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The effects of Tai Chi on balance and gait in patients with mild to moderate Parkinson's disease

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The effects of Tai Chi on balance and gait in patients with mild to moderate Parkinson's disease

Disciplines

Physical Therapy

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Critically Appraised Topic

Title: The effects of Tai Chi on balance and gait in patients with mild to moderate Parkinson's disease

Clinical Scenario: The patient who led us to pursue this question is a 61 y/o female with a diagnosis of Parkinson's disease who was seen in an outpatient orthopedic clinic. Problems identified include balance, initiation of gait and bradykinesia. Due to the clinical instructor not being a specialist in Parkinson's disease, more research was needed to find the most beneficial treatments.

Brief introduction: In order to address all of the impairments seen with Parkinson's patients, we wanted to know what the research states concerning the benefits of Tai Chi compared to standard outpatient orthopedic exercises. Tai Chi is also a common community class and could be recommended as a home exercise program after discharge if shown effective.

My Clinical question: Is Tai Chi effective at improving gait and balance in patients with Parkinson's disease?

Clinical Question PICO:

Population: Patients diagnosed with mild to moderate Parkinson's disease

Intervention: Tai Chi

Comparison: Standard outpatient orthopedic exercises

Outcome: Balance and Gait measures

Overall Clinical Bottom Line: Based on the results of the outcomes from Li et al., 2007, Li et al., 2012, and Hackney and Earhart, Tai Chi is effective at improving gait and balance in patients with mild to moderate Parkinson's disease. Of the three articles, the greatest improvement for Functional Reach was 4.9 cm, for the Timed Up and Go was 1.36 seconds, and for the Berg Balance Scale was 3.3 points. Improvements were also seen in maximum excursion of 11.98%, stride length of 12.3 cm, gait velocity of 14.9 cm/s, and 50-ft speed walk of 2.3 seconds. Participants in all three studies had similar characteristics to patients that would be seen in an outpatient clinic. Elements of the Tai Chi interventions could easily be incorporated into a physical therapy treatment session. Due to minimal threats to internal validity, the results from the Li et al., 2012 article and the Hackney and Earhart article can be extrapolated to a larger

patient population. However, the results from the Li et al., 2007 article should not be used for future clinical intervention due to many major threats to internal validity that significantly compromise the methodological quality of this study.

Search Terms: Parkinson's disease, Tai chi, balance, gait

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Rationale for articles:

We chose our three articles based on the population, intervention, and outcome measures that fit best with our clinical PICO and had similar outcome measures. To narrow down the scope of our search, we focused on similar outcome measures for gait and balance, such as the Timed Up and Go test, Functional Reach, and gait speed.

Table 1: Comparison of Article PICOs and PEDro Scores

Author	PEDro score	Population	Intervention	Outcome measurements
Li et al. (2007)	4/10	Adults with mild to moderate PD	90-minute Tai Chi exercise program for 5 consecutive days	50-foot speed walk, TUG, functional reach
Li et al. (2012)	7/10	People 40-85 y/o with mild to moderate PD	60 minute Tai Chi exercise sessions twice weekly for 24 weeks	Maximum excursion, Functional Reach, TUG, stride length, gait velocity
Hackney and Earhart	5/10	People \geq 40 years old with mild to moderate PD	20 1-hour long Tai Chi training sessions	Berg Balance Scale, TUG, and Six-Minute Walk test

Table 2. Comparison of PEDro Scores

	Li et al. (2007)	Li et al. (2012)	Hackney and Earhart
Random	0	1	1
Concealed allocation	0	1	1
Baseline comparability	1	0	0
Blind subjects	0	1	1
Blind therapists	0	0	0
Blind Assessors	0	0	0
Adequate Follow-up	1	1	1
Intention-To-Treat	1	1	0
Between Group	1	1	0
Point Estimates & variability	0	1	1
Total score	4/10	7/10	5/10

Article: Li et al., 2007. Tai Chi-Based Exercise for Older Adults with Parkinson's Disease: A Pilot-Program Evaluation

Clinical Bottom Line:

