KNEE EXTENSOR AND FLEXOR STRENGTH IN ELDERLY WOMEN AFTER RECENT HIP FRACTURE: ASSESSMENT BY THE CYBEX 6000 DYNAMOMETER OF INTRA-RATER INTER-TEST RELIABILITY

Ole Rentek Madsen, MD, and Ulrik Birk Lauridsen, MD

From the Department of Rheumatology and the Osteoporosis Research Center, Copenhagen Municipal Hospital, Denmark

ABSTRACT. The reliability of knee extensor and flexor strength measurements was assessed in 20 women (age 68–88 years) who had experienced a hip fracture two to four weeks before but who were otherwise healthy. Using the Cybex 6000 isokinetic dynamometer, isokinetic knee extensor and flexor strength (peak torque, total work and power) at 30 and 120°/second and isometric knee extensor and flexor strength (peak torque) were measured by the same examiner in both legs, successively, on four separate days within one week. Compared with the non-involved leg, the median reduction in peak extensor and flexor torque of the involved leg was 50% (p < 0.001). With the protocol used, no significant change in muscle strength occurred during the test period. Individual coefficients of variation (CVs) were calculated for each muscle strength variable. Depending on whether torque, work or power were measured, the median CVs of extensor and flexor strength measurements of the non-involved leg ranged from 5.6–14.6% and 10.8–28.6%, respectively. The corresponding CVs for the involved leg were 10.9–22.1% and 13.0–35.2%. Substantial variability between individual CVs were found for all strength variables. In conclusion, although muscle strength measurements may be applicable when comparing larger groups of hip fracture patients, the large CVs may be a limitation in monitoring individual patients. This finding should be taken into consideration when planning individual training programmes.

Key words: muscle strength, reliability, hip fracture.

Osteoporotic fractures are a major public health problem. For example, in the United States osteoporotic predisposes to more than 1.3 million fractures annually, including more than 250,000 hip fractures and costs the nation in excess of US $ 10 billion (9). Women aged 65–84 years are estimated to experience the largest number of fractures/person/year and fracture care costs (8).

In the elderly, muscle strength relates to functional status (20), chair rising ability (7) walking and stair climbing speed (4, 6, 7), and a strong association between impaired muscle strength and the risk of recurrent falls (25, 41) and fractures has been found (24, 33). Furthermore, muscle strength and physical activity have been shown to correlate with bone mineral density (26, 37). Thus a reduction in muscle strength may also result in an accelerated bone loss increasing the risk of fractures. Therefore, to avoid functional disability, immobilisation and further loss of bone mass, muscle strengthening exercises in the rehabilitation of hip fracture patients seems to be vital. The positive effects of strength training programmes in the elderly further indicate that testing for changes in muscle strength will become more widespread in these patients (14).

In studies of groups of patients, the probability of detecting differences in muscle strength between the groups for a given sample size is calculated on the basis of the standard deviate of the variable in question (power calculation) (2). In clinical practice, however, changes in the individual patient must be evaluated on the basis of the reliability of the measurements (27), otherwise, the clinician cannot determine whether the patient has become "stronger" or "weaker". In both clinical practice and in research studies, the reliability of the measurements is of interest with regard to the number of test sessions required to reach peak torques.

For the past decades the majority of studies involving isokinetic muscle strength measurements have been performed using the Cybex II. This system has now been replaced by a new isokinetic device, the Cybex 6000 dynamometer, for which only one previous study of the reliability of leg strength
measurements has been published (3). The study sample comprised young subjects. Studies of the reliability of other isokinetic dynamometers have been performed (13, 15, 16, 18, 30), but none of these have focused solely on old and disabled patients. The aim of the present study was to examine the test-retest reliability of muscle strength measurements including several strength variables of the lower limbs assessed by the Cybex 6000 dynamometer in elderly women after recent hip fracture.

MATERIAL AND METHODS

Subjects
Twenty women hospitalized at the Copenhagen Municipal Hospital for rehabilitation following a recent fracture of their hip were studied. Age ranged from 68 to 88 years (median 78), weight from 40 to 80 kg (median 60) and height from 146 to 175 cm (median 160). Time since the hip operation ranged from 14 to 30 days (median 18). At discharge the length of the hospital stay ranged from 21 to 42 days (median 30 days). All patients were discharged to their previous homes.

