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Original Article

The effect of comprehensive physiotherapy-based rehabilitation on stooped posture in Parkinson's disease

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Abstract. [Purpose] The effect of physiotherapy on stooped posture in Parkinson's disease patients remains to be clarified. Therefore, the purpose of this study was to investigate whether comprehensive physiotherapy-based rehabilitation can improve stooped posture in Parkinson's disease patients. [Participants and Methods] The participants were Parkinson's disease patients with stooped posture. Outpatients were assigned to the control group and inpatients to the postural rehabilitation group. The outcomes measured were trunk bending angle, lumbar lordosis, and thoracic kyphosis. Each group was assessed at baseline and 1 month later. [Results] Of 22 participants identified, 20 were included, with 10 participants in the postural rehabilitation group and 10 in the control group. The age in the postural rehabilitation group was significantly greater than that in the control group, while other parameters were comparable in both groups. After the month-long intervention, the trunk bending angle and lumbar lordosis were significantly improved in the postural rehabilitation group compared to the control group. [Conclusion] The results showed improvement in stooped posture in the postural rehabilitation group as compared to the control group. Furthermore, improvement of lumbar lordosis accompanied improvement of stooped posture. These findings suggest that comprehensive physiotherapy-based rehabilitation may improve stooped posture in Parkinson's disease patients.

Key words: Parkinson's disease, Postures, Neurological rehabilitation

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INTRODUCTION

Parkinson's disease (PD) is a progressive and degenerative disease, causing motor symptoms such as resting tremor, akinesia, postural instability, and rigidity. Additionally, patients with PD characteristically present with stooped posture, associated with substantial postural instability and affecting their activities of daily living (e.g., causing difficulties in rising from a chair and walking)[1)]. Stooped posture in PD patients may cause falls, resulting in extremity and spinal-compression fractures, which may cause deterioration in their quality of life[2–4)]. Given that stooped posture is likely to cause such second-

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ary disabilities, effective treatment for stooped posture is needed. It is known that drugs used for PD, such as levodopa, do not improve stooped posture[5, 6]. Moreover, previous studies have developed several invasive treatments for stooped posture, such as deep brain stimulation and botulinum toxin injected into the primary-culprit muscles for the condition. However, the effect of these treatments on stooped posture has remained controversial over the years[5, 7–9]. Therefore, novel, non-invasive treatment for stooped posture in PD patients needs to be established. In contrast to the invasive treatments mentioned previously, physiotherapy is a noninvasive and very safe intervention. It has always been presumed that physiotherapy could exert beneficial effects on stooped posture in clinical practice. However, since hard evidence of the efficacy of physiotherapy for stooped posture in PD patients is lacking, its effect remains to be clarified[10]. Thus, the purpose of this study was to investigate whether comprehensive physiotherapy-based rehabilitation can improve the stooped posture of PD patients.

