The present study had three objectives: (a) to characterize the functional capacity of patients with PD, (b) to assess the relationship between the physical fitness components of functional capacity with clinical characteristics and disease severity, and (c) to compare the physical fitness components of functional capacity with clinical characteristics according to disease severity. The study included 54 patients with idiopathic PD who were distributed into two groups according to PD severity: unilateral group (n = 35); and bilateral group (n = 19). All patients underwent psychiatric assessment by means of the Hoehn and Yahr (HY) staging of PD, the Unified Parkinson's Disease Rating Scale (UPDRS), the Hospital Anxiety and Depression Scale (HADS-A and HADS-D, respectively), and The Mini-Mental State Examination (MMSE). The physical fitness components of functional capacity were evaluated over a 2-day period, using recommendations by the American Alliance for Health, Physical Education, Recreation and Dance, and the Berg Balance Scale (BBS). Pearson correlation coefficients and multiple regressions were calculated to test the correlation between functional capacity and clinical characteristics, and to predict clinical scores from physical performance, respectively. Clinical variables and physical component data were compared between groups using analysis of variance to determine the effects of disease severity. Patients with advanced disease showed low levels of functional capacity. Interestingly, patients with good functional capacity in one of the physical fitness components also showed good capacities in the other components. Disease severity is a major factor affecting functional capacity and clinical characteristics. Medical providers should take disease severity into consideration when prescribing physical activity for PD patients, since the relationship between functional capacity and clinical characteristics is dependent on disease severity.

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standardized test, the Physical Functional Ability Test for Adults 60 Years of Age and Older (Osness et al., 1990). This instrument makes it possible to assess individual fitness components of functional capacity in PD patients, who may exhibit normal scores in some domains and weak scores in others.

Motor and non-motor manifestations and disease severity, which also can affect the performance of daily activities, have been assessed using clinical instruments such as the UPDRS (Fahn and Elton, 1987); the HY scale (Goetz et al., 2004); MMSE (Folstein et al., 1975); and the HADS-A and HADS-D (Mondolo et al., 2006). Motor functions, also, are associated with cognitive function, and depression and anxiety. Cognitive decline in PD patients appears to be associated with worsening motor symptoms (Van Spauwdonck et al., 1996). Depression and anxiety levels are related not only to cognitive impairment, but, also, to motor symptoms, dyskinesias, the prodromal period, and moderate HY stages (Hawkes et al., 2010). Thus, depression and cognitive impairment could be considered main predictors of poor quality of life in PD patients (Rahman et al., 2008).

In PD patients, this strong relationship between motor and cognitive functions affects quality of life. For example, depression and anxiety symptoms can negatively affect quality of life, resulting in impaired cognitive function. Conversely, a higher level of functional capacity can ensure a better quality of life. Therefore, the present study had three objectives: (a) to characterize the functional capacity of patients with PD; (b) to assess the relationship between the physical fitness components of functional capacity with clinical characteristics and disease severity, and (c) to compare the physical fitness components of functional capacity with clinical characteristics according to disease severity.

2. Materials and methods

2.1. Study population

The participants consisted of 54 patients with idiopathic PD, who participated in a multidisciplinary PD project conducted at São Paulo State University at Rio Claro (UNESP-RC). These patients regularly attended the neurology clinic at UNESP-RC. The inclusion criteria included both men and women who have had a clinically confirmed diagnosis of PD and were able to walk independently. The patients were interviewed from February 2004 to December 2008.

2.2. Clinical evaluation

Data were collected using demographic and anthropometric guidelines that included: gender, age, disease duration, education level, and body weight and height. All patients underwent psychiatric evaluation as follows: (a) PD symptoms and signs were assessed in all subsections of the UPDRS, and included mental, activities in daily living (ADL), and motor examinations (Fahn and Elton, 1987). This scale ranges from 0 to 176 points (mental: 16 points, ADL: 52 points, motor: 108 points), and a high score indicates greater impairment; (b) mental status was assessed using the MMSE (Folstein et al., 1975), which is a brief 30-point questionnaire, in which values up to 24 points are considered as mentally “intact” (Brucki et al., 2003); (c) PD severity was evaluated using the modified HY scale (Hoehn and Yahr, 1967; Goetz et al., 2004). This scale ranges from 0 (no signs of disease) to 5 (needing a wheelchair or bedridden unless assisted) in order to indicate a relative level of disability; and (d) anxiety and depression symptoms were assessed using the HADS-A and HADS-D (Mondolo et al., 2006). It consists of 14 items (seven for assessing anxiety, and seven for depression), ranging from 0 (no problem) to 3 (severe problem). Values of up to 9 points in each scale are representative of symptoms of anxiety and depression (Zigmond and Snaith, 1983).

