EFFECTS OF 12 WEEKS' TAI CHI CHUAN PRACTICE ON THE IMMUNE FUNCTION OF FEMALE COLLEGE STUDENTS WHO LACK PHYSICAL EXERCISE

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ABSTRACT: Objective: The present study investigated the effects of 12 weeks' tai chi chuan (TCC) practice on the immune function of female college students. Method: 60 female college students (19.3 ± 1.8 years) were recruited and were randomly assigned to either the TCC training (n=30) or the control group (n=30). In the TCC group, the exercise duration was 45 minutes per day and 5 days a week for 12 weeks. The TCC group performed TCC under the teaching of a TCC master. Immunoglobulin G (IgG), IgA, IgM, Cluster of differentiation 3 (CD3), CD4+, CD8+, interferon γ (IFN-γ), interleukin 4 (IL-4) and IL-12 were measured before and after 12 weeks of TCC practice. Results: The TCC group had significantly higher plasma levels of IgG (P=0.000), IgM (P=0.05) and CD4+ (P=0.032) after practice compared with their respective pre-practice levels. There were no significant differences in IgA, CD3, IFN-γ, IL-4 or IL-12, but IgA and IFN-γ levels increased and IL-12 decreased within the normal range. Conclusion: The results suggest that regular long-term TCC practice might be a potential method to improve the cellular immune function (anti-virus and anti-infection) of people who lack physical exercise. Further studies concerning other immune aspects are needed.

KEY WORDS: Tai chi chuan, anti-virus, female college student, popularization

INTRODUCTION

One aim of exercise is to maintain homeostasis of the body at some level that reduces the tendency to illness. One way to achieve this is by improving the immune system. Many forms of exercise can accomplish this aim, such as running, swimming, riding bike, etc. Such activities require special venues or are limited by the weather. Tai chi chuan (TCC, expressed in the Chinese phonetic alphabet as Taijiquan) is a traditional Chinese form of exercise, derived from martial arts folk traditions. The practice of TCC was originally related to concerns about physical fitness and the capacity for self-defence[11]. TCC exercise emphasizes continuous slow (flowing) movements, with small to large expressions of motion, unilateral to bilateral shifts of body weight, and rotation of the trunk, head and extremities, combined with deep diaphragmatic breathing and relaxation. During these movements, TCC practitioners have to control their centre of gravity and remain very stable. TCC practice requires only small areas of ground, and can be practised indoors. It is suitable for older people and people who seldom practise outdoor sports, such as female college students. A simplified 24-form TCC was designed to convey the most representative components of the traditional schools, and to make them easy and quick to learn. The government is making great efforts to promote and spread the simplified form of TCC among the population all over China, and it has been included in the compulsory teaching content of most colleges and universities [15,24].

Many research studies on exercise immunology were performed after a single session of exercise to exhaustion and show immunosuppression associated with risk of upper respiratory tract infection (URTI) [2,17,28]. Many exercise methods can improve health in many aspects such as reduction of low density lipoproteins and increase of high density lipoprotein, improvement in balance and muscle strength, reduction of the tendency to fall, and increased self-esteem [3,9,14,27,30,32].

A few studies have explored the impact of TCC exercise on immunological capacity. Zhang found that the practice of TCC for two months significantly increased the level of IgG in men, and significantly decreased the level of IgM in women. These changes were all within the normal range, which indicated that TCC exercise may enhance the capacity of the immune system [33]. Li and Shen

found a concomitant increase in the level of cortisone in the blood after long-term TCC practice [12]. In numerous studies, benefits of TCC to older people are reported, such as improved balance, decreased fall incidents, decreased blood pressure, and increased self-efficacy [6,10,29,31].

However, it is not sufficient to convey the effect of TCC to young people who seldom join outdoor sports, such as female college students.

