JAOA

Original contribution

Standard osteopathic manipulative treatment acutely improves gait performance in patients with Parkinson's disease

MICHAEL R. WELLS, PHD; SAL GIANTINOTO, DO; DAVID D'AGATE, MS; RD AREMAN, BA; ENRICO A. FAZZINI, DO, PhD; DENNIS DOWLING, DO; ANDREW BOSAK, BS

Patients with Parkinson's disease exhibit a variety of motor deficits which can ultimately result in complete disability. The primary objective of this study was to quantitatively evaluate the effect of osteopathic manipulative treatment (OMT) on the gait of patients with Parkinson's disease. Ten patients with idiopathic Parkinson's disease and a group of eight age-matched normal control subjects were subjected to an analysis of gait before and after a single session of an OMT protocol. A separate group of 10 patients with Parkinson's disease was given a sham-control procedure and tested in the same manner. In the treated group of patients with Parkinson's disease, statistically significant increases were observed in stride length, cadence, and the maximum velocities of upper and lower extremities after treatment. There were no significant differences observed in the control groups. The data demonstrate that a single session of an OMT protocol has an immediate impact on Parkinsonian gait. Osteopathic manipulation may be an effective physical treatment method in the management of movement deficits in patients with Parkinson's disease.

(Key words: Parkinson's disease, osteopathic manipulative treatment, computerized gait analysis, physical performance)

Parkinson's disease is the second most common of the neurodegenerative diseases in the world. It is estimated that currently in the United States more than 1 million people are affected with Parkinson's disease; of these, possibly 500,000 are in the early stages of the disease and are untreated because of misdiagnosis or lack of detection.[1] With the elderly population becoming the fastest growing population in the United States, the number of patients with Parkinson's disease is certain to increase.

The onset of symptoms in Parkinson's disease is associated with the loss of about 80% of the dopamine-containing neurons in the substantia nigra.[2] The lost dopaminergic neurons project widely to the caudate nucleus and putamen. The disease may have an insidious preclinical course of 30 years or more before the appearance of symptoms.[3] The primary symptoms encountered in Parkinson's disease include muscular (cogwheel) rigidity, a coarse resting tremor, which may be in the digits ("pill-rolling tremor") or other muscles of limbs and posture, bradykinesia, mask-like facies, and impaired postural reflexes. Symptoms, such as tremor and rigidity, are not necessarily bilateral or uniform over one side of the body. The symptoms are variably progressive and eventually may result in complete disability. Numerous other disease processes may produce Parkinsonian symptoms, but symptoms that present in conjunction with a degeneration of the substantia nigra and Lewy bodies in the remaining neurons are considered to be distinguishing characteristics of idiopathic Parkinson's disease.[1]

Although numerous aspects of functional deficits in patients with Parkinson's disease have been studied,[4-6] most quantitative studies have investigated gait and postural stability. Reasons for this emphasis are that falling and associated injuries are major factors that can contribute to eventual disability. Patients with Parkinson's disease have a characteristic gait, described as short and shuffling steps (festination) with a loss of associated arm movements. This may begin slowly and be unilateral. Sudden freezing in the course of movement may impair turning or initiation of movement. A reduction in postural reflexes may also contribute to falling backward (retropulsion) or forward (propulsion). With severe loss of postural reflexes, the patient may be confined to a bed or wheelchair.

The primary deficits appear to be associated with the amplitude parameters (such as stride length, cadence), yet the relationship between these parameters is also typically maintained.[6] Parkinson's disease patients typically show a reduced speed and stride-length and an increase in gait-cycle duration. An increase in duration of stance and double limb support occurs.[7] Vertical transverse move-

Research Supported by the New York College of Osteopathic Medicine (NYCOM) of the New York Institute of Technology. From NYCOM, where Dr Wells is the chairman of the Department of Biomechanics and Bioengineering ; Drs Dr Giantinoto, D'Agate, and Areman are currently residents, but were students at the time the paper was written; Dr. Fazzini is an associate professor of medicine; Dr Dowling is the chairman of the Stanley Schiowitz DO FAO Department of Osteopathic Manipulative Medicine; and Mr. Bozak is the director of the Adele Smithers Parkinson's Disease Treatment Center.

