1991

Relationship between stage and strength for people with Parkinson's Disease

Robert D. Austin
San Jose State University

Order Number 1344236

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Austin, Robert Daniel, M.A.

San Jose State University, 1991

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

Relationship Between Stage and Strength for People with Parkinson's Disease

A Thesis

Presented to the

Faculty of the Department of

Human Performance

San José State University

In Partial Fulfillment of the

Requirement for the Degree

Master of Arts

by

Robert D. Austin

May 1991

APPROVED FOR THE DEPARTMENT OF HUMAN PERFORMANCE

Dr. Bethany Shifflett, Committee Chair

B. Shifflett

Dr. Carol Christensen

C. Christensen

Guy McCormack, OT

Guy L. McCormack

APPROVED FOR THE UNIVERSITY

Dr. Serena Stanford

Serena Stanford

ABSTRACT

RELATIONSHIP BETWEEN STAGE AND STRENGTH FOR PEOPLE WITH PARKINSON'S DISEASE

by Robert D. Austin

This thesis examined the relationship of stage and strength using the Cybex isokinetic dynamometer for major muscle groups bilaterally about the elbows and the knees. Thirty three Parkinson's disease patients between 51 and 70 years of age participated.

Affected muscle groups were compared to the unaffected muscle groups to study how the disease affected strength. Affected and unaffected muscle groups were compared by stage separately. A slight trend in decreased strength across all stages was present for the affected side and for the unaffected side.

Too few subjects participated in the study to make any statistical conclusions about the hypothesis: stage of Parkinson's Disease is related to foot pounds of torque as measured bilaterally in the major muscle groups. The results suggested that the affected side was weaker than the non affected side. Strength decreased as stage increases.

ACKNOWLEDGEMENTS

This study investigated the relationship of strength to the stages of Parkinson's Disease. The study was not only meant to assess this relationship, but to encourage its subjects and all people with Parkinson's disease to exercise habitually. I hope this thesis is of help to Physical Educators and Health Professionals in any discipline who work with people who have Parkinson's Disease. I also hope that based on the data in this study, a better and more useful study can be implemented.

I want to thank Mom and Libo, Shari and Dan, Bruce and all the friends who encouraged and helped me throughout this endeavor. I also want to thank the staff at the California Parkinson Foundation, and the Board of Directors of the Peninsula Parkinson Support Group. I want to thank Maxine D. and Bob F.for thier inspiration. Thanks to my dad for his wise words.

The duration of this study endured not only a number of part-time jobs, but a trip to the Soviet Union where I met my wife, Natasha. Without her, I would never have finished this thesis. She was my prime inspiration. She will always be the love in my life.

A special word of appreciation to my committee, without whom I would not have turned out as good a paper as this is. I want to thank Guy for never hanging up first, Carol for the good advice and confidence in me, and much appreciation for all of Bethany's many constructive critiques. I sincerely thank you all.

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Chapter I

Introduction

Parkinson's disease, first described by James Parkinson in 1817 (Duvoisin, 1986), is a progressive neurological disease of unknown cause. It is characterized by four cardinal signs: bradykinesia, postural instability, rigidity, and, in most cases, a resting tremor. The United States has approximately one half million patients with Parkinson's disease (National Institutes of Health Publication 88-2957, January 1989). While research is being conducted to find a cure, the symptoms have become less debilitating through use of certain medications, especially levadopa. Drug therapy helps the body to move according to will but can cause dyskinesia and cognitive problems (Fahn & Calne, 1978) and other limiting side effects (LeWitt, 1988).

To measure the degree of severity of Parkinson's disease, Hoehn and Yahr (1967) created five categories, listed in Table 1. Although not free from limitations, this system is probably the most widely cited scale of the disease because of its simplicity (Diamond & Markham, 1983).

Table 1

Hoehn and Yahr Stages of Parkinson's Disease.

Stage I.	Unilateral involvement only, usually with minimal or no functional impairment.
Stage II.	Bilateral involvement or midline involvement without impairment of balance.
Stage III.	First sign of impaired righting reflexes. This is evident by unsteadiness as the patient turns or is demonstrated when pushed from standing equilibrium with the feet together and the eyes closed.
Stage IV.	Fully developed, severely disabled; the patient is still able to walk and stand unassisted but is markedly incapacitated.
Stage V.	Confinement to bed or wheelchair unless assisted.

Statement of the Problem

Parkinson's disease does not cause muscle weakness according to Dr. James Tetrud of the California Parkinson Foundation (CPF). He stated that based upon his personal clinical observations: (a) the Parkinson patient does not show signs of muscle weakness as a result of the disease, and (b) weakness occurs as a result of disuse, not as a result of the disease itself (Personal interview, July 18th, 1988). Wroe and Greer (1973, p. 850) state that clinically, the Parkinson patient is "immobile but not weak." Koller and Kase (1986) noted that weakness was a primary symptom of Parkinson's disease when evaluated isokinetically. Koller and Kase found that even when patients complained of muscle weakness, manual muscle testing revealed normal strength. Hand grip strength, as measured by a hand grip dynamometer, was slightly weaker on the affected limb of unilateral-parkinsonians (Parkinson's patients in the first stage of the disease). Muscle weakness may not be a distinct manifestation of the disease per se, but may be secondary to the immobility.

Furthermore, it is of concern to the adapted physical educator, to know at what stage of the disease strength begins to decline and at what stage the motor

decline accelerates. This could help identify at what stage of Parkinson's disease an exercise class should begin; in addition it may help in implementing an appropriate exercise program specifically for the Parkinson student in adult adapted physical education.

Knowledge of the five categorical stages of Parkinson's disease and their relationship to programs of exercise therapy may have an important economic impact. Specifically, Title V for the California Community Colleges limits the number of times any person can repeat any class for credit. Since July 1, 1988, a person can repeat a class six times. However, a person should be especially encouraged to begin participation in an exercise program before the permanent disabling effects of the disease set in, since there are a limited number of times a person can repeat the course.

Purpose of the Study

The purpose of this study was to assess idiopathic (cause unknown) Parkinson's disease patients in all five stages of the Hoehn and Yahr scale while performing knee flexion, knee extension, elbow flexion and elbow extension on a Cybex II machine. This was done to assess the relationship between strength of the affected and unaffected muscles and stage of the disease.

Research Hypothesis

A significant relationship between the stage of the disease and strength in flexors and extensors about each knee and elbow joint as measured by the Cybex II machine will be found among patients with idiopathic Parkinson's disease.

Delimitations

The delimitations of this study included: Parkinson's patients who gave informed consent to participate and whose pharmacological treatments were stable; patients with idiopathic Parkinson's disease who had their doctor's approval to participate; otherwise healthy male and female subjects in their sixth and seventh decade of life (as noted in the physician's approval form of Appendix C); and isokinetic strength assessed using the Cybex II.

Limitations

The study may have been limited if:

1. Any subject experienced motor fluctuations which resulted in the motoric "off" phase during the strength assessments. (See motoric fluctuations under definition of terms.)
2. Any subject was misdiagnosed during the initial assessment of the disease.

3. Subjects did not perform to the best of their ability.

Assumptions

The researcher assumed that:

1. Subjects did follow the protocol and did not perform stretching exercises beyond their normal range of motion prior to the evaluation.
2. Each subject performed at his/her best ability during the assessments.
3. Investigator's rating's of the stage of disease were accurate.

Definition of Terms

The following terms were used in this study and are defined for better understanding of the present study.

Affected Side. The affected side was the more impaired side for stages two through five, the bilateral stages. In stage one, by strict definition, one side is affected and the other unaffected.

Activities of Daily Living (ADL). Activities which are normally carried out in everyday life by the subject such as personal hygeine, grooming, dressing, and eating (Mosbey, 1981).

Bradykinesia. Slowness and poverty of movement which is independent of rigidity (Lieberman, 1974).

Dopamine. A neurotransmitter produced in the substantia nigra (a part of the basal ganglia). According to Mouradian, Juncos, Serrati, Fabbrini, Palmeri, and Chase (1987), the role of dopamine released in the striatum is the continuous inhibition of the release of acetylcholine from the cholinergic interneurons of the caudate nucleus. It is thus, used for the initiation and monitoring of motor planning and coordination.

Dyskinesia. Rapid involuntary movements associated with too much anti-Parkinson medication at one time.

Dystonia. A pathologic condition in which antagonistic muscles of both flexors and extensors contract simultaneously during an attempt of movement (Cooper, 1976).

Idiopathic disease. A disease for which the cause is unknown.

Isotonic contraction. "A muscle contraction in which the resistance remains at a constant level throughout the range of motion, but the rate can change" (Thistle, Hislop, Moffroid, & Lowman, 1967, p. 279).

