Influence of sensory integration training on postural instability in elderly with parkinsonian disease following stereotactic surgery

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Background

Impaired posture is strongly associated with function particularly in patients with parkinsonian disease (PD).

Objective

To detect the effect of sensory integration training on postural instability in elderly PD following stereotactic surgery.

Patients and methods

A total of 27 patients with idiopathic PD were assessed before and after 12 weeks by the postural stability test. They were randomly assigned into three groups: group I (sensory integration training), group II (stereotactic surgery), and group III (sensory integration training after 10 days postoperatively).

Results

There was significant improvement in group III more than in groups I and II. The percent of improvement of group III was higher concerning the overall stability index (48.86%, $t=7.088$ and $P=0.0001$(, anterior/posterior index (74.61%, $t=21.240$ and $P=0.0001$), and medial/lateral index (55.81%, $t=14.014$ and $P=0.0001$). Group III was superior to groups I and II ($P=0.026$ and 0.001, 0.040 and 0.0001, and 0.049 and 0.0001).

Conclusion

Sensory integration training improved postural stability in elderly with PD following stereotactic surgery.

Introduction

Parkinsonian disease (PD) is characterized clinically by postural instability [1]. Although it is primarily a disease of the elderly, some individuals have developed PD in their 30's and 40's [2].

Postural instability, probably the most relevant symptom, leads to a poor quality of life [3]. It is particularly challenging and difficult to treat as it does not respond well to dopaminergic therapy [4]. Several studies have examined possible ways of predicting falls, with previous occurrence of falls being one of the main predictors, and several motor factors including measures assessing postural stability [5].

Stereotactic surgery is a minimally invasive form of surgical intervention that makes use of a three-dimensional coordinate system to locate small targets inside the body and to perform on them some action such as radiosurgery, stimulation, and ablation [6].

Study design

This was a randomized case–controlled trial with pretest–post-test experimental design. It was conducted in the outpatient clinic of Faculty of Physical Therapy, Modern University for Technology and Information, during the period from January 2018 to August 2018. Patients signed an informed consent form before their engagement. The study was approved by the Ethical Committee of Faculty of Physical Therapy, Cairo University.

Sample size

A generated sample size, using the G*Power software (version 3.0.10) (Germany), of at least seven participants per group would be required. Allowing for a 20% dropout rate, it was necessary to reach a total sample level of a minimum of 27 participants.

Participants were randomly assigned using a hand-picked envelope.

Patients and methods

A total of 27 patients with PD were invited to participate in the study. Their age ranged from 60 to 70 years old (16 males and 11 females). The duration of illness ranged from 5 years till 16 years. Patients were stage three according to Modified Hoehn and Yahr (HY), as well as Schwab and England scales [7], and Mini Mental State Examination score was more than 23 [8].

Participants were randomly assigned into three groups, and each group included nine patients: group I (control group) received sensory integration training, group II underwent deep brain stimulation (DBS) through stereotactic surgery, and group III received sensory integration training after 10 days postoperatively to stereotactic surgery (as illustrated in Chart 1). Postural stability was estimated by measuring the overall stability index, anterior/posterior (AP) index, and medial/lateral (M/L) index [6] before and after 12 weeks using Biodex Balance System (Biodex Medical Systems Inc., Shirley, New York, USA).

Statistical analysis
Statistical analysis was done using statistical packages for the social sciences (SPSS) version 20 for Windows (SPSS, Inc., Chicago, Illinois, USA). Paired *t*-test was used to compare within each group and one-way analysis of variance test among three groups. Post-hoc multiple comparison test (least significance difference) was used to examine the superior group. Significant level of probability was *P* value up to 0.05.