We hypothesize that TCC may improve the immune capacity of young female college students after 12 week's simplified 24-form tai chi chuan practice. Therefore, the present study was designed to investigate primarily the effect of TCC on established markers of immune function, T helper (Th) cell count, cytokines and immunoglobulins (Ig) in the volunteers.

MATERIALS AND METHODS

Subjects. Sixty volunteers were enlisted among healthy female college students who seldom take part in outdoor sports and were non-trained. Subjects were randomly assigned to the control group (n=30) and TCC group (n=30) (see Table 1). Members of the control group were advised to maintain their normal activities. The TCC group did not attend any exercise except TCC practice. A medical examination, including measurement of height, weight, blood pressure and electrocardiogram, was performed for each subject before the study. Subjects were advised to maintain their normal dietary habits and avoid taking immune medicine during the study period. Brief interviews were also conducted for all subjects at baseline and endpoint. Subjects were asked about their health condition and lifestyle (including dietary and sleeping habits). No subject took anti-inflammatory or immune medicine during the study period. The purpose and procedures of this study, and all of the measurements, were fully explained, and written informed consent was obtained from all subjects before the study. This study has been approved by the Ethics Committee of Shandong Normal University, and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

TABLE 1. COMPARISON OF CHARACTERISTICS BETWEEN CONTROL GROUP AND TCC GROUP

Variables	Control group	TCC group
Participants (n)	30	30
Age (years, mean±SD)	19.2±1.3	19.5±2.1
Height (cm, mean±SD)	165±6	167±8
Weight (kg, mean±SD)	56.6±8.3	57.4±7.6

TABLE 2. COMPARISON OF URTI RATIO BETWEEN CONTROL GROUP AND TCC GROUP

Group	Ratio (before)	Ratio (after)
Control	0.26±0.31	0.25±0.38
TCC	0.25±0.45	0.17±0.21*

Note: Changes of URTI ratio between control group and TCC group *p<0.05, comparison of the changes from pre-exercise level between control group and TCC group.

Exercise protocol. TCC uses "meditation through movement" incorporating elements of balance, postural alignment, and concentration. Subjects learned to perform 24 standardized movements under the guidance of an expert TCC master who conducted all treatment sessions throughout the 12-week intervention period. Each TCC session was restricted to 45 minutes with a 10-minute warm-up, 30 minutes of practice, and a 5-minute cool-down. TCC practice was performed 5 times per week (60 sessions over 12 weeks) from 6:30 to 7:15 AM at a site on the campus.

Investigation of upper respiratory tract infections (URTI). Written investigations were carried out to determine the number of subjects catching URTI (Table 2) and the duration of each URTI (Table 3) in 1 month before the experiment and 1 month after the experiment. URTI ratio=number of persons with infection : total number of subjects.

Blood sampling and analysis. Blood samples of both TCC and control groups were collected before the experiment and immediately after the last practice. Venous blood samples (5 ml) were collected through single vein punctures with the participant in a seated position. The samples were centrifuged at 3,000 rpm for 15 min at 4°C and plasma was stored at -20°C until analysis of IgG, IgA, IgM, IFN-γ, IL-4 and IL-12. They were measured by enzyme-linked immunosorbent assay (ELISA), according to the manufacturer's instructions (R&D Systems, Minneapolis, MN, USA). The minimum detection level for all cytokines was 4 pg/mL. In all assays, mean OD450nm readings obtained from duplicate wells of diluent negative controls were subtracted from all readings (samples and controls) before making standard curves from which to calculate sample concentrations.

Venous blood samples (3 ml) were collected into full blood type vacuum EDTA blood collection tubes (Minston, Guangzhou, China) for CD3, CD4+ and CD8+ detection using a FACScan flow cytometer (BD Biosciences). Kits were from BD Biosciences (Mountain View, CA, USA).

Statistical analysis. Bivariate analysis was conducted to compare characteristics of subjects and all indices at baseline and demographic variables between the TCC group and the control group. Proportional differences were tested for significance using the χ^2 test. Differences between means were calculated and significance levels obtained using the independent-samples T test.