Isokinetic exercise. When exercise rate remains constant and the applied force is intrinsically matched by the exercise device at each point in the range of

motion (Moffroid, Whipple, Hofkosh, Lowman, & Thistle, 1969).

Motor fluctuations. This refers to a state when neurotransmitters are depleted and the medications are in an "off" or "on" phase. Medications have a peak effect on motor performance. But there are times, day to day, hour to hour, or even minute to minute, when some patients cannot move purposefully. The "off" phase refers to the period when medications have lost their efficacy and the body lacks a sufficient level or balance of neurotransmitters to carry out motoric commands. "The term 'motor fluctuation' refers to the transition from one phase to the other" (Marsden, 1982, pp. 520-21). It is during the "off phase" of this period that initiation of movement is most difficult.

Range of Motion. For the purposes of this study, range of motion (ROM) is defined as the amount of unassisted movement throughout the joint.

Resting Tremor. This symptom involves trembling or shaking at approximately three to twelve cycles per second; it is one of the four cardinal features of Parkinson's disease (Lieberman, 1974).

Rigidity. When increased tone of the muscles is equal in both the flexors and extensors (Lieberman,

1974); it is one of the four cardinal features of Parkinson's disease.

Strength. "The maximum contraction of muscle fibers that can be recruited in a muscle group" (Hislop & Perrine, 1967, p. 114). In this study strength was measured in terms of foot pounds of torque, which is a measure of the force that the contracting muscle can generate.

Torque. "The product of force which acts about an axis of rotation times its perpendicular distance from the axis of rotation" (Moffroid et al., 1969, p. 735).

Unaffected side. In stages two through five it is the side of the body which is least impaired. In stage one, by strict definition, one side is affected and the other unaffected.

Summary

Parkinson's disease is diagnosed through observation of any combination of four cardinal signs; bradykinesia, rigidity, resting tremor, and impairment of postural reflexes. Some researchers have found that with manual muscle testing, strength does not decrease in Parkinson's disease patients when compared to peers. Others have found that strength in the first two stages of the disease was less than non-Parkinson's peers. It

is of interest to adapted physical educators what the relationship is between strength and stage of disease. If stage was related to strength then the rating of stage could facilitate creating an individual exercise plan as well as assess progress.

The present study attempted to investigate the relationship between stage of Parkinon's disease and isokinetic strength using an isokinetic dynamometer at 90°/second. Muscles tested included the biceps, triceps, quadriceps, and hamstrings.

Chapter II

Review of Literature

This chapter will discuss the clinical and neurological description of Parkinson's disease, two rating scales of the disease, medical management, aging and exercise of Parkinson's patients, and general exercises.

The literature review did not reveal a study that provided quantitative data to show if there was decreased strength (as measured in foot pounds of torque) associated with all five stages of Parkinson's disease, and if so, at what stage did strength decrease significantly.

Parkinson's Disease Review

Definition of Parkinson's Disease

The symptoms of Parkinson's disease result from a dopamine deficiency in the striatum of the basal ganglia (Calne & Stoess, 1986). The disease attacks dopamine-producing cells of the substantia nigra, which affects pathways that are used as neurotransmitters for motor coordination. The disease is diagnosed based on the manifestation of four clinical symptoms which are considered cardinal to Parkinson's disease: tremor, rigidity, bradykinesia, and postural instability (Lang &

Fahn, 1989; Duvoisin, 1986; Fahn & Calne, 1978). The tremor is usually present in one of the upper limbs and may spread to other parts of the body (Lieberman, 1974).

Rigidity is found mostly in the muscles of the shoulder, trunk, neck, and arms (Webster, 1986; Lieberman, 1974). Throughout the passive range of motion, there is an equal plastic resistance in both agonist and antagonistic groups. Lieberman thoerized that rigidity in the muscles results from impairment of two areas of brain motor pathways that may be functionally affected; they are the globus pallidus and the putamen. Together they form the lenticular nucleus which receives and sends information from the substantia nigra. Lieberman cited Martin's study (1967) on the possible cause of the overactivity of the gamma efferent motor neurons, which regulate tone via the muscle spindles. Martin (1967) theorized that the gamma efferent motor neurons were controlled by the globus pallidus of the basal ganglia. If the putamen, which normally inhibits the globus pallidus, is functionally inactive, then the disinhibited globus pallidus may continuously release neuro-transmitters in the thalamus. This release, combined with overactivity of the gamma efferent neurons present in the muscle spindles, may be

the cause of rigidity. It is plausible that without the continued inhibition of dopamine or noradrenalin, enhanced discharge of excitatory noradrenergic neurons would cause increased muscle tone via the gamma efferent neurons.

Bradykinesia is primarily manifest in the impairment of ballistic movements (Marsden, 1982). Ballistic movement can be described as a result of a series of activated preprogrammed motor pathways. Fast ballistic movements are generated by a short burst of activity of fixed length in an agonist. It can be considered a reflex to a certain stimulus in which the limb is set in motion in a direction so fast that the preprogrammed series of movements are carried out before any feedback can be used. This type of movement is termed the "open loop mode." The opposite type of movement is termed the "closed loop mode" and is characterized by a constant monitoring of movement during the programmed motor pattern throughout the motion. Depending on the motor area in the brain being affected by the depletion of dopamine, the patient's ability to demonstrate both ballistic movement and spontaneous gestures may become impaired. In practical terms, the patient may be slow to initiate movement, but

will make use of the "closed loop" system to monitor movement, firing all the muscles for the needed motor sequence. One example of this condition is often seen in facial muscles which present a masked-like appearance.

The fourth clinical element for diagnosis is postural instability or diminished righting reflexes. This element is not consistently mentioned in the literature as a criterion for the diagnosis of Parkinson's disease. It refers to the inability to maintain an erect posture for long periods of time, resulting in loss of balance or stooped posture (Bloem, et al., 1989). Martin (1967) theorized that this inability was due to dysfunction of the brain's center for righting reflexes - the globus pallidus - to process kinesthetic, labyrinthine (information from the inner ear), and visual information.

As the disease progresses, activities of daily living (ADL) become more difficult resulting from motor deficits in the brain; Langston (1987) suggests that a daily exercise program involving balance, aerobic capacity, range of motion, and strength endurance is probably the best therapy to maintain independence and a positive self image.

Additional clinical signs and symptoms of the disease can include depression, drooling, difficulty swallowing, constipation, breathing problems, kyphosis (increased curve of the thoracic spine), speech problems, infrequent blinking, tendency to remain still for long lengths of time, slight flexion of fingers, difficulty performing two tasks simultaneously, and impaired convergence of eye muscles (Marsden, 1982).

Rating Scales

Various scales have been used to assess the severity of Parkinson's disease (Lang & Fahn, 1989). The first categorical scale was developed by Hoehn and Yahr (1967). It was easy to use, but lacked sensitivity to smaller changes resulting from medications and/or motoric fluctuations. Other scales have been developed to observe the minor fluctuations resulting from the disease and its medications (Marsden & Schacter, 1981; Ward, Sanes & Dambrosia, 1983).

In 1984, a group of investigators met to adapt the Unified Parkinson's Disease Rating Scale (UPDRS) using five points (0-to-4) for signs and symptoms of Parkinson's disease. The system uses both the Hoehn and Yahr scale and the Schwab-England ADL (activities of daily living) to observe the global (all aspects of the

disease with and without medications) severity of the disease allowing for observation of the slight changes resulting from treatment. The administration of the complete test takes several hours. Most often, only portions are used in a Parkinson's disease clinic dpending on the area of a clinician's specialty.

The UPDRS allows all clinicians for Parkinson's disease a common base of assessment. For example a speech therapist would rate the patient on speech, an occupational therapist would evaluate activities of daily living and the neulogist would evaluate the patients motor ability. The scores would be combined for an average somewhere on a scale of 0 to 4. Using this scale to assess a new or updated treatment allows the primary physician to analyze the treatment's overall effectiveness. Given the example, perhaps the medication improved the speech but not the motor control of the dominate hand. The UPDRS allows the neurologist a more knowledgeable assessment of a Parkinson's disease patient's condition than just one of the other mentioned scales for Parkinson's disease.

Drug Therapy

Management of new drugs and combinations of drugs for Parkinsonians has helped to make treatment more

effective in everyday functional activities. According to LeWitt (1988) there are five treatment approaches: a) increase the endogenous neurotransmitter with levodopa (L-dopa) which is a precursor of dopamine; b) utilize artificial dopaminomimetic agonists such as bromocriptine and other ergot derivatives which stimulate dopamine reception; c) alter the way the brain oxidizes the dopamine with a monoamine oxidase inhibitor to allow dopamine to be used longer; d) alter the balance of the neurotransmitter actions with anticholinergic agents; or e) alter the dopamine receptor function by taking a periodic drug holiday (cessation of drug use to cleanse body of all drugs).