Procedure

(1) Testing procedures:
 (a) The postural stability tests: The patient's score assesses deviations from center [9]. It includes overall stability index (SI), (b) AP index, and (c) M/L index.
 (b) The Mini Mental State Examination or Folstein test [8].
 (c) Timed up and go test (s) [10].
 (d) The unified Parkinson's Disease Rating Scale (UPDRS) [11,12].
 (e) The HY scale [7].
(2) Training procedures: Sensory integration training was done to improve both feedback and feed-
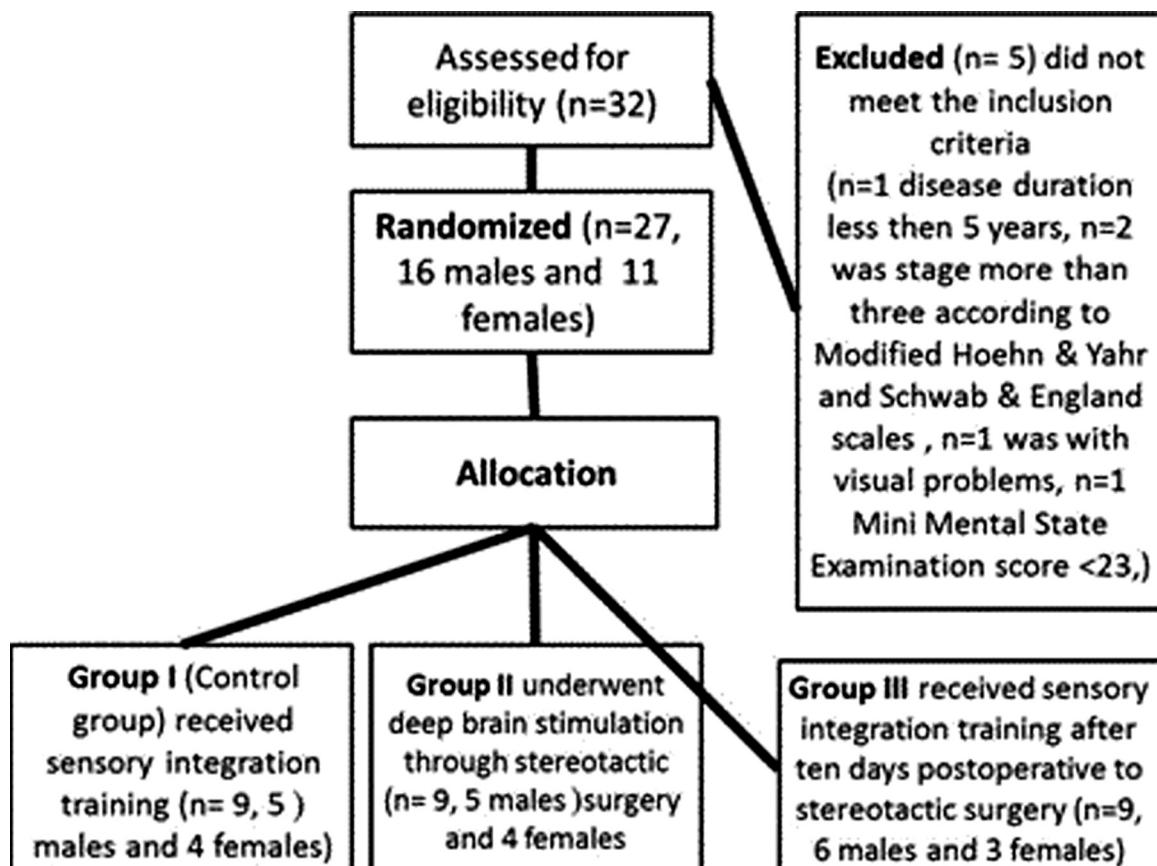
Chart 1

Chart describing the recruitment of patients.

forward postural reactions. Patients were asked to repeat exercises belonging to three different predetermined groups of exercises [13,14].

Results
Demographic data
Mean values were 62.20±1.14, 62.78±1.42, and 64.22 ±5.09 years for ages; 71.47±5.89, 69.22±3.27, and 69.58±4.90 kg for body mass; 165.44±8.33, 167.44 ±8.53, and 162.44±6.36 cm for height; 26.25±2.59, 24.82±3.64, and 26.51±3.37 kg/m² for BMI; 11.22 ±2.53, 11.60±3.26, and 12.78±3.34 years for duration of disease; 27.00±0.43, 27±0.59, and 27±0.55 for mini mental scale; 7.14±0.24, 7.05±0.25, and 7.04±0.21 s for timed up and go test; 45.38±4.96, 57±3.51, and 45.64 ±4.63 for UPDRS (part III score); and 3±0.56, 3±0.50, and 3.00±0.52 a.u. for HY staging scale values for Arbitrary unit groups I, II, and III, respectively. The sex distribution of male patients was six (66.67%), five (55.56%) and five (55.56%) respectively, and for female patients was three (33.33%), four (44.44%), and four (44.44%) for groups I, II, and III, respectively. The statistical analysis revealed that there were no significant differences ($P>0.05$) among groups in values of demographic data (age, weight, height, BMI, duration of disease, mini mental scale, times up and go test, UPDRS, HY staging scale, and sex) (Table 1 and Fig. 1).

