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Effects of a 12-week program of Tai Chi exercise on the kidney disease quality of life and physical functioning of patients with end-stage renal disease on hemodialysis

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ABSTRACT

Background: Previous studies have shown that exercise training in patients with end-stage renal disease could improve their physical functioning and quality of life. Nevertheless, few studies have evaluated the effects of Tai Chi exercise in patients on hemodialysis.
Objective: To investigate the effects of a Tai Chi exercise intervention on the quality of life and physical functioning in end-stage renal disease patients on hemodialysis.
Design: A pre-post experimental design.
Setting: Patients, aged 20 years or older, on hemodialysis recruited from the hemodialysis unit at a medical center in central Taiwan were assigned, based on their own preference, to either a control group (n = 25) or an intervention group (n = 21).
Intervention: A weekly one-hour short-form Yang style Tai Chi session for a total of 12 weeks.
Main outcome measures: Physical functioning and Kidney Disease Quality of Life (KDQOL) at the baseline and at the end of the intervention.
Results: The least square means of repetition of sit-to-stand cycles in one minute (STS-60), 6-min walk test, and gait speed test were significantly improved in the intervention group. In addition, the least square means of the five different dimensions of the KDQOL were all significantly higher in the intervention group, except the SF-12 physical health score.
Conclusions: Improvements in the kidney disease quality of life and physical functioning were observed in Taiwanese patients on hemodialysis with a 12-week Tai Chi exercise intervention.

1. Introduction

Taiwan has the highest incidence and prevalence of end-stage renal disease (ESRD) in the world.[1] A continuous decline in physical functions is commonly experienced by patients with ESRD and can increase their risk of additional health complications such as sarcopenia.[2] and depression [3] ESRD is also strongly associated with a lower health related quality of life,[4] which can lead to a further reduced levels of physical activity.

Exercise-based rehabilitation programs may improve the functional capacity of patients and thereby offering them a better quality of life. Previous studies have shown that aerobic endurance exercise training in patients with ESRD could improve physical functioning and quality of life.[5,6] In addition, resistance exercise has been reported to increase strength and functional capacity in hemodialysis patients.[7,8]

Tai Chi, a traditional Chinese form of conditioning exercise, has increasing evidence for its beneficial health effects such as improve balance, increase muscle strength, psychological well-being, and cardiovascular fitness in patients with chronic conditions.[9,10] Nevertheless, to date, few studies have evaluated the effect of Tai Chi exercise on the quality of life and physical functioning in patients with ESRD on hemodialysis.[11–13] Therefore, the aim of this study

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was to investigate the effects of a 12-week Tai Chi exercise intervention on the kidney disease quality of life and physical functioning in patients on hemodialysis.

2. Methods

2.1. Study design and participants

A pre-post experimental design was used in this study to compare the kidney disease quality of life and physical functioning of patients on hemodialysis between Tai Chi intervention group and control group. Patients on hemodialysis were recruited from the hemodialysis unit at a medical center in central Taiwan in October 2011. Inclusion criteria for participants in the study were age greater than 20 years, the ability to communicate in Chinese, and had no obvious cognitive impairment as determined by the study nurse. Exclusion criteria included patients with blindness, a history of myocardial infarction, limitations in mobility caused by bone diseases, had joint replacement surgery within six months, or were practicing Tai Chi exercise at the time of the study. A total of 48 patients who agreed to participate were assigned to either a control group (n = 27) or an intervention group (n = 21), according to the patients' own preference. The study protocol was approved by the institutional review board of the Chung Shan Medical University Hospital, Taiwan (no. CS11131). All subjects had been informed of their rights to refuse or discontinue participation in the study, according to the ethical standards of the Helsinki Declaration of 1983.

2.2. Tai Chi intervention and control

The intervention consisted of a one-hour Tai Chi session per week for 12 weeks held indoor at the hemodialysis unit of the study hospital. All sessions were led by an accredited Tai Chi instructor who had 20 years of Tai Chi experience and had received an international referee license from the International Tai Chi Federation in 2006. A typical session consisted of 10–15 min of warm-up exercise, followed by 40 min of 13-movement Tai Chi exercise, and ended with 5–10 min of cool-down. In addition to the supervised in-hospital weekly session, participants were asked to practice at home at least twice per week. Participants were given a training video with Tai Chi exercise performed by the instructor to help them to practice at home on their own. Moreover, a training diary was provided to each participant for recording the length of practice time of the home sessions. The diary was checked every week by the study nurse to ensure ongoing compliance with the intervention.