Correspondence to Michael R. Wells, PhD, New York College of Osteopathic Medicine, New York Institute of Technology, PO Box 8000, Old Westbury, NY 11568-8000.

ments of the trunk and hip are reduced, presumably as a consequence of the shortened stepping. However, in the early-to-moderate stages of the disease, such patients have retained the ability to alter their walking cadence. While on an effective medication cycle, these patients can generate almost normal walking patterns when given visual cues and are instructed to walk quickly.[8] This suggests that the hypokinesia in Parkinson's disease gait is associated with the inability to generate sufficiently large steps.[9] The primary characteristics of Parkinson's disease as expressed in gait offer the possibility of monitoring disease progression through the quantitative analysis of gait characteristics. A similar approach could be anticipated for the evaluation of physical treatment methods for the disease.

From an osteopathic medical point of view,[10,11] diseases that result in musculoskeletal disability may have symptoms not necessarily a direct result of the disease itself. However, these symptoms arise, in part, from a cycle that is initiated by the disease process. For Parkinson's disease, the muscular rigidity associated with muscle tone disturbances is of a primarily central origin, but symptoms may be exaggerated by a reflex cycle of pain, muscle spasm, and contraction. This would be expected to produce muscular reactions (for example, increased muscle tension, and muscle, fascial, and tendon shortening) that could limit joint ranges of motion, postural stability, and limit general movement. Pain and muscle spasms may further contribute to muscle tension and lead to a decrease in diffusion of nutrients and removal of waste products. They may also decrease blood and lymphatic flow in muscle tissues. The akinesia and bradykinesia are further limiting factors that inhibit the maintenance of general muscular strength and flexibility, and they are also associated with difficulties with posture and balance.

The rationale for osteopathic manipulative treatment (OMT) of Parkinson's disease is that because of the aforementioned mechanisms, symptomatic expression exceeds the level of the actual neurological deficit. Treatments may then be targeted toward breaking the cycle leading to excess disability and, thereby, reduce the expression of symptoms to a minimal level. In this study, OMT primarily included passive range of motion techniques, which are used to prevent muscle contractures, joint restrictions and the development of fibrous adhesions. The muscle energy technique also was used to lengthen muscle fibers around the joints, theoretically by activating the Golgi tendon organ.[11] A passive-linear pull or stretch was done to further lengthen the muscles before exercise. Through these manipulations, the flexibility and contraction properties of muscles around joints are facilitated, while the cycle of reflex contraction and muscle spasm is broken. Correspondingly, manipulations of the spine may be used to correct postural changes associated with abnormal contractions of postural muscles and gait.

It is hypothesized that manipulative treatments that are designed to improve flexibility, strength across joints, balance, and postural reflexes will be able to quantifiably improve the physical function and quality of life for patients with Parkinson's disease. In this regard, it is generally agreed that adjunctive use of physical treatments can be of benefit to patients with Parkinson's disease,[1,4,12,13] but a quantitative evaluation of various treatment strategies is lacking. A primary objective of the research reported here was to demonstrate that quantitative gait analysis could be used to examine the acute effects of OMT on patients with Parkinson's disease. The aim of a single treatment session evaluation is to identify any immediate effects of treatment that would be consistent with benefits of longer duration.

Materials and methods

All methods used in the study were part of a protocol approved by the institutional Human Studies Review Committee. Twenty patients with idiopathic Parkinson's disease exhibiting gait impairment and eight normal control subjects were admitted to the study as volunteers after signing an informed consent. All subjects underwent a physical and neurologic examination to determine that study requirements would be of no potential detriment to their health status. Patients were of either sex, ranged in age of 45 to 68 years, and had no preexisting conditions, other than Parkinson's disease, which were known to have altered their gait. The patients studied for Parkinson's disease could be classified as mild to moderately affected (Unified Parkinson's Disease Rating Scale [UPDRS] motor score average 14.3).

Ten patients were included in the experimental treated group, and the remaining group of 10 patients with Parkinson's disease were used as sham-treated control subjects. A group of eight unaffected volunteers (typically caregivers for the patients) of approximately the same age and physical condition were recruited as normal control subjects. The patients with Parkinson's disease were treated with either a course of OMT or a sham procedure as described herein. Normal patients were treated with the same set of OMT procedures described for the treated Parkinson's patient group. All subjects, including normal volunteers, were unaware of their experimental group placement. Prior to testing, all treated and sham-control Parkinson's patients were instructed to undergo a 12-hour washout of their medication.