The significance of the differences of all indices for pre- and post-TCC exercise of the TCC group was determined by T test for paired samples.

Independent-samples T tests were used to analyse differences between the two groups with respect to subject characteristics (i.e., age, height and weight). The Statistical Package for the Social Sciences (SPSS) version 12.0 was applied for the analysis, and $p<0.05$ was considered significant.

TABLE 3. COMPARISON OF URTI RATIO BETWEEN CONTROL GROUP AND TCC GROUP

Group	Days (before)	Days (after)
Control	5.3±0.37	5.5±0.38
TCC	5.4±0.45	3.9±0.57*

Note: Changes of the duration per URTI between control group and TCC group *p<0.05, comparison of the changes from pre-exercise level between control group and TCC group.

RESULTS

Comparison of changes of IgG, IgA and IgM between the TCC and control groups at pre- and post-exercise (see Fig. 1).

Comparison of changes of CD3, CD4+ and CD8+ cells between the TCC and control groups at pre- and post-exercise (see Fig. 2 and Fig. 3)

Comparison of changes of IFN-γ, IL-4 and IL-12 between the TCC and control groups at pre- and post-exercise (see Fig. 4).

DISCUSSION

The major finding in the present study was that there were no significant changes in IFN-γ, CD4+/CD8+ ratio or IL-12 in the TCC group compared with values obtained in the control group. IgG and IgM increased significantly, while IgA decreased. The above indices represent mostly the immunological function.

It has been suggested that the relationship between exercise and upper respiratory tract infection (URTI) follows a 'J-curve', with moderate and regular exercise improving the ability to resist infections[18,19,21] and heavy acute or chronic exercise decreasing it[1,16,20]. IgG and IgM are correlated with URTI. IgA is clearly negatively correlated with the duration of URTI and performs an anti-virus function. Our result supported the conclusion that regular TCC practice can improve the anti-virus function, but it was not similar to other studies. In line with a previous study, the plasma concentration of IgG increased significantly, while IgM and IgA remained within a stable range[6]. Liu et al. conducted a detailed

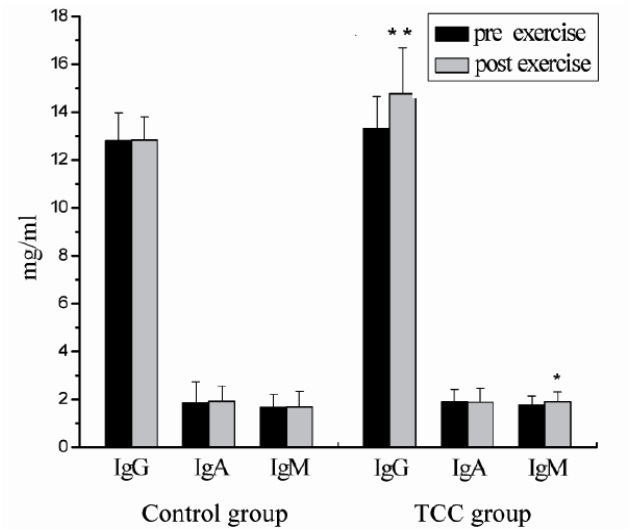

FIG. 1. CHANGES OF PLASMA IGG, IGA AND IGM LEVELS, Note: *p<0.05 ,** p<0.01 Significantly different from both control group and pre-exercise values of TCC group