The most popular strategy for lessening the symptoms has been the use of Sinemet, a combination of L-dopa and Carbidopa (Lieberman, 1974). This precursor drug is used in contrast to dopamine itself. This is because L-dopa can cross the blood brain barrier where it is converted into dopamine. The long term side effects of L-dopa include dyskinesias and motor fluctuations between "on" and "off" periods (LeWitt, 1988). The trial and error task of balancing neurotransmitters so that the patient maintains maximum "normal independence" is a delicate and continuous task

for both patient and physician.

The "on-off" motoric fluctuations in response to the use of L-dopa have been studied and attempts to curtail the "wearing off" phases have been made. The primary problem results from the brain's decreased sensitivity to L-dopa, hence the dosage of L-dopa needs to be increased. Dopamine agonists such as bromocriptine (Lang, 1987) or monoamine oxidase inhibitors like deprenyl (Calne & Stoess, 1986; LeWitt, 1988) help to keep the actual dose of L-dopa as low as possible and these drugs may be used in conjunction with L-dopa.

Ageing, Exercise and Parkinson's Disease

Larsson and Karlson (1977) demonstrated that isometric and dynamic muscle strength declines from 22 to 65 years of age based on muscle biopsies taken from fifty healthy men. An overview offered by Rondot, Bianco, and de Recondo (1986), of over 400 patients with Parkinson's disease stated that patients began to decline motorically when dyskinesias began to worsen regardless of rigidity and tremor.

Carlsson and Winblad (1976) pointed out that striatal dopamine appears to gradually decline at a progressive rate of 5-8% per decade. As previously

discussed, there are four clinical symptoms used to diagnose the disease. These symptoms are first noticed after there is an 80% decrease in the amount of dopamine in the striatum. Based on his review of Carlsson and Winblad (1976), Langston (1987) noted that if any person were to live 110 years, that Parkinson signs would begin to surface.

Lieberman (1974) stated that muscle tone is usually increased with the progression of the disease as a result of rigidity. The increased tone in both the agonist and antagonistic muscle groups results in decreased ROM. One might think that increased muscle tone would result in increased strength. However, maximum strength was found to decrease in a study by Koller and Kase (1986) possibly resulting from lack of motor programming in the basal ganglia. In their study, a comparison was made between manual muscle testing and quantitative isotonic muscle strength measurements on a Cybex II isokinetic machine at 30°/second. Koller and Kase examined subjects according to the Hoehn and Yahr rating scale. Twenty one male subjects in the first two stages (81% in stage one) of the disease were observed and compared to age matched non-Parkinson's disease controls. Patients showed an increased endurance of the

knee, $p < .05$, over the controls. The isokinetic strength of the Parkinson patient was significantly less than the controls for the biceps, triceps, quadriceps and hamstrings $p < .01$. This was possibly due to the ability to maintain low levels of strength in a static position. The results of Koller and Kase's study suggested that muscle weakness measured isokinetically was a primary sign of Parkinson's disease. No difference in manual muscle strength (which is a measure of one person's strength exerted against a clinician) was found between the two groups. While most subjects had unilateral Parkinsonism (81%), Koller and Kase believed that the decreased isokinetic strength in the unaffected side as compared to the controls may have been a sign that patients were entering the second stage.

Exercise Therapy

In another study (Palmer, Mortimer, Webster, Bistevins, & Dickinson, 1986), two different twelve week exercise programs were compared using grip strength, machine measurements of motor sign (using an EMG during arm extension of a karate type movement), motor coordination and speed, and neurophysiologic determinations of long-latency stretch responses.

Fourteen idiopathic Parkinson patients who were being treated with L-dopa and Carbidopa (Sinemet) were selected. The study by Palmer et al. (1986) lacked a control group which would have been able to take into account the motor learning that may have occurred with the repeated tests. The patients were matched for stage of disease, age, and gender. One person in each pair was randomly assigned to one of the two groups. One exercise group used the United Parkinson Foundation: Exercise Program (United Parkinson Foundation, 1984); the other group practiced a program of upper body Karate training. Both exercise regimens resulted in improved gait, decreased tremor, increased grip strength, and improved motor control. No resistive exercises were administered, and the electromyographic recordings of Palmer et al. (1986) were too inconsistent to make a conclusion about muscle activity. This study used the Hoehn and Yahr (1967) method of staging to pair the subjects but failed to report the number of people in any of the stages. The results of the study showed a lack of improvements in timed tests in both the arms and the legs. There was no change in the rigidity. The improvements in tremor, gait, and performance of coordination tests were attributed to the psychological

feelings of well-being, since one group did not have any gait training. Modest increases were found in the grip strength of both groups. Palmer et al suggested that exercise was a good adjunct to pharmacological treatment.

Summary

The symptoms of Parkinson's disease are related to a deficiency of dopamine in the substantia nigra. When the body is 80% deficient of dopamine, one of four cardinal symptoms begin to surface: tremor, rigidity, bradykinesia, or postural instability. Bradykinesia and rigidity are probably the most disabling aspects of this disease. Bradykinesia may result from an inability to use the "open loop" system. Hence, in advanced stages the person may lack ability to move ballistically. Rigidity may be a result of overactivity in the gamma efferent motor neurons that regulate tone via muscle spindles. There are various scales that rate the stage of the disease. The most practical scale is the Hoehn and Yahr because of its simple definitions of stages.

According to Koller and Kase (1986) in regard to strength, manual muscle testing shows no difference for patients in the first two stages of the disease, as compared to age-matched controls. However, when using

the Cybex machine, Koller and Kase (1986) found isokinetic strength of Parkinson's disease patients to be less than their age-matched controls and endurance to be greater than controls.

Chapter III

Methods and Procedures

The purpose of this chapter is to describe the subjects and present methods used to quantitatively observe strength for Parkinsonians in all five stages of the disease on the Cybex II machine while performing flexion and extension at the knee and arm joints on both the right and left extremities.

Selection of Subjects

Patients seen at the California Parkinson Foundation (CPF) were sent a letter of invitation to participate in the study (Appendix A). Another form letter (Appendix B) was sent to members of the Peninsula Parkinson's Support Group (PPSG). A total of five hundred letters were sent to CPF patients and PPSG members; forty responses were received. Thirty three subjects were used in the present study, twenty eight CPF patients and five PPSG members. Potential subjects responded by signing and returning their letter of invitation to the author. For CPF patients, the name of the positive respondents fitting the description of subjects (as stated below) were presented to either Dr. Langston or Dr. Tetrud to be approved as subjects. Dr. Tetrud and Dr. Langston are the two Parkinson's disease

specialists for CPF. The approved subjects were contacted by telephone to make an appointment for testing. Subjects who were recruited from Peninsula Parkinson's Support Group (PPSG) sent their invitation to their own neurologist for approval before informing the researcher of their intention to participate (Appendix B). A letter of informed consent (Appendix D and E), as approved by the Review Board at San Jose State University, was then sent out. Depending on the date and availability of the subject, principal investigator, and the physiology lab, either a letter of consent was sent in advance or the subject was given directions over the phone and asked to sign the letter of consent at the time of testing.

Description of Subjects

The background information gathered included height, weight, birth date, gender, date of diagnosis, approximate date of onset of symptoms, history of past physical activity, description of current activity, and the question, "If you experience motor fluctuations, can you predict within an hour of a scheduled time for assessment your 'on' phase?" Subjects stated whether they were acclimated enough to their medications to predict the "on" and "off" periods as well as the

duration of effects from medications.

The study included thirty-three Parkinson's subjects. The age range of all subjects between the sixth and seventh decade was 51 to 70 years. Subjects were first screened by their physician as noted by the physician's approval (Appendix C). Subjects with a history of cardiovascular disease, hypertension, muscular or orthopedic problems, peripheral neuropathies, or other neurological disorders as reported by the patient and/or physician were not approved by their physician. Upon futher screening for other health problems which implicated their health or the study (Appendix F) subjects were to be omitted from the study. None of the subjects needed to be omitted.

Reliability and Validity of the Cybex II

A number of studies have used the Cybex II machine to measure isokinetic strength. Factors related to isokinetic contractions are torque, range of motion, work, power, and speed of contraction (Moffroid & Whipple, 1970). The present study observed torque and speed. Moffroid and Whipple, (1970) tested torque measurements for reliability which was r = .995 and validity of r =.999. These findings were based on a test re-test method using weights as the load in place

of a muscular exertion. According to Moffroid et al. (1969) the Validity of the Cybex II for measuring various velocities of expected to obtained torque is 0.985, the reliability was r = .999. The Cybex dynamometer measures isokinetic strength in foot pounds of torque (Thistle et al., 1967).