PARTICIPANTS AND METHODS

The participants were PD patients with stooped posture in Hyogo Prefectural Rehabilitation Hospital at Nishi-Harima. We assigned outpatients to a control group and inpatients to a postural rehabilitation (PR) group. Computer allocation method was performed by a coordinator who did not know the contents of the intervention. The duration of entry was set from August 1, 2015 to March 31, 2017. Inclusion criteria were defined as follows: aged between 40 through 90; and able to remain in a standing position for 1 minute without assistance. Exclusion criteria were defined as follows: stooped posture in supine position; scoliosis (cobb angle ≥10 degrees); Pisa syndrome (lateral trunk bending angle in standing position ≥10 degrees); trunk bending angle <0 degrees with involuntary trunk extension; and/or Mini-Mental State Examination (MMSE) score ≤23 points. This study was approved by the ethics board of Hyogo prefectural rehabilitation hospital at Nishi-Harima (approval number: 1) and Kobe University Graduate School of Health Sciences (approval number: 494). This study was registered at the University Hospital Medical Information Network (UMIN) clinical trials registry (UMIN ID: UMIN000021798). Written informed consent was obtained from all patients before enrollment. We investigated the age, gender, duration of disease, weight, height, MMSE scores and whether they had undergone deep brain stimulation implantation surgery. We used Spinal Mouse (Idiag, Voletswil, Switzerland) to assess trunk bending angles at two test positions: comfortable standing position (the assessor asked the subjects “keep standing as you feel comfortable”) and upright standing position (the assessor asked the subjects “keep standing as you feel upright”). The assessor rolled this device along the spinal curvature of patients from C7 to S3, sending sampling data to a personal computer. The trunk bending angle, lumbar lordosis and thoracic kyphosis were calculated. We assessed these measures at baseline and 1 month. In this period, patients in the PR group underwent patient-tailored rehabilitation consisting of postural correction programs, while patients in the control group continued their usual home healthcare service. The components and the frequency of the rehabilitation programs in the PR group and the home healthcare service in the control group are displayed in Tables 1 and 2. After the intervention, we calculated the changes of the angles [(angles at baseline) − (angles at one month)] as outcome measures. Independent t-tests or χ^2 tests were used for comparison of the clinical data of both groups. Independent t-tests were used to assess the difference in changes in each angle between the PR and control groups. The α-level was set at 0.05, using SPSS Statistics 17 (IBM Japan, Tokyo, Japan) for statistical analysis.

Table 1. Rehabilitation programs in the PR group (each program was performed 6 times per week in all patients)

Participants	Duration of rehabilitation	Components of rehabilitation program
1	PT, OT, ST 40 min each	Muscle strength exercise, prone exercise, crawling exercise, sitting exercise, standing exercise using walking aids
2	PT 80 min, OT 40 min	Range of motion exercise, crawling exercise, relaxation for low back, standing exercise
3	PT, OT, ST 40 min each	Range of motion exercise, muscle strength exercise, standing balance exercise to lateral and back
4	PT, OT, ST 40 min each	Range of motion exercise, muscle strength exercise, prone exercise, standing exercise, backward walking exercise
5	PT 80 min, OT 40 min	Muscle strength exercise, prone exercise, crawling exercise, sitting exercise
6	PT, OT, ST 40 min each	Range of motion exercise, muscle strength exercise, prone exercise, relaxation for low back, standing exercise
7	PT, OT, ST 40 min each	Muscle strength exercise, prone exercise, standing balance exercise, step exercise, backward walking exercise
8	PT 80 min, OT 40 min	Range of motion exercise, crawling exercise, rolling-over exercise, sitting exercise, standing exercise
9	PT 80 min, OT 40 min	Muscle strength exercise, prone exercise, crawling exercise, step exercise, standing exercise, backward walking exercise
10	PT, OT, ST 40 min each	Range of motion exercise, crawling exercise, standing exercise, walking exercise

PR: postural rehabilitation; PT: physiotherapy; OT: occupational therapy; ST: speech-language-hearing therapy.

RESULTS

Twenty-two participants were included in this study according to our inclusion criteria. Two participants were dropped from the study due to the progression of psychiatric symptoms and dyskinesia, which compromised the accuracy of the measurements. Of the 20 participants finally included, 10 belonged to the PR group and 10 to the control group. The clinical profiles in each participant group and the comparison of the clinical profiles between groups are shown in Tables 3 and 4. The average age of the patients in the PR group was significantly greater than that in the control group ($p<0.05$), while other clinical parameters were comparable in both groups. The rehabilitation and home health programs were completed for all participants in both groups and no adverse events were recorded.