2.3. Functional capacity evaluation

All patients were evaluated in the morning—in the “on medication” state, one hour after taking the first morning dose of anti-Parkinson medications. The physical fitness components were assessed over 2 days, using the test proposed by the AAHPERD (Osness et al., 1990), and the BBS (Scalzo et al., 2009). The AAHPERD test includes measures of flexibility, muscular strength, agility, coordination, and aerobic endurance. It provides a set of standardized instructions, which were used with the participants in preparation for the assessment of the test items (Osness et al., 1990):

(a) Flexibility test: a standard sit-and-reach test in which participants are seated, with their heels 12 in apart and over a line that runs perpendicular to a measuring tape. They are asked to reach with both hands as far along the measuring tape as they comfortably can while keeping both knees straight. The score is their highest tape measure mark for three attempts.

(b) Muscular strength: requires female participants to lift a 4-lb object, and male participants to lift an 8-lb object, using a biceps curl motion, as many times as possible in 30 s.

(c) Agility: patients start from a seated position and are asked to rise from a chair, walk to the right around a cone, and return to the seat and sit down, stand again, walk to the left around a cone, return to their seat and sit down, and then repeat the entire procedure. The participants are given two attempts, and the raw score represents the faster of the two.

(d) Coordination: involves the movement of three 12-oz soda cans, using the dominant hand. The cans are placed on a table, topside-up and on a line indicated by a 30-in. length of masking tape. The cans are located at 10-in. intervals. The participants are seated at the table with the line of cans well within their grasp and they are then asked to perform two attempts in which they are asked to place each can top-side-down in a space adjacent to its original position. Then they return the cans to their original top-side-up position. Each trial consists of performing these movements twice, and the raw score reflects the faster of two trials.

(e) Aerobic endurance: an 880-yd walk, at the participant's maximum speed.

The BBS was used to assess global functional balance ability. This test rates performance from 0 (cannot perform) to 4 (normal performance) on 14 different tasks, which involve functional balance control (transfer, turning, and stepping).

2.4. Study procedures

All procedures described were approved by the Research Ethics Committee at UNESP-RC. Participants gave their written informed consent and were screened. Those eligible to participate in the study underwent a clinical evaluation. All who met the inclusion criteria were invited to participate in two additional testing sessions. During the first testing session, each participant performed balance, flexibility, coordination, strength, and agility tests. Aerobic resistance was evaluated on the second day. Both sessions were held in the morning between 8:00 a.m. and 11:00 a.m.

2.5. Statistical analysis

Demographic, anthropometric, and clinical characteristics and physical components of PD patients were described as means and
standard deviations (S.D.). The Shapiro–Wilk test was used to test the normal distribution. Pearson correlation coefficients were calculated to test the correlation of functional capacity with clinical characteristics. Multiple regressions (step-wise model) were used to predict the main functional capacity outcome variables, while controlling for clinical PD characteristics. The regression analysis model included physical fitness components as a predictive variable relative to all of the other variables (Field, 2005).

The participants were assigned to two groups according to PD severity: unilateral group (HY stages 1 and 1.5) \((n = 35)\); and bilateral group (HY stages 2–3) \((n = 19)\). The Student’s \(t\)-test was used to test for differences between the two PD severity groups (unilateral and bilateral). Pearson coefficients and multiple regressions (the same models noted previously) were calculated to assess the correlation and to predict the clinical scores by physical performance in each group, respectively. Statistical analyses were carried out using SPSS for Windows 10.0\(^{*}\) (the significance level was set at \(p < 0.05\)).

3. Results

The PD patients showed mild-to-moderate disease. The characteristics of the sample studied are shown in Table 1. All components of physical fitness, except flexibility, were correlated (Fig. 1). The strongest correlations were found for balance/agility, aerobic resistance/agility, balance/aerobic resistance, and balance/coordination.

The Pearson correlation showed a strong relationship between all physical fitness components and clinical variables (Fig. 2), except for flexibility, which did not reveal a significant relationship with clinical variables. The multiple regressions revealed that some of the physical fitness components are predictors of the clinical PD characteristics (Table 2). The most notable results for the regression were for the UPDRS-motor, which was predicted in 67.8% by coordination \((R^2 = 0.29; \beta = 0.44; p < 0.003)\) and strength \((R^2 = 0.38; \beta = –0.31; p < 0.003)\).

As for PD severity (Fig. 2), the analysis of variance showed that the PD patients with unilateral impairment scored significantly better in the UPDRS ADL \((p < 0.0001)\) and motor \((p < 0.0001)\), and HADS-D \((p < 0.01)\) than did those with bilateral impairment. HADS-A showed a difference trend \((p < 0.06)\) between the groups, with fewer anxiety signs for the unilateral group. For physical fitness, the unilateral group performed significantly better for balance \((p < 0.0001)\), agility \((p < 0.001)\), and coordination \((p < 0.007)\) than their bilateral group counterparts. The unilateral group showed a tendency toward a better performance for flexibility \((p < 0.07)\).