Postural stability tests
Overall stability index
Mean values were 1.54±0.47, 1.78±0.44 and 1.12±0.07 preoperatively and became 2.21±0.07, 2.30±0.23 and 2.19±0.44 postoperatively in groups I, II, and III respectively. There were significant differences within groups (t=4.754, 3.139, and 7.088 and P=0.001, 0.014, and 0.0001), insignificant differences among groups in pretreatment results, whereas significant differences among groups in post-treatment results (F=0.434 and 7.115 and P=0.653 and 0.004, respectively) (Table 2 and Fig. 2).

Anterior/posterior index
Mean values were 0.60±0.11, 0.77±0.13, and 0.49±0.09 preoperatively and became 1.69±0.42, 1.79±0.58, and 1.93±0.13 postoperatively in groups I, II, and III, respectively. There were significant differences within groups (t=6.927, 5.070, and 21.240 and P=0.0001, 0.001, and 0.0001), insignificant differences among groups in pretreatment results, whereas significant differences among groups in post-treatment results (F=0.748 and 13.769 and P=0.484 and 0.0001, respectively) (Table 3 and Fig. 3).

Medial/lateral index
Mean values were 0.45±0.14, 0.43±0.05, and 0.38±0.04 preoperatively and became 0.74±0.16, 0.56±0.07 and 0.86±0.07 postoperatively, in groups I, II, and III, respectively. There were significant differences within groups (t=2.776, 2.278 and 14.014 and P=0.024, 0.048 and 0.0001), insignificant differences among groups in pretreatment results whereas there were significant differences in post-treatment results (F=0.988 and 15.512 and P=0.387 and 0.0001 respectively) (Table 4 and Fig. 4).