Tai Chi is effective at improving gait and balance in patients with Parkinson's disease. The five-day treatment period consisted of a 90-minute Tai Chi exercise session every day. With the 50-ft speed walk, the Tai Chi group improved their time on average from 16.32 seconds to 14.02 seconds. On the Up and Go test, the Tai Chi group improved their time on average from 9.38 seconds to 8.02 seconds. On the Functional Reach, the Tai Chi group improved their average reaching distance from 22.42 centimeters to 25.38 centimeters. Effect size was calculated by the CAT authors for all three physical performance measures as follows: 0.87 for 50-ft speed walk, 0.51 for Up and Go, and 0.45 for Functional Reach. The 50-ft speed walk was found to have a large effect size and the Up and Go and Functional Reach having a medium effect size. A statistically significant change in all three physical performance outcome measures was found at the end of the intervention period. Major threats were selection, Hawthorne effect, rater bias, testing effect, inadequate power, and uncontrolled extraneous variables. The study found Tai Chi to be an effective and appropriate treatment to improve gait and balance in patients with Parkinson's disease. However, due to the many threats to internal validity, extrapolation of the results of this study to the larger population is not advised.

Article PICO:

Population— The population is older adults with mild to moderate idiopathic Parkinson's Disease.

Intervention— The intervention is Tai Chi based exercises.

Comparison— Subjects were compared to their pre-exercise state.

Outcomes—50-ft speed walk, Up and Go test, and Functional-Reach test.

Blinding: A research assistant made initial contact with all participants to explain the procedure and screen potential subjects. This same assistant collected data before and after treatment. The Tai Chi exercises were taught by the principal investigator. The study does not indicate that the rater or the subjects were blinded. Not having blinding could be a major threat due to possible rater bias and Rosenthal effect.

Controls: Participants served as their own controls through pretest and posttest assessments.

Randomization: Subjects were not randomized as all participants went through the same interventions.

Study: This study was a within-subjects design that included pretests and posttests of all 17 participants. The intervention occurred over five consecutive days with 90-minute Tai Chi exercises sessions per day. Initial data was measured one to two days prior to starting treatment, and the final assessment was performed one day after treatment ended. Participants were ruled eligible if they had a diagnosis of idiopathic Parkinson's disease not over stage III on the Hoehn and Yahr scale, if they ambulated independently, had a score of greater than 24 on the Mini-Mental State Examination signifying no severe cognitive impairments, no severe neurological, cardiopulmonary, or orthopedic issues, were not doing structured exercises for at least 2 months, and had their doctor's approval to participate in the study. Exercise sessions were at the same time everyday. Assessments were also consistent in regards to time and order of tests. Subjects were required to take their medications at the same time every day to minimize medication effects on physical performance. The Tai Chi exercise program included six stepping exercises from the Yang Tai Chi style, which emphasized repetitions, bilateral stepping with weight shifting, unilateral stance, and smooth movements. Participants were provided with a DVD and encouraged to practice at home. However, no follow up effort was made to monitor home practice. Class sizes were between three to five participants in order for the instructor to give more individualized attention.

Outcome measures: Three physical-performance measures were assessed before and after treatment. They included the 50-ft speed walk, Up and Go test, and the Functional-Reach test. Initial assessments were taken one to two days prior to starting treatment, and the final assessments were taken one day after treatment ended. The authors reported satisfactory 5-day test-retest reliability and provided stability coefficients as follows: 0.65 for 50-ft Walk, 0.71 for Up and Go, and 0.79 for Functional Reach. The authors also provided article references to support the usage of these three physical-performance measurements. There are no established MCID scores for the 50-ft speed walk, Up and Go test, or Functional-reach test for individuals with Parkinson's disease.

Study losses: All participants completed the five day exercise program and assessments.

Summary of internal validity: We deemed the internal validity of this study to be poor. There were seven threats to internal validity due to lack of randomization, blinding, and small number of participants. Six major threats were selection, Hawthorne effect, rater bias, testing effect, inadequate power and extraneous variables. The one minor threat was Rosenthal effect. Selection is a major threat due to all subjects being from the same local community Parkinson’s support group rather than from a diverse pool of participants. Hawthorne effect could be a major threat due to participants wanting to please the researcher by getting better. Rater bias is a major threat due to the same research assistant taking pretest and posttest assessment measures. Testing effect is a major threat because subjects served as their own controls and could have shown improvements in the post-test assessments as a result of undergoing the pre-test assessments. Inadequate power is a major threat due to the small sample size of 17 participants. Uncontrolled extraneous variables is the last major threat due to participants receiving a DVD to take home in order to practice without having to report how much they completed. Rosenthal effect could be a threat due to participants being in an unfamiliar environment.

