Effect of Eight-week Tai Chi Chuan Practice on Mindfulness Level

Mindfulness, a psychological concept that originated from Buddhism with a long history, emphasizes present moment awareness, focus on purpose, and non-judgmental thinking (Kabat-Zinn 2003). It is well established that mindfulness-based interventions are beneficial for alleviating stress and improving psychological well-being (Bostock et al. 2019). In addition, the practice can also serve as an alternative treatment for anxiety, depression, and other psychopathologies (Grecucci et al. 2015).

Tai Chi Chuan (TCC) is a common mindfulness-based exercise that involves maintaining a state of attentive presence and an enhanced sense of spatial perception during complex movements and the intentional use of breathing patterns. The awareness of movement, breath, and deeper understanding of the ultimate nature of things during TCC practice are regarded as core components of meditation in motion (Posadzki and Jacques 2009). Most of the empirical evidence from healthy populations and clinical trials consistently indicates that mindfulness skills may develop in response to TCC training by body movements and awareness of breath throughout the training (Salmoirago-Blotcher et al. 2020). Caldwell et al. (2011) reported that healthy students who engaged in TCC classes had higher mindfulness levels, better sleep quality, and decreased perceived stress. Improved mindfulness, as measured with the Five Facet Mindfulness Questionnaire (FFMQ), has been demonstrated after a 6-month TCC intervention in physically inactive patients with coronary heart disease (Salmoirago-Blotcher et al. 2020). One study reviewed the role of TCC in the treatment and prevention of mental disorders and suggested that the mindfulness component may explain why some patients experience greater benefits from TCC than from general aerobic exercise

(Abbott and Lavretsky 2013). However, some researchers did not find any significant difference in mindfulness level measured by the Chinese version of the Five Facet Mindfulness Questionnaire (FFMQ-C) after a 12-week TCC intervention (Lee et al. 2017). With regard to whether TCC can enhance an individual's mindfulness state, the results are still inconsistent for different teaching styles, populations, and intervention doses. It is argued that changes in interoceptive bodily awareness may be a potential mechanism of action for common mindfulness interventions (Farb et al. 2015; Gibson 2019; Hölzel et al. 2011). Therefore, the lack of interoceptive involvement during TCC practice may be one of the main reasons for the contradictory findings.

Some evidence has shown that interoception is fundamental to mindfulness (Gibson 2019). Each meditative technique could provide a unique perspective from which to investigate complex interoceptive signals (Gibson 2019). In psychology and neuroscience, interoception is commonly defined as the sense of the physiological condition of the body, which is a distinct cortical image of homeostatic afferent activity (Craig 2003). The primary interoceptive representation in the dorsal posterior insula engenders distinct highly resolved feelings from the body, including pain, temperature, itch, sensual touch, muscular and visceral sensation, vasomotor activity, and hunger (Craig 2003). One recent study observed that a 12-week mindfulness-based exercise also increased interoceptive awareness and mindfulness levels in war veterans with posttraumatic stress (Mehling et al. 2018). Even one session of acute mind-body practice could significantly improve the interoceptive accuracy measured by the heartbeat detection task in healthy controls (Demartini et al. 2020). In addition, a meta-analysis concluded that mindfulness showed functional convergence in the interoceptive cortices (Gutiérrez and Hilary 2019). Therefore, mindfulness and interoception seem tightly interwoven from behavioral and neural perspectives.

Given the close relationship between interoception and mindfulness, it has been hypothesized that involvement of interoceptive awareness during TCC practice may lead to improved mindfulness. However, they are evidently distinct constructs. Mindfulness does not distinguish among attention directed to exteroception, interoception, and thoughts, and interoceptive awareness only focuses on somatic experiences (Hanley et al. 2017). It may be that TCC influences mindfulness and interoception differently. The duration of mindfulness is likely to differ from that of interoception under the same TCC intervention condition.