There are many styles of Tai Chi with different exercise intensities. In this study, the13-movement short-form Yang style of Tai Chi was chosen because it is easier for novices to learn compared with the standard form with 42 movements. The 13 movements are (1) Beginning, (2) Cloud Hands, (3) Single Whip, (4) Fist Under Elbow, (5) White Crane Spreads its Wings, (6) Left Brush Knee and Push, (7) Hand Strums the Lute, (8) High Pat on Horse with Palm Thrust, (9) Turn Body and Chop with Fist, (10) Step Forward, Parry Block and Punch, (11) Grasp the Bird's Tail, (12) Cross Hands, and (13) Closing.[14]

Participants in the both the intervention group and the control group were instructed to engage in light intensity physical activities, such as strolling and stretching exercise, which is a part of the routine care suggested by the kidney disease management program of the study hospital.

2.3. Questionnaire and measurement scales

A self-administered questionnaire consisted of two sections was used in this study. A study nurse was responsible to distribute and collect the questionnaires. Section 1 was designed to ascertain the patients' basic characteristics at the baseline, including age, sex, marital status, educational level, marital status, working status, mean number of dialysis session per week, duration of dialysis therapy, total number of chronic diseases. Section 2 consisted of the outcome indicators of this study, which included (1) time to complete 5 sit-to-stand cycles (STS-5), (2) time to complete 10 sit-to-stand cycles (STS-10), (3) repetition of sit-to-stand cycles in one minute (STS-60), (4) 6-min walk test (6MWT), (5) gait speed, (6) Karnofsky Performance Status, and (7) Kidney Disease Quality of Life (KDQOL-36). These indicators were measured both at baseline and at the end of the 12-week Tai Chi program.

The STS-5 and STS-10 tests were used to quantify lower-extremity muscle strength by measuring the time, in seconds, required to complete 5 and 10 sit-to-stand cycles for 5 and10 times, respectively.[15] The STS-60 test was used to estimate muscle endurance by measuring the number of repetitions of sit-to-stand cycles achieved in 60 s.[16] The 6MWT was used to measure activities of daily living.[17] It was performed in a 25-m corridor located in the hemodialysis unit with a mark placed every 1 m. Participants were asked to walk the longest distance possible in 6 min by walking continuously, turning around at the end of the marked corridor without stopping. The gait speed was calculated for each participant using distance in meters and time in seconds. Participants were instructed to walk at their usual pace from a standing start over a 6-m distance. The gait speed test is a reliable measure of functional capacity and has been shown to have good predictive value for hospitalizations and mortality.[18] The Karnofsky Performance Status is an index that allows for patient classification based on their degree of functional impairment, graded on a 5-point Likert scale ranging from 0 (no evidence of any impairment) to 4 (death). [19] The Kidney Disease Quality of Life (KDQOL) is a self-reported questionnaire that combines the generic SF-36 Health Survey instrument and disease-specific components for assessing the health-related quality of life of chronic kidney disease patients. The disease-specific core contains 24 items comprising three scales: Symptoms and Problems (12 items), Burden of Kidney Disease (4 items), and Effects of Kidney Disease (8 items). The generic core consists of the 12 items from Short Form-12 (SF-12) Health Survey: physical health score (6 items) and mental health score (6 items). The raw scores were transformed linearly to a range of 0–100, with higher scores indicating better kidney disease quality of life.[20]

2.4. Statistical analysis

Sample size estimation was conducted based on the study by Shahgholian et al.[11], where a mean difference of 12.7 units and a standard deviation of 14.1 units in quality of life score between the intervention group and the control group were reported. A sample of 20 per group would be needed to achieve a power of 80% at two-sided 5% significance level.

The basic characteristics of the intervention and control group were compared with Chi-square test or Mann-Whitney *U* test, as appropriate. Analysis of Covariance (ANCOVA) was used to compare least-square adjusted group mean between the two groups, adjusting for baseline measurement, age, sex, and mean number of dialysis session per week.[21] A two-tailed p value of <0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics software package, version 23.0 (IBM Corp, Armonk, NY, USA).

3. Results

Of the 48 participants, two from the control group dropped out of the study due to fracture and severe gastroenteritis. Thus, 25

Table 1
Basic characteristics of the study participants at baseline (N = 46).

