Functional gait assessment in early and advanced Parkinson’s disease

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Abstract

Background: Postural instability and balance problems in patients with Parkinson’s disease (PD) can seriously affect the quality of life and lead to falls with a subsequent increase in the morbidity and mortality. Early identification of gait dysfunction in early stages of PD establishes an effective therapy, prevention of the falls and reducing health care costs. This work aimed to detect gait disorders in patients with PD using the functional gait assessment (FGA) scale and to correlate it with the disease severity in Egyptian PD patients. This is a case–control study in which 40 patients with PD were recruited from the Involuntary Movement Clinic at Alexandria University El-Hadara Hospital; 20 patients had early stages of PD (Hoehn Yahr stages 1 and 2) and 20 patients had advanced PD (Hoehn Yahr stages 3 and 4). Another 20 subjects were recruited as controls. All recruited subjects underwent gait assessment using FGA scale.

Results: Gait analysis using FGA showed significant differences ($P < 0.001$) between the recruited PD patients and the control group. Upon comparing the early and advanced PD patients’ groups, certain items in the FGA (gait with pivot turn, step over obstacle, gait with eyes closed and backward gait) together with time consumed for 6-m walk with eyes open and close showed significant statistical differences between early and advanced PD patients. The patients’ duration of illness with PD was reversely correlated with the total FGA score.

Conclusion: The FGA scale was strongly influenced by the duration of PD among the Egyptian patients and can potentially detect early stages of PD.

Keywords: Parkinson’s, FGA, Gait dysfunction, Hoehn Yahr

Background

Parkinson’s disease (PD) is a common progressive neurodegenerative disease affecting as many as 4 to 6 million worldwide and primarily affects dopaminergic pigmented neurons in the substantia nigra [1–3].

The burden of PD has more than doubled worldwide over the past two decades due to the aging of the population and the increased life expectancy with a solid expectation that this trend will continue in the next years [4]. In Egypt, a crude prevalence rate of PD was found to range from 213 to 557 per 100,000 people with an incidence of 82–62 per 100,000 people [5–7].

Typical manifestations of PD include resting tremors, bradykinesia, muscle rigidity and loss of postural stability. Even in the early stages of PD, patients may present with an abnormal gait pattern characterized by a shortened stride length, reduced walking speed, increased stride variability and festinating gait [8, 9].

Approximately, 78% of patients with PD have gait disturbances. Postural instability and balance problems in patients with PD can seriously affect the quality of life and lead to falls with a subsequent increase in the morbidity and mortality. Moreover, up to 68% of patients with PD will fall each year leading to injuries and large personal and societal costs [3, 8–14].

The pathognomonic characteristics of gait in early PD patient are the core of many studies all over the world; early identification is a key factor in establishing an
effective therapy, prevention of the falls and reducing health care costs [10, 15, 16].

Many clinical scales were developed to objectively evaluate balance and gait disturbances. The functional gait assessment (FGA) is a scale used to assess disturbances in balance and gait and was proposed by Wrisley and colleagues as a modified version of the Dynamic Gait Index (DGI) [17–19]. The DGI was less sensitive and the instructions for several items were ambiguous leading to difficulty in scoring by raters. Based on previous research, FGA was found to be a reliable means of assessing balance and gait in patients with PD. It was also demonstrated that the mean FGA scores were correlated with patients’ age as the scores systematically decreased with increasing age [10, 17–22].

The purpose of the present study was to detect and evaluate balance and gait disorders in patients with PD by the FGA and to correlate it with the disease severity of PD in Egyptian patients.

Methods

The study included 20 patients with early PD and 20 patients with advanced PD together with 20 healthy controls. All patients with PD were recruited from the Involuntary Movement Clinic of the Department of Neurology at Alexandria University El-Hadara Hospital. All recruited patients with PD met the following inclusion criteria: diagnosed with idiopathic PD according to the revised International Parkinson and Movement Disorder Society (MDS-PD) diagnostic criteria and the Montreal Cognitive Assessment (MoCA) score ≥ 20 [23, 24].

Patients diagnosed with secondary Parkinsonism or Parkinson plus syndrome and those having a comorbidity affecting motor function (such as stroke, amputation, or visual impairment) were excluded.

This study was approved by the Medical Ethics Committee of Alexandria University and informed consents were obtained from all participants.

