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Effects of Tai Chi Exercise on Physical Function and Parent-child Relationship in Adults and Children: A Pilot Study

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Abstract

Objective: This pilot study was aimed at testing the feasibility of parent-child Tai Chi training and also investigating the effects of Tai Chi on physical function and parent-child relationship in adults and children.

Method: Eighteen parents and 15 children were recruited in this pilot study. Physical outcome measurements included muscle strength, cardio-respiratory function and balance. Muscular strength was measured in bilateral hip flexors, extensors, knee flexors and extensors. Hand grip strength was also assessed. Cardio-respiratory function was tested with the YMCA 3-minute step test. Balance control was assessed with the limits of stability test. Apart from physical function, parent-child relationship was also investigated with the Chinese Family Assessment Instrument. All subjects were assessed before and after a 3-month baseline control period, and after subsequent 3-month Tai Chi training. The training was carried out once a week with 90 minutes per session.

Results: No adverse event related to Tai Chi training was reported throughout the study period. Attendance rate of the Tai Chi training course was 88%. Results of the pilot study showed significant increases in most muscle strength parameters in both parent and child groups after Tai Chi training. Significant improvement in heart rate changed in 3-minute step test was also found in both groups after Tai Chi practice. There was a significant decrease in mutuality reported by the parent group during the baseline control period, but no such change was found after the intervention period.

Conclusion: It was feasible to conduct parent-child Tai Chi training. In addition, Tai Chi is an option of exercise to promote muscle strength and cardio-respiratory function in adults and children.

Keywords: Balance; Cardio-respiratory function; Parent-child relationship; Muscle strength; Tai Chi

Abbreviations:

ACSM: American College of Sports and Medicine; COP: Center of Pressure

Introduction

Inactivity in adults and children is a common problem. A local survey showed that 72% of respondents aged between 7 and 12 consider that "they had sufficient or very sufficient amount of physical activities". However, only 65.5% of the interviewees exercise for once a week, while the remaining 34.5% performed exercise with an even lower frequency [1]. The frequency is not enough to maintain physical health according to guidelines from the American College of Sports and Medicine (ACSM) [2]. Another local survey showed that children aged between 9 and 13 years only exercised less than 400 minutes a week in average [3]. Inactivity is also common in healthy adults. A study investigating habit of physical activity in office workers in Hong Kong found that more than 44.2% of the subjects reported that they did not exercise at all [4]. Reasons for the lack of exercise include busy life style and inadequate facilities in Hong Kong [5]. Sedentary life style is associated with poor physical fitness, cardiovascular function, muscle strength [6] and increased cardiovascular risks in children [7]. On the other hand, inactivity in adults is associated with poor cardiovascular function, musculoskeletal problem and pain [8].

Apart from inactivity, lack of communication among family members is also under concern. A survey showed that average time for a working father or mother accompanying their children is less than 4 hours per day [9]. During the time period, most parents revise their children homework or watch television with them [9].

Another study found that only 50% of the adolescents are willing to communicate actively with their fathers, while 70% of them are willing to communicate with their mothers [10]. Previous study has shown a positive relationship between family support and level of physical activity adherence in a study studying the primary school boys in Hong Kong [11]. Increased time spent on physical activity would lead to improved physical function. A question arises is that would parent-child exercise improve both physical condition and relationship of parents and their children. Tai Chi is an option of exercise for people living a busy life. The exercise requires no special equipment, venue nor preparation. It is considered a moderate intensity exercise and mainly involves slow and smooth movement [12], which is suitable for sedentary individuals [13]. Various studies showed that Tai Chi training benefits muscle strength, balance control, cardiovascular function and psychological function in healthy older adults and

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subjects with different pathologies [14-18]. Cross-sectional studies investigating the effects of Tai Chi training showed that concentric and eccentric knee flexor and extensor strength were significantly higher in older Tai Chi practitioners than in controls [18]. Experienced Tai Chi practitioners also performed significantly better in the limits of stability test, as reflected by maximum excursion and directional control [14], and less bodily sway in a stepping down with a concurrent cognitive task [16] when compared with their age-match counterparts.