Only women who had not experienced any complications following the operation were included. Furthermore, only women with previous normal walking ability, who had no complaints of knee joint or ankle pain, who were able to sit, stand and walk independently for at least 90% of the distance, and who were able to follow instructions were included in the study. No change in medication was allowed during the test period. At the time of the examination, 15 women were monitored with scales and three volunteers completed the study. The subjects had no experience with muscle strength testing.

Informed consent according to the Helsinki II Declaration was obtained from all subjects. The protocol was approved by the local ethics committee.

Muscle strength measurements
Muscle strength expressed as peak torque in Newton meters (Nm), total work in Joule (J) and power in Watts was assessed by the isokinetic dynamometer Cybex 6000 (10). Isokinetic knee extensor and flexor strength (peak torque, total work and power) were recorded at velocities of 30 and 120°/second. Isometric knee extensor and flexor peak torque was measured with the knee flexed 75°.

Strength measurements were done four times on separate days, at the same time of day, within one week the same experienced examiner (OF Madisen). Positioning of the subjects was standardized. Hip position was maintained at 90° of flexion, and a shoulder and leg stabilisation belt was applied for each subject. A high strap stabilized the leg. The mechanical axis of rotation of the dynamometer lever arm was aligned to the axis of rotation of the knee. The resistance pad at the end of the lever arm was adjusted to the most distant point of the anterior iliacs that would allow full knee flexion of the subject. The contralateral limb was tucked behind a stabilizer to prevent unwanted movements. The subject held on to the handgrip on the side of the chair. Correction for the effect of gravity was performed. On the first test day the exact positions of the adjustable seat back tilt, the seat back, the sideways, the dynamometer height and the

Table I. Number of hip fracture patients who were able to produce measurable torques on the first test day and on all four test days, respectively

<table>
<thead>
<tr>
<th>Torque</th>
<th>Non-involved leg</th>
<th>Involved leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric</td>
<td>n</td>
<td>Median (range)</td>
</tr>
<tr>
<td>30°/sec</td>
<td>20</td>
<td>19-18</td>
</tr>
<tr>
<td>120°/sec</td>
<td>20</td>
<td>19-18</td>
</tr>
<tr>
<td>Total work</td>
<td>20</td>
<td>19-18</td>
</tr>
<tr>
<td>Power (watts)</td>
<td>30</td>
<td>19-18</td>
</tr>
<tr>
<td>30°/sec</td>
<td>20</td>
<td>19-18</td>
</tr>
<tr>
<td>120°/sec</td>
<td>20</td>
<td>19-18</td>
</tr>
</tbody>
</table>

The Wilcoxon signed rank test.

RESULTS

The dynamometer calibration measurements remained stable during the study. All values recorded during the calibration procedures were within the manufacturer's specified ranges for strength measurements (19). Table 1 shows the number of women who were able to perform the different tests. One patient was not able to stretch out her knee with the lever arm attached to the involved leg from which no data were collected. Another patient completed the first three test days but due to acute pain in the groin of the involved leg, only muscle strength of the non-involved leg was measured on the last day. Clinical examination and radiology

Scand J Rehab Med 27

O. R. Madisen & U. B. Lauridsen

Scand J Rehab Med 27
measurements has been published (3). The study sample comprised young subjects. Studies of the reliability of both isokinetic dynamometers have been performed (13, 15, 16, 18, 30), but none of these have focused solely on old and disabled patients. The aim of the present study was to examine the test-retest reliability of muscle strength measurements including several strength variables of the lower limbs assessed by the Cybex 6000 dynamometer in elderly women after recent hip fracture.

MATERIAL AND METHODS

Subjects

Twenty women hospitalized at the Copenhagen Municipal Hospital for rehabilitation following a recent fracture of their hip were studied. Age ranged from 64 to 88 years (median 78), weight from 40 to 80 kg (median 60) and height from 148 to 176 cm (median 160). Time since the hip operation ranged from 14 to 30 days (median 18). At discharge the length of the hospital stay ranged from 21 to 42 days (median 30). All patients were discharged to their previous homes.

