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Original Article

Tai Chi Chuan training improves the pulmonary function of asthmatic children

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Background and Purpose: Tai Chi Chuan, a traditional Chinese exercise, is thought to improve cardiopulmonary function in patients with chronic disease. This study investigated the effect of Tai Chi Chuan on the pulmonary function and daily symptoms of asthmatic children.

Methods: Thirty asthmatic children were enrolled into the study. Fifteen of the 30 children participated in a 12-week Tai Chi Chuan program and the remaining 15 constituted the control group. Prior to study participation, the pulmonary function of all enrolled children was assessed at rest, after exercise, and after exercise plus iced water. A 3-day symptoms questionnaire was also completed and a score obtained after each pulmonary function test.

Results: There were no significant differences between the two groups in baseline pulmonary function and severity of asthmatic symptoms before study commencement, at rest, after exercise, or after exercise plus iced water. However, after the 12-week program, children in the Tai Chi Chuan group had a significant improvement in pulmonary function compared to the control group. Although there were no significant differences in post-training symptom scores at rest and after exercise between the two groups, under the stronger challenge of exercise plus iced water, children in the Tai Chi Chuan group had milder symptoms than those in the control group.

Conclusion: Our data show that Tai Chi Chuan can improve the pulmonary function of asthmatic children. However, long-term follow-up is required to determine the impact of Tai Chi Chuan on the severity of asthmatic symptoms.

Key words: Asthma; Respiratory function tests; Tai Ji

Introduction

Although Tai Chi Chuan (TCC) had been practiced in China for hundreds of years, it has only recently gained the attention of the western world [1,2]. TCC has various English spellings, including Tai Chi, Tai Chi Quan, Tai Ji, and Tai Ji Quan [3-5]. TCC is an exercise emphasizing the balance of the body and the mind, and has various styles, including Chen, Yang, Wu, and Sun style [3]. Among these, the Chen style is the most ancient, while the Yang style is the most popular [3]. In general, TCC is a low-intensity exercise with the elements of serial semi-squatting postures, balance, relaxation, flexibility, and slow but deep breathing [6,7]. However, the intensity of TCC is variable and can be influenced by the duration of practice, height of the postures, and individual TCC style [4]. Performing TCC had been shown to be beneficial for overall balance and prevention of falls [5,8], muscular strength [9], flexibility [6,10], cardiopulmonary function [11-13], and reduction of blood pressure [1,14] in certain human populations. TCC is considered as a conditioning exercise for the promotion of health, memory, concentration, and digestion [9,15]. TCC is also thought to improve psychological condition and reduce emotional stress such as anxiety or depression [6,15]. However, the aforementioned published TCC studies relied on data from elderly subjects or patients with chronic conditions such as cardiopulmonary disease [1,2]. To our knowledge,

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there are no studies investigating the effect of TCC on the pulmonary function of asthmatic patients. In addition, there is a paucity of research on the benefits of TCC for the non-elderly, such as children [16]. Therefore, the purpose of this study was to investigate the effect of TCC on the pulmonary function and daily symptoms of asthmatic children.

Methods

Subjects

Thirty asthmatic children, from an elementary school in Taipei County, were recruited for participation in this study, from April to June 2004. The study was approved by the ethics committee of the National Taiwan University Hospital. Written informed consent was obtained from the parents of all recruited children. The diagnosis of asthma was made in accordance with the American Thoracic Society criteria [17]. The severity of asthma was determined for each subject based on information that included the method of medical control used, family history of atopic disease, and a completed International Study of Asthma and Allergies in Childhood questionnaire. Enrolled children were randomized into the TCC training group or the control group in a ratio of 1:1.

