Movement Disorders
CLINICAL PRACTICE

Postural Abnormality in Parkinson's Disease: A Large Comparative Study With General Population

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ABSTRACT: **Background:** Postural abnormalities in Parkinson's disease (PD) patients and unimpaired elderly are not well differentiated. Factors related to postural abnormality associated with PD are controversial.
Objective: We assessed differences in postural change between PD patients and unimpaired elderly and elucidated factors related to abnormal posture in PD patients.
Methods: We measured the dropped head angle (DHA), anterior flexion angle (AFA), and lateral flexion angle (LFA) of the thoracolumbar spine of an unprecedented 1,117 PD patients and 2,732 general population participants (GPPs) using digital photographs. Two statistical analyses were used for elucidating factors related to these angles.
Results: In GPPs, age was correlated with DHA, AFA, and LFA. DHAs, AFAs, and LFAs of PD patients and age-matched GPPs were $21.70° \pm 14.40°$ and $13.13° \pm 10.79°$, $5.98° \pm 12.67°$, and $-3.82° \pm 4.04°$, and $0.86° \pm 4.25°$ and $1.33° \pm 2.16°$, respectively. In PD patients, factors related to DHA were age, male sex, and H & Y stage during ON time. Factors related to AFA were age, duration of disease, H & Y stage during ON and OFF times, pain, vertebral disease, and bending to the right. A factor related to LFA was AFA.
Conclusions: DHA and AFA of GGPs correlated with age and were larger in PD patients than those with in GPPs. Some PD patients showed angles far beyond the normal distribution. Thus, factors associated with disease aggravation affected postural abnormality in PD patients.

Parkinson's disease (PD) patients often show a stooped and bent posture. In addition to the "common" stooped and bent posture, some patients show remarkable anteflexion (camptocormia), lateral leaning (Pisa syndrome), and dropped head. The frequency of camptocormia is 6.9%,[1] Pisa syndrome is 8.8%,[2] and dropped head is 1.5% to 6.3%.[3–5] However, the exact frequency of these postures is unclear owing to differences in target patients and methods for measuring and judging postural abnormalities.

Physically unimpaired people in the general population also develop bent posture with age.[6] The study by Oeda et al.[7] is the only previous study in which the postures of PD patients and general population participants (GPPs) were digitally imaged and compared. However, they examined comparatively few cases and did not measure the lateral flexion angle (LFA) of the thoracolumbar spine. We measured the dropped head angle (DHA), anterior flexion angle (AFA) of the thoracolumbar spine, and

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LFA from digital photographs and compared them with those of 1,117 PD patients and age-matched GPPs. To clarify related factors, we investigated the background and treatment of PD patients. As for therapeutic agents, we focused on dopamine agonists because abnormal postures related to these agents have been reported previously.[8,10]

Patients and Methods

PD Patients and GPPs

A total of 1,117 PD patients (540 males, 577 females; average age: 70.4 years) in 15 medical institutions of Tokyo metropolitan district and 2,732 medical checkup GPPs (1,199 males, 1,533 females; average age: 64.9 years) in five city areas of Japan (Shimotsuke City, Ayakawa City, Kami-ichi Town, Karatsu City, and Wara Town) were registered. This medical checkup service is performed once a year for independent businessmen and housewives by the government. The registration period was from April 2012 to March 2014. The clinical diagnosis of all PD patients was defined as per the UK Brain Bank Criteria.[11]

Measurement Procedure

We took digital photographs from the back and side of PD patients and GPPs. We identified the (1) external acoustic foramen, (2) acromion, and (3) greater trochanter in the printed photographs. Furthermore, we measured the DHA, AFA, and LFA with a straight line that linked those points and the perpendicular line by hand (Fig. 1).

PD patients assume an almost anteflexion posture when walking, but can adopt a vertical posture if they stop and make the effort. We photographed postures for these two situations (i.e., standing as straight as possible and relaxing while walking). Because there was correlation among these two postures, we used photographs taken in a relaxed state.

For PD patients, we investigated age, sex, onset side, type of oral medicine and dosage amount, physical work strength required in the occupation, presence of pain, rehabilitation to correct abnormal posture, vertebral disease, operation for PD, H & Y stage during ON and OFF times, and duration of PD. The work strength of the occupation was classified as first (slight, such as office and sewing workers), second (middle, such as salespersons and housewives), and third (severe, such as agricultural and industry workers) degrees. For GPPs, we only collected data on age and sex. We analyzed all GPPs and matched them by age with each PD patient by generating a random number to match against the same number assigned to PD patients for each age. This study was approved by the independent ethics committee of the Jichi Medical University.