The following variables were obtained from the participants: age, sex, duration of PD (in years), educational level, medical and surgical history and current medication regimen. The disease severity was assessed by the modified Hoehn and Yahr (HY) scale [25]. Balance and gait disturbances were assessed by the FGA [18]. The FGA is a 10-item test that includes 7 of the 8 items from the original DGI [19]. Each item is scored on a 4-point ordinal scale with scores of 0, 1, 2 or 3. The total score ranges from 0 to 30 with the higher scores indicating better balance and gait ability. The FGA was conducted in the ON medication phase in the involuntary movements’ clinic. All participants were evaluated and compared regarding their FGA [10, 18, 20, 25].

All data analyses were performed using International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) Statistics for Windows software version 20.0 (released 2011 by IBM Corporation in Armonk, New York, United States of America). For participants’ characteristics, descriptive statistics were used. The Kolmogorov–Smirnov was used to verify the normality of distribution of the variables. Comparisons between groups for categorical variables were assessed using Chi-square test (Monte Carlo). Student’s t-test was used to compare two groups for normally distributed quantitative variables while ANOVA was used for comparing the three studied groups and followed by post hoc test (Tukey) for pairwise comparison. Significance of the obtained results was judged at the 5% level.

Results

Forty patients with PD were recruited; 20 patients had early stages of PD (Hoehn Yahr stages 1 and 2) and 20 patients had advanced stages of PD (Hoehn Yahr stages 3 and 4) (Table 1). Another 20 subjects were recruited as controls.

Sixty-five percent of the patients with PD in each subgroup—the early and advanced PD subgroups—were males and 35% were females. There was no significant difference regarding the patient’s age, gender, duration of illness and the level of education between the two subgroups. However, comparing the patients with PD with the control group revealed significant difference regarding the age with the control subjects being slightly younger than the patients with PD (Table 2).

Gait analysis using the FGA in the recruited PD patients and the control group revealed significant statistical differences regarding the total score as well as all the 10 items included in the FGA between the PD patients’ groups and the control group. The total FGA score ranged from 25 to 30 in the control group with a median of 29, while the median in the early PD patients fall above 30.

Table 1  Stratification of the recruited patients with PD according to their Hoehn and Yahr stage

| PD patients | χ² | MCp |
|-------------|----|-----|
| Early (n = 20) | Advanced (n = 20) |    |
| Hoehn and Yahr stage |    |    |
| 1 | 7 (35%) | 0 (0%) | 44.611* | <0.001* |
| 2 | 13 (65%) | 0 (0%) |          |          |
| 3 | 0 (0%) | 13 (65%) |          |          |
| 4 | 0 (0%) | 7 (35%) |          |          |

χ²: Chi-square test; MC: Monte Carlo; PD: Parkinson’s disease
p: p value for comparing between the studied groups
*Statistically significant at p < 0.05
was 11 with a wide range of FGA scores from 5 to 27. The Advanced PD patients showed total FGA scores ranging from 4 to 15 and a median of 10 (Tables 3 and 4).

Upon comparing the early and advanced PD patients' groups, although there was no significant difference regarding the total score of the FGA between the two subgroups of PD patients, four items in the FGA showed significant statistical differences between the early and advanced PD patients. These items are: gait with pivot turn, step over obstacle, gait with eyes closed and ambulating backwards (Figs. 1, 2).

Time consumed by the PD patient during 6 m’ walk with eyes open and with eyes closed was also significantly affected. The median of the time duration consumed during 6 m’ walk by the controls was 5 s with eyes open and 6 s with eyes closed, but 16 s in the early PD patients and 26.5 s in the advanced PD group with eyes open and 19.5 s in the early PD patients and 32 s in the advanced PD patients with eyes closed (Tables 3 and 4).

Early PD patients consumed more time in comparison to controls; the median time duration they needed to walk 6 m was triple that consumed with the control group with their eyes open and was four times that needed by the control group with eyes closed. Also, time consumed by the PD patients during 6 m’ walk with eyes open and with eyes closed showed significant statistical differences between the early and advanced PD patients’ groups. Advanced PD patients also showed significantly slower gait in comparison to early PD patients; the median time duration consumed during 6 m’ walk by the advanced PD patients was 5 times the time needed by the control group with eyes open and about 6 times with eyes closed (Tables 3 and 4).

Using univariate and multivariate linear regression analysis, despite patients’ gender, age, level of education and stage of PD had no significant statistical impact on the total score of the FGA, the patients’ duration of illness with PD was reversely correlated with the total FGA score. Lower FGA’s total scores and more severe gait dysfunction were associated with longer durations of PD (Table 5).