Evidence: The outcome measures from this study that are related to our clinical questions are the results from the 50-ft speed walk, Up and Go test, and Functional Reach.

Table 3: Outcome Measures at pretest and posttest for the physical-performance assessments

Performance Measure	Pretest	Posttest	Effect Size
50 ft speed walk (s)	16.32	14.02	0.87
Up and Go (s)	9.38	8.02	0.51
Functional Reach (cm)	22.42	25.38	0.48

Participants displayed a statistically significant difference ($p = 0.05$) in all three physical-performance tests after performing Tai Chi based exercises. On average, the participants walked 2.3 seconds faster during the 50 ft speed walk test and performed the Up and Go test 1.36 seconds faster. Functional reach length increased by 2.96 cm. Effect size was calculated by the CAT authors as follows: 50 ft speed walk test portrayed a large effect size while the Up and Go test and Functional Reach test produced medium effect sizes. Confidence intervals could not be calculated due to the within-subjects design.

Applicability of study results:

Benefits vs. Costs:

This treatment was not expensive or time constraining. No adverse events were reported, and elements of the treatment plan could easily be added into an exercise treatment plan for patients. Therefore, the benefits outweigh the costs.

Feasibility of treatment: The interventions presented in this study can be easily applied to the clinical setting. The Tai Chi exercises were explained well enough to be able to reproduce and do not require equipment or extra clinical expertise. While the treatment sessions in the study were 90 minutes, they could easily be condensed into a time period appropriate for an average physical therapy session. Li et al. stated that treatment was appropriate for patients with Parkinson's disease, the exercises were not painful or harmful, and the participants expressed a desire to continue with Tai Chi based exercises in the future.

Summary of external validity: The sample of participants in this study would be similar to patients treated in an outpatient orthopedic clinic. However, due to the many threats to internal validity, the results should be cautiously extrapolated to a larger patient population.

Article: Li et al., 2012. Tai Chi and Postural Stability in Patients with Parkinson's Disease.

Clinical Bottom Line:

Tai Chi is more effective than resistance training and stretching at improving gait and balance in patients with Parkinson's disease. All three intervention groups participated in 60-minute exercise sessions twice weekly for 24 weeks. Outcome measures for all groups were taken at baseline, three and six months, and three months after completion. Effect size could not be calculated due to insufficient data given by the article authors. Statistical significance was found between the Tai Chi and resistance-training group in maximum excursion, stride length, and Functional Reach with the Tai Chi group showing greater change. Gait velocity and the Timed Up and Go were also measured for this group but did not reach statistical significance. The Tai Chi group also displayed statistically significant differences compared to the stretching group in all outcome measures. Significance was determined by 95% confidence intervals from between group means. No major threats to interval validity were found. Due to the participants being similar to patients seen in an outpatient orthopedic clinic, and no adverse events or major costs, results can be extrapolated to a larger patient population.

Article PICO:

Population— The population of this study included 195 participants with mild to moderate Parkinson's disease.

Intervention—The intervention was a Tai Chi exercise program.

Comparison— There were two comparison groups, which performed resistance training or stretching.

Outcomes— The outcomes relevant to our clinical PICO include: maximum excursion, stride length, gait velocity, Functional Reach, and Timed Up and Go

Blinding: Research staff initially screened possible study participants by telephone. In-person evaluation and baseline assessments were taken for those who met pre-screening criteria. The authors state that eligible participants were randomly assigned to one of the three intervention groups through the use of a permuted-block randomization. Patients were not blinded to intervention group, as this was not possible for this type of study. Outcome assessors were

blinded to group assignments; therefore we feel that blinding was not a major threat to the study outcomes.

Controls: In this study, the stretching group was used as the control group. They received the same frequency and duration of intervention as the resistance training and Tai Chi groups. While this is not a true control group because the participants received an intervention, the authors designed this group to receive the same social interaction and enjoyment benefits as the other two intervention groups without the same training benefits with regards to lower extremity weight-bearing, strength, or balance. Although this was not a true control group, we feel the differences in outcome measures can be attributed to the interventions.