Percentage of improvement
The percentages of improvement were 30.32, 22.61, and 48.86% in overall stability index; 64.50, 56.98, and 74.61% in AP index; and finally 39.19, 23.21 and 55.81%, in M/L index in groups I, II, and III, respectively, which indicated a significant improvement in group III more than in groups I and II (Fig. 5).
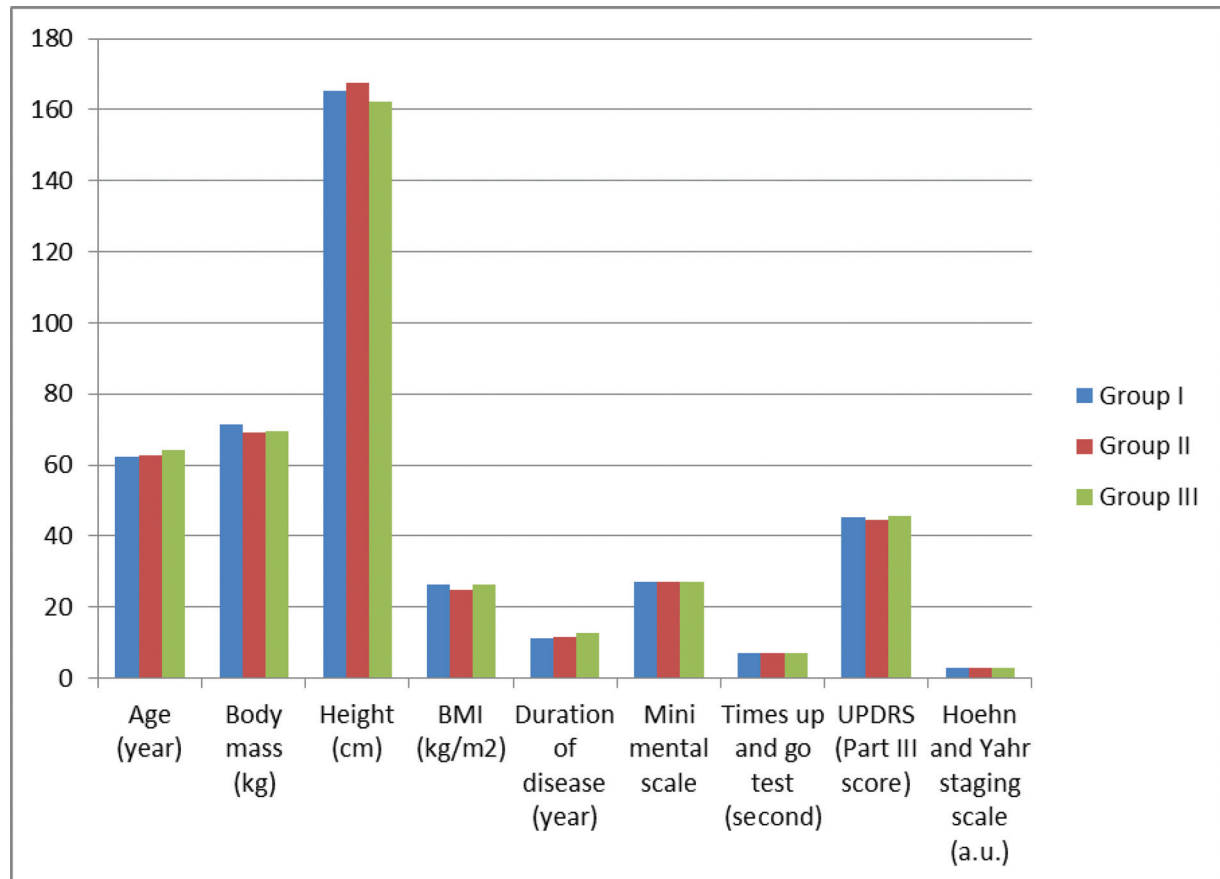
The superior group
Post-hoc multiple comparison test (least significance difference) indicated the superiority of group III on group I and II (P=0.026 and 0.001, 0.040 and 0.0001, and 0.049 and 0.0001) in overall stability index, AP stability index, and M/L. Stability index respectively. However, there was no superiority between groups I and II in all measures (P=0.190, 0.161 and 0.183 for

Table 1 Demographic data

Items	Group I	Group II	Group III	*F* value	*P* value	Significance
Age (years)	62.20±1.14	62.78±1.42	64.22±5.09	0.409	0.669	NS
Body mass (kg)	71.47±5.89	69.22±3.27	69.58±4.90	0.590	0.562	NS
Height (cm)	165.44±8.33	167.44±8.53	162.44±6.36	0.935	0.406	NS
BMI (kg/m²)	26.25±2.59	24.82±3.64	26.51±3.37	0.451	0.643	NS
Duration of disease (years)	11.22±2.53	11.60±3.26	12.78±3.34	0.629	0.542	NS
Mini mental scale	27.00±0.43	27.00±0.59	27.00±0.55	0.646	0.724	NS
Timed up and go test (s)	7.14±0.24	7.05±0.25	7.04±0.21	0.546	0.586	NS
Parkinson's Disease Rating Scale (part III score)	45.38±4.96	44.57±3.51	45.64±4.63	0.154	0.926	NS
Hoehn and Yahr staging scale (a.u.)	3.00±0.56	3.00±0.50	3.00±0.52	0.261	0.772	NS

Figure 1

Demographic data.