For testing, subjects were fitted with reflective markers bilaterally on the base of the fifth distal metatarsal of the foot, the most posterior aspect of the lateral heel, on the lateral malleolus, on the lateral fibular head of the knee, the greater trochanter, angle of the acromion process, lateral epicondyle, and distal ulna. A baseline gait analysis was performed bilaterally with a computerized two-dimensional sagittal gait analysis system (Peak Performance Technologies, Inc; Englewood, Colo). Subjects were requested to walk the length of the 40-foot pathway six consecutive times. The recorded measurement was made on the third passage in front of the camera.

Patients were unaware of when measurements were being taken, and no instructions were given to patients

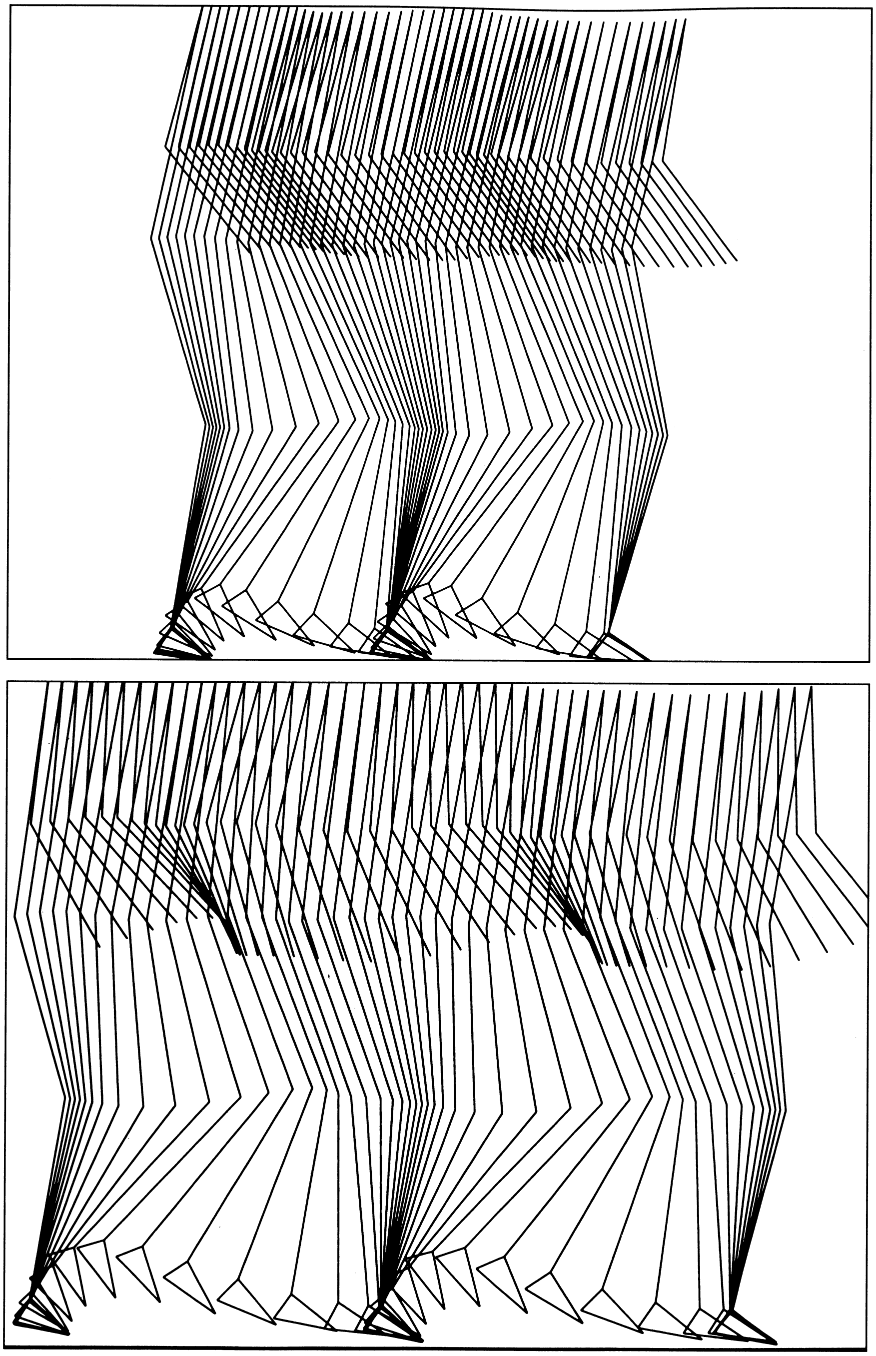

Figure 1. *A computer-generated stick figure time sequence of two stride lengths from a patient with Parkinson's disease before* (top) *and after* (bottom) *the single session of osteopathic manipulation treatment. The repeated drawings are made on the same time scale (horizontal axis). Differences in velocity are reflected by the distance separating each individual stick drawing. The drawings are made by connecting the markers placed on the anatomical landmarks heretofore described. The figure reflects the generalized increase in velocity, stride length, and cadence observed with treatment.*

regarding their walking. Gait parameters were derived from the digitized movements of the reflective markers recorded through the computer system (*Figure 1*). The gait parameters measured consisted of stride length, cadence (steps/second), shoulder velocity, arm movement velocity, wrist movement velocity, and lower limb velocity of hip, knee, and ankle. Subjects were then treated with either a standardized session of osteopathic manipulation immediately following their gait analysis, or a sham procedure. At the conclusion of the manipulation or sham procedure, gait analysis was once again performed.

The OMT was composed of established techniques designed to reduce rigidity and to improve flexibility and muscle length across the limbs, as well as mobility of the spine.[10,11] This treatment was given to the treated group of patients with Parkinson's disease and the normal control group. Manipulative treatments were conducted by a student physician with special training in osteopathic manipulative technique, under the direction of an osteopathic physician. The role of the physician was to ensure that the student was adequately trained to effectively apply the treatment regimen to the subjects and that a presumed active treatment would not be injurious to any subject. The student physician was blinded to the patient's condition.