Statistical Analysis

We analyzed the H & Y stage and physical work strength of the occupation classification under conditions of both pain and rehabilitation to correct abnormal posture to obtain two values representing the degree classification and analyzed the duration of PD and medication dosage as numerical values.

The levodopa-equivalent dose (LED) was assumed to have been as follows: pergolide, 1,000 μg; cabergoline, 2 mg; talipexole, 1.6 mg; pramipexole, 2 mg; ropinirole, 9 mg; and L-dopa/dopa decarboxylase inhibitor (DCI), 100-mg equivalency. Selegiline was assumed to have been given as one daily output × 30% of levodopa/DCI and entacapone one daily output × 20% of L-dopa/DCI, regardless of a daily dose.[12]

Two types of statistical analysis were conducted. First, Spearman's single-correlation analysis was used for correlations between a measurement angle and each factor as a pair. Statistical significance was set to $P < 0.05$ for coefficients of correlation $|r| > 0.06$ and to $P < 0.001$ for $|r| > 0.10$. Second, multiple regression analysis (step-wise method), which was a multivariate analysis, was used. Factors with high levels of significance were included in the final model without excluding basic factors, such as age or sex. To assess differences between PD patients and GPPs, we conducted the Mann-Whitney U test when there was a variance in the distribution between the groups and Student's t test when there was no variation. The level of statistical significance was set to $P < 0.05$. StatFlex software (Version 6; Artech Co., Ltd., Tokyo, Japan) was used for all statistical analyses.

Results

DHA

DHA was significantly larger in PD patients (mean ± standard deviation [SD]: 21.70° ± 14.40°] than in age-matched GPPs (13.13° ± 10.79°; Fig. 2A). DHA was 25.39° ± 13.68° in male PD patients, 18.25° ± 14.23° in female PD patients, 15.48° ± 10.54° in male GPPs, and 10.94° ± 10.57° in female GPPs. In both groups, DHAs were significantly larger in males than in females (Fig. 3A,D).

In GPPs, coefficients of correlation between DHA and age were 0.0904 ($P = 0.0017$) in total, 0.0944 ($P = 0.832$) in males, and 0.0929 ($P = 0.211$) in females.

Characteristically, distribution of DHAs was significantly wider in PD patients than in GPPs; 16.2% of PD patients had DHAs >34.7° (the mean + 2 SDs of DHA in GPPs). Moreover, 4.0% of PD patients had DHAs >48.9° (the maximum DHA in GPPs). The maximum DHA in PD patients was 94.2° (Fig. 2A, lower panel).

In the Spearman single-correlation analysis of DHA-related factors in PD patients, factors that exhibited equilateral correlation and $P < 0.001$ were male sex; duration of PD; H & Y stage during ON and OFF times; L-dopa/DCI dosage; L-dopa/DCI + adjuvant, such as selegiline or entacapone LED; total LED; and work strength of the occupation. Factors that exhibited equilateral correlation and $P < 0.05$ were age, operation for PD, and presence of pain.
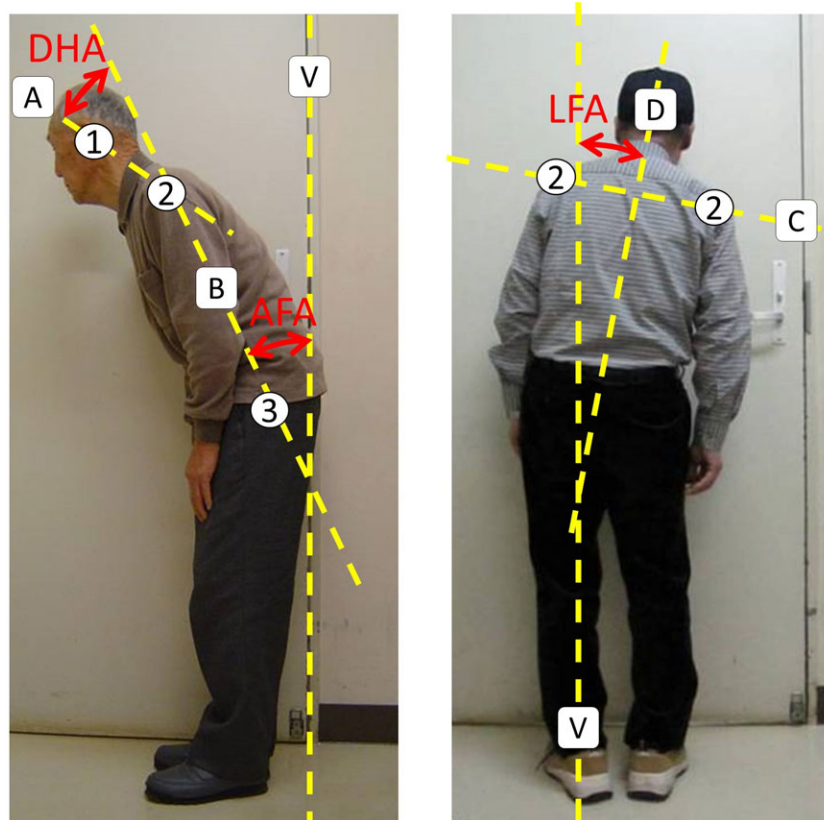
FIG. 1. Measurement procedure. 1: external acoustic foramen; 2: acromion; and 3: greater trochanter. A straight line A: between the external acoustic foramen and acromion; A straight line B: between the acromion and greater trochanter. The DHA is made by the straight lines A and B. The AFA is made by straight line B and a vertical line V. A straight line C: between both acromions shown in the back photographs and a straight line D crossing line C at a right angle. The LFA is made by straight line D and vertical line V. Plus sign indicates right direction and minus sign indicates left direction.