Table 2 Overall stability index

Items	Before treatment (mean±SD)	After treatment (mean±SD)	Improvement (%)	t value	P value	Significant
Overall stability index						
PT group	1.54±0.47	2.21±0.07	30.32	4.754	0.001*	S
Surgery group	1.78±0.44	2.30±0.23	22.61	3.139	0.014*	S
Surgery+PT group	1.12±0.07	2.19±0.44	48.86	7.088	0.0001*	S
F value	0.434	7.115				
P value	0.653	0.004*				
Significant	NS	S				

PT, Group I (Control group): received sensory integration training; S, significant. *Significant.

overall stability index, AP stability index, and M/L stability index, respectively) (Table 5).
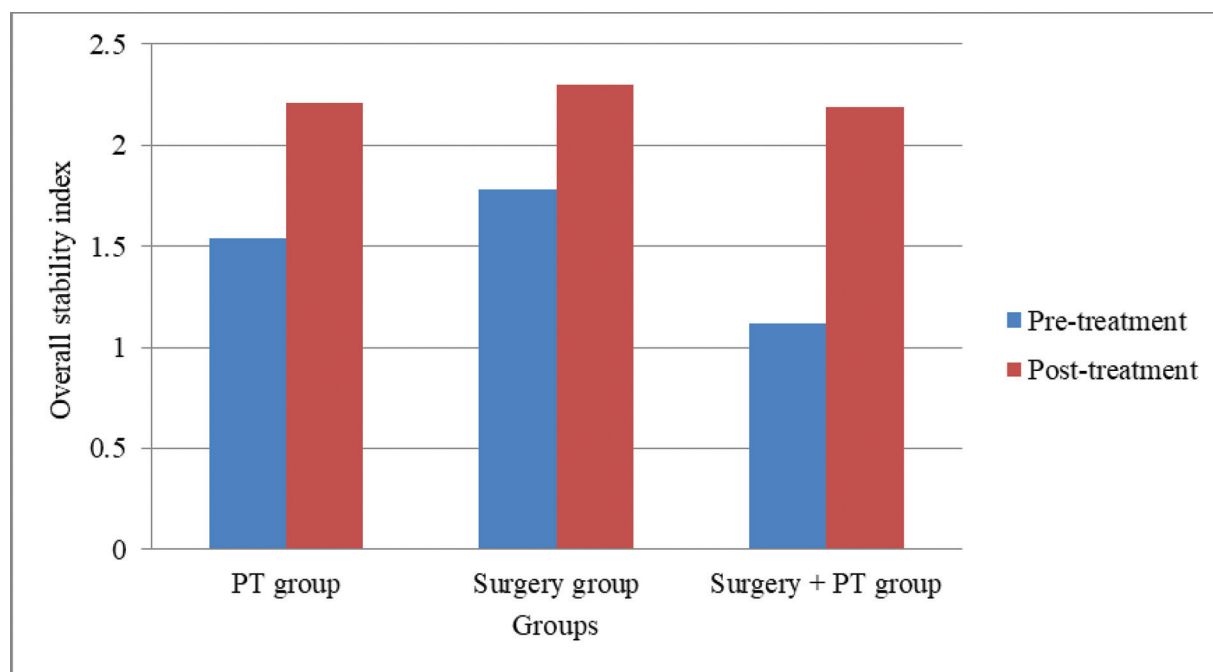
Discussion

Improving postural stability has been documented in patients with PD [15–17]. So, the mean values of overall stability index were 1.54±0.47 in pretreatment result and became 2.21±0.07 in post-treatment result in group I ($t=4.754$ and $P=0.001$). Furthermore, the exercise-induced benefits on overall brain health, including increased blood flow and trophic factors and a stronger immune system, may help address the environmental need for neuroplasticity in the damaged brain [18–20]. This, in turn, results in significant improvement in the mean values of AP index from 0.60±0.11 to 1.69±0.42 in group I ($t=6.927$ and $P=0.0001$).