**Discussion**

Parkinson’s disease is predominantly a disease of old age and male gender, as showed by the recruited patient in the current study, which was consistent with the epidemiological studies worldwide and in Egypt as well. It was suggested that PD is etiologically heterogeneous and a multifactorial disease involving many risk or protective factors that might be influenced by sex variables as

**Table 2** Comparison between the studied groups according to demographic data

|                      | Controls (n = 20) | PD patients | Test of sig | p     | p₁     |
|----------------------|------------------|-------------|-------------|-------|--------|
|                      | Early (n = 20)   | Advanced (n = 20) |             |       |        |
| Sex                  |                  |             |             |       |        |
| Male                 | 11 (55%)         | 13 (65%)    | χ² = 0.564  | 0.754 | 1.000  |
| Female               | 9 (45%)          | 7 (35%)     |             |       |        |
| Age (years)          |                  |             |             |       |        |
| Mean ± SD            | 50.4 ± 8.9       | 61.5 ± 9.8  | F = 14.407* | < 0.001* | 0.718  |
| Median (Min.–Max.)   | 50 (40–68)       | 62.5 (44–80)|             |       |        |
| Subject’s duration of Parkinson’s disease (in years) |                  |             | F = 14.463* | MC p = 0.115 | MC p₁ = 0.146 |
| Mean ± SD            | 5.1 ± 2.7        | 5.9 ± 2.4   | t = 0.995   | 0.326 | 0.326  |
| Median (Min.–Max.)   | 4.5 (1–10)       | 5.5 (3–11)  |             |       |        |
| Subject’s educational level |              |             |             |       |        |
| Illiterate           | 0 (0%)           | 1 (5%)      | χ² = 14.463 | MC p = 0.115 | MC p₁ = 0.146 |
| Primary              | 2 (10%)          | 7 (35%)     |             |       |        |
| Preparatory          | 5 (25%)          | 7 (35%)     |             |       |        |
| Secondary            | 1 (5%)           | 4 (20%)     |             |       |        |
| Diploma/institute    | 8 (40%)          | 7 (35%)     |             |       |        |
| College              | 4 (20%)          | 7 (35%)     |             |       |        |
| Postgrad studies     | 0 (0%)           | 0 (0%)      |             |       |        |

χ²: Chi-square test; MC: Monte Carlo; t: Student’s t-test; SD: standard deviation; PD: Parkinson’s disease; Min.: minimum; Max.: maximum

F: For ANOVA test, pairwise comparison bet. Each two groups was done using post hoc test (Tukey)

p: p value for comparing between the studied groups

p₁: p value for comparing between early PD patients and advanced PD patients

*Statistically significant at p ≤ 0.05
specific genes on sex chromosomes or the effects of sex hormones or pregnancy [4–7].

Gait analysis is essential for the diagnosis and follow-up of patients with PD and for prediction of falls and the impact of the disease on the quality of life of the patients as well. Despite the development of new digital technologies for more accurate and quantitative gait measures, FGA scale is a low-cost and easily accessed tool for gait analysis in medical clinics [9].

Various studies evaluated the reliability and validity of FGA in patients with PD and showed that FGA high reliability and stability regarding gait analysis and follow-up of patients with PD with good inter-rater and intra-rater consistency and is a good predictor of falls in patients with PD [9, 10, 15, 20, 26]. Recruited patients with PD showed significantly lower total FGA scores in comparison to the controls; recruited patients with early PD showed scores below

| Item 1: gait level surfaces | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|-----------------------------|------------------|-------------------------|-----------------------------|-------------|---|---|
| Severe impairment            | 0 (0%)           | 6 (30%)                 | 8 (40%)                     | χ² = 64.704*| MC p < 0.001* | 0.507 |
| Moderate impairment          | 0 (0%)           | 14 (70%)                | 12 (60%)                    |             |   |   |
| Mild impairment              | 0 (0%)           | 0 (0%)                  | 0 (0%)                      |             |   |   |
| Normal                       | 20 (100%)        | 0 (0%)                  | 0 (0%)                      |             |   |   |
| Time consumed in 6-m walk (s) |                |                         |                             | F = 53.361*| MC p < 0.001* | <0.001* |
| Mean ± SD                    | 5 ± 0.3          | 17.6 ± 7.4              | 26.3 ± 8.7                  |             |   |   |
| Median (Min–Max)             | 5 (4.5–5.5)      | 16 (8–32)               | 26.5 (13–41)                |             |   |   |