In this study, we aimed to investigate whether 8-week TCC practice with emphasis on interoceptive awareness improved mindfulness in healthy adults. In addition, participants were followed up for another 16 weeks to dynamically examine different durations induced by 8-week TCC practice between mindfulness level and interoception. Mindfulness was assessed with the FFMQ-C, which was originally developed by Baer et al. (2006). The scale has been found to have high internal consistency in diverse samples and is one of the most widely used scales for measuring mindfulness. Interoceptive awareness was assessed with the Multidimensional Assessment of Interoceptive Awareness-Chinese Version (MAIA-C) (Mehling et al. 2012), which measures eight dimensions of interoceptive awareness. The measurements were performed at baseline, the end of week 8, and the end of week 24. At the end of week 8, all participants were asked to stop TCC practice and maintain the same lifestyle as before.

Methods

Participants

In this study, 61 healthy young adults (men = 14, women = 47) were recruited from the Internet and local universities. Inclusion criteria for the study were as follows: (1) no physiological or psychological disorders, (2) not having participated in any regular mind-body practice activities, such as TCC, yoga, and meditation, in the past 3 years. Based on the quasi-experimental design, 30 participants were assigned to the TCC group and 31 to the control group. Four participants in the TCC group and one participant in the control group dropped out during the study for personal reasons; thus, 56 participants remained (TCC group: n = 26, 22.65 ± 3.92 years, 7 men; control group: n =30, 20.60 ± 4.8 years, 6 men) in the final analysis.

A total of 56 participants completed the intervention, and 53 completed the follow-up assessments. Demographic characteristics are described in Table 1. At baseline, no significant differences were found in gender (χ^2= 0.461, $p > 0.05$), age ($t = 1.285$, $df = 59$, $p > 0.05$), or education ($t = 1.897$, $df = 59$, $p > 0.05$) between the TCC and control groups. At post-test (the end of the 8th week), a significant difference in education ($t = 2.569$, $df = 54$, $p < 0.05$) was observed between the two groups, and there were still no significant differences in gender (χ^2= 0.375, $p > 0.05$) or age ($t = 1.731$, $df = 54$, $p > 0.05$).

Procedure

Figure 1 depicts the entire experimental procedure. Eligible participants were recruited and divided into the TCC and control groups. Before the intervention, a demographic questionnaire and the behavioral measurements were administered to each participant. After initial screening, 61 participants were eligible for this study. The TCC intervention was carried out for 8 weeks in the TCC group, and the control group did not receive the intervention. After the 8-week intervention,

all participants were administered the FFMQ-C and MAIA-C for the second time. To detect the long-term effect of TCC practice, 16 weeks after ending the intervention, all participants were asked to visit the lab for the third time to complete the same scales by the same experimenter. They were asked to maintain their daily lifestyle as usual during this period.

Participants in the TCC group practiced TCC three times per week over 8 weeks, supervised by a skilled TCC instructor with 10 years of TCC experience, while the control group received no intervention. Both the participants and instructors remained blind to the purpose of the study. Each TCC practice session consisted of a 15-minute warm-up exercise, 15-minutes of Zhan Zhuang, and 30-minute of Yang-style TCC. Zhan Zhuang is a type of standing meditation performed immediately before formal TCC exercises. Participants were instructed to bend their knees slightly while standing for 15 minutes, focusing on the somatic senses of the body, breathing slowly, and experiencing moment-to-moment changes of their body. In order to highlight the component of interoceptive awareness, the TCC instructor emphasizes the combination of movement, attention, and deep breathing during the entire session. In addition, this TCC intervention only involved 14 styles from the traditional Yang style, in order to avoid complex movements and to allow participants to focus on somatic changes. Attendance rates of all participants were recorded.

Measures

Mindfulness The FFMQ-C was used to measure each participant's mindfulness level (Deng et al. 2011). The FFMQ-C is a 5-point Likert scale consisting of 39 items and five dimensions: observing, describing, acting with awareness, nonjudging, and nonreactivity. Observing involves paying attention to internal and external experiences, such as sensations, cognitions, emotions, and sights.