However, effective sensory integration training protocols to improve postural stability have not yet been established. A previous study found that exercise training improved postural stability and also led to documented neurochemical and neuroplastic changes that occurred after the exercise intervention [21], so the concurrent study found a significant increase in the
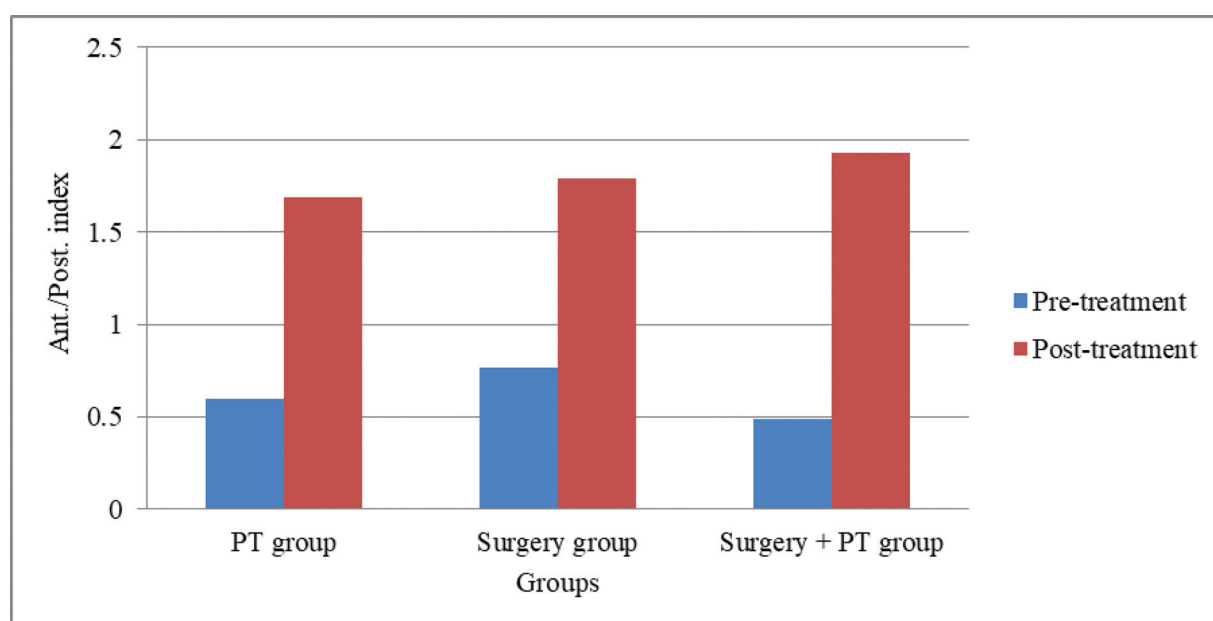
Figure 2

Overall stability index.

Table 3 Anterior/posterior index

Items	Before treatment (mean±SD)	After treatment (mean±SD)	Improvement (%)	t value	P value	Significant
Anterior/posterior index						
PT group	0.60±0.11	1.69±0.42	64.50	6.927	0.0001*	S
Surgery group	0.77±0.13	1.79±0.58	56.98	5.070	0.001*	S
Surgery+PT group	0.49±0.09	1.93±0.13	74.61	21.240	0.0001*	S
F value	0.748	13.769				
P value	0.484	0.0001*				
Significant	NS	S				

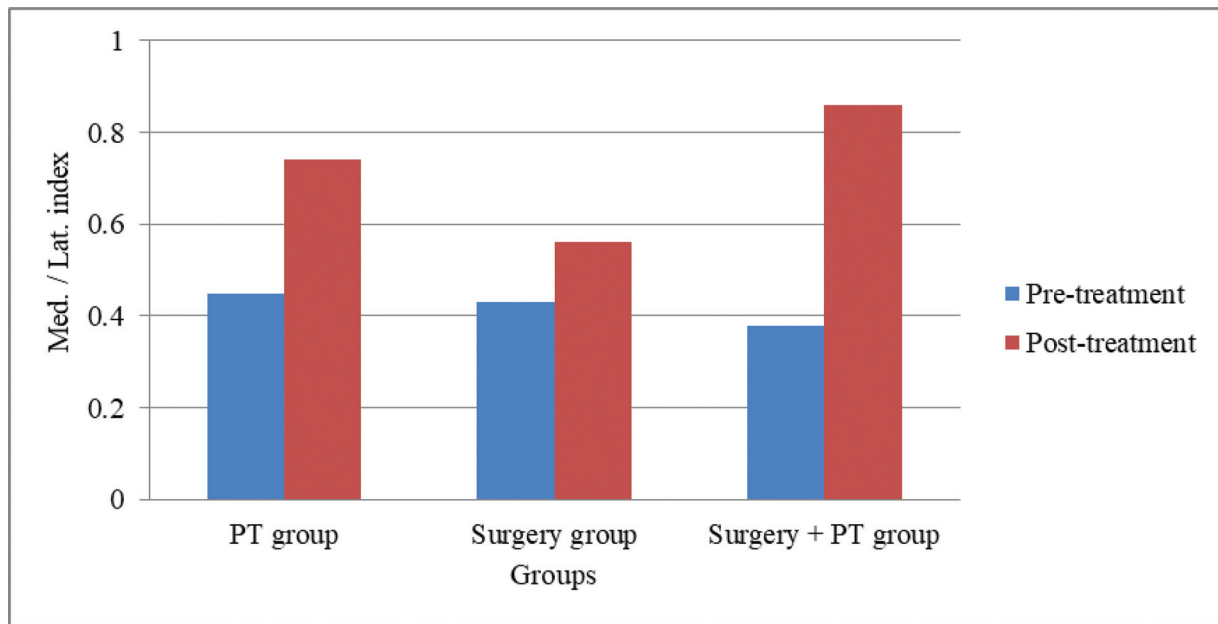S, significant. *Significant.

