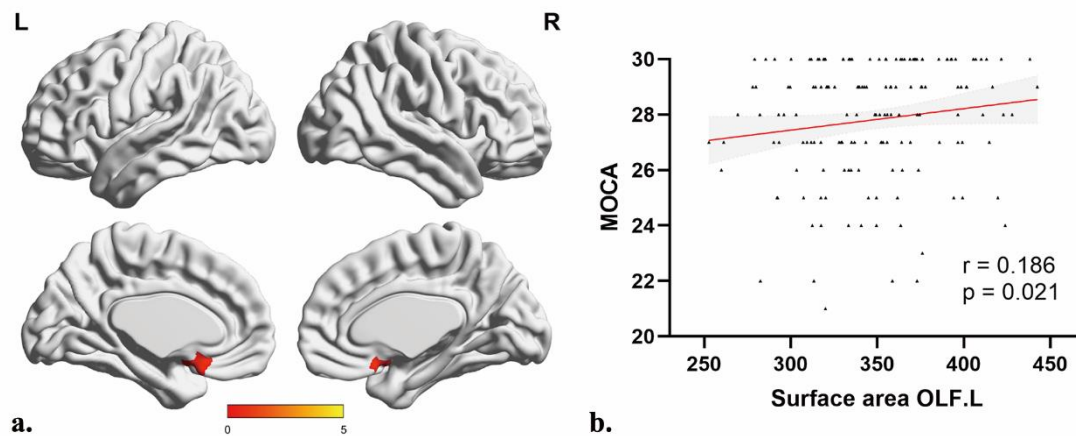


1 **Supplementary Material**

2 **Supplementary methods: Construction process of structural** 3 **morphological features**

4 The main pipeline processing steps were described below: i) The native three-
5 dimensional T₁ images of each subject were corrected for non-uniformity artifacts using
6 the N3 algorithm; ii) Classification of the grey matter (GM), white matter (WM) and
7 CSF was performed using the INSECT algorithm; iii) The Constrained Laplacian-based
8 Anatomic Segmentation with Proximity (CLASP) algorithm was applied to generate a
9 model of the cortical surface, including 40,962 vertices and 81,920 triangular meshes
10 per hemisphere; iv) Hemispheric surfaces were generated for both the WM/GM
11 interface and GM/CSF interface; v) surfaces for each hemisphere were non-linearly
12 registered to an average surface created from the ICBM152 brain template; vi) A reverse
13 linear transformation was carried out on each subject's images, and cortical thickness
14 estimations were calculated at each cortical point in native space using the tlink metric;
15 vii) Subjects' surface maps, including cortical thickness, surface area, GM surface mean
16 curvature, were blurred using a 20-millimeter full width at half maximum surface-based
17 diffusion smoothing kernel; viii) Process voxel-based morphometry (VBM) files to
18 calculate the GM volumes and WM volumes; ix) Blurring kernel size in 8 mm for
19 volume; x) Cortical thickness, surface area, surface mean curvature and GM volumes
20 were calculated at each region according to the Anatomical Automatic Labeling
21 (AAL)_90_1-mm atlas, while WM volumes were calculated at each region according
22 to the WM John Hopkins University Atlas JHU-ICBM-tracts-maxprob-thr25-1 mm.

23 **Supplementary Figure 1 Differences in surface area between Parkinson's disease**
24 **(PD) and healthy controls (HCs) and its relationship with the Montreal Cognitive**
25 **Assessment (MOCA).** (a) The bilateral olfactory cortex (OLF) showed significant
26 increasing surface area in PD patients than in HC. (b) Only surface area of the left OLF
27 was correlated with the MOCA. L = left; R = right.