Only women who had not experienced any complications following the operation were included. Furthermore, only women with previous normal walking ability, who had no complaints of knee joint or anesthetic pain, who were able to sit on a chair and who were 50% or less of their preinjury level and who were able to follow instructions were included in the study. No changes in medications were allowed during the test period. At the time of the examination, 15 women were mobilized with sticks and one with a walker. The subjects had no experience with muscle strength testing.

Informed consent according to the Helsinki II Declaration was obtained from all subjects. The protocol was approved by the local ethics committees.

Muscle strength measurements

Muscle strength expressed as peak torque in Newton meters (Nm), total work in Joule (J) and power in Watts was assessed by the isokinetic dynamometer Cybex 6000 (10). Isokinetic knee extensor and flexor strength (peak torque, total work and power) were recorded at velocities of 30° and 120°/second. Isometric knee extensor and flexor peak torque was measured with the knee flexed 75°.

Strength measurements were done four times on separate days, at the same time of day, within one week by the same experienced examiner (OR Madshen). Positioning of the subjects was standardized. Hip position was maintained at 90° of flexion, and a shoulder and hip stabilization belt was applied for each subject. A high strap stabilized the test leg. The mechanical axis of rotation of the dynamometer lever arm was aligned to the axis of rotation of the knee. The resistance pad at the end of the lever arm was strapped to the most distal point of the anterior iliac in line with the elbow. The contralateral limb was tucked behind a stabilizer to prevent unwanted movements. The subject held on to the handles on either side of the chair. Correction for the effect of gravity was performed. On the first test day the exact positions of the adjustable seat back tilt, the seat back, the patellar, the dynamometer height and the resistance pad were noted for each subject. On the following test days exactly the same positions were used. To obtain comparable data on peak torque, work and power range of motion was maintained as a window of 8° to 90°.

Strength was measured in both legs, separately. The non-involved leg was measured first. Each subject was tested in the same order, beginning with isokinetic strength measurements followed by measurements of isometric strength. The subjects were verbally encouraged during the tests. For peak velocity and isometric strength, the subject was given one submaximal trial to acquaint her with the test conditions. The subject was then allowed to rest for 30 seconds. The test consisted of three maximal repetitions recorded as data with rest intervals of 20 seconds. The highest values of peak torque, work and power were selected for analysis. Sixty seconds rest between testing at each angular velocity was allowed.

The isokinetic dynamometer was calibrated once a month according to the manufacturer's manual (10).

Statistics

For each strength variable in each patient, the reliability between repeated measurements was expressed as the coefficient of variation in % (CV = 100 x standard deviation/mean). Comparisons of several items were performed by the Friedman's two-way analysis of variance. Paired items were compared by the Wilcoxon signed rank test. Correlations between variables were assessed by Spearman's rank correlation test.

When correlating strength with age, hip height and weight, torque was expressed as the mean value of isometric torque and isokinetic torque at 30° and 120° per second. Total work and power were expressed as the mean value of total work and power, respectively, at the two velocities. This procedure was chosen to reduce the number of correlation analyses.

Multiple stepwise regression analyses were used to examine the influence of age and body weight on the correlations between paired observations of torque, total work and power. Before running these analyses all variables were normalized by a logarithmic transformation (2). Unless a p-value of 0.05 or less was noted, two tailed p-values of 0.01 or less were considered statistically significant. The software package SPSS Statistics V. 4.0 (SPSS International BV, Chicago, USA) was used for the statistical analyses (35).

RESULTS

The dynamometer calibration measurements remained stable during the study. All values recorded during the calibration procedures were within the manufacturer's specified ranges for strength measurements (10).

Table 1 shows the number of women who were able to perform the different tests. One patient was not able to stretch out her knee with the lever arm attached to the involved leg from which no data were collected. Another patient completed the first three test days but due to acute pain in the groin of the involved leg, only muscle strength of the non-involved leg was measured on the last day. Clinical examination and radiology

| Knee extensor and flexor strength in elderly women after recent hip fracture |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| | Non-involved leg | Involved leg | Non-involved leg | Involved leg |
| | Knee flexion | n=18/2 ** | n=18/2 ** | n=18/2 ** | n=18/2 ** |
| **n** = number of patients who were able to produce torque on the first test day. |
| *n* = number of patients who were able to produce torque on all four test days. |
no significant differences in any strength variable between day 1 and any of the following days.