| Item 2: change in gait speed | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|------------------------------|------------------|---------------------------|-------------------------------|-------------|---|---|
| Severe impairment            | 0 (0%)           | 2 (10%)                   | 0 (0%)                        | χ² = 55.274*| MC p < 0.001* | 0.148 |
| Moderate impairment          | 0 (0%)           | 5 (25%)                   | 6 (30%)                       |             |   |   |
| Mild impairment              | 0 (0%)           | 10 (50%)                  | 14 (70%)                      |             |   |   |
| Normal                       | 20 (100%)        | 3 (15%)                   | 0 (0%)                        |             |   |   |

| Item 3: gait with horizontal head turns | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|----------------------------------------|------------------|---------------------------|-------------------------------|-------------|---|---|
| Severe impairment                      | 0 (0%)           | 1 (5%)                    | 0 (0%)                        | χ² = 40.200*| MC p < 0.001* | MC p₁ = 0.258 |
| Moderate impairment                    | 0 (0%)           | 9 (45%)                   | 8 (40%)                       |             |   |   |
| Mild impairment                        | 4 (20%)          | 8 (40%)                   | 12 (60%)                      |             |   |   |
| Normal                                  | 16 (80%)         | 2 (10%)                   | 0 (0%)                        |             |   |   |

| Item 4: gait with vertical head turns | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|--------------------------------------|------------------|---------------------------|-------------------------------|-------------|---|---|
| Severe impairment                    | 0 (0%)           | 0 (0%)                    | 0 (0%)                        | χ² = 57.049*| MC p < 0.001* | MC p₁ = 0.273 |
| Moderate impairment                  | 0 (0%)           | 11 (55%)                  | 15 (75%)                      |             |   |   |
| Mild impairment                      | 0 (0%)           | 7 (35%)                   | 5 (25%)                       |             |   |   |
| Normal                                | 20 (100%)        | 2 (10%)                   | 0 (0%)                        |             |   |   |

| Item 5: gait with pivot turn          | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|--------------------------------------|------------------|---------------------------|-------------------------------|-------------|---|---|
| Severe impairment                    | 0 (0%)           | 2 (10%)                   | 6 (30%)                       | χ² = 55.778*| MC p < 0.001* | MC p₁ = 0.012* |
| Moderate impairment                  | 0 (0%)           | 11 (55%)                  | 14 (70%)                      |             |   |   |
| Mild impairment                      | 4 (20%)          | 6 (30%)                   | 0 (0%)                        |             |   |   |
| Normal                                | 16 (80%)         | 1 (5%)                    | 0 (0%)                        |             |   |   |

| Item 6: step over obstacle           | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p₁ |
|--------------------------------------|------------------|---------------------------|-------------------------------|-------------|---|---|
| Severe impairment                    | 0 (0%)           | 4 (20%)                   | 0 (0%)                        | χ² = 68.184*| MC p < 0.001* | MC p₁ = 0.001* |
| Moderate impairment                  | 0 (0%)           | 12 (60%)                  | 7 (35%)                       |             |   |   |
| Mild impairment                      | 0 (0%)           | 2 (10%)                   | 13 (65%)                      |             |   |   |
| Normal                                | 20 (100%)        | 2 (10%)                   | 0 (0%)                        |             |   |   |

χ²: Chi-square test; MC: Monte Carlo; SD: standard deviation; PD: Parkinson’s disease; Min.: minimum; Max.: maximum

F: F for ANOVA test, Pairwise comparison between each two groups was done using post hoc test (Tukey)

p: p value for comparing between the studied groups

p₁: p value for comparing between early PD patients and advanced PD patients

*Statistically significant at p < 0.05
27 and those with advanced PD showed scores below 15. All patients with PD showed significantly slower gait with lower speed values whether during walking with opened or closed eyes or walking backwards. This could be explained by the impact of the bradykinesia, rigidity, postural instability on the gait features, leading to high step number and shortened step length and both swing and stance phases are prolonged. All patients with PD also showed significantly affected gait skills like turning, accelerating or decelerating their gait, walking during vertical or horizontal head turns, stepping over an obstacle, narrow based walking and climbing up stairs. Many studies noted similar significant gait dysfunction in PD patients [9, 10, 15, 20, 26–32].

Although no statistically significant difference regarding the total FGA score was found between the early and advanced PD patients, advanced PD patients showed significantly affected—either slower or unaccomplished—pivot turning, gait with eyes closed and ambulating backwards in addition to the significantly slower gait in comparison to early PD patients.