Table 2 illustrates that the severity of PD impairment affects the relationship of the physical components relative to the other clinical variables. This is true, also, for the results in the multiple regression analysis. The unilateral group showed a stronger relationship between physical fitness components and indicators of disease severity. Coordination was an important predictor of scores on the MMSE \((R^2 = 0.42; \beta = –0.65; p < 0.001)\). In the bilateral group, the physical fitness components were strong predictors for clinical variables (more than 22%). Muscle strength was a predictor for scores on the UPDRS ADL \((R^2 = 0.41; \beta = –0.64; p < 0.003)\) and motor \((R^2 = 0.42; \beta = –0.65; p < 0.003)\), while flexibility was a predictor of scores on both the HADS-A \((R^2 = 0.40; \beta = 0.64; p < 0.01)\) and the HADS-D \((R^2 = 0.22; \beta = 0.47; p < 0.03)\).

4. Discussion

The purposes of this study were (a) to investigate the functional capacity of PD patients, (b) to assess the relationship between the physical fitness components of functional capacity with clinical characteristics and disease severity, and (c) to compare the physical fitness components of functional capacity with clinical characteristics according to disease severity. The PD patients in this study showed mild to moderate levels of the disease as defined by the UPDRS and HY stages assessments. Patients presented signs of anxiety and depression, and high variability relative to duration of disease. These clinical characteristics can explain the wide range between the minimum and maximum values found for the functional capacity components, particularly for agility and coordination.

Some functional capacity components decline with PD severity. PD patients have cognitive deficits (manifested in tasks that...
demand mental flexibility), which subsequently may lead to motor dysfunction and poor performance in the physical tests. In PD patients, personal, motor, and cognitive characteristics affect walking speed, mainly during complex dual tasks (i.e., motor and cognitive tasks performed simultaneously) (Rochester et al., 2009). Our results also illustrated that the participants who performed well in one of the functional capacity components also performed well in all the other components, with the exception of flexibility. It appears that during the successful performance of daily living activities, these components have an interdependent relationship. It should be noted that independent living requires a high level of functional capacity (Okamoto et al., 2006).

On the other hand, our findings suggest that in PD patients, flexibility is an independent component. It is possible that the evaluation method for flexibility is not as sensitive as those for the other components. It is also possible that the flexibility levels of the patients in this study simply are not sufficient to promote improvements in other functional capacity components and clinical variables. This seems evident, since no general relationship was found between flexibility and the other functional capacity components. Specifically, the results suggest that patients with advanced disease and high flexibility scores had more signs of anxiety and depression, which indicates that flexibility, is an important predictor for anxiety and depression. Motor symptoms do not have an association with cognitive decline, but depression symptoms can be a strong predictor of cognitive decline (Kandiah et al., 2009). Our findings with regard to flexibility suggest that further research is needed on this subject.

Functional capacity components can predict the clinical characteristics of PD. Patients in the unilateral group (initial stages of the disease) showed high levels of functional capacity. The relationship between functional capacity components and clinical characteristics may help medical providers better assess early physical functional impairment (Song et al., 2009) in these patients. Functional capacity components seem to be an effective parameter in the determination of UPDRS ADL and motor scores, Table 2

<table>
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<th>UPDRS mentation</th>
<th>UPDRS ADL</th>
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\[ p < 0.05. \]
\[ ** p < 0.01. \]
\[ *** p < 0.001. \]
\[ + Significant multiple regressions. \]

Fig. 2. Comparisons between the PD severity groups (mean ± SD). (A) Clinical variables; (B) physical fitness components. * Unilateral group ≠ bilateral group; + difference trend between unilateral and bilateral groups.

**Table 2**

Pearson correlations and multiple regressions results between physical fitness components with clinical variables for overall and according disease severity.
MMSE scores, HY stages, and depression. Non-motor symptoms more negatively affect the quality of life of PD patients than do motor symptoms (Qin et al., 2009). Motor impairment is common in PD patients and can be associated with increased risk of cognitive decline, dementia and depression symptoms (Camicioni et al., 2007). It is important to note that some clinical characteristics are particularly dependent on functional capacity components. For example, high levels of coordination and muscle strength can lead to improved UPDRS motor scores. For the unilateral group, better coordination implies more favorable MMSE scores. Therefore, the clinical characteristics of the bilateral group appear to be highly dependent on muscle strength and flexibility, which were the main predictors for this group.

**Conflict of interest statement**

All authors have disclosed any financial and personal relationships, with other people or organizations, that could inappropriately influence (bias) this work.

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