A clinical trial showed significant improvement in directional control in limits of stability test and vestibular ratio as measured in sensory organization test after four weeks of intensive Tai Chi training [17], while another randomized controlled trial found a significant improvement in arterial compliance in healthy older adults after 16 weeks of Tai Chi training, suggesting a causal relationship of Tai Chi training and improvement in balance control in healthy older adults [15]. Apart from physical functions, Tai Chi practitioners reported a higher level of confidence when performing daily activities [18]. However, there were only few studies investigated the physical effects of Tai Chi exercise on middle-aged adults. In addition, no research has been carried out to look into how parent-child Tai Chi training influences family relationship. Therefore, this pilot study was aimed at (1) testing the feasibility of parent-child Tai Chi training; and (2) investigating the effects of Tai Chi on physical function and parent-child relationship in adults and children.

Methods

Samples

Subjects were recruited in a local primary school. Interested students and their parents joined the study in voluntary base. Parents aged 18 or above and their children aged between 6 and 17 were included. Exclusion criteria included participating in any form of Tai Chi or parent-child exercise, unable to walk independently, having uncontrolled chronic diseases such as hypertension, cardiac problem and diabetes mellitus, recent musculoskeletal injury, underwent orthopedic or major surgery within 6 months and any history of neurological disease.

Procedures

This was a single-group repeated measure quasi-experimental study. The study was approved by the Ethics Committee of The Hong Kong Polytechnic University. Details of the experiment were explained to all subjects and inform consents were obtained prior to any procedures. Eligible subjects were assessed for 3 times: (1) initial assessment (T0); (2) pre-intervention assessment (T1), which is 3 months after the initial assessment, and (3) post-intervention assessment (T2) after the 3-month intervention period. Time between T0 and T1 is considered as control period, while time between T1 and T2 is defined as Tai Chi intervention period.

Measures

Muscle strength, cardio-respiratory function, balance and parent-child relationship were examined in random order within a single session. In order to avoid fatigue, adequate resting periods were provided to all subjects between each test. All assessments were carried out by a physiotherapist. Isometric muscle strength of bilateral hip flexors, extensors, knee flexors and extensors were measured with the Nicholas Manual Muscle Tester (Lafayette Instrument Company, Lafayette, Indiana). The handheld dynamometer has been shown to be reliable in repeated measures of muscle strength [19]. Testing position described in Hislop and colleagues [20] was adapted. Hand grip strength was measured by the Jamar Dynamometer (Therapeutic Equipment Corporation, Clifton, New Jersey). Subjects were seated with shoulder and forearm neutrally rotated and wrist extended between 0^{o}-30^{o} and ulnar deviated 1^{o}-15^{o}. The Jamar Dynamometer has been shown to be reliable and valid in measuring hand grip strength [21].

Resting was given between each test to prevent fatigue. Subjects were asked to repeat each muscle test for 3 times. Average value was used for data analysis. Cardio-respiratory function was measured with the YMCA 3-minute step test [22]. Subjects were asked to step onto a 12-inch high bench in time with a metronome set at 96 beats/minute, by one foot up on the step (first beat), another foot up (second beat), step down with the first foot (third beat) and step down with another foot (forth beat). Heart rates before and immediately after the test were recorded with heart rate monitoring watch (Polar FT1, Polar Electro Ltd. Finland).

Limits of stability were assessed with the EquiTest® Computerized Dynamic Posturography unit (NeuroCom International Inc., type Smart EquiTest®). Assessment was carried out according to the procedures described in the Smart EquiTest® System Operators Manual (Version 7.04) [23]. Subjects were asked to stand on the dual force platforms and shifted their weight as smoothly, as quickly and as far as possible towards 8 different directions (Figure 1) once a visual cue appeared on a screen placed in front of them. Visual feedback was given on the screen which showed the movement of the subjects' normalized center of pressure (COP). Reaction time, maximum excursion and directional control were measured. Reaction time was the time between the appearances of the visual cue to the voluntary shifting of the subject's center of pressure. Maximum excursion was defined as the maximum displacement of the normalized COP within the subject's theoretic limits of stability. Directional control was the smoothness of the COP shifting towards the target direction. It was calculated with the following formula:

$$\text{Directional control} = \frac{\text{Amount of on-target movement} - \text{Amount of off-target movement}}{\text{Amount of on-target movement}} \times 100$$