In the PR group, 9 of 10 patients showed improvement of the trunk bending angle in the comfortable standing position,

Table 2. Home health programs in the control group

Participants	Home healthcare service (frequency of programs per week)	Components of rehabilitation program
11	OR (40 min 1×, 60 min 1×)	Muscle strength exercise, self-stretching, standing exercise
12	None	None
13	OR (40 min 2×)	Relaxation for low back, walking exercise, aerobic exercise
14	OR (80 min 2×), HR (40 min 1×)	Range of motion exercise, muscle strength exercise, self-stretching
15	OR (40 min 2×, 90 min 2×)	Range of motion exercise, muscle strength exercise, self-stretching, crawling exercise
16	OR (80 min 1×), HR (40 min 3×)	Range of motion exercise, trunk extension exercise, relaxation for low back
17	None	None
18	OR (90 min 1×), HR (40 min 1×)	Range of motion exercise, muscle strength exercise, self-stretching
19	OR (120 min 1×), HR (60 min 1×)	Relaxation for lower extremities, muscle strength exercise, step exercise, aerobic exercise
20	OR (20 min 1×), HR (40 min 3×)	Range of motion exercise, muscle strength exercise, self-stretching

OR: outpatient rehabilitation, HR: home-visit rehabilitation.

Table 3. Clinical profiles of participants at baseline

Group	Participants number	Age (years)	Gender	Height (cm)	Weight (kg)	Disease duration (months)	Hoehn & Yahr Staging	MMSE	DBS
PR	1	67	M	162.9	49.6	182	III	26	-
PR	2	76	F	149.5	51.7	122	III	29	-
PR	3	72	M	159.1	53.4	106	III	24	-
PR	4	75	F	152	41.2	94	II	29	-
PR	5	70	M	164.5	55.2	108	III	26	-
PR	6	74	M	145.1	57.6	123	III	29	-
PR	7	67	M	164.7	59.5	164	III	28	-
PR	8	71	F	148.7	51	107	III	27	-
PR	9	74	F	153.5	49.1	67	III	28	-
PR	10	73	M	167.2	59.5	137	IV	25	+
control	11	69	M	156.5	58.6	82	III	30	-
control	12	59	M	161.9	57.8	120	III	25	-
control	13	67	F	147.6	45.2	216	III	26	+
control	14	76	F	147	32.6	181	III	26	-
control	15	71	F	140.6	51.4	46	III	30	-
control	16	68	F	147.3	53	167	III	30	-
control	17	70	F	147.9	51.3	114	III	27	-
control	18	65	M	169.7	68.4	47	II	29	-
control	19	71	F	150.7	42	270	IV	28	-
control	20	66	M	168	44.7	67	III	30	-

PR: postural rehabilitation; M: males; F: females; MMSE: Mini Mental State Examination; DBS: deep brain stimulation.

while only 4 of 10 patients in the control group showed improvement. In the upright standing position, the trunk bending angle was improved in all patients in the PR group, while only 4 out of 10 patients in the control group showed improvement of the trunk bending angle (Table 5). In the comfortable standing position, the mean trunk bending angle in the PR group decreased at 1 month, while that in the control group increased. In the upright standing position, the mean trunk bending angle in the PR group decreased at 1 month, while no change was detected in the control group (Table 6). The change of the trunk bending angle in the comfortable standing position in the PR group was significantly larger than in the control group (6.1° ± 3.6° vs. −0.4° ± 5.2°, $p<0.05$). The change of the trunk bending angle in the upright standing position in the PR group was significantly larger than that in the control group (6.0° ± 2.2° vs. 0.0° ± 3.6°, $p<0.05$) (Table 7).

In the comfortable standing position, the mean thoracic kyphosis angle in the PR group decreased at 1 month, while that in the control group increased. In the upright standing position, the mean thoracic kyphosis angle in the PR group decreased at 1 month, while that in the control group increased (Table 6). The change of the thoracic kyphosis angle in the comfortable standing position in the PR group was not significantly different from that in the control group (1.6° ± 10.3° vs. −6.1° ± 11.9°, $p=0.14$). The change of the thoracic kyphosis angle in the upright standing position in the PR group also was not significantly different from that in the control group (0.6° ± 9.1° vs. −5.7° ± 14.7°, $p=0.26$) (Table 7).