Pivot turning is a challenging task that requires deceleration, rotation of the axial body segments, and acceleration of the body’s center of mass in the new direction. This exerts unique challenges to patients with impaired postural control especially during their transition from

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### Table 4 Comparison between the studied groups according to functional gait assessment “Continue”

| Item 7: gait with narrow base of support | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p_1 |
|----------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Severe impairment                       | 0 (0%)           | 9 (45%)                  | 5 (25%)                     | \( \chi^2 = 57.226^* \) | MC \( p < 0.001^* \) | MC \( p_1 = 0.246 \) |
| Moderate impairment                     | 0 (0%)           | 7 (35%)                  | 11 (55%)                    | \( \chi^2 = 58.043^* \) | MC \( p < 0.001^* \) | MC \( p_1 = 0.039^* \) |
| Mild impairment                         | 0 (0%)           | 2 (10%)                  | 4 (20%)                     |              |   |    |
| Normal                                  | 20 (100%)        | 2 (10%)                  | 0 (0%)                      |              |   |    |

| Item 8: gait with eyes closed           |                  |                          |                             |             |   |    |
|----------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Severe impairment                       | 0 (0%)           | 7 (35%)                  | 14 (70%)                    | \( \chi^2 = 49.717^* \) | MC \( p < 0.001^* \) | MC \( p_1 = 0.015^* \) |
| Moderate impairment                     | 0 (0%)           | 10 (50%)                 | 6 (30%)                     |             |   |    |
| Mild impairment                         | 7 (35%)          | 3 (15%)                  | 0 (0%)                      |             |   |    |
| Normal                                  | 13 (65%)         | 0 (0%)                   | 0 (0%)                      |             |   |    |

| Time consumed in 6-m walk with eyes closed (s) | Controls (n = 20) | PD patients Early (n = 20) | PD patients Advanced (n = 20) | Test of sig | p | p_1 |
|------------------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Mean \( \pm SD \)                           | 6.7 ± 1.2        | 21.1 ± 8.3               | 32.6 ± 7.1                  | \( F = 82.972^* \) | < 0.001 * | < 0.001 * |
| Median (Min.–Max.)                           | 6 (5–9)          | 19.5 (8–36)              | 32 (24–45)                  |             |   |    |

| Item 9: ambulating backwards               |                  |                          |                             |             |   |    |
|--------------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Severe impairment                         | 0 (0%)           | 5 (25%)                  | 7 (35%)                     | \( \chi^2 = 52.862^* \) | MC \( p < 0.001^* \) | MC \( p_1 = 0.105 \) |
| Moderate impairment                       | 0 (0%)           | 13 (65%)                 | 18 (90%)                    |             |   |    |
| Mild impairment                            | 1 (5%)           | 0 (0%)                   | 0 (0%)                      |             |   |    |
| Normal                                     | 19 (95%)         | 4 (20%)                  | 0 (0%)                      |             |   |    |

| Item 10: Steps                             |                  |                          |                             |             |   |    |
|--------------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Severe impairment                         | 0 (0%)           | 3 (15%)                  | 2 (10%)                     | \( \chi^2 = 139.036^* \) | < 0.001 * | 0.337 |
| Moderate impairment                       | 0 (0%)           | 13 (65%)                 | 18 (90%)                    |             |   |    |
| Mild impairment                            | 1 (5%)           | 0 (0%)                   | 0 (0%)                      |             |   |    |
| Normal                                     | 19 (95%)         | 4 (20%)                  | 0 (0%)                      |             |   |    |

| Total score                                |                  |                          |                             |             |   |    |
|--------------------------------------------|------------------|--------------------------|-----------------------------|-------------|---|----|
| Mean \( \pm SD \)                         | 28.9 ± 1.4       | 12.1 ± 5.9               | 10.3 ± 2.9                  | \( F = 139.036^* \) | < 0.001 * | 0.337 |
| Median (Min.–Max.)                         | 29 (25–30)       | 11 (5–27)                | 10 (4–15)                   |             |   |    |

\( \chi^2 \): Chi-square test; MC: Monte Carlo; SD: standard deviation; PD: Parkinson’s disease; Min.: minimum; Max.: maximum

\( F \): For ANOVA test, pairwise comparison between each two groups was done using post hoc test (Tukey)

\( p \): p value for comparing between the studied groups

\( p_1 \): p value for comparing between early PD patients and advanced PD patients

*Statistically significant at \( p \leq 0.05 \)
double-limb to single-limb stance before returning back to double-limb stance. This explains why pivot turning is more challenging to patients with advanced stages of PD when postural instability is more evident, making turning difficulty a sensitive indicator of a higher falling risk in patients with advanced PD [33–39].