Randomization: The assignment of subjects to groups was randomized through the use of permuted-block randomization without stratification. The groups were homogenous with regard to baseline characteristics including age, sex, duration of Parkinson's disease, Hoehn & Yahr stages, and baseline study outcomes. Thus, randomization was successful and stratification was not necessary.

Study: The study was a randomized clinical trial with 195 eligible study participants, which were put into one of three intervention groups: Tai Chi, resistance training, or stretching. There were 65 participants in each intervention group. Inclusion criteria included the following: a clinical diagnosis of Parkinson's disease, stage 1 to 4 on the Hoehn & Yahr scale, between the ages of 40-85, one score of at least 2 or more on at least 1 limb for the motor section of the Unified Parkinson's Disease Rating Scale (UPDRS III), stable medication use, ability to stand independently and walk with or without an assistive device, medical clearance, and willingness to participate. Exclusion criteria included the following: current participation in another study or an exercise program, a score lower than 24 on the Mini-Mental State examination, any other serious conditions or impairments that would interfere with participation, and unavailability during the study period. The Tai Chi exercise group performed six Tai Chi movements designed to challenge balance and gait. The first ten weeks emphasized multiple repetitions of single forms and later focused on repetitions to enhance balance and locomotion. The resistance training exercise group performed 8-10 progressive strengthening exercise for muscles needed for posture, balance, and gait with weighted vests and ankle weights. The stretching group emphasized core activation through seated and standing stretches involving the upper body, lower body, and trunk.

Outcome measures: The outcome measures relevant to our clinical question include the following: maximum excursion, stride length, gait velocity, Functional Reach, and Timed Up

and Go. Outcome measures were assessed at baseline, at 3 months, at 6 months, and at 3 months post-intervention completion. However, the authors provided data only at baseline and at 6 months. The authors did not provide reliability or validity of the outcome measures. However, the authors reported a 0.96 inter-rater reliability. There are no established MCID scores for any of the outcome measures in individuals with Parkinson’s disease.

Study losses: The authors did not indicate the percentage of subjects who completed follow-up. However, they did report that 176 participants completed their assigned interventions, and 185 participants provided complete data on outcome measures. Upon visual inspection of the data presented, we noted that the authors did not include any outcome data from the 3-month and 3-month post-intervention assessments. The authors reported using an intention-to-treat analysis on all primary and secondary outcome measures. All subjects appeared to be analyzed in the groups to which they were randomly assigned.

Summary of internal validity: We deem the internal validity of this study to be good. There were four minor threats due to lack of a true control group and blinding of the participants. The four minor threats were Hawthorne effect, Rosenthal effect, history, and maturation. Hawthorne effect is a minor threat due to the possibly of participants wanting to get better in order to please the researchers. The Rosenthal effect could be a minor threat due to participants being in an unfamiliar environment. History and maturation are potential minor threats because the net gains from Tai Chi cannot be compared to a true control group.

Evidence: The outcome measures related to our clinical questions are maximum excursion, stride length, gait velocity, Functional Reach, and Timed Up and Go test.

Table 4: Comparison of Mean Differences Between Groups From Baseline to Six Months

Outcome Measure	Tai Chi vs. Resistance	Tai Chi vs. Stretching
Maximum Excursion (%)	5.55*	11.98*
Stride Length (cm)	5.9*	12.3*
Gait Velocity (cm/sec)	0.5	14.9*
Functional Reach (cm)	2.8*	4.9*
Timed Up and Go (sec)	-0.05	-1.03*

* Indicates statistical significance at $p < 0.001$

Statistical significance was found between the Tai Chi and resistance-training group in maximum excursion, stride length, and Functional Reach with the Tai Chi group showing greater change. The Tai Chi group also displayed statistically significant differences compared to the stretching group in all outcome measures. Effect size could not be calculated due to insufficient data given by the article authors.

Applicability of Study Results:

Benefits vs. Costs: The Tai Chi intervention does not require additional equipment, but may require further Tai Chi training for the therapist. No adverse events were noted during the Tai Chi intervention indicating that it is safe to use with patients. Elements of the Tai Chi could easily be added into an exercise treatment plan for patients. Therefore, the benefits outweigh the costs.