In the multiple regression analysis, the factor of male sex showed equilateral correlation and $P < 0.001$. Factors that showed equilateral correlation and $P < 0.005$ were age and H & Y stage during ON time. AFA showed an inverse correlation and $P < 0.001$.

Factors of age, male sex, and H & Y stage during ON time showed significant correlation in both analyses (Table 1).

AFA

Larger AFA indicates stronger anteflexion. AFA was anteflexion in PD patients ($5.98° \pm 12.67°$) and dorsoflexion in age-matched GPPs ($-3.82° \pm 3.04°$; Fig. 2B). AFA was $4.86° \pm 10.71°$ in PD males, $7.02° \pm 14.19°$ in PD females, $-3.93° \pm 3.58°$ in male GPPs, and $-3.72° \pm 4.45°$ in female GPPs. In PD patients, AFAs were significantly larger in females than in males, whereas in GPPs there was no significant difference between the sexes (Fig. 3B,E).
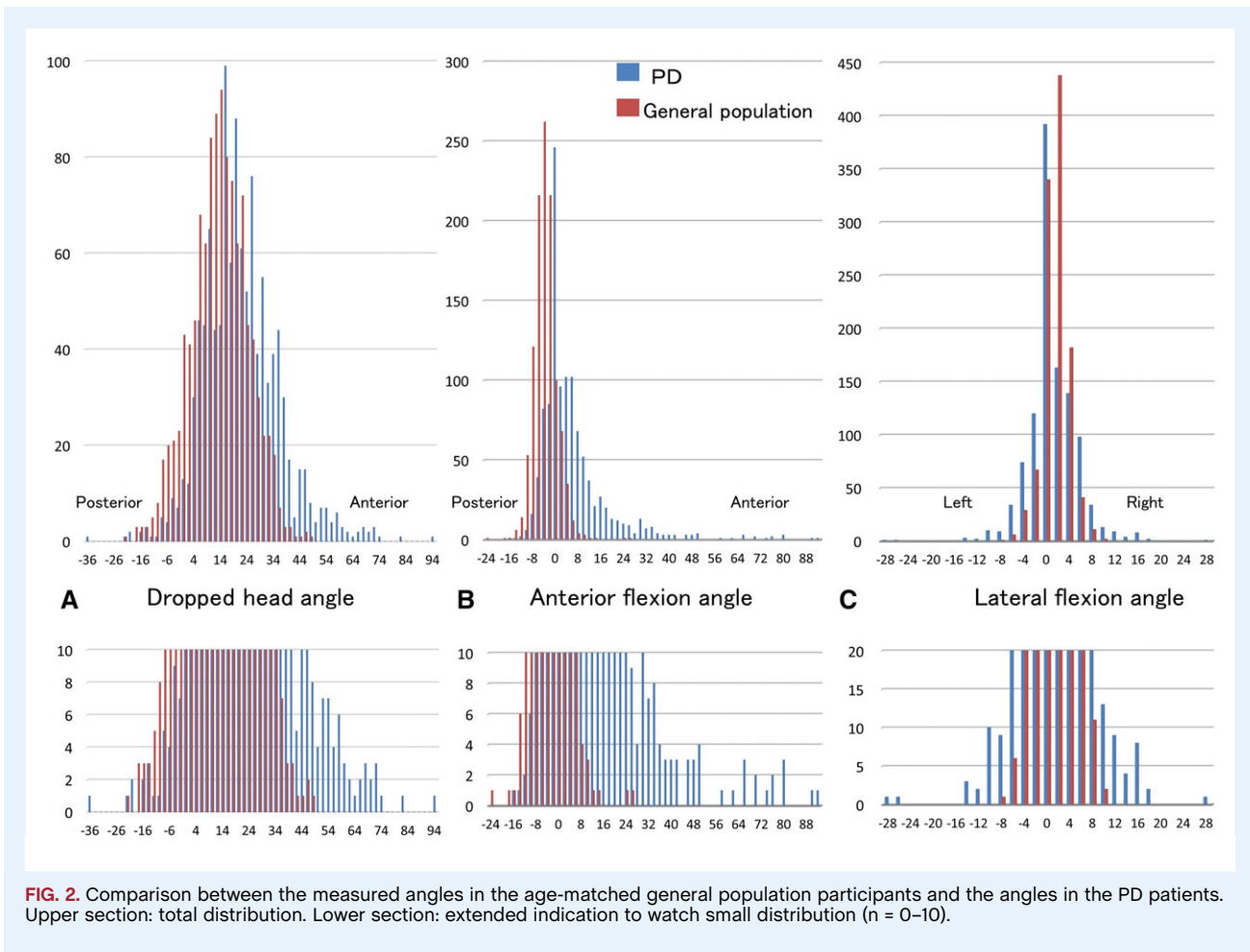
In the analysis of GPPs, coefficients of correlation between AFAs and age were 0.110 ($P < 0.001$) in total, 0.0386 ($P = 1.000$) in males, and 0.107 ($P = 0.022$) in females.