Method of Assessment

The study was undertaken at the Physiology Lab at De Anza Community College in Cupertino, California. The researcher calibrated the equipment according to Cybex II manual prior to each week of testing (Lumex Incorporated, 1983). Subjects were measured on the Cybex II isokinetic machine following the Cybex portion of the protocol used in Koller and Kase's study (1986), however a machine speed of 90°/second was used in the present study (this was slower than the standard strength testing procedures to accomodate the slow movement of the Parkinson patients in the later stages).

When subjects entered the lab they were greeted by the researcher. Each subject brought loose fitting clothing, a consent form and a doctor's approval if the investigator did not already have the forms prior to testing. If they had not read and signed the consent form, time was given for them to do so as well as ask

questions before they chose to sign.

The researcher used a questionnaire to collect background information including which side was their most affected side. This was filled out by both the researcher and the subject (Appendix F).

Testing began when all forms had been filled out by the patient's neurologist, the patient, and the investigator. The total time each subject spent in the lab testing was less than an hour. Subjects were given a copy of their consent form.

The present study used the Hoehn and Yahr scale because it is the scale most known and used by Parkinson's clinicians. The researcher examined the subjects according to the United Parkinson Disease Rating Scale (UPDRS) numbers 22 - 26 (the motoric portions used for assessing motoric stage of disease); however, these ratings were only of use in determining the Hoehn and Yahr stage of disease as well as which side was more affected and least affected by the disease. The UPDRS is noted in Appendix F. Items 22 - 26 of the UPDRS were only a small portion of a larger examination which require the expert skills of a neurologist specializing in Parkinson's disease.

The researcher took each limb of each subject and

went through a series of physical examinations similar to those the neurologists perform when evaluating stage of disease. Items 22-26 of the UPDRS look for rigidity and bradykinesia. Tremor and balance while standing were also observed when assessing stage of disease. Item 22, is assessed by moving each limb in a number of directions to look for rigity and evaluate its severity knowing what a maximum severity is like. Items 23-26 look for the speed and coordination of movement; they were all to be done at a rapid and consistent pace. For finger taps, the subject was asked to tap the index finger and thumb together. The hand grip item assessed the ability of the subject to open his/her hand with fingers fully extended then curl the fingers into a fist. For item 25, the subject was asked to pronate and supinate his forearm to full range of motion as though he were turning a door knob. The leg agility test evaluated the suject's ability to lift one leg at a time as high as a possible while sitting and put his/her heel to the floor. These were all done one side at a time then done simultaneously (except for leg agility test). This allows individual assessment as well as a comparison of the right and left side.

Scores for each subject were averaged and rounded off to the nearest tenth. These scores were used to determine stage on the Hoehn and Yahr scale.

It was desired that subjects who participated in the present study not be in the "off" phase if they did experience "on-off" motor fluctuations. All subjects either had no motor fluctuations or were able to be tested while in their "on" phase.

The researcher used the same instructions for each subject to explain the procedure and the basic mechanics of isokinetics, and then demonstrated the exercise once to allow the subject to relax and feel comfortable. The test was performed with only the researcher and the subject in the room. If present, the spouse was asked to leave the lab for the duration of the assessment procedure.

Each subject was shown how to warm-up with some exercises and stretch the muscle groups to be tested. These warm-ups lasted a minimum of five minutes or until the subject felt ready. Subjects jogged in place at a cadence fast enough to raise their heart rate and increase the circulation in the extremities. This was followed by a general strectch of the major muscle groups to be tested. Stretching took place before and

after testing each limb.

The progression of measurements for all subjects were standardized. The first extremity tested was the dominant knee followed by the opposite limb. Then the dominant elbow was followed by the opposite limb.

To test their quadriceps and hamstrings, subjects sat with the knee joint in a standard flexed position of 90° at the Cybex II machine. The proximal portion of the thigh was strapped to the table to stabilize the joint and maximize the measurement of energy output. The elbow was in full flexion while lying on the UBXT (a special Cybex table) to test the biceps and triceps. The investigator held the elbow in position to keep it from moving laterally. The machine was adjusted to each person's body segments according to the Cybex II operating procedures (Lumex Incorporated, 1983).

The subject took one practice repetition per limb at testing speed. This allowed the investigator to check that all measurements were recorded properly, and it also allowed the subject to become familiar with the type of resistance applied by the machine.

When the subject appeared ready the investigator asked, "Are you ready to start?" If the subject answered affirmatively, he/she was instructed to begin.

If the answer was no, then the subject was asked what was needed to facilitate the continuation of the experiment. No subject had any problem understanding or performing the task.

Before and during the exercise, subjects were instructed to move as hard and as fast as possible through the entire range of motion for ten repetitions. They were cautioned not to hold their breath while exerting their strength so as not to increase blood pressure on their heart. They were given the opportunity to stop at any time during the investigation. Verbal encouragement was given all subjects. The subject's safety was constantly considered throughout testing. A resting period of up to five minutes between the testing of each of the four limbs was allowed in order to rest and stretch the muscles and to allow set-up time for the next measurement. All subjects rested at least two minutes and no more than three minutes.

Speed of the Cybex machine was set at 90°/ Second. The Cybex II graph was set to record 90 foot pounds of torque through time at a paper speed of 5 mm/second. The recording chart used was marked and placed in the subject's folder after each subject was observed.

Maximum isokinetic strength was derived from the average of the three strongest repetitions of up to 35 repetitions total, as in Koller and Kase's experiment (1986).

Statistical Analysis

Cybex scores for each muscle group were considered continuous. Hence, the scores were divided into three categories based on the descriptive statistics for each muscle group of subjects in the present study: below average, average, and above average. One half standard deviation below the mean for the group to one half above was considered average; above that, the scores were considered above average; less than that, scores were considered below average. Strength categories for the affected and unaffected muscles were then compared to the stage of disease. The stage of the disease was the independent variable, and the strength measurement was the dependent variable. Since both variables were categorical a chi-square statistic was used to test the hypothesis that for patients with Parkinson's disease there is a relationship between stage of disease and strength. Affected and non affected scores were also compared to stage of disease using the chi-square.

The results of height and weight were reported

using descriptive statistics. Current physical activity, history of physical condition, and types of activity were categorized as "not active," "active," "recreation," or "athletic"; this data is presented in table format.

A non-active person performed activities of daily living and nothing more. An active person was someone who spent at least five hours a week participating in community affairs, or worked in the garden, someone who was physically busy much of the time. The recreation category consisted of people who went to some class for the purpose of exercise; the exercise level was low to moderate intensity - non aerobic enhancing. In short, recreation subjects took part in general fitness for the whole body. An athletic person was someone who trained for a sport or competition taxing their heart and breathing rate for an extended period of time on a regimented daily basis. An example would be participation in aerobic or tennis classes; or daily jog or bike ride.

Summary

This chapter included a description of the selection process of the population tested and the testing protocol. Before individual testing began, each of the

thirty three volunteer subjects had: a signed doctor's approval; had signed the consent form; and stated that they had no physical impairment (other than Parkinson's disease) which would impair their health or affect the measures collected. The laboratory experience consisted of filling out a questionaire, assessment of their Hoehn and Yahr stage, warm-up and stretch session, and strength test on Cybex at 90°/second for each bicep, tricep, quadricep, and hamstring, and concluded with a cool-down and stretch procedure. All data were either analyzed through descriptive statistics or presented in tables. All testing procedures were administered carefully by the researcher.

Chapter IV

Results

The purpose of this study was to examine the relationship between stage of Parkinson's disease and strength for four major muscle groups bilaterally about the elbows and knees. This study analyzed the statistical significance of this relationship using the chi-square statistic.

This chapter begins with a description of the population tested followed by the applicable descriptive statistics for strength measures by stage. Isokinetic measures of strength in the affected muscle groups were compared to those in the unaffected muscle groups for each stage. Also isokinetic strength of the affected and unaffected muscle groups were compared by stage separately.

Description of Population

Subjects consisted of 33 Parkinsonian patients ages 51 thru 70. Table 2 describes the height and weight for each gender. Table 3 describes by gender, subjects' age, age of onset, and the number of years with Parkinson's disease.

Means, Standard Deviations, and Ranges

Table 3 shows there was little difference in mean

Table 2

Weight and Height of Subjects

N	Gender	Mean Height (Inches)	SD	Range (Inches)	Mean Weight (Pounds)	SD	Range (Pounds)
27	Men	70.1	2.56	64-75	169	19.94	125 - 215
6	Women	68.3	1.55	62-66	132.5	13.57	110 - 172
33	Combined	69.18	3.75	62-75	163	18.72	110 - 215

Table 3

Subjects' Age, Age of Onset, and Years with Parkinson's Disease by Gender

N	Gender	Mean Age	Range (SD)	Mean Age of Onset	Range (SD)	Mean Years with PD	Range (SD)
27	Men	61.7	51-70 (5.90)	53.8	30-66 (8.29)	7.9	1-30 (7.57)
6	Women	62.5	51-69 (6.80)	53.5	46-64 (6.68)	9.0	5-21 (6.16)
33	Combined	61.8	51-70 (5.96)	53.7	30-66 (7.92)	8.1	1-30 (7.26)

age between females and males. The mean age of onset was 53.7 years; nearly the same as reported in the United Parkinson Foundation Handbook (1984) which is 53.3 years. A study by Diamond, Markham, Hoehn, McDowell, and Muenter (1989) studied 359 patients for six years which found the average age of onset to be higher (57.3) than the present study. The mean age of onset when subjects first noticed the signs or were diagnosed (whichever occurred first) for females and males was 53.5 and 53.8, respectively, with a combined range of 30 to 66 years for both genders. The mean age for the total population was 61.8 years, approximately the same age as the subjects in Koller and Kase's (1986) study. The mean number of years with Parkinson's disease experienced by both females and males together, was 8.1 years with a range of 1 to 30 years.