Parent-child relationship was assessed by the Chinese Family Assessment Instrument (C-FAI). The questionnaire consists of 33 questions and is categorized into 5 subscales, namely communication, mutuality, conflict and harmony, parental concern and parental control. The instrument has been tested to be reliable and valid for assessing family functioning in Chinese population [24].

Intervention

Eighteen-form Yang style Tai Chi was instructed once a week, 90 minutes per session for 12 sessions within 3 months. There was a 10-minute warm up and 5-minute cool down before and after Tai Chi exercise, respectively. The intervention was conducted by an experienced Tai Chi master. Participants were encouraged to practice with their family members after classes.

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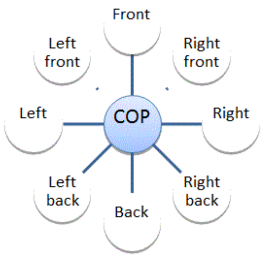

Figure 1: Center of pressure (COP) shifting directions in the limits of stability test.

Data analysis

Statistical Package for the Social Sciences software version 20.0 (SPSS, Inc., Chicago, IL, USA) was employed for statistical analysis. Data were conducted with intent-to-treat last observation carried forward principle.

All outcomes were analyzed by Friedman's test across T0, T1 and T2. Parametric tests were not used because the data were not normally distributed. A two-tailed alpha was set at $p = 0.05$. For every significant result found in Friedman's test, Wilcoxon-singed rank test with adjusted p-value ($p = 0.025$) by Bonferroni correction was conducted for the comparison between T0 vs T1 and T1 vs T2.

Results

Figure 2 shows the flowchart of the study. Eighteen parents (5 men and 13 women, mean age 41.3 ± 5.3 years) and 15 children (12 boys and 3 girls, mean age 9.5 ± 2.5 years) were recruited in this pilot study. Table 1 summarizes the characteristics of the subjects.

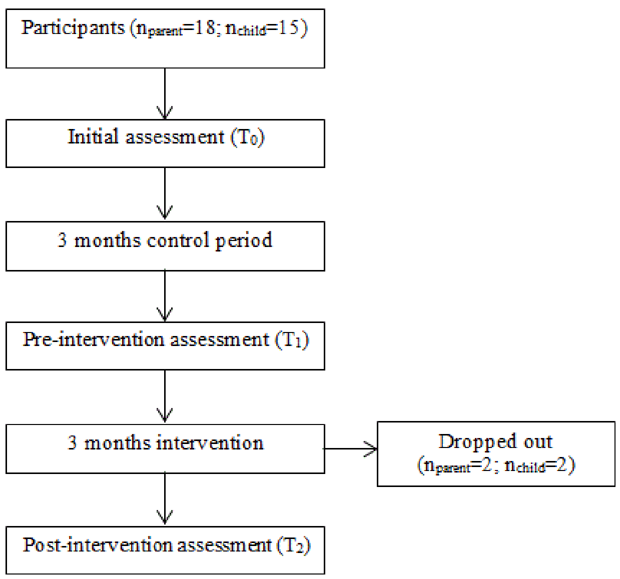

Figure 2: Diagram of study design and participants flow.

Attrition and compliance

Four subjects (2 parents and 2 children) dropped out during the intervention period due to personal reasons. There was no adverse event reported. Attendance rate of the Tai Chi course was 88%. Demographic data were shown in Table 1.

	Parent (n = 18)	Child (n = 15)
Age (year)	41.3 ± 5.3	9.5 ± 2.5
(Age range)	(32-67)	(6-15)
Height (cm)	158.6 ±7.1	134.6 ± 13.7
Body weight (kg)	55.7 ± 9.3	33.0 ± 11.8
Gender (male/female)	5/13	12/3
Values are mean ± SD		

Table 1: Demographic data of participants.