Similar to the distribution of DHAs, the distribution of AFAs was wider in PD patients than in GPPs. The 39.5% of PD patients had AFAs >4.28° (the mean + 2 SDs of AFA in GPPs; Fig. 2B, lower panel).

In the Spearman single-correlation analysis of AFA-related factors in PD patients, factors that showed equilateral correlation and $P < 0.001$ were age, duration of PD, H & Y stage during ON and OFF times, L-dopa/DCI + adjuvants LED, total LED, spinal disease, and LFA to the right. Factors of the presence of rehabilitation showed an inverse correlation and $P < 0.01$.

In the multiple regression analysis, factors of duration of PD, H & Y stage during ON time, and pain showed equilateral correlation and $P < 0.001$. Factors of spinal disease and LFA to the right showed equilateral correlation and $P < 0.01$. Factors of age and H & Y stage during OFF time showed equilateral correlation and $P < 0.05$. The factor of DHA showed an inverse correlation and $P < 0.001$. Factors of dopamine agonist LED and the presence of operation for PD showed an inverse correlation and $P < 0.05$.

Factors of age, duration of PD, H & Y stage during ON and OFF times, pain, spinal disease, and LFA to the right showed significant correlations in both analyses (Table 1).

FIG. 2. Comparison between the measured angles in the age-matched general population participants and the angles in the PD patients. Upper section: total distribution. Lower section: extended indication to watch small distribution (n = 0–10).

LFA

There was no dominant side of onset of the disease; 410 cases had right-sided onset, 366 had left-sided onset, and 341 had bilateral onset or lack of information. The 238 (58.0%) cases in the right–sided onset group bended to the right side, and the 126 (34.4%) cases in the left-sided onset group bended to the left side. Only in the cases that the onset side is clear, there was no statistical relation between onset side and bending side; however, there was a tendency of bending to right-side in both onset side groups.

The LFA tended to incline to the right more in age-matched GPPs (1.33° ± 2.16°) than in the PD patients (0.86° ± 4.25°; $P < 0.001$; Fig. 2C). In GPPs, LFA was 1.38° ± 2.00° in males and 1.28° ± 2.30° in females. In PD patients, LFA was 0.98° ± 3.84° in males and 0.75° ± 4.61° in females. In both groups, there was no significance difference in LFAs between the sexes (Fig. 3C,F).

In the analysis of GPPs, positive correlation of "left-side inclination" was observed between LFA and age either in the total analysis or in males and females.

Similar to the distributions of DHA and AFA, that of LFA was wider in PD patients than in GPPs. Twelve (8.68%) PD patients had LFA > −2.98°/+5.65° (the mean − 2/+2 SDs of LFAs of GPPs; Fig. 2C, lower panel).

In the Spearman single-correlation analysis of LFA-related factors in PD patients, the factor of AFA showed equilateral (right-sided) correlation and $P < 0.001$. Factors that showed equilateral correlation and $P < 0.01$ were H & Y stage during OFF time; L-dopa/DCI + adjuvants LED; and total LED. Factors that showed equilateral correlation and $P < 0.05$ were H & Y stage during ON time, duration of PD, and dopamine agonist LED.