Precision errors, expressed as CVs, for those women who were able to produce measurable torque on all four test days are presented in Table V. All measurements were characterized by large median CVs and by substantial variability between individual CVs, e.g. the range and 30% central range of CVs for extensor strength of the non-involved leg measured at 30°/second was 1.14–18.32% and 2.50–10.15%, respectively. Only extensor peak torque and total work at 30°/second of the non-involved were characterized by median CVs lower than 7%.

When comparing CVs of power, total work and peak torque measurements, power measurements had significantly higher CVs for both the non-involved and the involved leg. Flexor strength measurements had significantly higher CVs than extensor strength measurements. CVs of strength measurements of the involved leg were general significantly higher than those of the non-involved leg. A tendency toward a negative relationship between magnitude of strength and CVs was also found, although this relationship was not statistically significant.

**DISCUSSION**

A high incidence of falls after hospital discharge has been reported for patients who are functionally dependent [20] and fall characteristics have been shown to be important risk factors of hip fracture (17). Although a combination of factors such as body sway, coordination, vision, orthostatic hypotension and pain may be important predictors of falls in elderly people, quadriceps strength has been documented to be strongly associated with walking speed (6) and risk of falling (23, 38) and to be an independent and powerful predictor of fracture incidence (24, 33). Moreover, as the risk of a second hip fracture is increased six times compared to the risk of the first one (36), it seems reasonable to assume that muscle strengthening exercises in the rehabilitation of these patients is of major importance.

With the exception of a single study (41), previous studies of the relationship between muscle strength and falls or walking ability have, to our knowledge, focused solely on isometric extensor strength (4, 6, 7). From a theoretical point of view, adequate knee extensor and flexor strength at higher speeds may be an important factor in protecting against falls. This is in agreement with the findings of Whipple et al. (41), who found that the ability to develop knee and ankle extensor and flexor torque at higher limb velocities (120°/second) compared with low velocities (60°/second) were significantly more affected in fallers than in non-fallers. Accordingly, we found the measurements of knee and flexor strength at both low and high velocities to be of relevance.

In conclusion, no previous studies on muscle strength in subjects with a recent hip fracture exist. We found a 50% reduction in muscle strength of the involved leg two to four weeks after hip surgery. This weakness may be caused by several factors including pain, reflex inhibition, central factors and/or muscle atrophy (11, 38).

Table IV. Correlations (Ri) between isokinetic torque, total work and power at the velocities 30° and 120°/second of the knee extensors of the non-involved leg in 20 women two to four weeks after hip fracture operation

<table>
<thead>
<tr>
<th>Isokinetic</th>
<th>Torque</th>
<th>Total work</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°/second</td>
<td>1.00</td>
<td>0.97</td>
<td>0.96</td>
</tr>
<tr>
<td>60°/second</td>
<td>1.00</td>
<td>0.89</td>
<td>0.85</td>
</tr>
<tr>
<td>Total work</td>
<td>0.98</td>
<td>0.81</td>
<td>0.75</td>
</tr>
<tr>
<td>Power (watts)</td>
<td>0.97</td>
<td>0.86</td>
<td>0.72</td>
</tr>
</tbody>
</table>

* Using Spearman’s correlation test, all correlations were significant with p-values less than 0.0001.
no significant differences in any strength variable between day 1 and any of the following days.

Precision errors, expressed as CVs, for those women who were able to produce measurable torque on all four test days are presented in Table V. All measurements were characterized by large median CVs and by substantial variability between individual CVs, e.g. the range and 30% central range of CVs for extensor strength of the non-involved leg measured at 30°/second was 1.14–18.32% and 2.50–10.15%, respectively. Only extensor peak torque and total work at 30°/second of the non-involved leg were characterized by median CVs lower than 7%.

When comparing CVs of power, total work and peak torque measurements, power measurements had significantly higher CVs for both the non-involved and the involved leg. Flexor strength measurements had significantly higher CVs than extensor strength measurements. CVs of strength measurements of the involved leg were generally significantly higher than those of the non-involved leg. A tendency toward a negative relationship between magnitude of strength and CVs was also found, although this relationship was not statistically significant.

**DISCUSSION**

A high incidence of falls after hospital discharge has been reported for patients who are functionally dependent (26) and full characteristics have been shown to be important risk factors of hip fracture.