Outcome measures

No significant changes were found in muscle strength parameters between the initial assessment (T0) and the pre-intervention assessment (T1).

In the parent group, there were significant improvements in bilateral hip flexors, knee flexors, left knee extensor and left hand grip strength after Tai Chi training (all $p < 0.025$). In the child group, improvement in bilateral hip flexors, right hip extensor, left knee flexor and extensor and bilateral hand grip strength were significant after the intervention period (all $p < 0.025$). Although not significant, there were improvement trends in other muscle strength parameters (Table 2). Friedman test showed an overall difference in heart rate changes after 3-minute step test across the three measurement time points in both parent and child groups (Parent: $p = 0.011$; Child: $p = 0.019$). Significant improvement was found after intervention (Parent: T1 = 69.8 ± 12.4 bpm, T2 = 61.3 ± 12.9 bpm, $p = 0.007$; Child: T1 = 62.2 ± 13.9 bpm, T2 = 46.5 ± 17.0 bpm, $p = 0.005$) but not in the control period (Parent: T0 = 73.7 ± 10.7 bpm, $p = 0.085$; Child: T0 = 61.5 ± 17.9 bpm, $p = 0.955$) (Table 3). For the limits of stability test, no significant overall change was found in reaction time in parent group ($p = 0.247$), maximum excursion in the child group ($p = 0.052$) and directional control in both groups (Parent: $p = 0.068$; Child: $p = 0.160$). Significant difference was found across the three time points in maximum excursion in the parent group ($p = 0.039$) and reaction time in the child group ($p = 0.036$). However, there was no significant change in the subsequent Wilcoxon signed-rank test though the p value was approaching significance between T1 vs T2 in the maximum excursion in the parent group (T0 vs T1: $p = 0.507$; T1 vs T2: $p = 0.026$) (Table 4). Mutuality and parental control in C-FAI were found to have significant changes across the three time points in the parent group (Mutuality: $p = 0.016$; Parental control: $p = 0.034$). Wilcoxon signed-rank tests showed a significant decrease in mutuality between T0 and T1 ($p = 0.005$). No such change was found in mutuality between T1 and T2 ($p = 0.633$) and parental control (T0 vs T1: $p = 0.048$; T1 vs T2: $p = 0.072$). No significant change was found across the three time points in communication, conflict and harmony and parental concern in the parent group, and all five subscales in the child group (Table 5).

	T0	T1	T2	p values+
Mean ± SD		Parent (n = 18)		
R hip flexor strength, Nm	10.59 ± 3.39	10.35 ± 3.14	13.78 ± 3.91*	0
L hip flexor strength, Nm	10.47 ± 3.54	11.06 ± 4.26	12.82 ± 3.59*	0.019
R hip extensor strength, Nm	12.08 ± 4.45	14.81 ± 4.65	14.86 ± 3.49	0.061
L hip extensor strength, Nm	12.87 ± 4.93	14.24 ± 4.37	16.31 ± 4.00	0.005
R knee flexor strength, Nm	7.50 ± 3.92	8.59 ± 2.87	12.15 ± 3.83*	0
L knee flexor strength, Nm	7.72 ± 4.15	8.81 ± 2.79	12.22 ± 3.98*	0
R knee extensor strength, Nm	14.67 ± 6.62	16.14 ± 5.98	18.60 ± 5.80	0.026
L knee extensor strength, Nm	13.74 ± 6.30	14.84 ± 5.85	17.30 ± 5.41*	0.022
R handgrip, Kg	28.07 ± 8.36	26.54 ± 6.87	28.87 ± 6.21	0.077
L handgrip, Kg	26.24 ± 8.63	24.80 ± 7.15	28.33 ± 7.05*	0.006
Mean ± SD		Child (n = 15)		
R hip flexor strength, Nm	5.56 ± 2.37	5.48 ± 1.80	7.27 ± 2.24*	0.002
L hip flexor strength, Nm	5.71 ± 2.51	5.72 ± 2.65	7.11 ± 2.54*	0.01
R hip extensor strength, Nm	6.41 ± 3.32	6.97 ± 3.88	8.50 ± 3.60*	0.034
L hip extensor strength, Nm	6.09 ± 3.06	7.5 ± 3.70	8.80 ± 3.46	0.013
R knee flexor strength, Nm	5.80 ± 3.27	5.00 ± 3.29	7.58 ± 3.02	0.071
L knee flexor strength, Nm	5.85 ± 3.52	5.23 ± 3.46	7.99 ± 3.33*	0.002
R knee extensor strength, Nm	9.28 ± 4.92	8.92 ± 3.58	11.71 ± 4.23	0.078
L knee extensor strength, Nm	7.99 ± 3.99	7.58 ± 3.81	11.19 ± 3.65*	0
R handgrip, Kg	12.24 ± 4.63	12.98 ± 5.23	16.27 ± 5.52*	0
L handgrip, Kg	11.47 ± 5.26	12.31 ± 5.38	14.83 ± 5.56*	0