In the multiple regression analysis, the factor of AFA showed equilateral correlation and $P < 0.05$. Factors of presence of rehabilitation showed inverse (left-sided) correlation and $P < 0.05$.

Only AFA showed correlation in both analyses (Table 1).

Finally, as supplementary analysis, in the single correlative analysis involving all 2,732 GPPs, age was correlated with DHA (r = 0.0848), AFA (r = 0.1134), and LFA (r = 0.0780; $P < 0.0001$).

Discussion

In this study, we measured DHA, AFA, and LFA in 1,117 PD patients and in 2,732 medical checkup GPPs and conducted an age-matched comparison of these angles between the two groups.
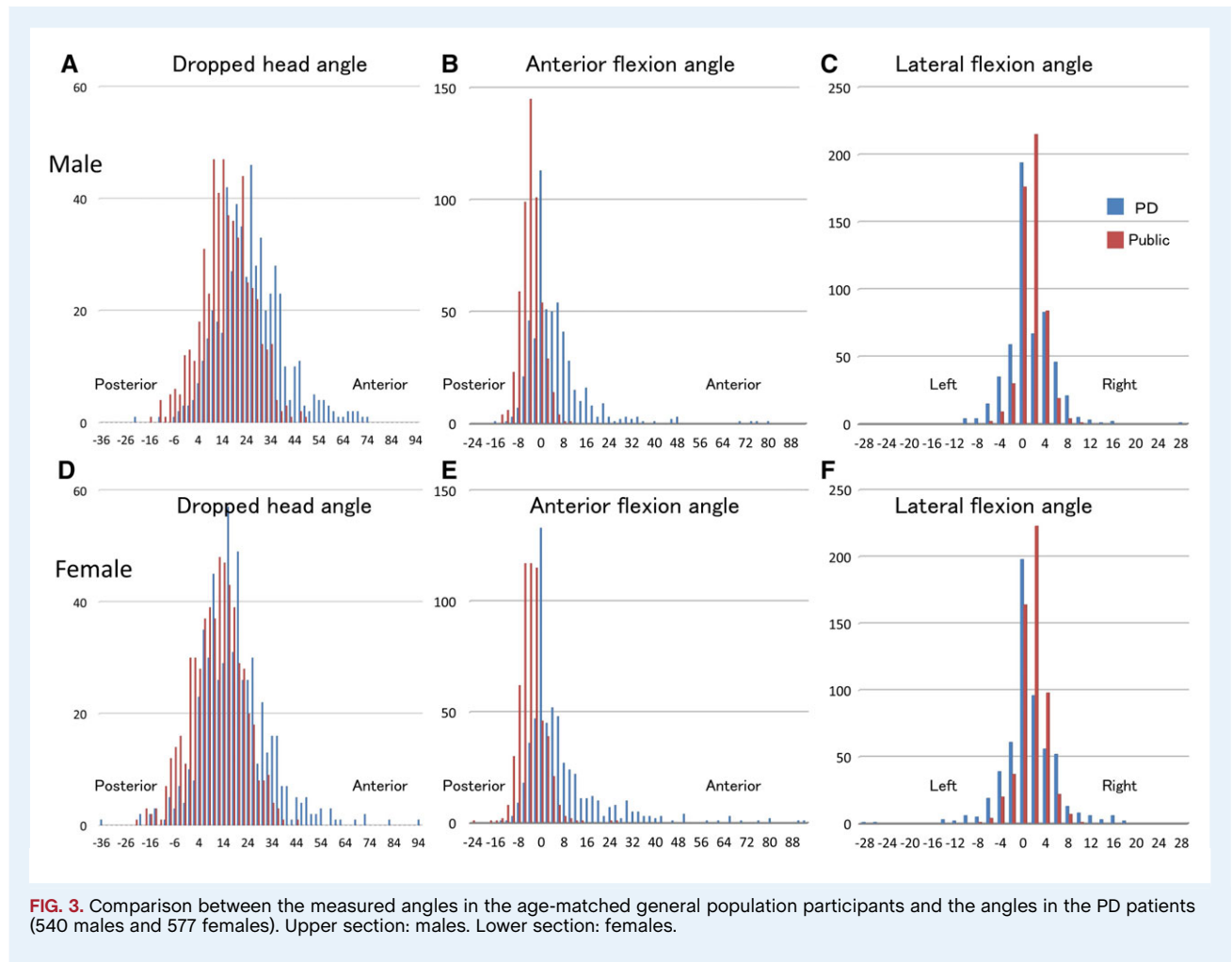
FIG. 3. Comparison between the measured angles in the age-matched general population participants and the angles in the PD patients (540 males and 577 females). Upper section: males. Lower section: females.