Similarly, a study found that poor performance in functional balance tests is strongly associated with poorer reactive postural responses. In advanced PD, there is complete or partial dysfunction of the sensorimotor control of posture which involves the integration of multisensory proprioceptive, visual and vestibular inputs to
provide a proper neuromuscular response in muscles with an already disturbed muscle tone background. Thus once more, postural instability could explain the poorer performance in patients with advanced PD during ambulating backwards or with eyes closed [28, 32, 40–49].

The significant difference in the gait speed and the other mentioned gait skills between the early and advanced PD patients is not attributed to demographic features like age or gender of the PD patients as they were not significantly different between the early and advanced PD patients. Yet, it was attributed by the multivariate regression analysis to the patients’ duration of illness with PD. Patients with longer duration of Parkinson’s disease showed significantly lower FGA’s total score and more severe gait dysfunction [50].

This was consistent with what Ospina and colleagues demonstrated in his age-stratified sample. It showed that although younger PD patients usually tend to have shorter disease duration and fewer gait changes, especially, in early disease stages, no significant differences in the oldest group between the PD patients and the healthy control group were found. This could be explained by the gait changes induced by the physiological aging process in the healthy control group, leading to positive correlational relationship between aging and prolonged swing and stance times of gait. Ospina and colleagues emphasized that PD patients showed different motor impairment patterns, and that the progression of their motor symptoms varied according to the age of onset of PD and the duration of the disease rather than the patient’s age [9, 27, 28, 51–53].

Some studies suggested that PD patients with an older age of onset have a faster rate of motor progression than those with early onset of disease. Yet, there is individual variability in the rate of progression of PD among PD patients and this might explain the insignificant correlation between the PD patients’ age and the spatiotemporal variables of gait [9, 28, 54, 55].

In the era of the emergence of new digital technologies for quantitative gait dysfunction assessment, FGA scale is still a ubiquitous, economic, and time-efficient way for gait analysis in medical clinics, that can complement clinical assessment and follow-up of gait dysfunction in Egyptian PD patients, potentially detecting earlier stages of PD.

Limitations of the current study included small number of PD patients and less age-matched controls and UPDRS could not be done to all the recruited patients. However, it illustrated the significant value of FGA scale in detecting early gait dysfunction in PD patients. Nevertheless, more multicentric studies including larger numbers of PD patients are recommended.

**Conclusions**

Functional gait assessment scale was strongly influenced by the duration of Parkinson’s disease among the Egyptian PD patients and can potentially detect early stages of PD.

**Table 5** Univariate and multivariate linear regression for the parameters affecting total score for PD patients (n=40)

| PD patients (n=40) | Univariate | Multivariate |
|-------------------|------------|--------------|
|                   | p          | B (95% C.I)  | p          | B (95% C.I)  |
| Female (c)        | 0.506      | 1.049 (−2.11 to 4.21) |          |              |
| Age (years)       | 0.258      | −0.107 (−0.297 to 0.082) |          | −0.621* (−1.91 to −0.051) |
| Duration of Parkinson’s disease (in years) | 0.033*      | −0.621* (−1.91 to −0.051) | 0.033* | −0.621* (−1.91 to −0.051) |
| Subject’s educational level (c) | 0.711      | 0.190 (−0.840 to −1.219) |          |              |
| Advanced PD patients (c) | 0.242      | −1.750 (−4.73 to 1.233) |          |              |

Beta: standardized coefficients; C.I: confidence interval; c: categories

* All variables with p < 0.05 was included in the multivariate

*Statistically significant at p ≤ 0.05

**Abbreviations**

DGI: Dynamic Gait Index; FGA: Functional gait assessment; HY: Hoehn and Yahr scale; IBM: International Business Machines; MoCA: Montreal Cognitive Assessment; PD: Parkinson’s disease; SPSS: Statistical Package for the Social Sciences.

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**Authors’ contributions**

HME: Idea of the research, contribution to the statistical analysis of the data and revision of the results and the manuscript. HSA: FGA scale application, data collection and sorting and writing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The research data supporting the results reported in this article are totally available upon reasonable request from the authors.

Declarations

Ethics approval and consent to participate
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Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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