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Is reduced arm and leg swing in Parkinson's disease associated with rigidity or bradykinesia?

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ABSTRACT

Background and purpose: Arm and leg swings during gait are reduced and asymmetric in Parkinson's disease (PD). Although rigidity and bradykinesia are interconnected with each other, and related with gait hypokinesia including arm and leg swing alteration, it remains uncertain which factor is more responsible for the decrease of arm and leg swings. The study aimed to uncover which factor between rigidity and bradykinesia is more associated with the reduction of arm and leg swings during gait.
Methods: Patients with PD were selected and divided into a concordance group (21 patients) representing a match of both symptoms and a discordance group (nineteen patients) exhibiting a mismatch of pronounced rigidity and bradykinesia. Visual inspections of video clips for asymmetric features of gait and posture including arm swing, leg swing, shoulder position, external foot rotation were analyzed and accessed by two independent neurologists blindly.
Results: The side of more pronounced rigidity was significantly and moderately related with the side of more decreased arm and leg swings ($p < 0.001, \kappa = 0.592$ in arm swing; $p = 0.011, \kappa = 0.432$ in leg swing, respectively), but the side of more dominant bradykinesia was associated with neither arm nor leg swing asymmetry ($p = 1, \kappa = 0.014$ in arm swing; $p = 1, \kappa = -0.036$ in leg swing). In addition, asymmetric posturing including shoulder position and a laterally rotated foot showed no relationship with rigidity or bradykinesia.
Conclusion: The reduction of arm and leg swings during gait in PD was associated with rigidity, but not with bradykinesia.

1. Introduction

One of the characteristics of Parkinson's disease (PD) representing resting tremor, rigidity, and bradykinesia is asymmetry of cardinal motor signs [1]. Patients with PD exhibit asymmetry as well as reduction in arm and leg swings during gait [2–4]. It has been assumed that abnormality of arm and leg swings in Parkinsonian gait is associated with rigidity and bradykinesia due to the evidence as follows: 1) L-dopa treatment or subthalamic nucleus stimulation ameliorates reduced amplitude of arm and leg swings [4]. 2) Arm and leg swings show a significant relationship with rigidity and bradykinesia but not with tremor [5]. 3) In addition, reduced interlimb coordination of gait is correlated with rigidity and bradykinesia [6]. However, in general, it is very difficult to distinguish between rigidity and bradykinesia for gait analysis, because rigidity is highly associated with bradykinesia in PD.

The present study aimed to evaluate which factor between rigidity and bradykinesia in patients with PD is more related to the alteration of arm and leg swing during gait. We additionally sought to uncover whether rigidity or bradykinesia is associated with postural asymmetry including shoulder position and foot rotation. To make it possible to investigate relationships between rigidity/bradykinesia and asymmetry of gait/posture, we blindly analyzed video clips for gait and posture in PD patients representing discordance as well as concordance for dominant side of limb rigidity and bradykinesia.

2. Methods

2.1. Patient selection

We retrospectively reviewed clinical data of consecutive PD patients [7] registered at the Parkinson's Disease Centre in Korea University Guro Hospital between January 2010 and April 2013. Patients having serious musculoskeletal problems, stroke, trauma, or other structural brain lesions were excluded. To access asymmetry of limb motor functions, our center often permits to add +0.5 point to the original rating score of 0–4 (0, absence of motor signs; 4, most severe motor signs) of the

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more pronounced limb compared with the contralateral limb. For example, when a patient with PD reveals mild rigidity in both arms (rating as 1/1 according to the original UPDRS), we rated it as 1.5/1 if rigidity was more pronounced in the right arm compared to the left arm. Patients were selected through the review of medical records containing the Unified Parkinson's Disease Rating Scale (UPDRS) motor function (part 3) [8] which assessed while video recording was undertaken. Previous reports have suggested that arm and leg swings are a little related with tremor [5,6]. In addition, there was a concern about the interference of 'moderate to severe tremor' in assessing bradykinesia as well as rigidity: Actually, we had some difficulty in rating the exact rigidity or bradykinesia score in tremor dominant PD. Since this study only focused on asymmetry of rigidity and bradykinesia, thereby we excluded tremor-dominant type patients according to the literature [9]. We defined that at least 0.5 point difference between two sides was required for asymmetry. After assessment of asymmetry in arm or leg, we classified and enrolled PD patients into a discordance group who possessed one rigidity-dominant arm and leg side and a bradykinesia-dominant arm and leg on the contralateral side. We also chose and classified PD patients between July 2012 and April 2013 into a concordance group defined as showing both rigidity and bradykinesia pronounced on the arm and leg on the same side of the body. Patients were enrolled regardless of antiparkinsonian medication state (13 patients with MED-OFF and 27 patients with MED-ON): 1) because of the paucity of discordance group and 2) because of simultaneously checking of UPDRS part 3 while recording video. Finally, discordant group between January 2010 and April 2013 was 5.7% (19 out of 331 PD patients), and concordant group between July 2012 and April 2013 was 20% (21 out of 105 PD patients). All patients, except one who is ambidextrous, were right-handed.