We confirmed that DHA and AFA were larger in PD patients than in age-matched GPPs. Notably, AFA was dorsoflexion in GPPs but anteflexion in PD patients. Drzal-Grabiec et al. reported that the angle of inclination of the trunk in healthy individuals aged >60 years declines backward (dorsoflexion) compared to that in young individuals.[6] DHA was larger in males in both PD patients and GPPs. Because AFA is larger in females, the head may turn upward to compensate. In both PD patients and GPPs, DHAs of both sexes were inversely correlated with AFA ($P < 0.01$).

The hallmark of angles in PD patients was the very wide distribution. Many PD patients showed angles larger than the average + 2 SDs of GPPs for all three angles; 16.2% for DHA; 39.5% for AFA; 8.68% on the right side in LFA; and 12.0% on the left side in LFA. These results demonstrate that some PD patients exhibited extremely abnormal posture, which was rarely observed in GPPs.

Some researchers use an arbitrary number of at least 45° of AFA for defining camptocormia.[1] In this study, PD patients with an AFA of ≥45° accounted for 2.24%, which was relatively less compared with that observed in previous studies (6.9% by Tiple et al.,[1] 4.1% by Seki et al.,[13] and 6.5% by Song et al.[14] Bonanni

et al.[15] defined Pisa syndrome as an LFA of >15°, whereas Tinazzi et al.[2] defined it as an LFA of >10°. In this study, PD patients with an LFA of ≥15° accounted for 1.25% and ≥10° accounted for 4.65%, which was relatively less compared with 8.8% in the study by Tinazzi et al.[2] These discrepancies may be a result of differences in patient backgrounds and measuring methods. Some researchers did not measure,[1,4,16] some measured by hand,[7,13] or by wall goniometer,[2,14,15] some measured using a computer software,[17] and some used a mechanical computer-assisted, hand-held device for measuring the angle of vertebral bones.[18,19]

Regarding the onset side of PD symptoms, the lateral flexion side might not depend on the onset side. Absolute values of angles leaning to the right and left were offset because we assigned the plus sign to the right side and minus sign to the left side for the statistical analysis.

Some previous studies have reported factors influencing postural abnormalities in PD as Table 2. Djaldetti et al.[20] first reported a relationship between anterior waist bending and male sex, duration of PD, and H & Y stage. Bloch et al.[21] found that the UPDRS Part III scores of patients with waist bending were significantly high, especially on the walk item. Tiple et al.[1] noted

TABLE 1 *Relationship between the measured angles and PD patient background*

	DHA					AFA					LFA				
	SCA		MRA			SCA		MRA			SCA		MRA		
	r	P Value	β (α = −1.1519 ± 3.72984)	std β	P Value	r	P Value	β (α = −15.68 ± 2.89)	std β	P Value	r	P Value	β (α = 2.10 ± 1.16)	std β	P Value
Age	0.092	0.002**	0.13 ± 0.053	0.063	0.013*	0.196	<0.0001***	0.084 ± 0.041	0.061	0.043*	−0.0282	0.3442	−0.031 ± 0.016	−0.053	0.057
Sex (male)	0.273	<0.0001***	6.29 ± 0.86	0.230	<0.0001***	−0.035	0.236	−0.96 ± 0.69	−0.047	0.160	0.0101	0.7345	0.15 ± 0.27	0.013	0.575
Duration	0.111	0.000***	0.05 ± 0.099	0.012	0.610	0.242	<0.0001***	0.47 ± 0.76	0.180	<0.0001***	0.072	0.0162*	−0.017 ± 0.031	−0.022	0.578
H & Y (ON)	0.168	<0.0001***	2.82 ± 0.95	0.088	0.003**	0.448	<0.0001***	3.45 ± 0.74	0.140	<0.0001***	0.0633	0.0362*	−0.17 ± 0.30	−0.015	0.570
H & Y (OFF)	0.141	<0.0001***	0.18 ± 0.87	0.002	0.840	0.426	<0.0001***	1.66 ± 0.68	0.073	0.015*	0.0965	0.0014**	0.37 ± 0.27	0.037	0.168
PD operation	0.052	0.029*	3.34 ± 2.03	0.055	0.100	0.018	0.547	−3.34 ± 1.60	−0.037	0.037*	0.0287	0.3369	0.65 ± 0.63	0.023	0.304
L-dopa + assist LED	0.156	<0.0001***	0.0041 ± 0.0023	0.067	0.068	0.249	<0.0001***	−0.0016 ± 0.0018	−0.023	0.360	0.0804	0.007**	0.00026 ± 0.00070	0.019	0.712
Agonist LED	−0.0088	0.768	−0.0006 ± 0.0079	−0.0098	0.940	0.053	0.075	−0.013 ± 0.0062	−0.066	0.031*	0.0593	0.0468*	0.001 ± 0.0024	0.025	0.672
Total LED	0.138	<0.0001***	Excluded^a	0.248	<0.0001***	Excluded^a	0.0891	0.0028**	Excluded^a						
Job	0.137	<0.0001***	1.17 ± 0.61	0.048	0.056	0.029	0.333	0.85 ± 0.48	0.044	0.078	−0.0108	0.7181	−0.10 ± 0.19	−0.0076	0.600
Pain	0.064	0.032*	0.62 ± 1.00	0.016	0.540	0.317	<0.0001***	3.90 ± 0.78	0.160	<0.0001***	0.0324	0.2775	0.021 ± 0.31	0.0089	0.947
Spinal lesion	0.026	0.383	0.61 ± 1.13	0.013	0.590	0.197	<0.0001***	2.43 ± 0.89	0.080	0.006**	−0.0165	0.581	−0.23 ± 0.35	−0.026	0.508
Rehabilitation	0.015	0.614	0.59 ± 1.15	0.007	0.610	0.084	0.005*	−0.78 ± 0.90	−0.031	0.390	−0.0431	0.1486	−0.83 ± 0.36	−0.063	0.019*
Dropped head angle	—	—	—	—	—	−0.0354	0.236	−0.097 ± 0.024	−0.12	<0.001***	0.0469	0.1157	0.017 ± 0.0095	0.045	0.069
Anterior flexion angle	−0.0354	0.236	−0.16 ± 0.039	−0.12	<0.0001***	—	—	—	—	—		<0.0001***	0.034 ± 0.012	0.087	0.005**
Lateral flexion angle	0.047	0.116	0.18 ± 0.098	0.045	0.069	0.144	<0.0001***	0.22 ± 0.077	0.087	0.005**	—	—	—	—	—