Procedure

The study used the following 3 conditions to investigate pulmonary function and asthmatic symptoms: resting status, after exercise, and after exercise plus iced water. The resting status and exercise represented the daily activities of children and exercise plus iced water was previously reported as a trigger of asthma exacerbation [18]. Before TCC training, all enrolled children were assessed to examine baseline pulmonary function at the resting status, after exercise, and after exercise plus iced water. The pulmonary function test (PFT) included forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV1) and peak expiratory flow (PEF) and was performed by using ChestGraph HI-701 (Chest M. I. Inc., Japan). All children were well instructed on the use of this machine. Before each PFT, all medicines, including oral and inhaled corticosteroids, oral and inhaled bronchodilators, and oral antihistamines were withheld for a period of 12 to 24 h. For each PFT, the best value of 3 attempts was recorded. After each PFT, all enrolled children were assisted by their parents in the completion of a 3-day symptoms questionnaire. The symptoms questionnaire included common asthma symptoms such as those observed during sleep (e.g., night cough and wheezing), after rousing in the morning, and those noted during daily activity and after exercise. Symptom severity was rated on a scale ranging from 0 (no symptoms) to 3 (most severe). Total scores for 3 days were calculated and divided by 3 to obtain the average daily symptom score (SS) to represent the severity of asthmatic symptoms.

Before performing PFT in the resting status, all enrolled children took a 10-min rest indoors. PFT after exercise was assessed after the children had ran around a sports field for a distance of at least 400 meters and had a heart rate greater than 100 beats per min. Running on the sports field was selected over running on the treadmill because, in our opinion, the former more closely resembled the daily activity of the enrolled children. After the run, the heart rate was measured and PFT was performed 15 min later. In order to examine the PFT after exercise plus iced water, the children initially ran at least 400 meters and the heart rate was measured. The children then drank 200 mL of iced water (0-4°C) as fast as possible, and the PFT was performed 15 min later.

From early April to late June in 2004, fifteen children in the TCC group participated in a 40-min TCC training session 3 times a week for 12 weeks, using the classical Chen 32-style. In addition to the TCC exercise, no restrictions were placed on the level of daily activity and other exercises undertaken by children in both groups. All the TCC practitioners completed the 12-week training course. PFT and SS, determined at the beginning of the study, were repeated at the end of the 12-week TCC program.

Statistical analysis

Descriptive continuous data are presented as mean ± standard deviation. The baseline PFT and SS in the above 3 conditions as well as age, body weight (BW), body height (BH) and body mass index (BMI) of the 2 groups were compared using the Wilcoxon rank-sum test. In order to investigate the impact of weather and temperature on the pulmonary function and symptoms of asthmatic children, end-study PFT and SS data for each individual subject were compared with the corresponding baseline data using the Wilcoxon signed-rank test. In addition, differences in PFT and SS between the end of study and study baseline were calculated. For example,

Delta (Δ)FVC = $FVC^{end} - FVC^{baseline}$;

$\Delta SS = SS^{end} - SS^{baseline}$

In order to estimate the effect of TCC training on pulmonary function and symptoms of asthmatic children, the ΔFVC, ΔFEV1, ΔPEF and ΔSS of the TCC group were compared with those of the control group using the Wilcoxon rank-sum test. In order to minimize the impact of variations in age, BW and BH, differences in PFT were divided by BMI and they were defined as ΔFVC/BMI, ΔFEV1/BMI and ΔPEF/BMI. The above 3 items of both groups were compared statistically. For all analyses, a p value <0.05 was considered statistically significant.

Results

Thirty asthmatic children were enrolled into the study; 15 TCC-trained children and 15 non-trained children (control group). There were no significant differences in age, BW, BH and BMI between children in the TCC and control groups (Table 1). Other baseline subject characteristics, including the severity of asthma, family history of atopic disease, and current medication for both groups, are also summarized in Table 1. In addition, there were no significant differences in baseline PFT and SS between children in the TCC and control groups (Table 2).

For both groups at the resting status, pulmonary function at the end of the study was significantly better than that at baseline, as was the SS. Similar results were noted in the conditions of after exercise and after exercise plus iced water (Table 3 and Table 4), demonstrating that both the TCC group and the control group had significant improvements in pulmonary function and asthmatic symptoms in the summer compared with the spring. These findings support the clinical experience that the daily symptoms and pulmonary function status could be altered by the status of weather.

We compared the changes in PFT and SS of both groups to estimate the effect of the 12-week TCC exercise program (Table 5). At the resting status, changes in FVC, FEV1 and PEF of the TCC group were significantly better than those of the control group (p=0.003, p=0.004 and p=0.026, respectively). After exercise, the ΔFVC, ΔFEV1 and ΔPEF of the TCC group were significantly better than those of control group (p=0.012, p=0.015 and p=0.021, respectively). However, the ΔSS of the 2 groups did not show significant differences at the resting status and after exercise.