In the comfortable standing position, the mean lumbar lordosis angle in the PR group decreased at 1 month, while that in the control group increased. In the upright standing position, the mean lumbar lordosis angle in the PR group decreased at 1 month, while that in the control group increased (Table 6). The change of the lumbar lordosis angle in the comfortable standing position in the PR group was significantly larger than that in the control group (4.6° ± 3.6° vs. −4.0° ± 9.1°, $p<0.05$). The change of the lumbar lordosis angle in the upright standing position in the PR group was also significantly larger than that in the control group (6.0° ± 5.5° vs. −1.0° ± 7.1°, $p<0.05$) (Table 7).

DISCUSSION

In this study, we investigated whether comprehensive physiotherapy-based rehabilitation can improve stooped posture in PD patients. In general, the assessment of stooped posture was conducted using photographs in which assessors measured the trunk bending angle[11]. In contrast, we used Spinal Mouse to assess trunk bending angle. This device was an objective measurement tool for stooped posture in PD patients, with proven validity in the sagittal plane for stooped posture in PD

Table 4. Comparison of group clinical profiles at baseline

		PR group (n=10)	Control group (n=10)
Age (years)*		71.9 ± 3.1	68.2 ± 4.4
Gender (males/females)		6/4	4/6
Height (cm)		156.7 ± 7.9	153.7 ± 9.8
Weight (kg)		52.8 ± 5.5	50.5 ± 10.0
Disease duration (months)		121.0 ± 33.4	131.0 ± 75.6
Hoehn & Yahr Staging (II/III/IV)		1/8/1	1/8/1
MMSE		27.1 ± 1.7	28.1 ± 1.9
DBS(+/−)		1/9	1/9
Trunk Bending Angle (deg)	CSP	29.4 ± 22.2	29.5 ± 20.4
	USP	23.8 ± 20.6	21.5 ± 16.2

Values are mean ± SD, *significant difference.
PR: postural rehabilitation; MMSE: Mini Mental State Examination; DBS: deep brain stimulation; CSP: comfortable standing position; USP: upright standing position.

Table 5. Trunk bending angle of participants at baseline and 1 month

Group	Participants number	Trunk Bending Angle (deg) CSP		USP	
		baseline	1 month	baseline	1 month
PR	1	77	71	68	59
PR	2	17	3	11	3
PR	3	22	15	20	13
PR	4	11	8	8	6
PR	5	39	32	28	20
PR	6	59	59	53	48
PR	7	20	14	16	13
PR	8	22	17	18	12
PR	9	11	6	6	−1
PR	10	16	8	10	5
control	11	17	12	11	5
control	12	26	24	17	17
control	13	12	12	6	10
control	14	45	37	35	31
control	15	43	45	31	32
control	16	51	61	32	38
control	17	67	65	55	53
control	18	8	11	4	6
control	19	11	11	10	8
control	20	15	21	14	15

PR: postural rehabilitation; CSP: comfortable standing position; USP: upright standing position.

patients[12–14]. Additionally, this device allowed us to evaluate in detail, showing thoracic kyphosis angles and lumbar lordosis angles in addition to trunk bending angles. Therefore, we believe that this device objectively and reliably measured the effects of the intervention on stooped posture in PD patients.