Table IV. Correlations (Rj) between isokinetic torque, total work and power at the velocities 30° and 120°/second of the knee extensors of the non-involved leg in 20 women two to four weeks after hip fracture operation

<table>
<thead>
<tr>
<th>Torque (Nm)</th>
<th>Median (range)</th>
<th>Total work</th>
<th>Power (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iso-</td>
<td>30°/sec</td>
<td>120°/sec</td>
<td></td>
</tr>
<tr>
<td>Torque (Nm)</td>
<td>0.79</td>
<td>0.81</td>
<td>0.80</td>
</tr>
<tr>
<td>Total work</td>
<td>0.78</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>Power (watts)</td>
<td>0.81</td>
<td>0.80</td>
<td>0.67</td>
</tr>
</tbody>
</table>

* Using Spearman’s correlation test, all correlations were significant with p-values less than 0.0001.

(17). Although a combination of factors such as body sway, coordination, vision, orthostatic hypotension and pain may be important predictors of falls in elderly people, quadriiceps strength has been documented to be strongly associated with walking speed (6) and risk of falling (23, 38) and to be an independent and powerful predictor of fracture incidence (24, 33). Moreover, as the risk of a second hip fracture is increased six times compared to the risk of the first one (36), it seems reasonable to assume that muscle strengthening exercises in the rehabilitation of these patients is of major importance.

With the exception of a single study (41), previous studies of the relationship between muscle strength and falls or walking ability have, to our knowledge, focused solely on isometric extensor strength (4, 6, 7). From a theoretical point of view, adequate knee extensor and flexor strength at higher speeds may be an important factor in protecting against falls. This is in agreement with the findings of Whitfield et al. (41), who found that the ability to develop knee and ankle extensor and flexor torque at higher limb velocities (120°/second) compared with low velocities (60°/second) were significantly more affected in fallers than in non-fallers. Accordingly, we found the measurements of knee and flexor strength at both low and high velocities to be of relevance.

No previous studies on muscle strength in subjects with a recent hip fracture exist. We found a 50% reduction in muscle strength of the involved leg two to four weeks after hip surgery. This weakness may be caused by several factors including pain, reflex inhibition, central factors and/or muscle atrophy (11, 38). Pain and reflex inhibition prevent full voluntary activation of muscles and may directly contribute to atrophy and weakness of affected muscle groups, thereby undermining effective rehabilitation.

During flexion, half of the women were not able to accelerate the involved leg to 120° per second making measurements of strength impossible. Although the clinical significance of this finding is unclear it does suggest that a high testing velocity reveals flexor strength deficits better than slower velocities.

Most of the previous studies on the reliability of muscle strength measurements have expressed reliability as coefficients of correlation. However, as shown by Altman & Bland (1, 2) the correlation coefficient between repeated measurements reflects the strength between the measures and not the agreement between them. They concluded that the correlation coefficient is inappropriate and misleading in studies of reliability. Furthermore, in the present study muscle strength correlated to age and body weight, making the use of correlations in the assessment of reliability even more problematic. Consequently, we chose to express reliability as CVs.

The reproducibility of isokinetic strength measurement has previously been studied in young women (3, 27).
to investigate the technical reliability and validity of the isokinetic devices (5, 12, 34). The Kincom, the Lido and the Cybex II system have been shown to be technically reliable and valid for some measurements (5, 12, 34), but the Cybex 6000 dynamometer has not yet shown reliability. Although the results of the calibration procedures in this study indicate that the Cybex 6000 system is valid for measuring outputs by known calibration weights, methodological studies of the technical reliability and validity of this new isokinetic device should be performed.

In conclusion, muscle strength of the involved leg in women with a fracture of the hip was substantially reduced two to four weeks after surgery. Pain and/or reflex inhibition may be the main reason for this finding, although the possibility of subsequent muscle atrophy cannot be excluded. Therefore, in these patients, studies of changes in strength over longer periods of time may be of interest, especially with respect to falling and thereby the risk of rehospitalization with or without new fractures. Although muscle strength measurement may be applicable when comparing groups of hip fracture patients, the large CVs may limit the use of muscle strength measurements in the individual patient.

ACKNOWLEDGEMENT

This work was supported by the 100 Years Anniversary Fund of the Copenhagen Municipal Hospital.