Therefore, the 12-week TCC exercise had favorable effects on the pulmonary function of asthmatic children, but did not appear to cause significant improvement in asthmatic symptoms. Nevertheless,

Table 1. Demographics and clinical characteristics of Tai Chi Chuan (TCC) practitioners and controls

Variable	TCC	Control
Age (range ± SD)	9 years 11.6 months ± 1 year 9.3 months	9 years 3.9 months ± 1 year 10 months[a]
Gender (M:F)	9:6	6:9
Body weight (kg) [mean ± SD]	37.3 ± 11.3	31.9 ± 7.6[b]
Body height (cm) [mean ± SD]	138.9 ± 12.1	134.6 ± 12.1[c]
Body mass index (kg/m^2) [mean ± SD]	18.95 ± 3.72	17.41 ± 2.87[d]
Asthma degree		
Mild intermittent	8	8
Mild persistent	4	4
Moderate	3	3
Family history		
Asthma	7	9
Allergic rhinitis	7	8
Atopic dermatitis	4	1
None	3	2
Regular medication		
Inhaled corticosteroids	1	3
Inhaled bronchodilators	3	4
Regular PFM usage	0	1

Abbreviations: SD = standard deviation; M = male; F = female; PFM = peak flow meter

[a]p=0.345.

[b]p=0.305.

[c]p=0.389.

[d]p=0.187.

Table 2. Baseline pulmonary function and symptom score (SS) at rest, after exercise, and after exercise plus iced water in the Tai Chi Chuan (TCC) and control groups

Variable (mean ± SD)	TCC	Control
Resting		
ΔFVC (L)	2.61 ± 0.55	2.34 ± 0.51
ΔFEV1 (L)	2.41 ± 0.49	2.23 ± 0.50
ΔPEF (L/sec)	5.82 ± 0.99	5.81 ± 1.16
ΔSS	1.55± 0.69	1.26 ± 0.69
After exercise		
ΔFVC (L)	2.44 ± 0.58	2.20 ± 0.49
ΔFEV1 (L)	2.29 ± 0.51	2.11 ± 0.46
ΔPEF (L/sec)	5.39 ± 0.89	5.36 ± 0.90
ΔSS	1.75 ± 0.67	1.22 ± 0.66
After exercise + iced water		
ΔFVC (L)	2.33 ± 0.54	2.06 ± 0.52
ΔFEV1 (L)	2.13 ± 0.50	1.96 ± 0.48
ΔPEF (L/sec)	5.04 ± 1.03	5.19 ± 0.86
ΔSS	2.73 ± 0.81	2.49 ± 0.81

Abbreviations: SD = standard deviation; Δ = delta; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 sec; PEF = peak expiratory flow

if a stronger trigger factor, such as exercise plus iced water, was administered, the TCC group demonstrated not only superior pulmonary function but also a better SS than the control group (Table 5).

In order to reduce the influence of BW and BH, the values of ΔFVC, ΔFEV1 and ΔPEF were divided by BMI, to produce: ΔFVC/BMI, ΔFEV1/BMI and ΔPEF/BMI. After this adjustment, there were still some significant differences between the 2 groups (Table 6). At the resting status, the TCC group had significantly better improvement in FVC and FEV1 (p=0.024 and p=0.049, respectively), but not in PEF. When PFT was measured after exercise, the improvement of FVC of the TCC group was significantly greater than that of the control group (p=0.019). Although the improvements in FVC and FEV1 were not statistically different between the 2 groups under the challenge

Table 3. Comparison of pulmonary function and asthmatic symptoms between baseline and the end of the study among Tai Chi Chuan practitioners

Variable (mean ± SD)	End of study	Baseline	p
Resting			
ΔFVC (L)	3.45 ± 0.68	2.61 ± 0.55	<0.001
ΔFEV1 (L)	3.22 ± 0.66	2.41 ± 0.49	<0.001
ΔPEF (L/sec)	8.08 ± 1.46	5.82 ± 0.99	<0.001
ΔSS	0.73 ± 0.61	1.55 ± 0.69	<0.001
After exercise			
ΔFVC (L)	3.37 ± 0.61	2.44 ± 0.58	<0.001
ΔFEV1 (L)	3.15 ± 0.58	2.29 ± 0.51	<0.001
ΔPEF (L/sec)	7.90 ± 1.32	5.39 ± 0.89	<0.001
ΔSS	0.67 ± 0.56	1.75 ± 0.67	<0.001
After exercise + iced water			
ΔFVC (L)	3.12 ± 0.62	2.33 ± 0.54	<0.001
ΔFEV1 (L)	2.93 ± 0.58	2.13 ± 0.50	<0.001
ΔPEF (L/sec)	7.29 ± 1.04	5.04 ± 1.03	<0.001
ΔSS	1.64 ± 0.72	2.73 ± 0.81	<0.001