In the rank-difference Spearman correlation analysis, the coefficient of correlation |r| value is low for P values with many patients. The items with P < 0.05 are displayed in bold.
In the multiple regression analysis, the L-dopa + assist drug LED and agonist LED were excluded by multicollinearity characteristics. The items with P < 0.05 are displayed in bold.
^a Excluded by multicollinearity.
*P < 0.05;
**P < 0.01;
***P < 0.001.
Abbreviation: stdβ, standard partial regression coefficient.

TABLE 2 *Postural abnormality and related factors in PD*

Author	Year	N	Postural Abnormality	Method	Related Factors
Djaldetti et al.[20]	1999	8	Camptocormia	Unmeasured	Male sex, duration of PD, H & Y stage
Bloch et al.[21]	2006	63	Camptocormia	Unmeasured	UPDRS Part III scores
Tipple et al.[1]	2009	275	Camptocormia	Unmeasured (partially goniometer)	Age, duration of PD, dosage of L-dopa, duration of L-dopa treatment, H & Y stage, rigidity and bradykinesia item score of UPDRS PPart III, dementia, vertebral surgery
Seki et al.[13]	2011	531	Camptocormia	Measured (photograph)	Age, H & Y stage, UPDRS Part III scores, total LED, dosage of L-dopa, urinary incontinence, severe constipation
Kashihara et al.[22]	2012	365	Dropped head	Unmeasured	H & Y stage
			Camptocormia		H & Y stage, age, female sex, deterioration of MMSE score, duration of PD, lumber pain
			Lateral flexion		H & Y stage, age, female sex, deterioration of MMSE score, duration of PD, lumber pain
Song et al.[14]	2013	705	Camptocormia	Measured (goniometer)	Duration of PD, H & Y stage, UPDRS Part III scores, motor fluctuation, dyskinesia, MMSE
Oeda et al.[7]	2013	216	Dropped head	Measured (photograph)	H & Y stage, history of postural abnormalities induced by dopamine agonists
			Camptocormia		Age, duration of PD, H & Y stage, UPDRS Part III score, dosage of L-dopa, LED of dopamine agonists, vertebral disease, mental symptoms
Zinazzi et al.[2]	2015	1,631	Lateral flexion	Measured (goniometer)	Age, body mass index, duration of PD, H & Y stage, UPDRS scores, LED, ongoing pharmacological therapy, falls, veering gait
Khlebtovsky et al.[19]	2017	190	Camptocormia	Measured (spinal mouse)	Age, older age at disease onset, duration pf PD, UPDRS motor and posture scores, back pain
Ameghino et al.[16]	2018	63	Dropped head	Unmeasured	Urinary incontinence, exposure to pribedil and quetiapine
			Camptocormia		Age, history of orthopedic disorder, duration of PD, H & Y stage, UPDRS Part III scores, exposure to dopamine agonists and amantadine
			Lateral flexion		H & Y stage, less depression, exposure to amantadine
Present study	2018	1,117	Dropped head	Measured (photograph)	Age, male sex, H & Y stage during ON time
			Camptocormia		Duration of PD, H & Y stage during ON and OFF times, spinal disease, LFA to the right
			Lateral flexion		Anterior flexion angle