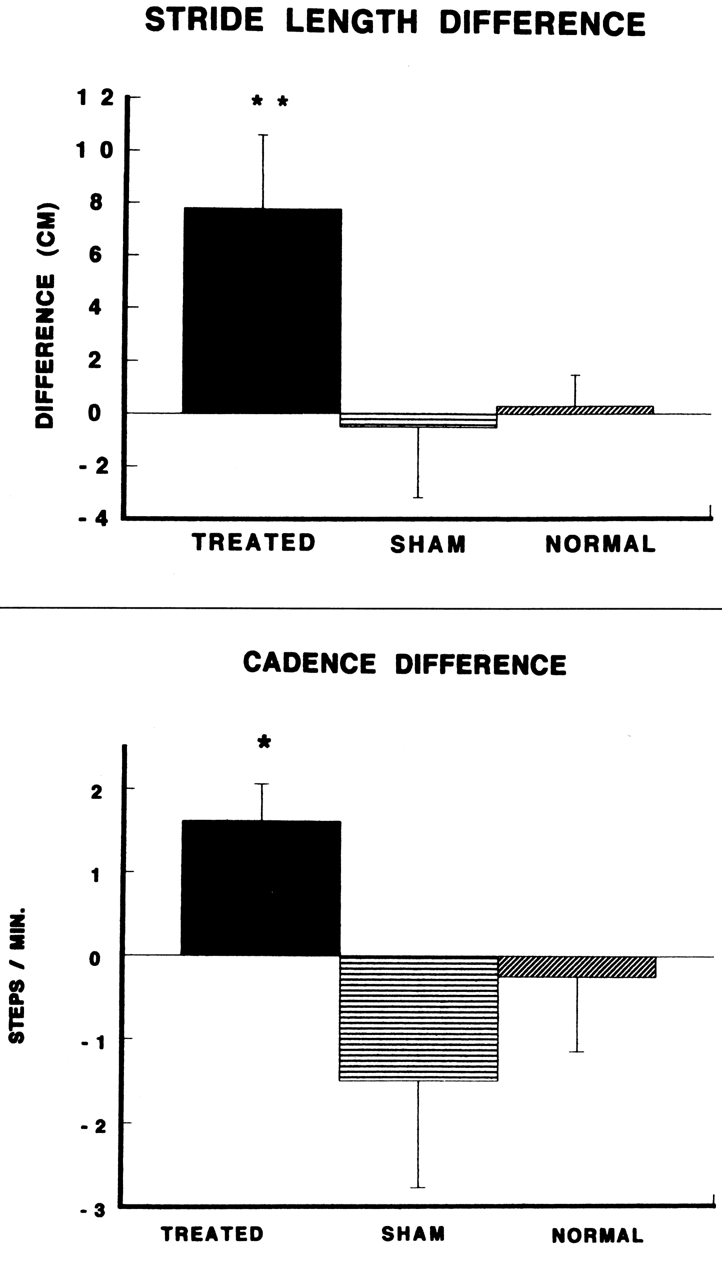

Figure 2. *Differences in stride length (top) and cadence (bottom) for normal subjects and patients with Parkinson's disease before and after a single session of osteopathic manipulation treatment. Stars (**) indicate significant differences between the treated and control groups before and after treatment. A single star indicates a difference within the group before and after treatment.*

Each patient was treated with one standardized session of OMT, which lasted approximately 30 minutes. A standard treatment protocol that was designed prior to the onset of this study was followed. As a requirement of this protocol, each patient was to have the same OMT with respect to both the types of techniques performed and the order in which they were applied. All techniques were done bilaterally. It is important to note that, although some patients suffered from a primarily unilateral impairment, with increased rigidity on the right or the left, the student physician was instructed to place no greater emphasis on the patient's dysfunctional side. It is clear that treatment applied in this manner is not entirely consistent with osteopathic principles of treatment or optimally beneficial for patient treatment. However, for experimental purposes, this measure was deemed necessary to maintain a uniform, defined treatment protocol. Treatment consisted of the application of 14 osteopathic techniques, which were performed exactly in the following order:

1. Lateral (and anteroposterior) translation of vertebrae in the thoracic/lumbar spine performed with the patient in a seated position;
2. Active myofascial stretch to the thoracic spine with the patient in a seated position;
3. Occipito-atlanto (OA) release[14];
4. Translation of cervical spine performed with the patient in a supine position;
5. Muscle energy techniques of the cervical spine;
6. Spencer technique applied to the shoulder bilaterally [10];
7. Supination/pronation of the forearm bilaterally;
8. Circumduction of the wrist bilaterally;
9. Sacroiliac joint gapping bilaterally;
10. Muscle energy technique applied to adductor muscles of lower extremity bilaterally;
11. Psoas muscle energy technique applied bilaterally;
12. Hamstring muscle energy technique applied bilaterally;
13. Articulatory technique applied to the ankle bilaterally; and