Abbreviations: SD = standard deviation; Δ = delta; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 sec; PEF = peak expiratory flow; SS = symptom score

Table 4. Comparison of pulmonary function and asthmatic symptoms between baseline and the end of the study in the control group

Variable (mean ± SD)	End of study	Baseline	p
Resting			
ΔFVC (L)	2.83 ± 0.52	2.34 ± 0.51	<0.001
ΔFEV1 (L)	2.71 ± 0.47	2.23 ± 0.50	<0.001
ΔPEF (L/sec)	7.09 ± 0.98	5.81 ± 1.16	<0.001
ΔSS	0.58 ± 0.57	1.26 ± 0.69	<0.001
After exercise			
ΔFVC (L)	2.58 ± 0.61	2.20 ± 0.49	0.031
ΔFEV1 (L)	2.49 ± 0.59	2.11 ± 0.46	0.027
ΔPEF (L/sec)	6.91 ± 1.32	5.36 ± 0.90	0.002
ΔSS	0.51 ± 0.60	1.22 ± 0.66	0.003
After exercise + iced water			
ΔFVC (L)	2.51 ± 0.56	2.06 ± 0.52	<0.001
ΔFEV1 (L)	2.43 ± 0.52	1.96 ± 0.48	<0.001
ΔPEF (L/sec)	6.43 ± 1.12	5.19 ± 0.86	<0.001
ΔSS	1.66 ± 0.78	2.49 ± 0.81	<0.001

Abbreviations: SD = standard deviation; Δ = delta; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 sec; PEF = peak expiratory flow; SS = symptom score

Table 5. Changes in pulmonary function and symptom score (SS) before and after Tai Chi Chuan (TCC) training

Variable (mean ± SD)	TCC	Control	p
Resting			
ΔFVC (L)	0.85 ± 0.31	0.50 ± 0.24	0.003
ΔFEV1 (L)	0.81 ± 0.32	0.48 ± 0.21	0.004
ΔPEF (L/sec)	2.26 ± 1.20	1.27 ± 0.70	0.026
ΔSS	–0.82 ± 0.30	–0.69 ± 0.43	0.592
After exercise			
ΔFVC (L)	0.93 ± 0.35	0.38 ± 0.68	0.012
ΔFEV1 (L)	0.86 ± 0.23	0.38 ± 0.65	0.015
ΔPEF (L/sec)	2.51 ± 0.84	1.56 ± 1.22	0.021
ΔSS	–1.09 ± 0.53	–0.71 ± 0.49	0.062
After exercise + iced water			
ΔFVC (L)	0.79 ± 0.40	0.45 ± 0.25	0.017
ΔFEV1 (L)	0.80 ± 0.38	0.47 ± 0.22	0.014
ΔPEF (L/sec)	2.25 ± 0.68	1.24 ± 0.66	0.001
ΔSS	–1.09 ± 0.35	–0.82 ± 0.31	0.035

Abbreviations: SD = standard deviation; Δ = delta; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 sec; PEF = peak expiratory flow

Table 6. Changes in pulmonary function and symptom score (SS) before and after Tai Chi Chuan (TCC) training adjusted for body mass index (BMI)