that patients with waist bending were older, had higher L-dopa dosages and durations, higher H & Y stage, higher rigidity, and akinesia scores of the UPDRS than those without waist bending. Seki et al.,[13] Song et al.,[14] and Ameghino et al.[16] reported H & Y stage and UPDRS Part III score as common factors for camptocormia. Moreover, Ameghino et al.[16] indicated the relationship between postural abnormality and exposure to dopamine agonists or amantadine. Kashihara et al.[22] found that DHAs, AFAs, and LFAs of PD patients correlated with H & Y stage and that AFA and LFA were influenced by age, female sex, deterioration of Mini-Mental State Examination (MMSE), degree of lumbago, and duration of disease. Oeda et al.[7] found DHA was influenced by H & Y stage and a history of postural abnormalities induced by dopamine agonists, and AFA was influenced by age, duration of disease, H & Y stage, UPDRS Part III score, dosage of

L-dopa, LED of dopamine agonists, vertebral disease, and mental symptoms. Zinazzi et al.[2] reported age, body mass index, and falls as factors related to lateral flexion other than those of severity of PD. Benninger et al.[18] found no correlation between the angle of incline and age, sex, disease duration, total UPDRS score, and presence of low back pain. Khlebtovsky et al.[19] found that the spinal angle was associated with age, older age at disease onset, disease duration, UPDRS motor and posture scores, and presence of back pain.

In the present study, DHA and AFA of PD patients were associated with factors related to disease progression, including H & Y stage during ON and OFF times, and duration of PD. DHA and AFA were related to the dosage of L-dopa/DCI, LED of L-dopa/DCI + adjuvant, and total LED. However, we regarded these as confounding factors because quantities of

medicines taken increased with disease progression. Recently, postural abnormalities attributed to dopamine agonists have been reported.[8–10] Therefore, we confirmed the correlation between each angle and the dosage of LED of dopamine agonists. Consequently, LED of dopamine agonists showed an inverse correlation with AFA. We speculated that the use of dopamine agonists in patients with extremely abnormal posture was discontinued when it was widely recognized in Japan that these abnormalities could be caused by dopamine agonists.

We found that LFA inclined to the right side and was related to the medicines taken, H & Y stage, and duration of disease. Rehabilitation to correct abnormal posture demonstrated inverse (left–sided) correlation. Paolucci et al.[23] also reported the efficacy of perceptive training for treating balance impairment in PD patients.

Benninger et al.[18] and Djaldetti et al.[20] reported that there was no significant correlation between postural abnormality and pain. Conversely, Khlebtovsky et al.[19] and Kashihara et al.[22] noted a correlation between postural abnormality and lumbago. In the present study, DHA and AFA were correlated with pain. As described in several previous reports,[1,7,16,18] we found that a past history of vertebral operations or diseases can promote the anteflexion of the trunk and that a past history of vertebral disease was a significant factor related to AFA. In addition, AFA was larger and DHA was smaller for people with occupations that required higher physical strength.

Conclusion

We measured DHA, AFA, and LFA of PD patients and GPPs and statistically confirmed that DHA and AFA of PD patients were larger than those of age-matched GPPs. In GPPs, DHA, AFA, and LFA showed normal distribution pattern. In PD patients, these angles also showed an almost normal distribution, whereas in some patients, these angles were showed skewed distribution.

DHA, AFA, and LFA correlated with age in GPPs.

The relationship between postural abnormality and patient background or treatment was elucidated using two statistical analyses. Factors related to DHA were age, male sex, and H & Y stage during ON time. Factors related to AFA were age, duration of disease, H & Y stage during ON and OFF times, pain, vertebral disease, and lateral flexion angle to the left side. The only factor related to LFA was AFA. DHA, and AFA were associated with the dosage of L-dopa/DCI, LED of L-dopa/DCI + adjuvant, and total LED. LED of dopamine agonists showed an inverse correlation with AFA. We speculated that types and dosage of a therapeutic drug did not essentially influence the angles because the dosage of drugs increased as the severity of disease increased.

Author Roles

(1) Research project: A. Conception, B. Organization, C. Execution;
(2) Statistical Analysis: A. Design, B. Execution, C. Review and

Critique; (3) Manuscript: A. Writing of the First Draft, B. Review and Critique.

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