14. Muscle energy technique applied to the ankle in dorsi and plantar flexion bilaterally.

The sham procedure consisted of an examination of the patient's voluntary range of motion in each joint to which manipulation would have been applied without the manipulation procedure, and some passive movement of the limbs without reaching the patient's range of motion limit. Additional time was used to record some physical structural measurement parameters normally utilized in gait analysis procedures (for example, length of the legs and arms), such that the approximate time taken was equal to that for an OMT session.

Statistical comparisons between groups were made on the basis of the magnitude of differences in parameters before and after treatment. This approach alleviated a very broad baseline intersubject difference in gait parameters. Pretreatment and posttreatment differences within groups were examined on the basis of a paired t-test. Although there was some risk of spurious false-positive results by several repeated paired t-tests, one objective of the study was to identify which gait parameters might be improved by osteopathic manipulation. The possibility of intergroup differences was examined using analysis of variance.

Results

In response to a single session of OMT, Parkinson's patients showed a significant increase in gait parameters related to stride and velocity for the upper and lower limbs compared with their pretreatment values (*Figure 1*). Normal patients treated with OMT and sham-treated patients with Parkinson's disease did not show any significant changes compared with their pretreatment values. Compared with their own pretreatment gait parameters, Parkinson's patients treated with OMT had changes in primary gait measurements, which included an increase in stride length (*Figure 2*, $P < 0.02$), and an increase cadence (*Figure 2*; $P < 0.005$). The magnitude of this change in stride length for Parkinson's patients treated with OMT was also significantly greater than that observed in normal patients treated with OMT ($P < 0.048$), and Parkinson's subjects treated with the sham procedure ($P < 0.022$), where the stride length actually declined. Although cadence increased in patients with Parkinson's disease who received OMT compared with pretreat-