Variable (mean ± SD)	TCC	Control	*p*
Resting			
ΔFVC/BMI	0.044 ± 0.016	0.029 ± 0.015	0.024
ΔFEV1/BMI	0.041 ± 0.015	0.028 ± 0.013	0.049
ΔPEF/BMI	0.115 ± 0.065	0.073 ± 0.036	0.065
ΔSS	−0.82 ± 0.30	−0.69 ± 0.43	0.592
After exercise			
ΔFVC/BMI	0.049 ± 0.020	0.022 ± 0.038	0.019
ΔFEV1/BMI	0.045 ± 0.013	0.022 ± 0.037	0.059
ΔPEF/BMI	0.131 ± 0.055	0.087 ± 0.074	0.085
ΔSS	−1.09 ± 0.53	−0.71 ± 0.49	0.062
After exercise + iced water			
ΔFVC/BMI	0.041 ± 0.024	0.027 ± 0.017	0.085
ΔFEV1/BMI	0.042 ± 0.022	0.028 ± 0.015	0.054
ΔPEF/BMI	0.119 ± 0.045	0.071 ± 0.036	0.001
ΔSS	−1.09 ± 0.35	−0.82 ± 0.31	0.035

Abbreviations: SD = standard deviation; Δ = delta; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 sec; PEF = peak expiratory flow

of exercise plus iced water, the TCC group had significantly better improvement in PEF than the control group (p=0.001). The p values of ΔFEV1/BMI after exercise and after exercise plus iced water were not statistically significant (p=0.059 and p=0.054, respectively). However, the data showed a trend indicating that TCC exercise could lead to improvement of pulmonary function.

Discussion

TCC is a popular Chinese exercise that has gained more and more attention from the western world [1,2]. It is a unique form of calisthenics with the characteristics of slow, smooth, harmonic and graceful movements, consisting of a series of semi-squatting postures [6,7]. During performance of TCC, it is important to develop hand-eye coordination, mind-body interaction, breathing regulation with body movement, and a state of tranquility [2,5,15].

TCC has some advantages over other exercise forms in that it is a convenient low-cost exercise, which requires no special facility or equipment, and can be easily performed at anytime and in any location, either individually or as part of a group. In contrast to some heavy types of exercises, the intensity of TCC is low; the oxygen consumption [4,13], orthopedic and neuromuscular burdens of TCC exercise are lower than those associated with heavy types of exercises [15]. Therefore, TCC is suitable for persons of all ages, regardless of previous exercise experience and aerobic capacity [8].

TCC training has been shown to be beneficial for balance and prevention of falls [5,8], cardiopulmonary function [2,11-13], reduction of blood pressure and some psychiatric symptoms [1,6,14,15], and delaying the decline of aerobic capacity and overall health [11] in certain populations. In addition, TCC was shown to be beneficial for health-related fitness and was claimed to be a suitable aerobic or conditioning exercise for the elderly [11,14]. Studies have also shown that TCC training could increase heart rate variability [4,6] and enhance microcirculation [19] and endothelium-dependent dilation [20] in skin vasculature of healthy older men.

Overall, studies showed TCC to be a suitable conditioning exercise for the elderly and patients with chronic conditions such as coronary artery disease [2]. In addition, TCC training had been associated with psychological responses. Several studies demonstrated that regular practice of TCC could reduce psychological stress such as tension, anxiety and depression, and also improve positive well-being, life satisfaction and self-perception of health [15,16].

Asthma, a reversible obstructive airway disease, is characterized by hyperresponsiveness of the airways to respiratory irritants [21]. The cardinal symptoms of asthma include chest tightness, cough, dyspnea and episodic wheezing [21]. These symptoms may be life-threatening in a severe attack and are reversible, either spontaneously or as a result of medical treatment. Asthma has a close relationship with atopy, although a patient with asthma might not be atopic and not all atopic patients have asthma [22]. However, all patients with the diagnosis of asthma have the above cardinal symptoms, irrespective of their atopy status. In patients with allergic asthma, acute episodes of asthma may be trigged by exposure to allergens or other non-allergic irritants.

The treatment of asthma includes environment control and medication. In the former, environmental irritants such as fumes, smoke, dust and aerosols are to be avoided [23]. Furthermore, asthmatic patients that are allergic to animal danders, fungi, feather, molds or house dust, should eliminate these allergic materials from their living environment. Conventional medicines for relieving acute symptoms include beta-adrenergic bronchodilators, systemic corticosteroids and xanthines. Inhaled corticosteroids, leukotriene inhibitors, long-acting beta-adrenergic bronchodilators, cromolyn and nedocromil are medicines used for long-term prophylaxis [22]. In addition to conventional medicines, an increasing number of patients are using complementary alternative medicines for asthma treatment, in both the eastern and western worlds [24,25].