+Denotes comparison across the three time points (T0, T1, T2)

*Denotes significant difference between T1 and T2 at $p < 0.025$ using Wilcoxon signed-rank tests, after Friedman test showing an overall significant difference at $p = 0.05$.

Table 2: Changes in muscle strength across the three assessment periods.

	T0	T1	T2	p values+
Mean ± SD		Parent (n = 18)		
Heart rate after 3-min step test, bpm	73.7 ± 10.7	69.8 ± 12.4	61.3 ± 12.9*	0.011
Mean ± SD		Child (n = 15)		
Heart rate after 3-min step test, bpm	61.5 ± 17.9	62.2 ± 13.9	46.5 ± 17.0*	0.019

+Denotes comparison among the three time points (T0, T1, T2)

*Denotes significant difference between T1 and T2 at $p < 0.025$ using Wilcoxon signed-rank tests, after Friedman test showing an overall significant difference at $p = 0.05$.

Table 3: Changes in heart rate after 3-minute step test across three assessment periods.

	T0	T1		T2	p values+
Mean ± SD			Parent (n = 18)		
Reaction time, sec	0.59 ± 0.14	0.59 ± 0.13		0.56 ± 0.08	0.247
Maximum excursion, %	85.44 ± 10.59	86.83 ± 9.56		90.89 ± 6.73	0.039
Directional control, %	71.88 ± 5.42	70.50 ± 6.39		74.83 ± 7.38	0.068
Mean ± SD			Child (n = 15)		
Reaction time, sec	0.67 ± 0.23	0.61 ± 0.19		0.57 ± 0.17	0.036
Maximum excursion, %	86.53 ± 10.38	86.67 ± 11.82		90.47 ± 13.74	0.052
Directional control, %	59.93 ± 9.39	59.93 ± 8.50		64.20 ± 11.25	0.16
+Denotes comparison among the three time points (T0, T1, T2). *Denotes significant difference between T1 and T2 at p < 0.025 using Wilcoxon signed-rank tests, after Friedman test showing an overall significant difference at p = 0.05.					

Table 4: Changes in physical functioning across three assessment periods.

	T0	T1		T2	p values+
Mean ± SD			Parent (n = 18)		
Mutuality	14.33 ± 3.87	12.33 ± 3.66*		12.89 ± 4.90	0.016
Communication	10.56 ± 3.47	10.11 ± 2.85		10.11 ± 4.19	0.755
Conflict & harmony	22.72 ± 2.37	23.67 ± 1.94		23.39 ± 2.77	0.073
Parental concern	6.67 ± 0.49	6.56 ± 0.51		6.50 ± 0.62	0.629
Parental control	10.56 ± 3.17	11.67 ± 3.11		10.06 ± 3.64	0.034
Mean ± SD			Child (n = 15)		
Mutuality	13.60 ± 3.94	13.00 ± 3.07		17.13 ± 7.05	0.178
Communication	11.93 ± 3.01	11.07 ± 3.33		14.27 ± 6.87	0.081
Conflict & harmony	23.33 ± 3.29	22.93 ± 2.52		21.40 ± 4.82	0.249
Parental concern	6.73 ± 0.59	6.53 ± 0.64		6.93 ± 1.49	0.459
Parental control	11.67 ± 3.85	11.27 ± 3.81		10.53 ± 3.62	0.275
+Denotes comparison across the three time points (T0, T1, T2)					
*Denotes significant difference between T0 and T1 at p < 0.025 using Wilcoxon signed-rank tests, after Friedman test showing an overall significant difference at p = 0.05.					