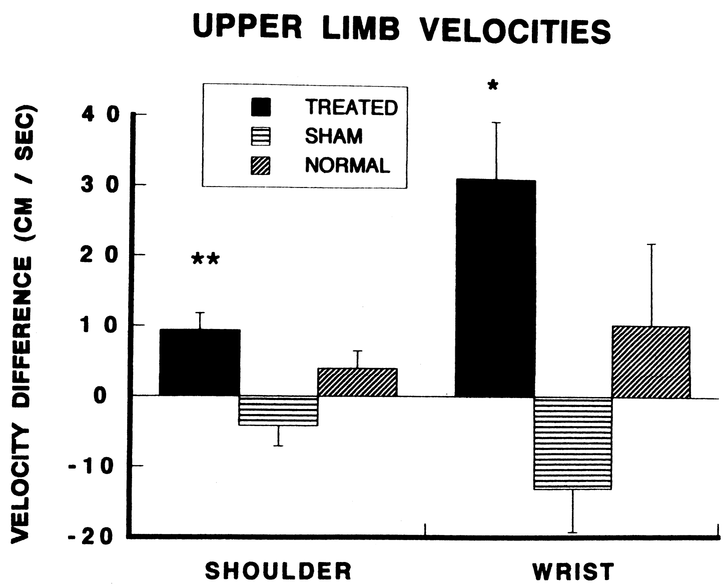

Figure 3. *Differences in the maximum velocity of the shoulder and wrist before and after a single session of osteopathic manipulation treatment. Stars (**) show significant differences between the treated and control groups before and after treatment. A single star indicates a difference within the group before and after treatment.*

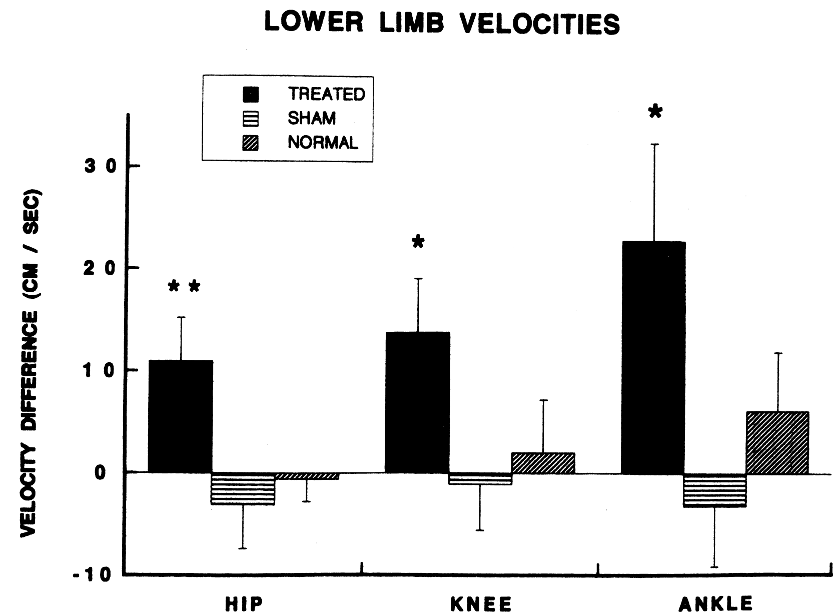

Figure 4. *Differences in the maximum velocity of markers placed on the hip, knee, and ankle during gait before and after a single session of osteopathic manipulation. Stars (**) show significant differences between the treated and control groups before and after treatment. A single star indicates a difference within the group before and after treatment.*

ment values ($P<0.004$), the change was not significantly different from control groups ($P<0.073$).

The increase in velocity after treatment, suggested by an increased stride length and cadence in Parkinson's patients who received OMT was confirmed by measurements of the maximum linear velocity of the shoulder compared with pretreatment ($P<0.004$; *Figure 3*). This change was also significantly greater than that seen in normal subjects who received OMT ($P<0.028$) and sham-treated patients ($P<0.0009$). The velocity of arm movements measured by the wrist marker also increased significantly in Parkinson's patients who received OMT compared with pretreatment values ($P<0.0042$; *Figure3*). This change was also significantly greater from that in the sham-treated group ($P=0.001$).