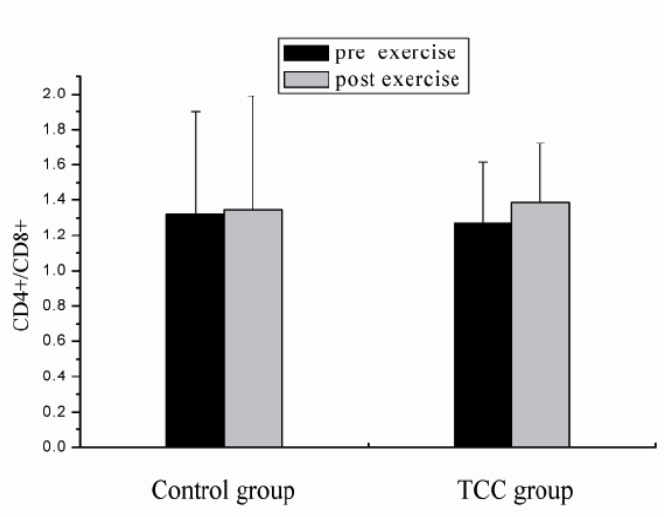

FIG. 3. CHANGES OF PLASMA CD4+/CD8+ BETWEEN CONTROL GROUP AND TCC GROUP.

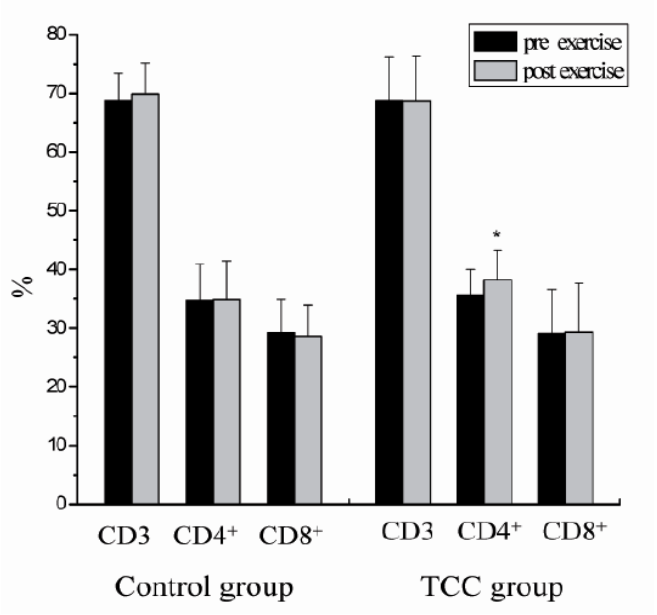

FIG. 2. CHANGES OF PLASMA CD3, CD4+, CD8+, Note: *P<0.05, Significantly different from both control group and pre-exercise values of TCC group.

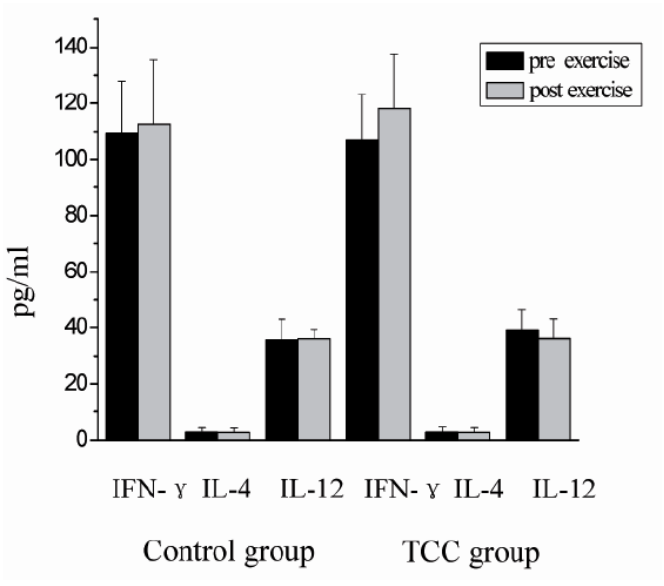

FIG. 4. CHANGES OF PLASMA IFN-γ, IL-4 AND IL-12 LEVELS BETWEEN CONTROL GROUP AND TCC GROUP.

study to investigate the influence of TCC on female college students. They found that average duration of URTI decreased significantly after exercise in training groups [13]. Our result of lower incidence of colds and shorter time of the URTI phase agreed with that opinion. A complementary study indicated that regular moderate TCC exercise did not alter the level of specific antibodies in college students [4]. It is not clear why regular TCC for 12 weeks retained the same level of IgA in this study. It might be the result of an insufficient load of the exercises. The changes of the indices probably depend on the exercise season, intensity and duration, etc. This warrants further investigation.