Table 5: Changes in subscales of the Chinese Family Assessment Instrument (C-FAI) across the three assessment periods.

Discussion

Attendance of the intervention was 88% and no adverse effect was reported during the training period. It showed that it is feasible to carry out parent-child Tai Chi training in a school setting.

There were limited studies investigated the effects of Tai Chi training on physical function in middle-aged adults and children without known pathology. Significant increases in strength after Tai Chi training but not in the control period were found in most muscle groups in this study. Our previous findings showed a significantly better knee flexor and extensor strength in older Tai Chi practitioners [18]. The current study showed significant improvement in left knee flexor and extensor in both the parent and the child group, and in right knee flexor in the parent group, but not right knee extensor in both groups and right knee flexor in the child group. However, those non-significant parameters showed a trend of improvement. Other than the age difference, another possible reason for the discrepancies between the two study results could be the shorter training period adapted in this study. Subjects in Tsang and Hui-Chan's study had been practicing Tai Chi for at least 3 years at the time of assessment, while participants in the current study only learnt Tai Chi for 12 sessions.

Cardio-respiratory function was improved after three months of Tai Chi training. There was a significantly less heart rate increased from resting upon completion of the 3-minute step test. This showed disagreement with another study, which found no significant effects of Tai Chi training on maximal oxygen consumption [25]. However, it should be noticed that exercise intensities are different across various types of Tai Chi styles and population. Lan and colleagues suggested that the traditional Tai Chi routine has a higher exercise intensity than simplified Tai Chi, as the simplified form "comprises fewer postures and excludes strenuous movements" [26]. Yang style Tai Chi was adapted in this study, but the information on the style was not found in Brown and colleagues' study.

There was no significant change in the limits of stability test after Tai Chi training. Tai Chi movement is slow but fluid in nature. It is expected that the reaction time would not change significantly after practice. For the maximum excursion, the parent group showed a trend of improvement after Tai Chi training. Also, there were trends of improvement in the directional control in both the parent and the child groups. This suggests that Tai Chi practice could have a potential to improve balance control in these two groups.

There were no significant changes in parent-child relationship after training. However, mutuality during the control period, but not after Tai Chi training, was found to be declined significantly in the parent group. It was suggested that parent-child activities may benefit mutuality.

Study Limitations

There are several limitations in this study. Firstly, only one group of subject was recruited, with a no-treatment period served as control. Future research should include a control group as well as an exercise control group with a randomized clinical trial design. In addition, the training frequency was only once a week. The frequency is lower than the recommendation from the ACSM [2]. Although subjects were encouraged to practice with the family members apart from the weekly training class, subjects should be monitored for their "off-class training". Either increasing training frequency or keeping an exercise log book should be done in future studies. In this pilot study, only changes in physical function and parent-child relationship were compared before and after training. Future studies may also investigate the correlation among physical function, quality of life and family functioning after parent-child Tai Chi training.

Conclusion

Tai Chi may be an effective exercise in promoting muscle strength and cardio-respiratory function in middle-aged adults as well as children. Although no significant change was observed in parent-child relationship after intervention, mutuality was found declined during the control period, suggesting the possible beneficial effect of parent-child Tai Chi training on mutuality. Further studies with a randomized control trial design and a more frequent training are suggested in order to determine its effectiveness in these two groups.

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