Significant changes were also present in Parkinson's patients who received OMT with regard to the velocity of movements of the lower limb. The maximum linear velocity of the hip ($P=0.0331$), knee, ($P=0.0297$) and ankle ($P=0.0428$) increased significantly in Parkinson's patients who received OMT, compared with pretreatment values (*Figure 4*). The increase in the hip velocity also was greater than the control groups ($P<0.017$), including subjects in the normal group who received OMT ($P<0.031$) and the sham-treated Parkinson's patients ($P<0.007$). However, in comparisons between experimental groups, Parkinson's patients who received OMT did not have a significantly greater increase in the maximum velocity measurements on the knee ($P<0.10$) and ankle ($P<0.059$), compared with the sham and normal groups, although trends were present in that direction (*Figure 4*).

Other parameters measured, including joint ranges of motion during gait and joint angular velocities, were not significantly different before and after treatment in any of the groups, ostensibly because of a larger variability in these parameters. However, the trends of the data were consistent with the significant differences in the velocities observed (data not shown). There was some suggestion that sham-treated Parkinson's subjects appeared to do slightly worse compared with their pretreatment measurements (*Figures 2-4*), but any suggestive changes were never statistically significant. Likewise, the normal control subjects who received OMT (*Figures 2-4)* showed no clear trends in pretreatment and posttreatment comparisons for those factors that did change significantly in the Parkinson's patients who received OMT. The magnitude of pretreatment to posttreatment change in the normal control subjects who received OMT did not differ significantly from pretreatment to posttreatment changes in sham-treated patients.

Discussion

The data demonstrate that significant increases in some gait parameters can be detected in Parkinson's disease patients after a single session of OMT. With treatment, patients ambulated with longer strides and quicker steps and had improved arm swing. The overall results can be divided into two primary findings: significant differences were found between the subjects with Parkinson's disease and normal subjects in their response to osteopathic manipulation. Parkinson's patients showed a significant positive change in their gait parameters after OMT treatment, while normal subjects did not. Second, significant differences occurred only in subjects with Parkinson's disease treated with OMT, but not in sham-treated Parkinson's patients. This finding indicates that the changes were produced as a consequence of manipulative treatment.

The results are consistent with improvements in motor function observed with physical therapy in other studies.[15] However, it is noteworthy that these studies involved treatment over an extended period (several weeks) and did not examine the acute effects of therapy.

While an acute benefit of therapy suggests that more may be better, it is not clear from the present study how long the changes lasted for the treated patients, or how a more extended period of treatment might prove beneficial. The rationale for a single-session study was based on the premise that a short-term demonstrated benefit may help to identify those techniques that will prove beneficial in long-term therapies.

It was also important to demonstrate that a biomechanical analysis of gait could be used as a mechanism to detect potential benefits produced with osteopathic treatment, even after a single session. This indicates that the same type of analysis should be effective in the determination of other aspects of treatment, including treatment frequency, methods, duration, and potential maximum benefit. All these factors must be addressed in the development of appropriate physical treatments for the effective management of patients with Parkinson's disease; they are presently under study, as part of a treatment development program in the Adele Smithers Parkinson's Disease Treatment Center at NYCOM.

In addition, several factors are important to the interpretation of the changes seen in Parkinson's patients in the present study. Among these is the medication status of patients. In the present study, patients were examined and treated 12 hours after having taken their last dose of medication. Clearly, medication can make dramatic and significant differences in patient gait. While on an effective cycle of medication, moderately affected patients with Parkinson's disease can achieve an almost-normal walking pattern with instruction and visual cues, such as lines painted on the floor at appropriate stride distances.[8,9] Published studies examining the effects of physical therapy on Parkinson's patients both on and off medication have suggested that more uniform results may be obtained if testing is done at times when medication is most effective.[13] Yet, our experience and clinical observations indicate that differences produced with physical-based treatment methods are most consistently expressed with patients off medication.

The potential of some type of treatment being applied (placebo effect, or expectation of improvement) having a psychosomatic effect on patients, thereby, unintentionally encouraging them to walk in an improved manner posed some concern in this study. From an osteopathic treatment point of view, encouragement and physical contact are an integral part of active treatment. However, it is important to attempt to distinguish between the effects of the physical techniques applied and the more general aspects of receiving treatment. This distinction could become important in future studies to determine which techniques are most effective for a particular set of Parkinsonian symptoms.