2.2. Visual assessment of video clips for gait and posture

Blinded to clinical data including asymmetry of rigidity and bradykinesia, two neurologists independently executed the analysis of the video clips of each patient for gait and posture (K-Y.K. and M.K.). Each rater evaluated video clips only exhibiting walking and standing posture; neither referred to other video clips showing other motor signs including tremor, rigidity, or bradykinesia. From the recorded videos, each rater assessed only the more affected side (i.e., right, left, or symmetric) for arm swing, leg swing, lower shoulder position, and lateral foot rotation. After the independent analysis, final decisions were made by the consensus of both raters. This study was approved by the Institutional Review Board of the Korea University Guro Hospital (IRB #13058).

2.3. Statistical analysis

Demographic parameters were analyzed with an independent sample *t*-test or a Mann–Whitney *U* test as well as a Chi-square test. Inter-rater reliability was assessed with Cohen's kappa coefficient. The relationship between rigidity/bradykinesia asymmetry and asymmetry of gait and posture was investigated with a Chi-square test or Fisher's exact test for the analysis of sampling distribution as well as with Cohen's kappa coefficient for the analysis of side-to-side agreement. The strengths of inter-rater agreements and concordances between asymmetry of rigidity–bradykinesia and asymmetry of gait–posture were determined by the Landis and Koch criteria ($\kappa < 0.0$, poor; $\kappa = 0$–0.2, slight; $\kappa = 0.21$–0.4, fair; $\kappa = 0.41$–0.6, moderate; $\kappa = 0.61$–0.8, substantial; and $\kappa = 0.81$–1, almost perfect) [10]. Statistics were performed using SPSS (version 20.0, Chicago, IL). The statistical significance was set at $p < 0.05$ for all analyses.

3. Results

3.1. Demographic and clinical data

The concordance and discordance groups revealed no significant difference in basic characteristics (Table 1) including onset age, disease duration, UPDRS motor function (part III), and modified Hoehn and Yahr stage. The median value of the UPDRS score difference between both sides in arm and leg rigidity as well as in leg bradykinesia was 1 in each group. However, the median value of the score difference in arm bradykinesia was 2 in each group, because the arm bradykinesia score was calculated by summing the scores of three items including hand movement, finger tap, and rapid pronation and supination. Fifteen out of 21 in the concordant group showed more pronounced rigidity/bradykinesia on the left side, whereas 18 out of 19 in the discordant group revealed more rigidity on the right (and more bradykinesia on the left side).

3.1.1. Detailed frequencies of asymmetric features

Inter-rater reliability was assessed after the independent visual inspection of video records. Cohen's kappa coefficients of the side of more reduced arm swing, lower shoulder, more reduced leg swing, and more laterally rotated foot were 0.950, 0.802, 0.798, and 1.000, respectively. The two investigators rated 'symmetric' for 13 patients (32.5%) in shoulder position, 9 (22.5%) in leg swing, and 12 (30%) in foot rotation, and the regarded value of 'symmetric' was excluded in statistical analyses.

In Table 2, the revealed concordant group matching frequencies for the side of more rigid/bradykinetic limb were 77% and 73% on the side of more reduced arm and leg swing, respectively, while 46% and 47% on the side of more lower shoulder and more externally rotated foot, respectively. On the other hand, the exhibited discordant group matching frequencies for the side of more pronounced rigidity were 84%, 79%, 69%, and 77% on the side of more affected arm swing, lower shoulder, leg swing, and rotated foot, respectively. Consequently, bradykinesia in the discordant group showed the diametrical opposite results. From the data of all patients, the side of more noticeable rigidity was associated with 80% of more reduced arm swing, 63% of lower shoulder, 71% of more reduced leg swing, and 61% of externally rotated foot, respectively. Whereas, the side of more dominant bradykinesia was related to 48% of more reduced arm swing, 33% of lower shoulder, 52% of more reduced leg swing, and 36% of externally rotated foot, respectively.

3.2. Accordance between asymmetry of rigidity/bradykinesia and asymmetry of gait and posture

Our data from all patients enrolled in this study (Table 3) revealed that more pronounced limb rigidity was significantly associated with greater decrease in arm and leg swings, according to the Chi-square test ($p < 0.001$ in arm swing and $p = 0.011$ in leg swing) as well as the kappa coefficient ($\kappa = 0.592$ in arm swing and $\kappa = 0.432$ in leg swing). However, more dominant limb bradykinesia was not related with any asymmetric features of gait and posture.

4. Discussion

The underlying and detailed mechanism for gait hypokinesia including the reduction of arm and leg swings has not yet been fully elucidated. Decreased arm and leg swings during gait indicate a problem or difficulty in locomotive function [11]. Previously, Nieuwboer and colleagues showed that both rigidity and bradykinesia were significantly related with reduced arm and leg swings [5]. However, in general, the discordant type for rigidity and bradykinesia in PD is very uncommon. It was highly possible that rigidity was interconnected with bradykinesia in the majority of patients with PD in the previous research. Therefore, we could discriminate between rigidity and bradykinesia by