Our results showed that the stooped posture in the PR group improved, compared to the control group. Only one case-control study has previously reported the effect of rehabilitation on stooped posture in PD patients compared to the control group. This study indicated that patient-tailored rehabilitation based on stretching, posture training, and proprioceptive discrimination exercises might reduce mild to moderate stooped posture in PD patients whose trunk bending angle ranged from 5° to 20°[15]. Our results showed improvement of stooped posture in PD patients, comparable with the previous study's findings. Furthermore, the range of stooped posture of participants in our study was mild to severe, with trunk bending angles from 8° to 77° in the comfortable standing position. In this context, our results suggest that even severe stooped posture could also be improved with such interventions. Some other case reports have indicated that the effects of rehabilitation for severe stooped posture in PD patients vary among patients[16, 17]. Moreover, invasive treatments for severe stooped posture such as deep brain stimulation and botulinum toxin injected into the primary-culprit muscles yielded unsatisfactory effects in some cases[5, 7–9]. Given that the etiology of stooped posture is quite heterogeneous, investigation and management in all of these different directions is needed[18–20]. Continuity of rehabilitation is an important consideration in treatment for PD[10]. In this context, our interventions were continuous patient-tailored rehabilitation devised by each physiotherapist, addressing the complex mechanisms of stooped posture in PD patients. For this reason, it is conceivable that these improvements could be attributed to the comprehensive and continuous physiotherapy-based rehabilitation received by the intervention group.

It is notable that the lumbar lordosis in the PR group was also improved as compared to the control group. To the best of our knowledge, no studies have shown that comprehensive physiotherapy-based rehabilitation could improve lumbar lordosis in PD patients. One previous study indicated that the restoration of lumbar lordosis by orthosis might lead to the improvement of severe stooped posture. In that study, the loss of lumbar lordosis induced sagittal spinal imbalance in many cases[16]. Although the etiology of stooped posture is heterogeneous, lumbar lordosis is quite important for maintenance of sagittal spinal balance. Therefore, the effect of improvement of stooped posture may depend on restoration of the lumbar lordosis.

Our study has several limitations. First, a limited number of participants resulted in wide variations of their clinical profiles. Second, unanswered questions remained concerning long-term effects, due to the short follow-up period in this study. Finally, since our results only broadly indicate beneficial effects of comprehensive physiotherapy-based rehabilitation, further studies are required to elucidate best practices of intervention for stooped posture.

In conclusion, our results suggest that comprehensive physiotherapy-based rehabilitation shows promise in the treatment of stooped posture in PD patients.

Table 6. Mean each angle at baseline and 1 month

		PR group (n=10)		Control group (n=10)	
		baseline	1 month	baseline	1 month
Trunk Bending Angle (deg)	CSP	29.4 ± 22.2	23.3 ± 23.5	29.5 ± 20.4	29.9 ± 20.9
	USP	23.8 ± 20.6	17.8 ± 19.9	21.5 ± 16.2	21.5 ± 16.1
Thoracic Kyphosis Angle (deg)	CSP	36.2 ± 15.5	34.6 ± 16.7	33.0 ± 18.6	39.1 ± 19.9
	USP	32.3 ± 18.6	31.7 ± 17.1	28.5 ± 21.9	34.2 ± 21.5
Lumbar Lordosis Angle (deg)	CSP	16.1 ± 31.2	11.5 ± 29.8	12.7 ± 28.3	16.7 ± 25.4
	USP	14.0 ± 31.6	8.0 ± 30.6	10.1 ± 25.8	11.1 ± 24.2

Values are mean ± SD, PR: postural rehabilitation; CSP: comfortable standing position; USP: upright standing position.

Table 7. Changes in each angle from baseline to 1 month

		PR group (n=10)	Control group (n=10)	p-value
The change of the Trunk Bending Angle (deg)	CSP	6.1 ± 3.6	−0.4 ± 5.2	<0.05*
	USP	6.0 ± 2.2	0.0 ± 3.6	<0.05*
The change of the Thoracic Kyphosis Angle (deg)	CSP	1.6 ± 10.3	−6.1 ± 11.9	0.14
	USP	0.6 ± 9.1	−5.7 ± 14.7	0.26
The change of the Lumbar Lordosis Angle (deg)	CSP	4.6 ± 3.6	−4.0 ± 9.1	<0.05*
	USP	6.0 ± 5.5	−1.0 ± 7.1	<0.05*

Values are mean ± SD, *significant difference; independent t-test.
PR: postural rehabilitation; CSP: comfortable standing position; USP: upright standing position.

Conflict of interest

None of the authors has any conflicts of interest to be declared.

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