REFERENCES


to investigate the technical reliability and validity of the isokinetic devices (5, 12, 34). The Kincom, the Lido and the Cybex II system have been shown to be technically reliable and valid for some measurements (5, 12, 34), but the Cybex 6000 dynamometer has not yet been evaluated. Although the results of the calibration procedures in this study indicate that the Cybex 6000 system is valid for measuring outputs by known calibration weights, methodological studies of the technical reliability and validity of this new isokinetic device should be performed.

In conclusion, muscle strength of the involved leg in women with a fracture of the hip was substantially reduced only two to four weeks after surgery. Pain and/or reflex inhibition may be the main reason for this finding, although the possibility of subsequent muscle atrophy cannot be excluded. Therefore, in these patients, studies of changes in strength over longer periods of time may be of interest, especially with respect to falling and thereby the risk of rehospitalization with or without new fractures. Although muscle strength measurement may be applicable when comparing groups of hip fracture patients, the large CVs may limit the use of muscle strength measurements in the individual patient.

ACKNOWLEDGEMENT
This work was supported by the 100 Years Anniversary Fund of the Copenhagen Municipal Hospital.

REFERENCES
ABSTRACT. The incidence of hip fractures has increased over the past decades, and for patients with hip fractures, medical and social conditions have deteriorated during the same time. In this study the results of orthopaedic rehabilitation of patients with Parkinson's disease and a hip fracture are compared with those in all other hip fracture patients. A total of 74 patients with Parkinson's disease and hip fracture were compared with 1,961 patients without the disease. Prior to fracture, patients with Parkinson's disease were less likely to be living an independent life in their own homes. Postoperatively, women with Parkinson's disease were hospitalized for a significantly longer period. Postoperative rehabilitation was significantly slower and less successful than among patients without the disease. Patients with Parkinson's disease comprise a subgroup of hip fracture patients who need more rehabilitation resources than can easily be provided at an ordinary orthopedic ward. A team-work between an orthopaedic surgeon, a neurologist and a rehabilitation unit seems to be mandatory in order to achieve shorter hospitalization and earlier return to the pre-fracture environment.

Key words: hip fracture, Parkinson's disease, postoperative rehabilitation.

INTRODUCTION

The age-specific incidence of hip fractures has increased in the city of Malmo during the past 30 years (9). Similar observations have been reported from other West European cities (3, 7, 16, 18). In order to meet the increasing demands for hospital beds for the treatment of hip fractures there has been a tendency towards shortening the period of hospitalization after a hip fracture (8). It has, therefore, become more important to identify those patients for whom prolonged hospitalization is anticipated and for whom more intensive rehabilitation is needed.

Compared with age- and sex-matched controls, concomitant diseases such as Parkinson's disease are more common in hip fracture patients (6, 10). Parkinson's disease as a pre-fracture condition has increased during the past decades in the city of Malmo (15). Since Parkinson's disease reduces the mobility of the patient it can be anticipated that the post-fracture care of affected patients may be adversely affected. The purpose of this study was to analyse and compare the rehabilitation of hip fracture patients with and without Parkinson's disease.

MATERIAL AND METHOD

From 1982 to 1985 a total of 1429 patients with hip fracture were studied prospectively. Seventy-five (5.7%) of the patients had the diagnosis M. Parkinson on admission (Table II). The diagnosis had been made by other physicians before the fracture. All other patients with a hip fracture were used as controls and were compared with the patients with Parkinson's disease.

Social and various background factors were registered before and after the fracture, as well as the fate of the patient and the progress of rehabilitation after the fracture (Table II).

Postoperatively, all patients were treated at the same orthopaedic department and according to the same routines. The daily care was provided by specialists in orthopaedic surgery, with consultations by neurologists or geriatricians on demand.

Since no significant difference in the prevalence of Parkinson's disease have been found between osteoporotic and cervical fractures in Malmo (10), the results were not divided according to fracture type, in order to avoid further distribution of the limited number of patients with Parkinson's disease into smaller subgroups. All patients were followed up for at least 1 year, with cervical hip fracture followed by clinical examinations and radiography for 2 years.

The percentage of uncertain or missing answers was less than 2%, except for age and mental status, 6% each. Most of the uncertain variables were in patients admitted from nursing homes and geriatric hospitals.

Statistics

Statistical analysis was done using the odds ratio of probability of the variables for patients with Parkinson's disease.