Whether humoral or cellular immunity will dominate depends largely on the type of cytokines that are released by the activated T helper cells. IFN-γ and IL-4 are released by Th1 and Th2 cells respectively. In our study, IL-4 values before and after exercise in the study showed no changes. This indicated that the TCC exercise intensity was moderate and had no severe influence on the body. The IFN-γ value of the TCC group and control group increased but there was no significant difference. However, the magnitude of the rise in the TCC group was higher than in the control group. The result meant that the Th1 cell function and the function of anti-virus and anti-URTI improved. In comparison, S-H Yeh demonstrated a true post-exercise decline in IFN-γ [24].

It is generally established that intracellular pathogens initiate a strongly cellular (type 1) immune response resulting in the differentiation of bipotential naive CD4+ and CD8+ T cells into T helper and T cytotoxic type 1 (Th1/Tc1) phenotypic cells characterized by the production of IFN-γ and IL-2. On the other hand, they initiate a humoral (type 2) immune response resulting in the differentiation of naive CD4+ and CD8+ T cells into T helper and T cytotoxic type 2 (Th2/Tc2) phenotypic cells characterized by the production of IL-4, IL-5, IL-10, and IL-13[23]. It has been demonstrated that prolonged exercise causes a redistribution of circulating Th1/Tc1 and Th2/Tc2 cells, resulting in a shift toward type 2 dominance[5,26], and this decline in type 1 cells has been suggested as a mechanism for the increased susceptibility to URTI after prolonged exercise [26]. T cells are functionally polarized, depending on the cytokines they produce. Type 1 cells produce, e.g., IFN-γ, whereas type 2 produce, e.g., IL-4. CD4+ and CD8+ T cells can be recognized as representatives of Th and Tc cells respectively. CD4+ cells and CD8+ cells play different roles in cellular immunity. CD4+ cells exert a helping and inducement effect, while CD8+ cells kill and inhibit the germs and viruses. Immunity imbalance occurs if the ratio of CD4+/CD8+ is not in balance. Exercise may influence the CD4+ and CD8+ cell counts and the CD4+/CD8+ ratio. Appropriate exercise can raise the CD4+/CD8+ ratio to some extent, but long-term exhaustive exercise or training can down-regulate the CD4+/CD8+ ratio, then inhibit the immune functions. In general, exercise influences CD8+ cells more than CD4+ cells[22]. A number of regulatory CD4 T cell populations capable of inhibiting immune responses in vivo and in vitro have been described previously [7,8,25]. There is evidence that higher CD4+, normal CD8+ and the stable status of CD4+/CD8+ improved the cellular immunity while keeping the immune homeostasis at a higher level in the study.

The fact that the students in the TCC group caught fewer colds and had shorter duration of the URTI phase confirmed that regular TCC practice enhanced the anti-virus and anti-infection function.

There was an important limitation in this study. To examine the effects of TCC intervention on blood markers, we only compared those variables at pre-and post-exercise time points, without measuring the variables at other exercise phases. Thus, the evidence that TCC improved the immune homeostasis function was relatively weak.

CONCLUSIONS

In conclusion, the results of the present study suggested that 12-week TCC practice increased the anti-virus and anti-infection function, and the cellular immune function was improved by the increase of CD4+ cells, higher plasma IFN-γ, lower IL-12, and higher level of IgM and IgG. The study shows that TCC exercise benefits not only health but also the activity of the immune system. It provides some rational scientific basis for the popularization of TCC.

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