Figure 3

Anterior/posterior index.

Table 4 Medial/lateral index

Items	Before treatment (mean±SD)	After treatment (mean±SD)	Improvement (%)	t value	P value	Significant
Medial/lateral index						
PT group	0.45±0.14	0.74±0.16	39.19	2.776	0.024*	S
Surgery group	0.43±0.05	0.56±0.07	23.21	2.278	0.048*	S
Surgery+PT group	0.38±0.04	0.86±0.07	55.81	14.014	0.0001*	S
F value	0.988	15.512				
P value	0.387	0.0001*				
Significant	NS	S				

S, significant. *Significant.

Figure 4

Medial/lateral index.

mean values of M/L index from 0.45±0.14 to 0.74 ±0.16 in group I (t=2.776 and P=0.024). However, this improvement was not enough to prevent falling [22] and did not exert beneficial effects on balance performance [23–27].
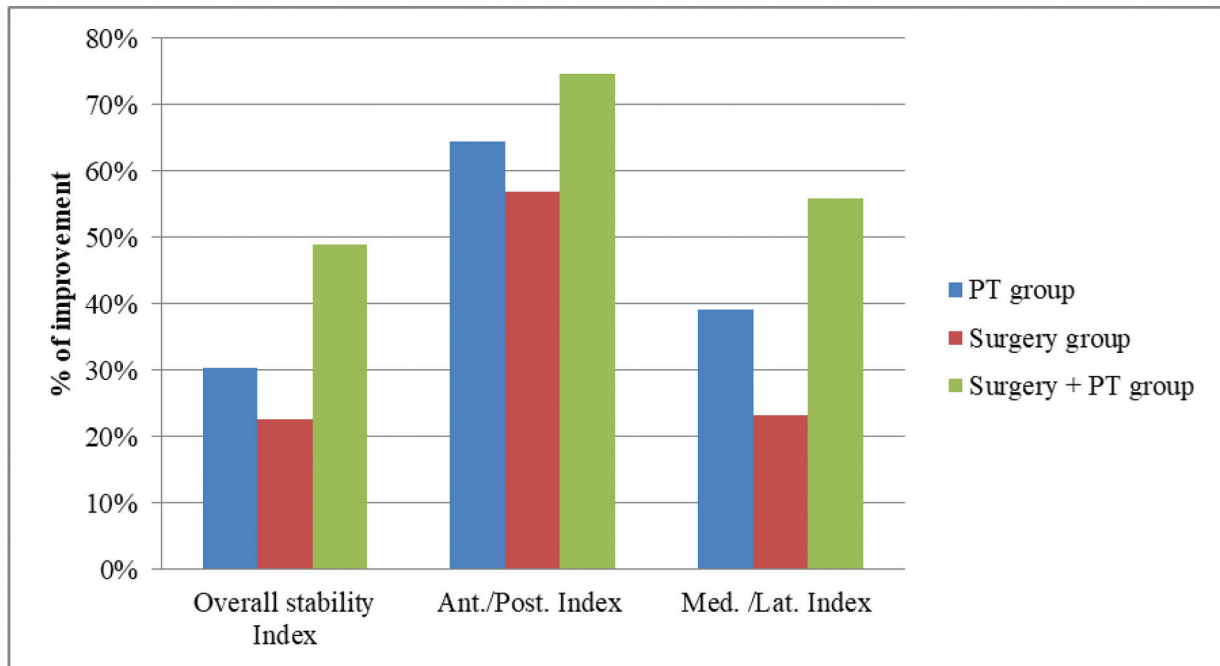
Furthermore, stereotactic surgery might be more effective [28–31]. Studies that used quantified gait analysis and dynamic posturography also confirmed our findings that stereotactic surgery can improve postural Instability and gait disorder [32,33]. However, its effects on PIGD are uncertain [34,35]. Based on the findings of this study, the mean values of overall stability index was 1.78±0.44 and became 2.30 ±0.23 in group II (t=3.139 and P=0.014).