Variable	n (%)		p
	Intervention group21 (45.7)	Control group25 (54.3)	
Age (year)			0.755
≤50.9	8 (38.1)	7 (28.0)	
51.0–64.9	9 (42.9)	13 (52.0)	
≥65.0	4 (19.0)	5 (20.0)	
mean ± SD	54.2 ± 15.2	54.6 ± 12.7	0.691
range	29–83	21–72	
Sex			0.665
male	13 (61.9)	17 (68.0)	
female	8 (38.1)	8 (32.0)	
Educational level			0.288
elementary school or below	4 (19.0)	9 (36.0)	
high school	9 (42.9)	11 (44.0)	
university or above	8 (38.1)	5 (20.0)	
Marital status			0.685
being married	17 (81.0)	19 (76.0)	
other	4 (19.3)	6 (24.0)	
Work status			0.845
working currently	12 (57.1)	15 (60.0)	
not working currently	9 (42.9)	10 (40.0)	
Mean number of dialysis session per week			0.223
<3	1 (4.8)	4 (16.0)	
3	20 (95.2)	21 (84.0)	
Duration of dialysis therapy (months)			0.247
mean ± SD	68.7 ± 49.5	49.8 ± 41.7	
range	1–206	2–138	
Total number of chronic diseases			0.233
0	3 (14.3)	2 (8.0)	
1	4 (19.0)	9 (36.0)	
2	6 (28.6)	11 (44.0)	
3	5 (23.8)	2 (8.0)	
4	3 (14.3)	1 (4.0)	
mean ± SD	2.0 ± 1.3	1.6 ± 0.9	0.215

SD: standard deviation.

Table 2
Kidney disease quality of life and physical functioning of the study participants at baseline (N = 46).

Variable	Mean ± standard deviation (median)		p
	intervention group n = 21	control group n = 25	
STS-5 (s)	18.1 ± 6.8 (15.6)	13.9 ± 4.2 (13.1)	0.021
STS-10 (s)	36.6 ± 15.7 (31.2)	26.9 ± 7.9 (25.2)	0.007
STS-60 (repetitions)	19.3 ± 6.5 (19.0)	24.4 ± 6.7 (25.0)	0.013
6MWT (m)	389.9 ± 86.1 (429)	387.2 ± 63.9 (380)	0.421
Gait speed (m/s)	98.9 ± 23.9 (102.0)	102.2 ± 17.6 (98.0)	0.741
Karnofsky Performance Status	0.76 ± 0.70 (1.00)	0.76 ± 0.66 (1.00)	0.981
Kidney Disease Quality of Life (KDQOL) score			
Symptoms and problems	70.8 ± 15.2 (75.0)	68.3 ± 17.6 (64.6)	0.446
Burden of kidney disease	29.8 ± 21.6 (25.0)	23.8 ± 23.2 (18.8)	0.286
Effects of kidney disease	60.3 ± 17.4 (65.6)	62.1 ± 20.0 (62.5)	0.842
SF-12 physical health score	39.8 ± 8.1 (38.3)	39.9 ± 7.7 (36.4)	0.921
SF-12 mental health score	42.5 ± 12.3 (39.5)	42.3 ± 12.6 (43.4)	0.869

STS-5: time to complete 5 sit-to-stand cycles; STS-10: time to complete 10 sit-to-stand cycles; STS-60: repetition of sit-to-stand cycles in one minute; 6MWT: 6-min walk test.

Table 3
Least squares means obtained from analysis of covariance of kidney disease quality of life and physical functioning of patients on hemodialysis between Tai Chi group and control group (N = 46).

Variable	Least squares means (95% CI)		p
	Intervention groupn = 21	Control groupn = 25	
STS-5 (s)	11.4 (9.9–13.0)	12.4 (11.1–13.7)	0.226
STS-10 (s)	22.4 (18.2–26.6)	25.6 (22.1–29.1)	0.146
STS-60 (repetitions)	29.7 (27.0–32.4)	24.7 (22.4–27.0)	0.001
6MWT (m)	421.6 (394.7–448.4)	388.0 (365.2–410.9)	0.016
Gait speed (m/s)	118.3 (107.8–128.8)	104.4 (95.5–113.4)	0.011
Karnofsky Performance Status	0.60 (0.22–0.99)	0.88 (0.56–1.20)	0.128
Kidney Disease Quality of Life (KDQOL) score			
Symptoms and problems	89.8 (82.1–97.5)	77.6 (70.9–84.2)	0.003
Burden of kidney disease	40.6 (29.6–51.7)	27.0 (17.8–36.2)	0.018
Effects of kidney disease	80.6 (69.4–91.8)	67.0 (57.5–76.5)	0.018
SF-12 physical health score	43.8 (39.2–48.5)	41.7 (37.8–45.7)	0.357
SF-12 mental health score	53.8 (47.7–59.9)	46.1 (40.9–51.3)	0.014

Least squares means were adjusted for covariate effects of age, sex, mean number of dialysis session per week, and the baseline value of the respective outcome variable. 95% CI: 95% confidence interval; STS-5: time to complete 5 sit-to-stand cycles; STS-10: time to complete 10 sit-to-stand cycles; STS-60: repetition of sit-to-stand cycles in one minute; 6MWT: 6-min walk test.

patients in the control group and 21 patients in the intervention group were included in the final analysis. The basic characteristics of the study participants are shown in Table 1. There were no significant differences in the basic characteristics between the two groups at the baseline. The physical functioning and KDQOL-36 of the study participants at the baseline are shown in Table 2. The time to complete STS-5 and STS-10 were significantly longer and the number of repetitions for STS-60 was significantly fewer in the Tai Chi group, which indicated that lower-extremity muscle strength and muscle endurance were poorer in the Tai Chi group at the baseline.

Results of the analysis of covariance are shown in Table 3. The least square means of STS-60, 6MWT, and the gait speed test were significantly higher in the intervention group, indicating an improvement in the performance of these indicators. In addition, the least square means of the five different dimensions of the KDQOL-36 were all significantly higher in the intervention group, except the SF-12 physical health score. In other words, the Tai Chi intervention was able to improve the kidney disease-specific aspect and the general mental health of the patients' quality of life.

4. Discussion

Previous research indicated that quality of life, both the physical and mental components, is impaired in renal patients in the early stages of disease.[4,22] Quality of life and functional status have been found to be an independent predictor of the risk of early mortality among new dialysis patients.[23] In this nonrandomized interventional study, a 12-week program of Tai Chi exercise was able to improve both the kidney disease quality of life and physical functioning in Taiwanese patients with ESRD on hemodialysis.

Studies on hemodialysis patients suggested that exercise can improve their physical functioning and quality of life.[24,25] Moreover, previous studies have reported an enhanced quality of life with Tai Chi exercise in patients with various chronic illnesses.[26] Regarding patients with ESRD, a pilot study of six Canadian patients on peritoneal dialysis reported that a three-month Tai Chi Wu-style exercise was able to significantly improve the total mental health dimension score of the Short Form with 36 questions (SF-36). The total physical health score or the total SF-36 score also improved but did not reach statistical significance.[13] Conversely, a single group quasi-experimental study in Iran on 25 hemodialysis patients found that a once-a-week session of a 12-week Tai Chi exercise program was able to significantly improve quality of life scores in all four measured dimensions including health and functioning, socioeconomic, psychospiritual, and family. Quality of life was assessed in the study based on a questionnaire modified from the Ferrans and Powers Quality of Life Index Dialysis Version and the KDQOL-SF questionnaires.[11] In the present study, we also found that our Tai Chi exercise program could significantly improve four of the five dimensions of the KDQOL-36. The lack of a significant improvement in the SF-12 physical health score with the intervention was not unexpected. It is unlikely that the perceived overall health and the ability to perform moderate activities could be drastically improved with a 12-week intervention. Nevertheless, the significant improvements in STS-60, 6MWT, and gait speed suggested the benefits of Tai Chi exercise is more readily observed in muscle endurance and performance related to the lower limbs.

Furthermore, a study of a 3-month home-based Tai Chi exercise program on 33 patients with ESRD in Hong Kong reported significant improvements in the timed "Up & Go" and "Sit & Reach" tests. However, no significant changes were observed in the 6MWT and Kidney Disease Quality of Life-Short Form (KDQOL-SF) scores. Nevertheless, the study suffered from a high drop-out rate of 54%.[12] Conversely, our study found improvements in 6MWT and muscle endurance as measured by the STS-60. On the other hand, no significant changes were observed in the lower-extremity muscle strength in our study. In other words, 12 once-a-week hourly session of Tai Chi exercise appeared to able to increase muscle endurance but not muscle strength. In patients with chronic kidney disease, reductions in muscle mass and strength is common as a result of protein-energy wasting.[27] Long-term practice of Tai Chi exercise might be required to significantly increase muscle strength.[28]

There are a few limitations of this study that are worth mentioning. First, while a control group was included in this study, the patients were not randomly allocated to the intervention or control groups. The use of random allocation might increase nonadherence in those who had low motivation to engage in regular Tai Chi exercise. While it is possible that patients who chose to take part in the Tai Chi group might have a better cardiorespiratory function, exercise tolerance, or active attitude to exercise, a comparison of the physical functioning variables at the baseline revealed the opposite. The patients in the Tai Chi group actually had a significantly poorer performance in STS-5, STS-10, and STS-60 at the baseline. In other words, such difference in the two groups should bias our results towards the null rather than contribute to false-positive findings. Second, without the use of a sham Tai Chi exercise in the control group, the possibility of a placebo effect could not be completely ruled out. The extent of the Hawthorne effect, that is, the reactivity in response to the awareness of being studied, on the observed improvement in the Tai Chi group could not be quantified.[29]

In conclusion, the improvements in the kidney disease quality of life and physical functioning among Taiwanese ESRD patients on hemodialysis observed in this study were consistent with the beneficial effects of Tai Chi exercise in patients with other chronic diseases. Additional investigations on the effects of Tai Chi exercise in patients at different stages of chronic kidney disease are warranted.

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