In Table 4, mean age and mean number of years with Parkinson's disease tended to remain similar across all stages observed. For each stage observed there was a consistent age range. There was confounding evidence that age increased with stage. However, when looking at the mean age of onset and years with Parkinson's disease there does not seem to be any consistency with increasing stage.

Table 4

Age, Age of Onset and Years with Parkinson's Disease by Stage

N	Stage	Mean Age	Range (SD)	Mean Age of Onset	Range (SD)	Mean Years with PD	Range (SD)
6	I	58.0	51 - 66 (6.87)	54.3	46 - 65 (8.52)	3.66	1 - 5 (1.75)
17	II	62.1	53 - 69 (5.40)	56.4	45 - 66 (5.84)	5.58	1 -12 (3.40)
6	II	63.8	55 - 69 (5.34)	45.6	30 - 58 (10.17)	18.16	7 - 30 (9.36)
3	IV	62.3	54 - 70 (8.02)	55.3	52 - 59 (4.53)	7.00	2 - 11 (4.58)
1	V	69.0	- (0.00)	48.0	48 - 48 (0.00)	21.00	- (0.00)
33	Combined	61.8	51 - 70 (5.96)	53.7	30 - 66 (6.78)	8.12	1 - 30 (5.76)

Chi-Square Statistic

There were six people in the first stage, seventeen in the second stage, six in the third, three in the fourth. All subjects were used to find a chi-square statistic except the one in the fifth. No significant relationship was found between stage and strength as measured in foot pounds of torque. Due to a small sample size, results of the chi-square remain inconclusive. Hence, any reference to analysis is only a trend or tendency.

Fourteen subjects were more involved on the left side (or mostly on the left side depending on the stage of disease) of their bodies and 19 subjects were affected on the right side.

Affected Strength by Stage

Mean strength measures across most stages of the affected muscle groups in Table 5 demonstrate how biceps, triceps, and hamstrings decreased in strength. However, the mean of the affected quadriceps scores increased in stages two and three.

While the decrease from stage to stage for most affected muscle groups (except for the quadriceps) was slight, there was an overall

Table 5

Mean Strength Measures for Affected Muscle Groups by Stage of Parkinson's Disease

	Stage of Disease				
	I	II	III	IV	V
N	6	17	6	3	1
Affected Muscles					
Biceps					
M	26.76	24.93	23.85	*23.80	8.30
SD	(9.65)	(10.31)	(9.40)	(1.62)	-
Range	12.0 - 41.3	6.0 - 56.7	12.0 - 34.0	22.7 - 25.0	-
Triceps					
M	25.00	24.58	24.33	*17.50	4.30
SD	(6.14)	(8.46)	(10.62)	(2.5)	-
Range	14.8 - 32.0	11.0 - 48.0	11.0 - 38.7	15.7 - 19.3	-
Quadriceps					
M	42.56	54.40	45.61	37.90	4.50
SD	(22.20)	(17.70)	(26.45)	(22.35)	-
Range	17.7 - 71.7	17.6 - 96.0	25.0 - 80.0	24.3 - 63.7	-
Hamstrings					
M	41.18	35.23	30.66	30.43	4.50
SD	(19.81)	(11.54)	(9.54)	(10.16)	-
Range	20.0 - 72.0	14.0 - 63.3	20.3 - 43.7	18.7 - 36.3	-

Note. These values represent raw scores in foot pounds of torque tested at 90°/second.

* Based on two subjects, one subject had a fused elbow with approximately 130° extension.

difference from stage one to stage four. The largest difference of the quadriceps was from stage two to four for any three stages. The score in stage five was obviously lower than all other stages.

Unaffected Strength by Stage

The mean strength measures across all stages of the unaffected muscle groups as demonstrated in Table 6 show a decrease in strength. However, the hamstrings and not the quadriceps increased in strength in stage three. The largest difference for the unaffected muscle groups occurred across four stages, which was from stage one to stage four. Again, the measurement in stage five was obviously the lowest score by far.

Affected and Unaffected Muscle Groups by Stage

Table 7 shows the difference between means given in Tables 5 and 6. The difference of mean scores for unaffected and affected triceps, and quadriceps showed that the affected side was weaker than the unaffected side for each stage. In stage one, the affected biceps and hamstrings are stronger than the unaffected side. Overall, all the scores between the affected and unaffected were very

Table 6

Mean Strength Measures for Unaffected Muscle Groups by Stage of Parkinon's Disease

	Stage of Disease				
	I	II	III	IV	V
N	6	17	6	3	1
Unaffected Muscles					
Biceps					
M	26.56	26.07	25.53	23.96	6.00
SD	(9.77)	(8.50)	(9.38)	(.57)	-
Range	11.40 - 41.0	12.3 - 48.3	13.3 - 37.7	23.3 - 24.5	-
Triceps					
M	25.53	25.31	25.06	22.00	7.00
SD	(7.81)	(8.77)	(9.97)	(2.87)	-
Range	16.3 - 38.7	13.3 - 48.6	13.0 - 41.0	18.7 - 24.0	-
Quadriceps					
M	61.76	60.66	47.46	59.10	10.00
SD	(20.18)	(20.46)	(23.89)	(23.50)	-
Range	36.4 - 94.0	17.6 - 98.7	24.3 - 84.3	35.3 - 82.3	-
Hamstrings					
M	40.66	34.95	36.88	26.3	5.00
SD	(12.03)	(8.39)	(7.83)	(6.14)	-
Range	27.7 - 58.3	15.8 - 45.5	27.3 - 47.0	21.7 - 33.3	-

Note. These values represent raw scores in foot pounds of torque tested at 90°/second.

Table 7

Strength Differences between Unaffected and Affected Muscle Groups

	Stage of Disease				
	I	II	III	IV	V
N	6	17	6	3	1
Biceps					
M diff.	- .20	+ 1.14	+ 1.68	+ .16	- 2.30
Triceps					
M diff.	+ .53	+ .73	+ .73	+ 4.50	+ 2.70
Quadriceps					
M diff.	+ 19.20	+ 6.26	+ 1.85	+ 21.20	+ 5.50
Hamstrings					
M diff.	- .52	- .28	+ 6.22	- 4.13	+ .50

Note. These values represent the unaffected scores minus the affected scores in foot pounds of torque. The negative scores show where the mean of the affected muscle group was larger than the unaffected muscle group.

similar. The greatest difference in foot pounds of torque across all stages was the decreased strength of the affected quadriceps. The mean difference for all stages combined for each muscle group showed a slight trend in decreased strength for the affected side, as shown in Table 8.

Table 8 compares each of the affected to the unaffected muscle groups. Using the mean of each unaffected muscle group minus the mean of the affected muscle group shows a positive difference for all groups tested. The quadriceps showing the largest difference.

When qualitatively comparing current activity exercise to stage, as in Table 9, the mode category was recreational (57.6%) for each stage, but the fourth and fifth. Twelve percent of the total sample were athletic. These subjects either trained for cycling events or competed in local tennis matches. All subjects currently participated in some type of exercise for the purpose of general fitness. Which, in theory, would have enhanced the measures of torque. Every Parkinson patient walked a little each day for the purpose of exercise; the shortest distance being "to the end of the block and back."

Table 8

Mean Raw Strength Scores for each Affected and Unaffected Muscle Groups

	Mean of all Stages Combined N = 33		
Muscles	Unaffected	Affected	Mean Difference
Biceps			
M	25.26	*24.48	+ .78
SD	(8.79)	(9.69)	
Range	6.60 - 48.3	8.3 - 72.0	
Triceps			
M	24.45	*23.54	+ .91
SD	(8.65)	(8.77)	
Range	7.0 - 48.6	4.30 - 48.0	
Quadriceps			
M	56.78	47.64	+ 9.14
SD	(22.23)	(21.70)	
Range	10.0 - 98.7	4.50 - 96.0	
Hamstrings			
M	34.65	34.11	+ .54
SD	(10.56)	(13.77)	
Range	5.00 - 98.7	4.50 - 72.0	

Note. These values represent raw scores in foot pounds of torque tested at 90°/second. The mean of the unaffected muscle groups minus the mean of affected values equal the mean difference. * One subject in stage four had a fused elbow.