Feasibility of treatments: The study procedures in the article were not described well enough to exactly reproduce, however, the authors reference a supplementary appendix that provides more details. Therapists might require additional guidance for how to teach Tai Chi. The treatment sessions are longer than what would be available for a standard physical therapy appointment, but elements of the Tai Chi intervention could easily be added into the allotted time. The intervention time also went for a longer period of time than insurance would provide, however, the Tai Chi exercises could be given as home exercise programs to be continued for the remaining necessary time. Li et al., indicated that the Tai Chi training was feasible, useful, and safe for patients with Parkinson's disease

Summary of external validity: The sample of participants in this study would be similar to patients treated in an outpatient orthopedic clinic. While the study had four threats to internal validity, we feel they did not compromise the ability to extrapolate these results to a larger patient population.

Article: Hackney and Earhart, 2008. Tai Chi improves balance and mobility in people with Parkinson disease.

Clinical Bottom Line:

Tai Chi demonstrates favorable trends in improving balance in patients with Parkinson's disease, although only one of the three outcome measures achieved statistical significance. The treatment group received 20, one-hour sessions of Tai Chi exercises and the control group received no intervention. Each group was evaluated on the same test measures at the same times. On the Berg Balance Scale, the Tai Chi group improved by an average of 3.3 points, while the control group regressed by an average of 0.5 points ($P < 0.001$). On the Timed Up and Go, the Tai Chi group improved their time by an average of 1.0 second, while the control group improved their time by an average of 0.1 second ($P < 0.093$). On the Six-Minute Walk test, the Tai Chi group improved their distance walked by an average of 44.4 meters, while the control group improved their distance walked by an average of 0.8 meter ($P < 0.046$). Effect size for the three physical outcome measures are as follows: 1.47 for Berg Balance Scale, 1.15 for Timed Up & Go, and 0.78 for the Six-Minute Walk Test. The Berg Balance Scale and Timed Up & Go were found to have large effect sizes with 95% confidence intervals that did not cross zero. The Six-Minute Walk Test was found to have a medium effect size with a 95% confidence interval that did cross zero. Hackney et al. stated that statistical significant difference was only found on the Berg Balance Scale; however, trends were seen in other two outcome measures favoring Tai Chi over the control group. No MCID was found for the any of the outcome measures for patients with Parkinson's disease. Although there is an established MCID for the Six-Minute Walk Test for the population of "geriatrics and stroke," this value should not be applied to our patient population due to the progressive neurodegenerative nature of Parkinson's disease. The one major threat to internal validity was inadequate power. The study found Tai Chi to be effective at improving balance, but not gait, in patients with Parkinson's disease. Due to the participants being similar to patients seen in an outpatient orthopedic clinic, results can be extrapolated to a larger patient population.

Article PICO:

Population— The population of this study included 33 people with mild to moderate Parkinson's disease.

Intervention— The intervention group received 20, one-hour Tai Chi exercise sessions over the course of 13 weeks.

Comparison— The comparison group received no intervention.

Outcomes— The outcome measures relevant to our clinical PICO include: Berg Balance Scale, Timed Up and Go, and Six-Minute Walk test.

Blinding: The first author who randomly assigned participants to either the Tai Chi group or the control group was not blinded to group assignment. However, the rater who scored participant evaluations was blinded to group assignment. We feel there was sufficient blinding in this study, therefore, it was not a significant threat to the study outcomes.

Controls: The control group did not receive any interventions during the study period. They were evaluated on the same test measures and at the same times as the intervention group. This was a true control group, so differences between groups can be attributed to the intervention.

Randomization: Subjects were randomly assigned to either the Tai Chi group or the control group through a coin toss. The authors state that the two groups were not significantly different at baseline with regard to age, UPDRS scores, Hoehn & Yahr values, or duration of Parkinson's disease. Due to the similarities between groups at baseline, randomization was successful and stratification was not needed.

Study: The pilot study was a randomized clinical trial with 33 eligible study participants, which were put into either the Tai Chi exercise group (n=17) or a control group (n=15) who received no intervention. Inclusion criteria were as follows: at least 40 years old, able to walk independently for at least 3 meters with or without an assistive device, between 1.5 to 3 on the Hoehn & Yahr scores, and demonstrated benefits from levodopa. Exclusion criteria was a serious medical problem or neurological deficit that could interfere with study results. The control group received one-hour long Tai Chi exercise sessions twice a week for 13 weeks with a total of 20 completed sessions. The control group received no intervention.