Describing involves labeling internal experiences with words. Acting with awareness refers to attending to one's activities in the moment and can be contrasted with behaving mechanically while attention is focused elsewhere. Nonjudging of inner experience refers to taking a nonevaluative stance toward thoughts and feelings. Nonreactivity to inner experience is the tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them (Baer et al. 2008). The Cronbach's α range from 0.45 to 0.84 for the individual scales.

Interoceptive Bodily Awareness Interoceptive awareness was evaluated with the Multidimensional Assessment of Interoceptive Awareness-Chinese Version (MAIA-C) (Lin et al. 2017). The MAIA-C includes eight interrelated but distinct subscales with a total of 32 items (noticing, not-distracting, not-worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting), all of which are scored on a 6-point scale. These eight subscales fall into five domains of interoceptive body awareness: (1) awareness of body sensations (noticing): assesses the awareness of uncomfortable, comfortable, and neutral body sensations; (2) emotional reaction and attentional response to sensations (not-distracting, not-worrying): assesses the reaction to specific physical sensations and physiological emotions, (3) capacity to regulate attention (attention regulation): assesses the ability to stay focused when facing numerous sensory stimuli competing for attention; (4) awareness of mind-body integration (emotional awareness, self-regulation, body listening): assesses the more developed levels of body awareness; and (5) trusting body sensations (trusting): assesses the experience of one's body as safe and trustworthy (Mehling et al. 2012). The higher the score, the higher the interoceptive body awareness level. The Cronbach's α for the individual scales range from 0.46 to 0.88.

Data Analyses

Four participants whose attendance rates were lower than 80% were excluded from the analyses and one participant in the control group dropped out during the study. Finally, 56 participants were involved in the data analyses. All statistical analyses were conducted using SPSS 23.0 software (IBM Corp., Armonk, NY, USA). Independent-sample t-tests (two-tailed) were conducted to compare group differences in age and education between the TCC and control groups, while group differences in gender were performed using the Chi-square test. A mixed linear model was then employed to evaluate behavioral differences between the TCC and control groups before and after the intervention. This model was tested by a two-way repeated multivariate analysis of variance, in which time (pre- and post-intervention) was considered as the within-subject factor and group (intervention and control groups) was the between-subject factor. In the same model, both age and education were considered as random effects. Finally, a multiple regression analysis was conducted to compare the behavioral differences in follow-up between the two groups. Age and educational level were also entered into this model as covariates to exclude the confounding effect. All significance levels were set at 0.05.

Results

Mindfulness

The results indicated that there were significant interactions between time and group in describing ($F = 29.942$, $df = 52$, $p < 0.001$, partial $\eta^2 = 0.365$), acting with awareness ($F = 45.776$, $df = 52$, $p < 0.001$, partial $\eta^2 = 0.468$), nonjudging ($F = 28.399$, $p < 0.001$, partial $\eta^2 = 0.353$), and nonreactivity ($F = 6.083$, $df = 52$, $p < 0.05$, partial $\eta^2 = 0.105$) in the FFMQ-C. Within-group simple effect analysis

showed that compared with the mean scores at baseline, the mean scores in describing ($p < 0.01$), nonjudging ($p < 0.01$), and nonreactivity ($p < 0.01$) increased significantly after the intervention in the TCC group. In the control group, the mean scores in describing ($p < 0.001$), acting with awareness ($p < 0.001$), and nonjudgement ($p < 0.01$) decreased significantly in the post-test relative to those at baseline. Between-group simple effect analysis showed no significant difference between the two groups in the above-mentioned dimensions. After the intervention, the scores of the TCC group in describing ($p < 0.001$), acting with awareness ($p < 0.001$), and nonjudging ($p < 0.001$) were significantly higher than those of the control group (Fig. 2).