Table 9

Current Activity Level by Stage

Stage	Not Active	Active	Recreational	Athletic
I	0	2	4	0
II	0	4	11	2
III	0	2	3	1
IV	0	1	1	1
V	0	1	0	0
Combined	0	10	19	4
	0.0%	30.3%	57.6%	12.1%

Results displayed in Table 10 suggest there is a tendency for those in the early stages to exercise for longer periods of time. Table 11 shows that there was no tendency for the number of days spent exercising per week to vary because of stage. Less than half of the study's subjects exercised six to seven days a week. Everyone exercised at least one to three days a week. It should be noted that not all subjects were part of a regular exercise program for Parkinson's disease patients. All subjects felt the need or importance to spend some time exercising.

When comparing exercise history to the stage of disease in Table 12, some people became less active as they aged and others increased their activity level. People in stage one tended to maintain some activity throughout their exercise history. All subjects maintained or increased level of activity after diagnosis (which is not noted in the table).

Table 10

Duration of Current Daily Exercise

N	Stage	Not Active	10-19 Minutes	20-29 Minutes	30-49 Minutes	50-more Minutes Plus
6	I	0	0	3	1	2
17	II	0	1	2	3	11
6	III	0	2	2	1	1
3	IV	0	2	0	1	0
1	V	0	0	1	0	0
33	Combined	0	5	8	6	14
		0.0%	15.1%	24.2%	18.2%	42.4%

Table 11

Number of Days per week Subjects Exercised

Stage	Days Per Week			
	Does Not Exercise	1 - 3	4 - 5	6 - 7
I	0	1	3	2
II	0	4	4	9
III	0	1	2	3
IV	0	2	1	0
V	0	0	0	1
Combined	0	8	10	15

Table 12

History of Activity Level

	Exercise level Age 18 - 25				Exercise level Age 26 - 35				Exercise level Age 36 - 49			
Stage	NA	Act	Rec	Ath	NA	Act	Rec	Ath	NA	Act	Rec	Ath
I	0	1	2	3	0	1	4	1	0	1	3	2
II	1	6	4	6	2	5	10	0	2	9	6	0
III	0	0	2	4	0	1	3	2	0	3	3	0
IV	0	0	2	1	0	0	3	0	0	1	1	1
V	0	0	1	0	1	0	0	0	1	0	0	0
Combined	1	7	11	14	3	7	20	3	3	14	13	3

Note. NA - Not Active; Act - Active;

Rec - Recreational; Ath - Athletic.

Regarding exercise history, it should be noted that subjects gave answers to the best of their recollection for these categories.

Summary

Descriptive statistics were provided for a sample population of 33 Parkinson's disease subjects aged 51 to 70. Descriptive statistics were also given for age, age of onset of Parkinson's disease, and the number of years with Parkinson's disease.. The mean number of years with Parkinson's disease was 8.1 years.

All subjects participated in some type of activity for the purpose of exercise at least one to three days a week. Tables were given to show exercise history, current level of exercise, and amount of time spent exercising.

Too few subjects participated in the study to make any conclusions about the hypothesis using the chi-square statistic. A slight trend in decreased strength across stage was present for the affected side and for the unaffected side as well.

Chapter V

Discussion, Conclusion and Recommendations

The purpose of this study was to investigate the relationship between stage of Parkinson's disease and strength. The stage of disease was also compared to the age, the age of onset, the number of years with Parkinson's disease, exercise history, and current exercise profile for 33 subjects. The primary focus of the study was the affected and unaffected muscle groups compared to the stage of disease.

Discussion

In general, the subjects tended to participate in some kind of exercise for the purpose of maintaining or improving their fitness; none was totally inactive. Some subjects tended to become less athletic over three periods of life and others who were non-active began some type of activity or increased it to help cope with the disease. Subjects in stage one showed little or no tendency to decrease their level of activity throughout their life.

When comparing the unaffected to affected muscles of the four bilateral muscle groups observed, the unaffected quadriceps were the strongest. This may be due to the increase of attention to walking (many of the

Parkinson help pamphlets and clinicians encourge walking) which would help to maintain hip flexors (the quadriceps) and not so much the hamstrings which assist the gluteal muscle groups in hip extension.

A slight trend of weakness across stage was present for the affected side. The same was true of the unaffected side. At first glance this may suggest that stage is unrelated to strength since both the affected and unaffected sides decreased in strength. However, after stage one, one side of the body is the more affected side, the other side is the least affected - both sides are affected. A combined mean of affected scores of all stages for each muscle group showed that the affected muscles were weaker than the unaffected muscles. This suggests that Parkinson's disease is related to strength as a result of decreased use due to the disease itself.

When observing the tables of age, age of onset, and the number of years with Parkinson's disease with stage, there seemed to be no relationship.

Palmer et al. (1986) demonstrated that strength improvements can be made in Parkinson's disease patients using either a general exercise routine as developed by the United Parkinson Foundation or by participating in a

modified karate class. The role of the adapted physical educator is to assess the strength of the students in the class and take note of their improvement over the duration of the class using the individually planned exercise program for each student.

Assessments of Parkinson's disease which rate stage are qualitative and subject to individual physician interpretations (Montgomery, 1984; Marsden & Schacter 1981). The rating scale which is easiest to use is Hoehn and Yahr (1967), yet when following this format of stage assessment in the present study, only general conclusions could be made regarding the relationship between strength and stage. This resulted mostly from lack of an adequate number of subjects.

Strength measurements in the present study were reliable, but they could not be used to predict stage of disease. There were subjects in stage three who demonstrated greater strength in the quadriceps than those in first stage. This may be a result of people in the earlier stages not being active or that people in the third stage have taken a serious attitude toward exercise and have improved their strength.

All bicep and tricep scores were quite similar to each other. This tends to corroborate with Webster's

(1986) finding that suggested mostly upper body segments are impaired. That is to say, if the biceps were not impaired their strength would be greater than the triceps.

The present study was modeled after a similar study conducted by Koller and Kase (1986) with three changes. One, in the present study, the speed of the Cybex machine was set faster to lessen resistance. The reason for this change was to protect subjects in the later two stages from possible injury. The second change in the present study was to recruit subjects from all five stages, not just the first two stages of the disease. And third, no age matched controls were used in the present study.

There was one major similarity in the results of the present study to Koller and Kase's study that could be noted. Strength of each muscle group in the affected and unaffected side of subjects in stage two was slightly decreased than those in stage one. This suggests that decreased strength does occur with Parkinson's disease with advancing stage from a unilateral to bilateral phase as in stage two.

Larsson and Karlsson (1977) noted in normal subjects, strength of quadriceps decreased from the

third decade to the fifth decade of life. The present study of subjects 51 - 70 did not compare strength measures to a control group of the same age. This shows a need for a study to observe age-matched controls as well.

In a study by MacRae and Gluck (1986), it was found that as one maintains a high fitness level throughout life, torque production levels can be maintained as well. When observing the tables of activity level there seems to be a qualitative relationship between recreation and stage. Fifty seven percent of all subjects were involved in recreation. Most of these people were in stage two; the number of recreational subjects for the following stages declines from there.

There were two idiosyncrasies that the researcher noted while collecting the strength scores. First, a subject in stage one demonstrated a greater strength in his hamstrings than in his quadriceps. The quadriceps are usually at least one third stronger than the hamstrings. Second, there was a particular pattern of strength curves on the chart often had spiked curves which suggested that subjects were not able to maintain a consistent concentric contraction throughout the full range of motion.

Conclusion

The hypothesis that stage and strength are related was not confirmed. No relationship could be found between stage and strength, but a slight decrease of raw strength scores for all muscle groups was indicated as the stage of the disease progressed.

Perhaps, the small number of Parkinson's disease patients who participated resulted from lack of motivation to do more than any daily activity. It was noticed that in general, Parkinsonians tend to focus on things they are familiar with; not seemingly new and complicated events. Furthermore, the number of able patients in the latter stages could be a reflection of those actually in the population in the County of San Mateo and Santa Clara. Patients in the fourth stage tend to stay at home more often. Also, patients in the fifth stage are more than likely in either a board and care home or a convalescent home if their spouse or caregiver (if they have one) can no longer take care of them.

Subjects in the present study all exercised for the purpose of maintaining their level of fitness or improving it. As a result of the disease, some subjects who were athletic in their younger years reported they

had to limit their activity level and participate in athletic sports more as a recreation. This could be a result of the ageing, but subjects noted abrubt decreases in their ability level. Which in turn can be a result of their increased awareness of disease.