Outcome measures: The relevant outcome measures to our clinical question included the Berg Balance Scale, Timed Up & Go, and Six Minute Walk Test. These outcome measures were assessed one week prior to starting the intervention and one week following completion of intervention for both study groups. The authors did not provide reliability or validity of the

outcome measures nor intra- or inter-rater reliability from other studies. The authors do not discuss a threshold for minimal clinically important difference (MCID) for the outcome measures we are interested in. Upon research performed by the CAT authors, it was found that there are no established MCID scores for the Berg Balance Scale, Timed Up and Go, or Six-Minute Walk Test for the population of individuals with Parkinson's disease. However, there is an MCID for the Six-Minute Walk Test for the population of "geriatrics and stroke," but this value should not be applied to our patient population due to the progressive neurodegenerative nature of Parkinson's disease.

Study losses: From the Tai Chi intervention group, four participants did not complete the study, which is 23% of the group. From the control group, three participants were unable to complete post-testing, which is 19% of the group. It does not appear that these study losses were related to interventions, the authors providing the following reasons: from the Tai Chi group, one withdrew due to being hospitalized for unrelated issues, one withdrew citing that the exercise was not sufficiently intense, and two had transportation issues and were unable to complete the required 20 lessons in 13 weeks. From the control group, three participants were unable to complete post-testing due to: an ankle injury, a hospitalization, and a death in the family, respectively. The authors only analyzed data from the remaining 26 participants, and subjects were analyzed in the groups to which they were randomly assigned. An intention-to-treat analysis was not done.

Summary of internal validity: We deem the internal validity of this study to be good. There were three threats to internal validity due to lack of blinding of the participants and inadequate power. The one major threat was inadequate power due to a small number of study participants. The two minor threats were the Hawthorne effect due to participants wanting to please the researcher and the Rosenthal effect due to participants being in an unfamiliar environment.

Evidence: The outcome measures related to our clinical questions are the Berg Balance Scale, Timed Up and Go, and Six-Minute Walk Test.

Table 5: Comparison of average change scores between Tai Chi and control groups on the Berg Balance Scale, Timed Up & Go, and Six-Minute Walk Test

Outcome measure	Tai Chi	Control group	Effect Size (95% CI)
Berg Balance Scale	3.3*	-0.5*	1.47 (0.60 to 2.33)
Timed Up and Go (s)	-1.0	-0.1	1.15 (0.32 to 1.98)
Six-Minute Walk Test (m)	44.4	0.8	0.78 (-0.02 to 1.58)

* The asterisk indicates that a statistically significant difference was seen in the Berg Balance Scale with the Tai Chi group performing better than the control group, $p = 0.001$.

The Timed Up & Go and the Six-Minute Walk were not found to be statistically significant, however, the Tai Chi group performed better than the control group with these measures. Effect size was calculated by the CAT authors as follows: the Berg Balance and Timed Up & Go portrayed a large effect size of 1.47 and 1.15, respectively, while the Six-Minute Walk Test portrayed a medium effect size of 0.78. The 95% confidence intervals crossed zero only for the Six-Minute Walk Test, which indicates that Tai Chi may not have been more effective than the control group at improving Six-Minute Walk Test scores.

Applicability of study results:

Benefits vs. Costs: The treatment was not expensive or time-consuming. No adverse events were reported, and participants reported enjoying the class. Elements of Tai Chi could easily be added into an exercise treatment plan for patients. Therefore, the benefits outweigh the costs.

Feasibility of treatment: The study procedures were not described well enough to be exactly reproduced in the clinical setting. The exercises did not require equipment, nor were harmful. However, the clinician would require more guidance about the specific Tai Chi exercises this study used. The sessions were twice weekly for one-hour, and they could easily be condensed into a time period appropriate for an average physical therapy session.

Summary of external validity: The sample of participants in this study would be similar to patients treated in an outpatient orthopedic clinic. While the study had three threats to internal validity, we feel they did not compromise the ability to extrapolate these results to a larger

patient population. While only one of the outcome measures showed statistical significance, the other two showed trends favoring Tai Chi over the control group.