Interoceptive Awareness

Regarding interoceptive awareness, two-way repeated measurement analysis showed marginally significant interaction effects between time and group in attention regulation ($F = 2.981$, $df = 52$, $p < 0.1$, partial $\eta^2 = 0.054$), self-regulation ($F = 2.927$, $df = 52$, $p < 0.1$, partial $\eta^2 = 0.053$), and trusting ($F = 3.052$, $df = 52$, $p < 0.1$, partial $\eta^2 = 0.055$) in the MAIA-C. Within-group simple effect analysis showed that compared with the scores at baseline, scores for attention regulation ($p < 0.05$) and self-regulation ($p < 0.001$) increased significantly after TCC in the TCC group, while there were no significant changes in the control group in attention regulation ($p > 0.05$) and self-regulation ($p > 0.05$). Between-group simple effect analysis showed that there were no significant differences between these two groups in the above three dimensions at baseline. However, after 8 weeks of intervention, the TCC group showed significantly higher scores in attention regulation ($p < 0.05$), self-regulation ($p < 0.01$), and trusting ($p < 0.05$) compared with the control group (Fig. 3).

Persistent Effects

With regard to the FFMQ-C, the TCC group continued to show significantly higher scores in the subscales of describing ($p < 0.05$), acting with awareness ($p < 0.005$), and nonjudging ($p < 0.05$) compared with the control group. In MAIA-C, the scores of trusting were still significantly higher in the TCC group compared with the control group ($p < 0.005$).

Discussion

Consistent with our main hypothesis, this longitudinal study with follow-up measurement showed that 8-week TCC practice with emphasis on somatic experience can significantly improve mindfulness in terms of describing, acting with awareness, nonjudging, and nonreactivity, as measured with the FFMQ-C, and marginally increase interoceptive awareness in terms of attention regulation, self-regulation, and trusting, as measured with the MAIA-C. In addition, at the end of week 24, the TCC-induced benefits on three dimensions of mindfulness (describing, acting with awareness, and nonjudging), and the trusting dimension of interoceptive awareness still remained. The findings shed light on the mindful nature of TCC and advance the understanding of the associations between TCC, mindfulness, and interoceptive awareness.

One of the main findings of this study is that short-term TCC practice could induce an improvement in mindfulness. This result is consistent with previous longitudinal studies on TCC-induced physical and psychological effects. An 8-week TCC intervention in adolescents with subthreshold depression also showed that participants' mindfulness levels increased significantly after TCC practice, and there was also a decrease in their depression (Zhang et al. 2018). Higher mindfulness levels involve no reaction toward external experiences, attention to bodily sensations, and

acceptance of internal experiences (Hanley et al. 2017). In the present study, during TCC sessions, instructors asked participants to concentrate on their body with slow movement and rhythmic breathing, emphasized the process of controlling the body, and focused on using awareness of interoception to maintain physical balance, following the basic principles of mindfulness. Notably, Zhan Zhuang was an integral part of each session. It optimizes mindfulness practice by requiring standing meditation under supervision (Newnham, 2019). During the Zhan Zhuang portion, participants were asked to perform diaphragmatic breathing and to concentrate on it, get into a resting state, and to release themselves from random thoughts. This process is similar to mindfulness-based training and is intimately linked with the relaxation of the body. Moreover, deep breathing is another core component of mindfulness-based stress reduction (Kabat-Zinn 1990). It was found that training that focuses heavily on conscious breathing can effectively improve mindfulness (Neto et al. 2019).

The psychological mechanisms underlying the effects of TCC practice on mindfulness level may involve interoceptive awareness during TCC training. Substantial evidence in the past two decades has suggested that interoceptive awareness is closely linked to mindfulness. Although few studies have demonstrated that interoceptive awareness may result in increased mindfulness, most studies found that mind-body practice may improve bodily interoceptive awareness. For instance, Bornemann et al. (2014) observed that a 3-month integrative mind-body exercise that includes “body scan” and “breathe meditation” improved practitioners’ interoceptive awareness. Similarly, clinical trials also found an improvement in the interoceptive awareness of patients after mindfulness-based practice. Researchers found that in patients with chronic pain and comorbid active depression, an 8-week mindfulness-based cognitive therapy intervention significantly