Other subjects who were inactive in their younger years had begun to participate in some type of activity to improve their fitness level. Those in stage two were active for longer periods of time than those in stage one. This was probably a result of subjects in stage two realizing the significance of the disease, that it is motorically limiting. It should also be noted that during the warm-up session many subjects shared an appreciation of being taught how to warm-up and stretch.

There was no relationship between age, age of onset or number of years with Parkinson's disease and stage of the disease. Parkinson's disease tends to progress at different rates individually. A study by Diamond et al. (1989) found that patients diagnosed under 50 years of age have a more favorable prognosis from stage to stage.

The results of this study implied that the unaffected side was generally stronger than the affected side. Although after stage two, the affected side was considered the more involved side, it was still weaker

than the least affected side across all stages.

Recommendations

The Cybex II machine was was found to be an appropriate tool in quantitatively assessing the strength of Parkinson's disease patients. For the purposes of this study, Parkinson's disease patients could be tested more slowly at a rate of 60°/second and it would, in the researcher's opinion, still be just as safe and would allow a quantitative measure of strength in foot pounds of torque. This is a result of the positive and safe response to testing at 90°/second. A study of 60°/second with a similar protocol is recommended.

For future studies, the following changes are recommended for the collection of data:

1. A narrow age category within one decade to control for age as a factor in decreased strength. There was a period before more of the older patients in the earlier stages joined in the study that age was a potential confounding variable.
2. Fewer repetitions (3-5) are necessary for assessing peak torque of strength, especially if subjects are familiar with the machine prior

to testing. Using more than a few repetitions tends to test endurance rather than strength (Milner-Brown, Mellenthin, & Miller, 1986).

3. Use age matched controls to compare results of any strength study involving Parkinson's disease patients.
4. Using the same protocol in the present study, familiarize subjects with the Cybex a week ahead of the scheduled time before testing.
5. Retest subjects for reliability at least twice to show if measurements are reliable.

Future studies are needed to observe how Parkinson's disease patients respond to different types of standard exercise programs over a three to six month period. The school programs usually take about three to six months to complete. If testing for three month exercise programs using a school exercise program, they are limited by breaks for holidays and vacations. Subjects would have to commit to maintaing a consistent attendance regardless of school breaks in order to validate the results.

Adapted physical educators would also benefit from a study observing the strength scores at different

speeds on an isokinetic dynamometer to see the relationship of strength to endurance in Parkinson's patients as compared to their age-matched peers. This would facilitate making an individual exercise plan by knowing if and how Parkinson's students need to improve their endurance and or strength.

A study with a similar protocol would be of interest comparing depression and or dyskinesia, tremor, rigidity, and bradykinesia to strength as noted by the Cybex machine.

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Appendix A

Invitation letter to

California Parkinson's Foundation

Patients

INVITATION LETTER

To: Patients of California Parkinson's Foundation.
From: J. William Langston MD and James W. Tetrud MD
Regarding: A research project by Bob Austin,
Master's Candidate at San José State University

We wish to know if you would be willing to have your name placed on a resource list of volunteers for future clinical research studies at the California Parkinson's Foundation. At this time, you are invited to participate in a study to determine the relationship between isokinetic arm and leg strength and the stage of Parkinson's disease, if you are interested.

To be eligible for the present study, you must be between the ages of 50 and 70, have no major medical condition other than Parkinson's disease and be stable on your medications. This is a non-invasive test, meaning you will not have to give blood nor receive an injection.

Your signature on the attached form will acknowledge your interest in participating in Bob Austin's worthy study. Please send your response as soon as possible. Bob Austin will inform you whether or not you are accepted into the study. If you are accepted you will be mailed a consent form which you may sign upon entering the study. You will be contacted by phone to set up a date to perform a strength test using the Cybex® II+ at the De Anza College Physiology laboratory.

The Cybex® II+ is an isokinetic machine that provides equal resistance to the amount of force exerted. That is, the more you push against the lever, the more it seems to resist you as you move throughout the range of the
motion. The machine will move at a constant rate no matter how hard you press as you move your limb through its range of motion.

Any information obtained in this study will remain confidential and be disclosed only with your permission.

Whether or not you participate will not prejudice your future relations with San Jose State University, De Anza College or the California Parkinson's Foundation.

If you wish to participate, please fill out the attached form and use the stamped envelope to send it to the

California Parkinson's Foundation,
Atten; Austin's Research
2444 Moorpark Ave. Suite 316
San José, CA 95128

If you have questions, contact Bob Austin at 408/555-5555 (If not at home, please leave message).

Thank you for taking time to read this invitation letter. Bob Austin would like to talk with you if you have any questions.

Sincerely,

Dr. J. William Langston
Dr. James W. Tetrud

Appendix B

Invitation Letter to

Peninsula Parkinson's

Support Group Members

INVITATION LETTER

To: Members of the Peninsula Parkinson Support Group
From: Bob Austin, Director of PPSG and Master's
Candidate at San José State University
Regarding: A research project by Bob Austin

Good Day,

I am currently working on my thesis on Parkinson's Disease and strength. I would like to know if you would be willing participate in a study to determine the relationship between isokinetic leg & arm strength with the stage of Parkinson's disease.

To be eligible for the present study, you must be between the ages of 60 and 70, have no major medical condition other than Parkinson's disease and be stable on your medications. This is a non-invasive test, meaning you will not have to give blood nor receive an injection.

I need you to fill out the attached form, sign it, and have your doctor sign it then call me at (408) 555-5555 to make an appointment to test the strength in each of your legs and arms. The test will take a maximum of 45 minutes. I have included a consent form and a map of where the test sight is. All testing is at the De Anza College Physiology laboratory. Your immediate response will be much appreciated.

What is this test for?

The purpose of this study is to assess strength of Parkinson diseased patients throughout five stages of the disease. Clinical evaluations of clinical strength measurements compared to isokinetic measurements on a Cybex have demonstrated conflicting results. When testing Parkinson patients in the first two stages and comparing them to age matched controls, non PD patients are slightly stronger then PD patients. The affected limb was slightly weaker than the non affected limb of patients.

The results of this study have implications for doctors and health professionals who work with PD patients who may underestimate the importance of daily exercise. Furthermore, the results of this type of test may show quantitatively the rate of progression from stage to stage when no difference is noted clinically

What machine is used to measure strength?
It is a Cybex II +.

The Cybex II+ is an isokinetic machine that provides equal resistance to the amount of force exerted. That is, the more you push against the lever, the more it seems to resist you as you move throughout the range of the
motion. The machine will move at a constant rate no matter how hard you press as you move your limb through its range of motion.

Is the Cybex machine safe?

Yes it is, provided you warm-up and stretch properly prior to and after the test. I plan to show you how to stretch and warm-up prior to the test and after the test. You will do less than 15 repetitions total for each leg and arm.

Any information obtained in this study will remain confidential and be disclosed only with your permission.

Whether or not you participate will not prejudice your future relations with San Jose State University, De Anza College or the Peninsula Parkinson Support Group.

If you wish to participate, please fill out the attached forms and call me at
(408) 555-5555. Please read and sign the consent form at the test sight, De Anza College. You will find a map with directions enclosed.

If you have questions, contact Bob Austin at 408/555-5555
(If not at home, please leave message).

Thank you for taking time to read this invitation letter. I would like to talk with you if you have any questions.

Sincerely,

Robert D. Austin
Executive Director

Appendix C

Physician's Approval Form

PATIENT'S NAME _____

ADDRESS _____ CITY_____ ZIP_____

TELEPHONE _____ DATE OF BIRTH _____

1. Yes I am interested in participating in the Stage and Strength study

which is being conducted by Bob Austin.

2. Yes, I would like to have my name on a list for future research studies

conducted through the California Parkinson's Foundation.

3. No, I am not willing to participate in any type of research nor have my name included on a list for future studies.

If you marked number 1 above please sign the release below. I hereby release my records at the California Parkinson's Foundation for the purposes of the Stage and Strength study being conducted by Bob Austin.

SIGNATURE _____ DATE _____

PLEASE SEND IMMEDIATELY TO:
CALIFORNIA PARKINSON'S FOUNDATION
ATTENTION: AUSTIN'S RESEARCH
2444 MOORPARK AVENUE, SUITE 316
SAN JOSE, CA 95128

Once we have received your acknowledgement to participate in the Strength and Stage study, your records will be reviewed and either Dr. Langston or Dr. Tetrud will sign below. You will be contacted whether or not you have been approved to continue.

I _____ HEREBY GIVE THE ABOVE PATIENT

PHYSICIAN'S NAME _____

PERMISSION TO PARTICIPATE IN THIS STUDY. _____

PHYSICIAN'S SIGNATURE _____ DATE _____

Your signature below acknowledges that you, a person who has Parkinson's disease and is between 60 and 70 years of age and in good health overall (that is no diagnosis of heart problems, rheumatoid arthritis, or high blood pressure especially) are willing to participate in my study of strength and stage of Parkinson's Disease.