The inclusion of a sham treatment and a group of normal control subjects who were treated was intended to address this issue. However, we cannot unequivocally exclude the possibility that the treated group of Parkinson's patients responded with an increased expectation of improvement to some aspect of osteopathic treatment that might influence them to improve their gait. To produce the observed results, this scenario would also presume that the separate Parkinson's group treated with a sham procedure would not have a perception of being treated actively, and also that normal control subjects who received OMT would not be encouraged by treatment. Although patients included in the study had been undergoing medical management for varying periods, none had been previously aware of or treated with osteopathic manipulation. Therefore, we consider it unlikely that patients would be able to distinguish between the treatments, because all subjects were generally naive as to the nature of osteopathic versus sham treatment for their condition. Furthermore, considering the described level of encouragement and cues necessary to elicit a more normal gait pattern in patients while on medication,[8,9] the effect of any potentially implicit encouragement of patients while off medication would probably be insufficient to produce the significant changes seen in this study.

It is also important to note that subjects with Parkinson's disease used in this study were drawn from a patient population who had an entry criteria of being able to walk unassisted while off medication. This population tends to skew the data toward an interpretation based on subjects with mild-to-moderate symptoms, and these results may not be equally applied to patients with more severe forms of Parkinson's disease. Although almost all patients showed improvement in the parameters, some patients showed dramatic improvement, while others showed less, albeit definite, change. At present, we have not detected any clear correlation between disease severity or particular symptoms expressed and response to treatment. This lack of correlation may be an important question for patient selection and will be a subject for future study.

Conclusion

The data clearly demonstrate that a single session of an OMT protocol can have a significant positive effect on gait characteristics of patients with Parkinson's disease. Patients walked with significantly longer stride lengths, increased cadence, and at a higher velocity after therapy. The significant changes in gait parameters demonstrate that a computerized biomechanical analysis of gait can be an effective mechanism for the detection of some of the effects of OMT in outcome studies. The data further support our hypothesis that patients with Parkinson's disease have symptomatic expression in excess of their direct neurologic deficits. Therefore, it may be possible to effectively manage some of these deficits with physical treatment techniques—including OMT—as part of a comprehensive treatment program for patients with Parkinson's disease.

References

1. Stern MB. Parkinson's disease: Early diagnosis and management. *J Fam Pract* 1993; 36: 439-446.

2. Bennet JP. Biochemical pathology and pharmacology of Parkinson's disease. In: Stern, MB, Hurtig, HI, editors. *The Comprehensive Management of Parkinson's Disease.* New York: PMA Publishing: 1988. pp. 63-76.

3. Marsden CD. Parkinson's disease. *Lancet* 1990; 335: 948-952.

4. Marsden CD. Parkinson's disease. *J Neurol Neurosurg Psychiat* 1994; 57: 672-681.

5. Stern MB, Hurtig HI. *The comprehensive management of Parkinson's disease.* New York: PMA Publishing, 1988.

6. Blin O, Ferrandez AM, Serratrice G. Quantitative analysis of gait in Parkinson patients: increased variability of stride length. *J Neurol Sci* 1990; 98: 91-97.

7. Murray MP, Sepic SB, Gardner GM, Downs, WJ. Walking patterns of men with parkinsonism. *Amer J Phys Med* 1978; 57: 278-294.

8. Morris ME, Iansek R, Matyas TA, Summers JJ. Ability to modulate walking cadence remains intact in Parkinson's disease. *J Neurol Neurosurg Psychiat* 1994; 57:1532-1534.

9. Morris ME. The pathogenesis of gait hypokinesia in Parkinson's disease. *Brain* 1994; 117: 1169-1181.

10. DiGiovanna EL, Shiowitz S, editors. *An Osteopathic Approach to Diagnosis and Treatment.* J.B. Lippincott Co., New York: 1991.

11. Ward RC, editor. *Foundations for Osteopathic Medicine.* Williams and Wilkins, Baltimore: 1997.

12. Duvoisin RC. *Parkinson's Disease—A Guide for Patient and Family.* Raven Press. New York: 1991. pp. 133-151.

13. Morris ME, Matyas TA, Iansek R, Summers JJ. Temporal stability of gait in Parkinson's disease. *Physical Therapy* 1996; 76: 763-780.

14. Sutherland AS, Wales, AL, editors. *Contributions of Thought : Collected Writings of William Garner Sutherland.* Dallas Tex: The Sutherland Cranial Teaching Foundation; 1967. p.12-13.

15. Comella CL, Stebbins GT, Brown-Toms N, Goetz CG: Physical therapy and Parkinson's disease: A controlled clinical trial. *Neurology* 1994; 44: 376-378.