement was associated with decreased regularity regardless of medication state. Anti-PD medication improved movement speed and decreased movement regularity, implying improved functional adaptability of the wrist motion. However, the influence of anti-PD medication and movement speed on functional adaptability of the wrist remains to be tested.

**Figure 2**: Correlation between Number of cycles of movement and ApEn value

REFERENCES

3. Hanson et al. *Abstract of Society for Neuroscience*, San Diego, CA, USA, 2010
4. Pincus S. M. *Application of nonlinear dynamics to developmental process modeling*, Lawrence Erlbaum Assoc., 1997

ACKNOWLEDGEMENTS

This study was funded by Faculty Development Fund, School of Pharmacy and Health Professions, Creighton University, Omaha Nebraska, USA. Authors would like to thank Matija Radovic and Andrea Benes for the diligent work in data processing.