PATIENT'S NAME

ADDRESS _____ CITY _____ ZIP _____

TELEPHONE _____ DATE OF BIRTH _____

SIGNATURE _____DATE _____

After you have signed and filled the above information please have your doctor approve your participation and call me, Bob Austin, at 408-555-5555 immediately. Thank you for your time and cooperation.

PLEASE HAVE YOUR PRIMARY PHYSICIAN SIGN BELOW

Once you have received your doctor's acknowledgement to participate in the Strength and Stage study we can proceed with this one time test.

I _____ HEREBY GIVE THE ABOVE PATIENT
PHYSICIAN'S NAME

PERMISSION TO PARTICIPATE IN THIS STUDY.

PHYSICIAN'S SIGNATURE _____ DATE _____

Appendix D

Agreement

of California Parkinson's Foundation

Patients

to Participate

AGREEMENT TO PARTICIPATE IN RESEARCH
SAN JOSE STATE UNIVERSITY

RESPONSIBLE INVESTIGATOR: ROBERT D. AUSTIN
TITLE OF PROTOCOL: Strength testing using the Cybex® II+ machine on persons with Parkinson's disease.

I have been asked to participate in a research study that is investigating the relationship of the stage Parkinson's disease to strength in my knees, and elbows. The results of this study will help further our understanding of how strength is affected by the progression of Parkinson's disease.

I understand that

1) I will be asked to: fill out a questionnaire, have a consent form filled out by either Dr. Langston or by Dr. Tetrud (which was sent with the invitation letter), and asked to perform exercise at each of the joints described above using the Cybex® II+.

2) the possible risks of this study are a cramping of muscles from not stretching enough prior to the test, muscle soreness from the fatiguing bout of exercise. The response to the exercise may increase my heart rate, sweating, and blood pressure. These are common occurrences of physical exertion.

3) the possible benefits from this study to me include an appreciation for exercise and the need to take part in a daily exercise program, and the idea to take this initial exercise test as a starting or continuing point to perform exercise to the best of my ability on a daily basis. The benefits of my participation will contribute additional knowledge to the study of Parkinson's disease in general.

4) the procedures are to be followed as stated above and my

participation is going to be to the best of my ability. That what I do is going to be observed and used as raw data for the completion of this investigation.

5) the results of this study may be published, but any information from this study will remain confidential and will be disclosed only with my permission or as required by law.

6) in the advent of any unusual symptoms longer than the forty eight hours following this assessment I will notify Bob Austin at 555-5555 and my physician, and Dr. Tetrud. I will report any symptoms other than those expected such as muscle soreness or unusual fatigue.

7) the location for testing is at the De Anza Physiology Laboratory and that approximately 45 minutes to one hour will be needed for testing.

8) I will be needed only once for the purposes of testing.

9) any questions about me will be answered by Robert D. Austin at (408) 555-5555. Complaints about the procedures may be presented to Dr. Jim Bryant at (408) 924-3010. For questions or complaints about research subject's rights or in the event of research-related injury, contact Serena Stanford, Ph.D. (Associate Academic Vice President for Graduate Studies & Research)at (408) 924-2480.

10) my consent is given voluntarily without being coerced; I may refuse to participate in this study or in any part of this study, and I may withdraw at any time, without prejudice to my relations to SJSU or the California Parkinson Foundation.

11) I will receive a copy of my consent form for my file.

I HAVE MADE A DECISION WHETHER OR NOT TO PARTICIPATE. MY SIGNATURE INDICATES THAT I HAVE READ THE INF0RMATION PROVIDED AND THAT I HAVE DECIDED TO PARTICIPATE.

DATE: _____ SUBJECT'S SIGNATURE

_____

INVESTIGATOR'S SIGNATURE

_____

Appendix E

Agreement

of Peninsula Parkinson's

Support Group

Members

to Participate

AGREEMENT TO PARTICIPATE IN RESEARCH
SAN JOSE STATE UNIVERSITY

RESPONSIBLE INVESTIGATOR: ROBERT D. AUSTIN
TITLE OF PROTOCOL: Strength testing using the Cybex® II+ machine on persons with Parkinson's disease.

I have been asked to participate in a research study that is investigating the relationship of the stage Parkinson's disease to strength in my knees, and elbows. The results of this study will help further our understanding of how strength is affected by the progression of Parkinson's disease.

I understand that

1) I will be asked to: fill out a questionnaire, have a consent form filled out by my doctor (which was sent with the invitation letter), and asked to perform exercise at each of the joints described above using the Cybex® II+.

2) the possible risks of this study are a cramping of muscles from not stretching enough prior to the test, muscle soreness from the fatiguing bout of exercise. The response to the exercise may increase my heart rate, sweating, and blood pressure. These are common occurrences of physical exertion.

3) the possible benefits from this study to me include an appreciation for exercise and the need to take part in a daily exercise program, and the idea to take this initial exercise test as a starting or continuing point

to perform exercise to the best of my ability on a daily basis. The benefits of my participation will contribute additional knowledge to the study of Parkinson's disease in general.

4) the procedures are to be followed as stated above and my participation is going to be to the best of my ability. That what I do is going to be observed and used as raw data for the completion of this investigation.

5) the results of this study may be published, but any information from this study will remain confidential and will be disclosed only with my permission or as required by law.

6) in the advent of any unusual symptoms longer than the forty eight hours following this assessment I will notify Bob Austin at 555-5555 and my physician. I will report any symptoms other than those expected such as muscle soreness or unusual fatigue.

7) the location for testing is at the De Anza Physiology Laboratory and that approximately 45 minutes to one hour will be needed for testing.

8) I will be needed only once for the purposes of testing.

9) any questions about me will be answered by Robert D. Austin at (408) 555-5555. Complaints about the procedures may be presented to Dr. Jim Bryant at (408) 924-3010. For questions or complaints about research subject's rights or in the event of research-related injury, contact Serena Stanford, Ph.D. (Associate Academic Vice President for Graduate Studies & Research)at (408) 924-2480.

10) my consent is given voluntarily without being coerced; I may refuse to participate in this study or in any part of this study, and I may withdraw at any time, without prejudice to my relations to SJSU or the Peninsula Parkinson Support Group.

11) I will receive a copy of my consent form for my file.

I HAVE MADE A DECISION WHETHER OR NOT TO PARTICIPATE. MY SIGNATURE INDICATES THAT I HAVE READ THE INFORMATION PROVIDED AND THAT I HAVE DECIDED TO PARTICIPATE.

DATE: _____ SUBJECT'S SIGNATURE

_____

INVESTIGATOR'S SIGNATURE

Appendix F

Questionaire

United Parkinson's Disease Rating Scale items 22-26

Hoehn and Yahr rating score

Cybex Measurements

CONFIDENTIAL RELEASE OF INFORMATION TO BE FILLED OUT BY

PATIENT

Diagnosis IS PATHOLOGY IDIOPATHIC? YES / NO

Height ____ Weight ____

Approx. date symptoms were first noticed __/__ Date diagnosed__/__/__
Other diagnosis such as heart problems, rheumatoid arthritis, high blood pressure, stroke or others that participation may negatively affect the outcome of this study and be unsafe for the patient: YES / NO
IF YES, PLEASE STATE:

What kind of exercise(s) do you currently participate in?

How long have do you exercise for? 10 min, 20 min, 30 min, or 50 min

How often do you exercise each week? 1-3, 4-5, or 6-7 days a week

Were you active when 18-25 years Y/N, 26-35 years Y/N 36-49 years Y/N
What type of activity did you participate in when you were age 18-25?
What type of activity did you participate in when you were age 26-35?
What type of activity did you participate in when you were age 36-49?

Do you experience motor fluctuations? YES / NO

IF SO, FOR A DAY(S), HOUR, MINUTE, OR MOMENTARY

ARE MEDICATIONS STABLE YES / NO

CAN YOU THE PREDICT DURATION OF "ON" TIMES? YES / NO

Which is your: dominant arm? R/ L ; dominant Leg? R/ L

PAGE 1 OF 2 (PLEASE TURN OVER)

UPDRS Rating

	Most recent date on/off	Testing Date on/off
Q. 22 Rigidity		
neck		
R/L UE		
R/L LE		
Q. 23 Finger Taps		
R/L		
Q. 24 Hand Grips		
R/L		
Q. 25 Hand Pro-Sup		
R/L		
Q. 26 Leg Agility		
R/L		
Hoehn & Yahr Stage	1 2 3 4 5	1 2 3 4 5

Cybex Scores

	Biceps/Triceps	Quads/Hamstring
R	____ / ____	____ / ____
L	____ / ____	____ / ____

Date of testing ___ / ___ / ___
Time of testing ___ / ___ / ___

Comments: