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RESEARCH PAPER

The effect of supervised Tai Chi intervention compared to a physiotherapy program on fall-related clinical outcomes: a randomized clinical trial

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Purpose: To assess some fall-related clinical variables (balance, gait, fear of falling, functional autonomy, self-actualization and self-efficacy) that might explain the fact that supervised Tai Chi has a better impact on preventing falls compared to a conventional physiotherapy program. _Methods_: The participants (152 older adults over 65 who were admitted to a geriatric day hospital program) were randomly assigned to either a supervised Tai Chi group or the usual physiotherapy. The presence of the clinical variables related to falls was evaluated before the intervention (T1), immediately after (T2), and 12 months after the end of the intervention (T3). _Results_: Both exercise programs significantly improved fall-related outcomes but only the Tai Chi intervention group decreased the incidence of falls. For both groups, most variables followed the same pattern, i.e. showed significant improvement with the intervention between T1 and T2, and followed by a statistically significant decrease at the T3 evaluation. However, self-efficacy was the only variable that improved solely with the Tai Chi intervention ($p = 0.001$). _Conclusions_: The impact of supervised Tai Chi on fall prevention can not be explained by a differential effect on balance, gait and fear of falling. It appeared to be related to an increase of general self-efficacy, a phenomenon which is not seen in the conventional physiotherapy program.

Keywords: Balance exercise, fall prevention, older people, physical therapy, self-efficacy, Tai Chi

Implications for Rehabilitation

- Each participant received a multidisciplinary intervention with either Tai Chi or physical therapy.
- Both interventions were associated with improved balance, gait, less fear of falling, improved functional autonomy and greater self actualisation.
- Only Tai Chi decreased the incidence of falls which appeared to be related to self-efficacy.
- Tai Chi seems to be a good alternative to physical therapy exercises to prevent falls in frail older people.

Introduction

Multifactorial strategies to reduce falls are effective, particularly balance exercise programs, which are often considered as the most crucial component of this kind of intervention [1–3]. It has already been shown that physical therapy intervention, including progressive balance exercises and gait training, is effective [4]. Indeed, Tai Chi appears to be an alternative form of exercise with good potential to improve balance and decrease the risk of falls in older adults [5,6]. Tai Chi exercises consist of a series of sequential, graceful, and balanced movements executed in a slow, meditative, and relaxed manner [7]. With its mild-to-moderate intensity, Tai Chi develops cardiopulmonary capacity, muscle strength, postural control, spinal flexibility and balance [7]. All of these characteristics made this exercise program safe for the elderly [8]. Tai Chi has been studied as a way to prevent falls, mainly in relatively healthy older adults [9–11].

More recently, a randomized clinical trial was conducted by our research team to compare the effectiveness of a Tai Chi intervention program with conventional physical therapy; both were based on a personalized rehabilitation program with regards to incidence and severity of the falls in frail older adults [12]. Results showed that Tai Chi offers more protection against the incidence of falls than conventional physiotherapy

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(RR: 1.3; CI=1.019–1.772). This conclusion concerning the effect of supervised Tai Chi on frail older adults is a breakthrough in fall prevention.

To date, published studies on the efficacy of Tai Chi interventions focus mainly on the impacts of fall incidences. Of these studies, only a small number concerns fall-related clinical variables associated with this new approach and their results are not related to the effects of Tai Chi movements on the clinical variables [13]. Therefore, the aim of this study was to measure fall-related outcomes such as balance, gait, fear of falling, functional autonomy, self-actualization and self-efficacy previous to and following the intervention (Tai Chi or conventional therapy) in order to shed light on the clinical variables that influence the probability of future falls.

Methods

Design

This study is an embedded study within a single blind randomized controlled trial design and intends to document the efficacy of supervised Tai Chi exercises versus the conventional physiotherapy used in fall prevention programs for seniors presenting multiple disabilities [12]. Measurements were taken three times: (i) prior to the intervention (T1), (ii) immediately after (T2), and (iii) 12 months following the end of the intervention (T3).

Participants

The eligible participants were seniors aged over 65 admitted to a geriatric hospital (GDH) program at the Sherbrooke Geriatric University Institute (IUGS) in Quebec, Canada. Inclusion criteria were: (i) being at high risk for a fall (Berg balance scale (BBS) score of ≤49/56 and at least one accidental fall in the previous 6 months), (ii) presenting multiple disabilities and (iii) being mentally able to take part in an exercise program (3MS > 65). Exclusion criteria were: (i) being declared unfit for physical activities following a medical assessment and (ii) presenting a mental or physical condition incompatible with physical activities.

Recruitment and sampling

All referrals to the GDH for falls were screened by a medical team. During the first visit, a physician assessed each patient using the modified mini-mental state examination (3MS [14]) whereas the BBS [15] was administered by a physiotherapist. Thereafter, inclusion and exclusion criteria were verified by the physician. All subjects who met the criteria were then contacted by a research assistant and the project was explained to them. Those who agreed to participate were included in the study. All participants gave informed consent prior to data collection and the study protocol was approved by the institution's ethics board.

Randomization

Assignment to either one of the groups (Tai Chi intervention or conventional physiotherapy program) was done by a random number generator. To ensure that both groups were equivalent in terms of balance disabilities, the sample was stratified according to the BBS score with a cut-off score of 36/56, generating two groups for each type of intervention: (i) high balance disabilities: score under 36, (ii) low balance disabilities: score between 36 and 49. Two sets of sealed envelopes were prepared prior to the beginning of the study for the two strata. With the exception of the Tai Chi instructor and the physiotherapist delivering the interventions, all the research assistants involved in the assessment were unaware of group assignment.

Description of the independent variable

Physiotherapy intervention

In this study, the conventional physiotherapy balance rehabilitation intervention consisted of weight transfer, strengthening and walking exercises. This one-on-one intervention was adapted to the condition of every participant.

Tai Chi intervention

The Tai Chi intervention consisted of an eight-form BA-DUAN-JIN, a Tai Chi Chuan sequence involving: turning, weight shifting, leg bending and extension, single-leg standing and various arm movements. The eight chosen movements were taken from the global sequence of Tai Chi used in previous studies [16,17]. Warm-up exercises were done at the beginning of each session. The most important principles of Tai Chi were explained to the participants: body awareness, relaxation and breathing. A personalized approach was taken to adapt the movements to the participants' condition and to ensure their safety. The intervention was a group session of two to four participants at a time and was delivered by a Tai Chi Chuan instructor who had 20 years of experience. He was assisted by a trained physiotherapist who helped him adapt the movements to the participants' individual abilities.

Treatment intensity was the same for both experimental and comparison groups. Each session was planned to last 60 minutes twice a week for 15 weeks. In total, each participant had a total of 30 hours of intervention.

Description of the clinical outcome variables

The choice of variables was determined according to what the literature demonstrated as known variables related to falls: balance, gait, fear of falling, functional autonomy [4], self-actualization and self-efficacy [12].

Balance, defined as the ability to maintain the projection of the body's centre of mass within manageable limits of the base of support [18], was measured with the BBS [15] and the foam and dome test [19]. Gait is described as a way to apply balance to the patient's reality [8]. The timed up and go test (TUG) which is a clinical instrument that measures speed during several functional manoeuvres, which include standing up, walking (3-meter distance), turning and sitting down [20] and the 5-meter walking time [21] were used to assess this variable. Both of these clinical evaluations were measured with and without a walking aid. Fear of falling, the leading fear in the elderly known to cause a reduction in physical activity, functional abilities and quality of life [22], was tested with the survey of activities and fear of falling in the elderly (SAFE [23]). Functional autonomy was measured using the functional autonomy measurement system (SMAF [24]). The measure of actualization of potential (MAP [25]) was used to assess the self-actualization variable, and finally, the general self-efficacy scale (GSES [26,27]) was chosen to measure the self-efficacy of participants. Other variables were collected to compare the two groups: age, co-morbidity [28] and self-perceived health [29].

Data collection procedures

Participants underwent a complete evaluation at baseline (T1), after 15 weeks of exercises (T2), and at one-year post-intervention (T3). Evaluations were done by a blinded research agent rather than by the two individuals in charge of recruitment.

Data analyses

Descriptive statistics are presented as usual. To evaluate the treatments' effect upon the clinical variables, analysis of variance for repeated measures was done with a two-level inter-subject factor (i.e. group) and a three-level intra-subject factor (i.e. time). Additionally, depending on whether or not the interaction between time and group was significant, analyses of variance for repeated measures were completed for each group to describe the change. All analysis was done using intention to treat. A significant difference was set at a p value <0.05 Analyses were conducted using the SPPS statistical program.

Results

Description of the sample

Overall, 152 participants were enrolled in the study. The flow diagram of the study is presented in Figure 1.

Descriptive statistics are presented in Table I. There was no difference found between the two groups with regards to age, Charlson co-morbidity index, BBS, foam and dome test, and self-perceived health. Of these 152 participants, some of them withdrew from the study during the intervention period (24 in the Tai Chi group and 26 in the comparison group) and other during the 12-month follow-up period (seven from the Tai Chi group and four from the comparison group). The main reasons for these losses (during the intervention and the follow-up) are drop out, lost of sight, worsening sickness, hospitalization and death.

Effect of the interventions

Table II shows the effect of the physiotherapy and Tai Chi interventions on the clinical variables. Both interventions were associated with improvement on all variables except for the

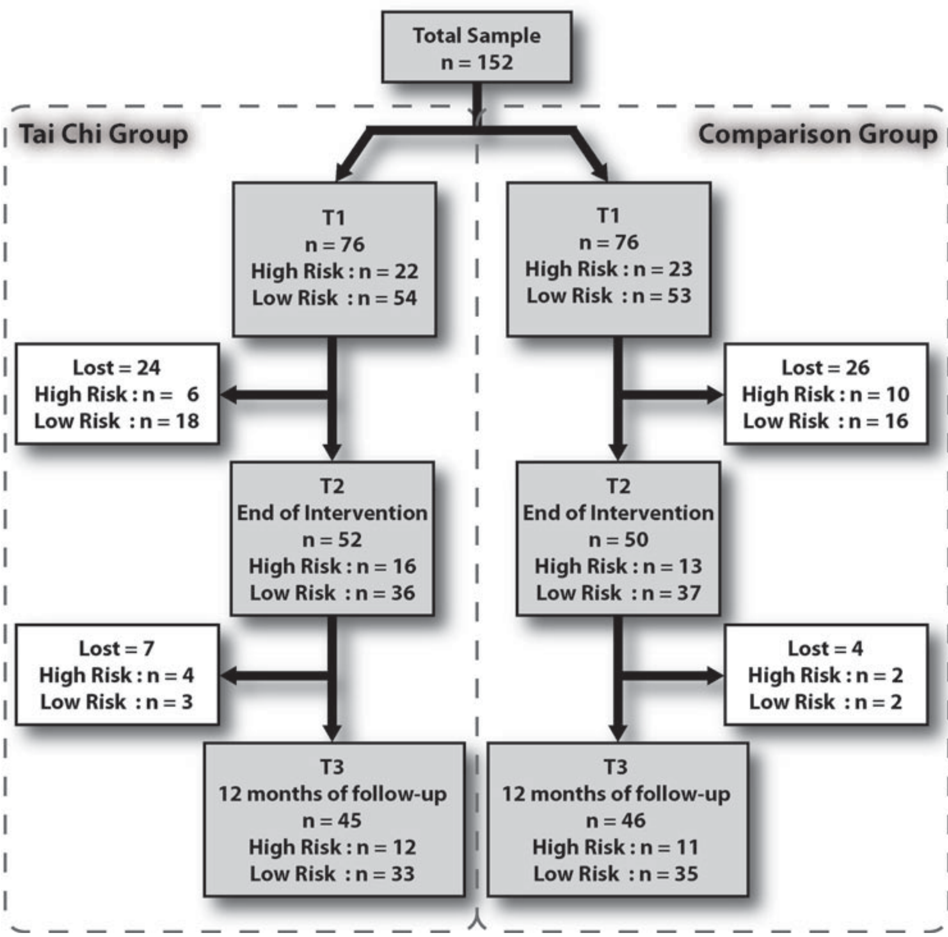

Figure 1. Flow diagram of the study.

Table I. Characteristics of the groups at the beginning of study (T1) (n = 152).

		Tai Chi (n = 76, mean ± SD)	Comparison (n = 76, mean ± SD)	p value
Age (years)		79.1 ± 6.4	80.7 ± 6.0	0.122[a]
Charlson co-morbidity index/41 points		2.3 ± 1.8	2.7 ± 2.1	0.253[a]
Berg balance test/56 points		38.3 ± 7.0	38.5 ± 9.0	0.928[a]
Foam & dome test/24 points		16.9 ± 3.1	17.3 ± 3.5	0.489[a]
Self-perceived health		3.2 ± 1.0	3.4 ± 0.8	0.294[b]
		%	%	
Gender	Men	25	29	0.584[c]
	Women	75	71	
Living environment	Owner	27	23	0.882[c]
	Tenant	49	51	
	Resident	24	26	
Fragility	Berg < 36	29	30	0.859[c]
	Berg ≥ 36	71	70	
Marital status	Single	9	5	0.804[c]
	In a relationship	33	37	
	Separated/Divorced	11	11	
	Widowed	47	47	

[a]Inter-group difference - Experimental versus comparison: two-tailed *t*-test for two independent samples.
[b]Inter-group difference - Experimental versus comparison: two-tailed Mann Whitney test.
[c]Inter-group difference - Group versus categories: two-tailed X^2 for two independent samples.

Table II. Clinical outcome measures of Tai Chi and physiotherapy programs.

		T1 Mean ± SD	T2 Mean ± SD	T3 Mean ± SD	Time p value[a]	Time × group p value[b]	Group p value[c]
Berg (/56)	Experimental (n = 43)	38.3 ± 7.0	42.4 ± 6.6	37.6 ± 11.5	<0.001	0.536	0.814
	Control (n = 46)	38.5 ± 9.0	42.0 ± 8.3	37.2 ± 12.2			
Foam and dome (sec.)	Experimental (n = 43)	16.9 ± 3.1	16.4 ± 3.6	18.1 ± 3.3	0.019	0.189	0.792
	Control (n = 44)	17.3 ± 3.5	16.9 ± 3.5	17.4 ± 5.2			
TUG without aid (sec.)	Experimental (n = 26)	22.7 ± 7.3	20.5 ± 6.8	19.5 ± 7.0	<0.001	0.101	0.964
	Control (n = 34)	22.2 ± 8.5	21.7 ± 30.0	20.5 ± 7.0			
5-meter walking time without aid (sec.)	Experimental (n = 26)	8.6 ± 3.1	8.0 ± 3.2	7.4 ± 2.3	0.001	0.347	0.663
	Control (n = 34)	9.6 ± 6.7	7.6 ± 4.6	7.6 ± 2.7			
SMAF (/87)	Experimental (n = 25)	18.4 ± 9.5	20.7 ± 11.4	18.4 ± 12.1	0.048	0.332	0.751
	Control (n = 30)	20.4 ± 11.5	18.0 ± 10.1	21.2 ± 12.5			
GSES (/40)	Experimental (n = 43)	27.7 ± 6.2	29.8 ± 5.8	27.9 ± 5.2	<0.001	0.020	0.872
	Control (n = 46)	29.2 ± 5.4	29.9 ± 5.1	25.9 ± 5.7			
SAFE (/3)	Experimental (n = 44)	0.9 ± 0.5	0.8 ± 0.6	1.1 ± 0.7	<0.001	0.484	0.436
	Control (n = 45)	1.1 ± 0.6	0.8 ± 0.6	1.2 ± 0.7			
MAP (/135)	Experimental (n = 43)	82.9 ± 12.4	–	83.9 ± 9.2	0.767	0.173	0.517
	Control (n = 46)	82.9 ± 9.9	–	81.3 ± 9.9			

[a]Analysis of variance for repeated measures with a two-level inter-subject factor.
[b]Analysis of variance for repeated measures with a three-level intra-subject factor.
[c]Analysis of variance for repeated measures for each group.

MAP (p = 0.767). The majority of these variables followed the same pattern: they showed a significant improvement between T1 and T2 followed by a statistically significant decrease at the T3 evaluation.

The general self-efficacy as measured by the GSES was the only variable that did not react similarly in both groups (see Figure 2). In fact, the interaction between time and group calculated in the analysis of variance for repeated measures was significant (p = 0.020) for this variable. The control group decreased significantly between T1 and T3 (p = 0.001) whereas the experimental group increased between T1 and T2 (p = 0.018), yet lost what had been gained during the one-year follow-up (p = 0.006). For every other variable, graphics showed parallel variations (p > 0.05) across time and even showed merged curves (p > 0.05).

Discussion

Based on the strong evidence that supervised Tai Chi has a greater impact in reducing the incidence of falls in the following year compared to a conventional physiotherapy program in the population of frail elderly [12], the general objective of this study was to understand which of the fall-related clinical variables might explain this effect. The present study shows that all of the physical variables related to gait and balance improved over time between T1 and T2 and decreased over

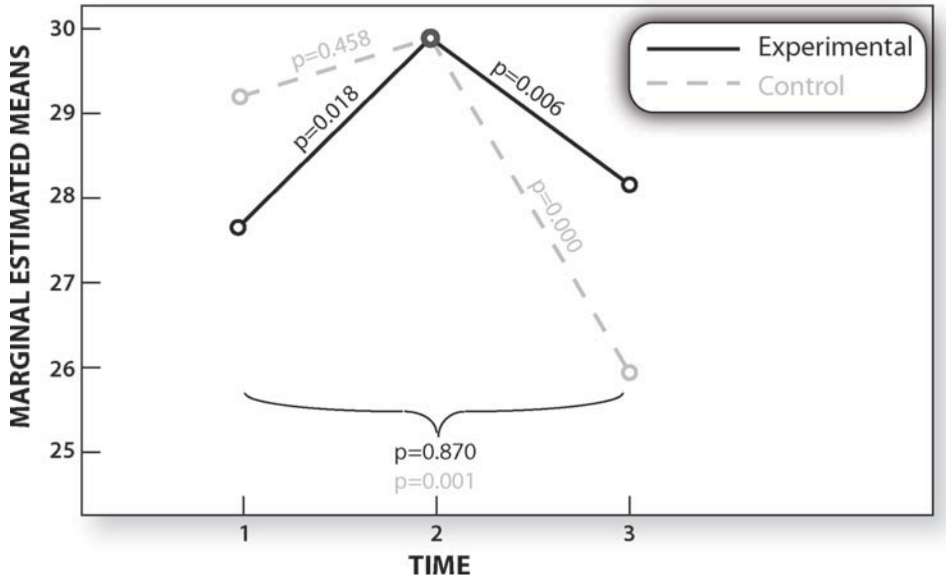

Figure 2. GSES score for both groups by time.

time between T2 and T3 in both groups. Since there was no significant difference between the groups, we must reject our hypothesis that Tai Chi would have a greater effect on clinical variables such as balance, gait, fear of falling and functional autonomy. However, the result shows that the Tai Chi intervention improved the GSES significantly, a phenomenon which is not seen in the conventional physiotherapy program. That was the only variable that did not react similarly in both intervention groups.

The GSES scale assesses a general sense of perceived self-efficacy with the aim of predicting coping with daily hassles as well as adaptation after experiencing all kinds of stressful life events [30,31]. Self-efficacy is positively related to extraversion, failure or action orientation, decision or action orientation, and hope of success, but negatively related to fear of failure. The norm for the GSES scale is around 29.5 ± 5.1. Our results show that the Tai Chi group was under the norm at T1 (27.7 ± 6.2), returned to the norm at T2 (29.8 ± 5.8), and decreased slightly to the original state at T3 (27.9 ± 5.2). The pattern was different for the conventional physiotherapy group, where they were around average at T1 (29.2 ± 5.4) and at T2 (29.9 ± 5.1) yet regressed at T3 (25.9 ± 5.7). Consequently, for both groups, self-efficacy diminishes after the intervention. Therefore, the diminution was more important in the conventional physiotherapy program than the Tai Chi intervention (4 points compared to 2 points).

Recent systematic reviews suggest that community-based Tai Chi programs delivered to groups can have a positive impact on fall-related psychological outcomes but the variables studied referred mainly to the fear of falling [32]. In this present study, the effect of both programs was the same with regards to the fear of falling. This result must be interpreted in light of a new finding related to self-efficacy and motor control. It was recently shown that self-efficacy contributes to independent community ambulation in older adults, indicating the multidimensional complex nature of the task [33]. In Lord *et al.*'s work, self-efficacy was shown to be more relevant than executive function in gait performance, suggesting the need for a broader approach to assessment and intervention strategies. According to this author discussion section, this result may in part be due to current research efforts that have focused on cognitive rather than behavioral aspects of gait. We should probably shift to this new paradigm for Tai Chi research and suggest that Tai Chi movements seem to increase self-efficacy. A strong sense of competence facilitates cognitive processes and performance in a variety of settings including quality of decision-making [27]. Therefore, self-efficacy has an influence on action and would consequently help in developing better strategies to prevent falls.

Major strengths of this study include the comparison of two balance exercise programs on frail elderly. Fortunately, even if there were a relatively high percentages of losses during the follow-up period (nearly 40% of the participants in both groups dropped out of the study), there was no difference between groups based on the main risk factors for falls (age, comorbidity, balance, vision, and self-perceived health) in either the entire sample or the high/low fall risk subgroups. The fact that we were dealing with frail individuals with multiple medical problems admitted to a multidisciplinary geriatric day hospital may partly explain this result. Although our study focused on balance problems, other medical conditions may have caused acute health problems leading to a substantial loss of functional autonomy. For example, 26 of the 50 participants who showed losses between T1 and T2 withdrew voluntarily during the intervention. It seems that 15 weeks of exercises was a burden for the participants in both groups. This result suggested that the length of the exercise program for this frail population might be too long. Twenty-three others left due to a worsening condition or hospitalization, and one died. The same pattern was observed during the 12-month follow-up. However, the relevance of treating this frail population is not an issue given that the clinical effect is clearly demonstrated and lasts for at least one year.

Furthermore, the study was conducted at one site which assures the validity of the data. First, we standardized the team of assessors by conducting a training session to ensure face-to-face interaction in the standardization process. The principal investigators supervised these sessions. Second, one of the study's strengths is that all instruments used have been proven valid and reliable. Third, blinding with regards to the intervention group was maintained for the assessors.

As a whole, we can be confident that our study has good internal validity. Nevertheless, the generalization is limited and the results can only be applied to typical frail older patients referred to a geriatric day hospital for multiple problems where fall is the index problem. Following these considerations, the present research supports the assumption that supervised Tai Chi movements, as part of a rehabilitation program, is a practical alternative to the usual balance exercises for frail patients and can contribute to improve the general self-efficacy and reduce the incidence of falls.

Conclusions

This study aimed to explore the possible explanations regarding the impact supervised Tai Chi has on preventing falls compared to a conventional physiotherapy program. Our hypothesis was that the participants in the Tai Chi group would show greater improvement on the clinical variables than the physiotherapy group. Unexpectedly, we found that the physical variables could not explain the effects of supervised Tai Chi on fall prevention. However, an improvement in self-efficacy seems to be a possible explanation for this tendency since it is the only variable that acts differently between the two groups.

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