Synthesis/Discussion: Overall, these three studies had similar results suggesting that Tai Chi is effective at improving gait and balance in patients with mild to moderate Parkinson's disease. Due to the Li et al., 2007 article being a pilot study, it had low methodological quality, but statistically significant differences were seen in all outcome measures. The Li et al., 2012 article showed statistically significant changes in all outcomes measures between Tai Chi and stretching as well as in three of the five outcomes measures between Tai Chi and resistance training. The Hackney and Earhart article exhibited statistically significant changes only in the Berg Balance Scale, but trends were seen in the other two outcomes measures favoring Tai Chi over the control group. These differences between studies can be attributed to the following:

Rankings of Methodological Quality: PEDro scores were calculated for the three studies to be; Li et al., 2007 was 4/10, Li et al., 2012 had a score of 7/10, and Hackney and Earhart was 5/10. In order for PEDro scores to be moderate to high quality, the scores should be greater than or equal to 5/10. Due to one of the PEDro scores being less than 5, the methodological quality for these three studies was moderate.

The common areas of the PEDro scale lacking in the three studies were allocation not being concealed and no blinding to participants or therapists. The Li et al., 2012 article and the Hackney and Earhart article were randomized control trials that had blinding of outcome assessors and random allocation. Li et al., 2007 was lacking these criteria and therefore had many threats to internal validity. While the articles by Li et al., 2012 and Hackney and Earhart were lacking certain criteria of the PEDro scale, we deemed the internal validity of these studies to be good.

Population Eligibility Criteria: The three studies had similar eligibility requirements of participants. These included diagnosis of Parkinson's disease, a Hoehn and Yahr scale between 1 and 4, Mean ages between 62 and 71 years old, ability to ambulate independently with or without an assistive device, or lack of other medical conditions that would interfere with participation. For the Li et al., 2007 and 2012 articles, participants were also required to have a Mini-Mental State Examination score of 24 or greater indicating no cognitive impairments and medical clearance by their physician. The Li et al., 2012 article and the Hackney and Earhart article both calculated the Unified Parkinson's Disease Rating Scale (UPDRS) scores for their participants. The UPDRS is a scale used to rate the progression of Parkinson's disease.

Number of Subjects: Our first article by Li et al., 2007 and our third article by Hackney and Earhart were found to have inadequate power with N=17 and N=33, respectively. Hackney and Earhart potentially made a type II error in which statistical significance was not seen in two of

the outcomes because of having inadequate power. Li et al., 2012 has 195 participants, but only 185 participants provided complete data. An intention to treat analysis was performed.

Treatment Differences: Differences in PICO for the three studies can be seen in Table 5.

Table 6: Comparison of PICO Descriptions

	Li et al., 2007	Li et al., 2012	Hackney and Earhart
Population	17 subjects, 5 consecutive days	195 subjects, twice weekly for 24 weeks	33 subjects, 20 treatment sessions within 10-13 weeks
Intervention	Tai Chi	Tai Chi	Tai Chi
Comparison	Subjects compared to pre-exercise state	Resistance training group or stretching group	Control group that received no intervention
Outcome Measures	50-ft speed walk, Up and Go, and Functional Reach	Maximum excursion, stride length, gait velocity, Functional Reach, and Timed Up and Go	Berg Balance Scale, Timed Up and Go, and Six-Minute Walk Test

Duration of treatment in the Li et al., 2012 and Hackney and Earhart articles was sufficient to see improvements due to muscular changes from the interventions, but the Li et al., 2007 article has an insufficient period of time indicating that results may not have been due to the Tai Chi intervention. All outcome measures emphasized gait and balance even though they were not consistent between the studies.

Methodological Flaws: The Li et al., 2012 and Hackney and Earhart articles had moderate to high methodological quality due to appropriate duration of intervention periods and randomized control study designs. The Li et al., 2007 article had low methodological quality with the primary flaw being uncontrolled extraneous variables from participants being given exercise DVDs to

take home, and not having to report how much practice was done outside of designated intervention times.

Conclusion: Based on the results of these three studies, Tai Chi was found to be a safe and effective treatment for patients with mild to moderate Parkinson's disease. Therefore, we would recommend incorporating elements of Tai Chi into outpatient orthopedic physical therapy treatment sessions.

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