Although many different complementary alternative medicine modalities are available, only a few techniques account for the majority of use, and include Chinese herbal medicines, acupuncture, homeopathy, bioresonance and autologous blood injection [24]. Although TCC has been an increasingly popular alternative therapy for many conditions, there were no studies investigating the impact of TCC on asthmatic subjects. In addition, the majority of TCC studies focused on the elderly and patients with chronic conditions, not children. Our study showed that TCC training had favorable effects on the pulmonary function of asthmatic children.

PFT results at resting status and after exercise were considered as the normal pulmonary function during ordinary daily activity of the asthmatic children. In fact, exercise is also recognized as a factor triggering the exacerbation of asthma [26,27]. Exercise followed by the drinking of iced water was used as a stronger trigger for inducing asthma [18]. There were no significant differences in the baseline pulmonary function and severity of asthmatic symptoms, at resting status and after exercise, between the two groups.

After the 12-week training program, the TCC group had significantly better improvement in FVC, FEV1, and PEF than the control group, in the resting status. When measured after exercise, the pulmonary function of the TCC practitioners was significantly better than that of the children in the control group. However, the improvement in symptoms, represented by the SS values, was not significantly different between the two groups, both in the resting status and after exercise. Therefore, a 12-week TCC program led to a significant improvement in the pulmonary function of asthmatic children, but the improvement of their daily symptoms was less apparent. This discordance may indicate that the 12-week program was not long enough for the practitioners to reach a satisfactory improvement in their symptoms, or that the 2 study phases, i.e., the resting status and after exercise, were not robust enough to induce an exacerbation of asthmatic symptoms. Although the p value of ΔSS after exercise was not statistically significant (p=0.062), it was relatively small and might be meaningful to some degree. When a stronger challenge, such as exercise plus iced water, was provided, the TCC group had better results in not only the PFT but also the SS. Our results indicate that practicing TCC might provide more resistance against some trigger factors that might be encountered frequently in the daily life of asthmatic children. Furthermore, the ΔFVC/BMI, ΔFEV1/BMI and ΔPEF/BMI variables were used to minimize the influence of BW and BH. Despite the adjustment, the TCC group still had significantly better improvements in FVC and FEV1 when compared to the control group in the resting status.

The improvement in FVC of the children in the TCC group after exercise was significantly better than that of children in the control group. Although the improvement in FEV1 measured after exercise was not statistically significant, the relatively small p value might indicate the effectiveness of TCC training to some degree. Under the stimulation of exercise plus iced water, the TCC group still showed better resistance in PEF than the control group. Overall, our data indicated that disparities in age, BW and BH among the 30 children had limited influence on the results of this study, and that practicing TCC has genuine beneficial effects for asthmatic children.

One limitation of our study was that children in the TCC group, as well as in the control group, all showed significant improvements in pulmonary function and subjective symptoms at the end of the study. The pulmonary function and symptoms of asthmatic children are profoundly affected by the weather. Indeed, studies demonstrated that the incidence of asthma exacerbation varies according to season [28]. The weather in Taiwan is cold and unstable in the spring and hot and constant in the summer. In line with the time sequence of this study, i.e., from early April to late June, it was reasonable to expect that both groups would have improved pulmonary function and milder symptoms in summer than in spring. Moreover, the study provided data to support the notion that both the daily symptoms and pulmonary function status could be altered by the status of weather. In addition to weather, the influence of respiratory viruses should also be considered, because they are more prevalent in cold weather and are also well-known triggers of acute asthma [29]. Another shortcoming of our study was that the daily activities of the children were difficult to limit. Therefore, it was very difficult to evaluate the effects of other daily exercises on the pulmonary function of asthmatic children.

Overall, our data demonstrated that a 12-week TCC program enhanced the pulmonary function of asthmatic children. The improvement in subjective symptoms of children in the TCC group was also better than that of children in the control group. However, the difference was not statistically significant. Under the stimulation of exercise plus iced water, children in the TCC group demonstrated milder symptoms and better resistance against a decline in pulmonary function.

Therefore, TCC exercise may be considered as an alternative therapy for asthma in the future. In order to minimize the impact of weather and identify the long-term effects of TCC training on asthmatic children, it is recommended that practitioners should maintain a TCC program with follow-up for at least one year, that contains a full cycle of the 4 seasons. Further studies should also compare the benefits of TCC to those conferred by other types of exercises.

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