28

29 **Supplementary Table 1: Participants numbers of each center.**

Center number	HCs	Future NFOG	Future FOG	PD	Total
7	4	11	8	19	23
12	0	1	2	3	3
28	5	10	3	13	18
32	12	11	9	20	32
73	10	9	4	13	23
88	9	10	7	17	26
120	5	13	8	21	26
196	2	2	1	3	5
289	7	7	11	18	25
290	10	13	9	22	32
291	8	3	2	5	13
304	1	2	2	4	5
Total	73	92	66	158	231

30 HCs = healthy controls; PD = Parkinson's disease; FOG = freezing of gait; NFOG =
 31 non-freezing of gait.

32

33 **Supplementary Table 2: EV-SVM model performance for different proportions of**
 34 **future NFOG and FOG in train and test sets.**

Features	Future NFOG : FOG	AUC	ACC	SEN	SPE
BF	4:6	0.7	0.69	0.55	0.84
	5:5	0.67	0.66	0.59	0.78
	3:7	0.76	0.75	0.85	0.66
SF	4:6	0.73	0.72	0.7	0.74
	5:5	0.83	0.76	0.89	0.67
	3:7	0.86	0.79	0.77	0.81

All	4:6	0.77	0.78	0.74	0.83
	5:5	0.91	0.84	0.94	0.71
	3:7	0.91	0.84	0.90	0.83

35 FOG = freezing of gait; NFOG = non-freezing of gait; AUC = area under curve; ACC
36 = accuracy; SEN = sensitivity; SPE = specificity; BF = both clinical and laboratory
37 features; SF = structural features.

38

39 **Supplementary Table 3: Regions with increased surface area in PD patients.**

Group	Region	x	y	z	T- value	Peak voxel p	FDR corrected p	Size (voxel)
PD > HC	OLF.L	82	141	61	3.536	0.039	0.05	87
	OLF.R	100	142	61	3.317	0.042	0.05	81

40 PD = Parkinson's disease; HC = healthy controls; FDR = false discovery rate; OLF =
41 olfactory cortex; L= left; R = right.

42

43 **Supplementary Table 4: Aberrant structural brain regions in patients with future**
44 **FOG compared with future NFOG at baseline.**

Group	Region	x	y	z	T- value	Peak voxel p	Size (vertex/voxel)	
	Cortical thickness							
NFOG > FOG	PCG.L	85	83	97	1.595	0.025	137	
	Cortical mean curve							
NFOG < FOG	ROL.L	43	118	86	-1.642	0.013	302	
	INS.L	55	133	75	-1.949	0.002	566	
	CUN.R	104	47	100	-1.231	0.012	434	
	MOG.R	127	46	91	-0.241	0.009	595	
NFOG > FOG	SMA.R	99	126	134	1.323	0.028	666	
	Surface area							
NFOG < FOG	SMA.R	99	126	134	-1.389	0.030	666	
	SOG.R	114	45	103	-1.027	0.013	428	
	PoCG.R	131	101	125	-0.505	0.032	1138	
	SPG.L	67	66	131	-0.032	0.027	631	
	SPG.R	116	67	134	-0.128	0.014	647	
NFOG > FOG	MOG.R	127	46	91	0.171	0.024	595	
	PoCG.L	48	103	121	0.050	0.031	1159	
	PCUN.L	83	70	120	0.751	0.043	1079	
	MTG.L	34	92	70	0.448	0.024	1439	
	MTG.R	147	89	71	1.209	0.008	1356	

	Grey matter volume						
NFOG < FOG	SMA.R	99	126	134	-0.943	0.039	666
	CUN.R	104	47	100	-0.339	0.015	434
	LING.R	106	59	68	-0.276	0.030	678
	IOG.L	54	48	64	-2.696	0.013	268
	IOG.R	128	44	64	-2.956	0.006	314
	FFG.L	59	86	52	-1.989	0.042	687

45 * None of the above structural measurements could be corrected by false discovery
46 rate (FDR). FOG = freezing of gait; NFOG = non-freezing of gait; L = left; R = right;
47 PCG = posterior cingulate gyrus; ROL = rolandic operculum; SMA = supplementary
48 motor area; INS = insula; CUN = cuneus; MOG = middle occipital gyrus; SOG =
49 superior occipital gyrus; PoCG = postcentral gyrus; SPG = superior parietal gyrus;
50 PCUN = precuneus; MTG = middle temporal gyrus; LING = lingual gyrus; IOG =
51 inferior occipital gyrus; FFG = fusiform gyrus.