The improvements in AP index values was changed from 0.77±0.13 to 1.79±0.58, in group II (t=5.070 and P=0.001). However, DBS may slow functional progression because patients are more active and exercising more after surgery.

In addition, there also is evidence that exercise may improve function without preserving dopaminergic neurons presumably through compensatory mechanisms. There is growing evidence that physical activity can curb the rate of motor function decline. This was noticed in this study by the mean values of M/L index, which was 0.43±0.05 and became 0.56±0.07 (t=2.278 and P=0.048). Despite improvements in clinical ratings of PIGD immediately after DBS, patients tend to fall more [36].

Patients, both in group I and group II, were improved but still tend to fall, so it was the idea of adding group III, who received sensory integration training after 10 days postoperative to stereotactic surgery. Based on these findings, the mean values of overall stability index was 1.12±0.07 and became 2.19±0.44 (t=7.088 and P=0.0001). Based on the recent results, the mean values of AP index was 0.49±0.09 and became 1.93±0.13 (t=21.240 and P=0.0001). The mean values of M/L index was 0.38±0.04 and became

Figure 5

Percentage of improvement.

Table 5 Post-hoc multiple comparison test (least significance difference) for overall stability index anterior/posterior index, and medial/lateral index

Items	Means	Groups		
		PT group	Surgery group	Surgery+PT group
Overall stability index				
PT group	2.21±0.07	–	0.190	0.026*
Surgery group	2.30±0.23		–	0.001*
Surgery+PT group	2.19±0.44			–
Anterior/posterior index				
PT group	1.69±0.42	–	0.161	0.040*
Surgery group	1.79±0.58		–	0.0001*
Surgery+PT group	1.93±0.13			–
Medial/lateral index				
PT group	074±0.16	–	0.183	0.049*
Surgery group	0.56±0.07		–	0.0001*
Surgery+PT group	0.86±0.07			–

*$P \leq 0.05$, pairs of groups significantly.

0.86±0.07 (t=14.014 and P=0.0001). Therefore, each subsystem underlying control of posture and gait may be related to different neural circuits with varying sensitivities to levodopa or DBS [37–39]. In addition to the significant improvements within groups I, II and III, there were significant post-treatment results in- between groups (F=7.115, 13.769, and 15.512 and P=0.004, 0.0001, and 0.0001). This was confirmed by the superior the percentage of improvement (30.32, 22.61 and 48.86, 74.61, 64.50 and 56.98, 55.81, 39.19 and 23.21%) in overall stability index, AP index and M/L index in groups I, II, and III, respectively. This was confirmed by the superiority of group III on group I and II (P=0.026 and 0.001, 0.040 and 0.0001, and 0.049 and 0.0001) in overall stability index, AP stability index, and M/L stability index, respectively. Therefore, stereotactic deep brain surgery partially improved limb kinesthesia and could restore medication-induced reductions of short latency afferent inhibition, and physiotherapy can be considered as a possible treatment to correct or compensate for kinesthetic deficits [11]. Ongoing exercise and physical fitness should be highly encouraged for patients with PD who are at risk of physical deconditioning and fear of falling because it is

beneficial with regards to physical functioning, health-related quality of life, strength, balance, and gait speed [35].

Conclusion
Accordingly, the physical therapy program should include sensory integration training for improving postural instability following stereotactic surgery in elderly with PD.

Conflicts of interest
There are no conflicts of interest.

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