increased the facets of body awareness, suggesting that interoceptive awareness is a mediator of the effect of mind-body practice on depression (de Jong et al. 2016). An integrative exercise program that emphasized mind-body centering and mindful breathing coordinated with slow movement also found that such practice could improve self-reported interoceptive awareness in war veterans with posttraumatic stress symptoms, reducing their posttraumatic stress symptoms, and increasing their psychological quality of life (Mehling et al. 2018). In view of the close link between mindfulness and interoceptive awareness, it is suggested that more focus on interoceptive practice when performing TCC movements may help bolster mindfulness levels. In fact, in this study, we observed that after 8 weeks' TCC practice, attention regulation and self-regulation were improved, both of which are regulatory aspects of interoceptive awareness. During TCC sessions, participants needed to rotate their waists in all directions to exercise and maintain their balance. They had to focus on kinesthetic sense and regulating the senses of the body and joint extension; therefore, attention to their mental state was crucial in the performance of the movements. Therefore, it is plausible that such complex requirements on body movement, combined with deep breathing, can increase mindfulness by enhancing the regulative ability of bodily interoceptive awareness.

In addition, some neurological evidence has revealed that the brain regions responsible for mindfulness functionally overlap with those of interoception, including the insular cortex, cingulate cortex, and inferior frontal gyrus (Gibson 2019). Animal and human studies have suggested that the insular cortex plays a central role in interoceptive signals (Cameron 2009; Hassanpour et al. 2018). A functional magnetic resonance imaging study in healthy adults suggested that the right mid-insula is a key node in the interoceptive network, which could preferentially respond to cardiorespiratory stimulation, a form of interoceptive sensations (Hassanpour et al. 2018). A

repetitive transcranial magnetic stimulation study also observed that inhibiting the anterior insula, part of the interoceptive network, resulted in a significant decline in cardiac and respiratory interoceptive accuracy (Pollatos et al. 2016). Notably, the insula and surrounding neural circuits are believed to be responsible for a number of other functions beyond interoception, including attention, awareness, and all subjective experiences, many of which have been linked to mindfulness (Gibson 2019). Previous studies have found that practicing meditation is associated with increased neural activation in the insula (Fox et al. 2016; Tang et al. 2015). This brain region has been linked to a number of roles in higher-order cognitive functioning, including awareness of interoceptive experience (Young et al. 2017). A recent meta-analysis systematically reviewed seven longitudinal studies on mindfulness-based interventions and found that task-relevant activity in the insula was increased following mindfulness-based intervention (Young et al. 2017), suggesting that an increase in insula activation is a "typical" response to mindfulness intervention. This finding has also been supported by some studies on generalized anxiety disorder (Grecucci et al. 2015) and elite athletes (Haase et al. 2015). Together, these findings suggest that the insula cortex acts as a bridge linking mindfulness and interoceptive awareness, which warrants further research. Interestingly, one structural magnetic resonance imaging study that compared the differences in brain structures between TCC practitioners and controls found that the TCC group showed greater cortical thickness in the insula sulcus (Wei et al. 2013). It is plausible that TCC practice with an emphasis on bodily interoception optimizes the function of the insula or partly reshapes the anatomical structures of the insula, contributing to increased mindfulness. In sum, 8 weeks' TCC practice improved mindfulness and interoceptive awareness in healthy adults. Even 16 weeks after the end of the practice, the effects continued. These findings provide meaningful insights for advancing the

understanding of the association of mind-body practice, mindfulness, and interoceptive awareness. They can be applied in mind-body interventions for health promotion in healthy populations and in the clinical treatment of neurological disorders.

Limitations and Future Research

Although this study has potential implications for mind-body interventions, several limitations should be acknowledged. First, heterogeneous samples of age and education in the intervention and control groups existed at post-test and follow-up. Thus, caution should be taken when drawing any conclusions about the effect of TCC practice on mindfulness and interoceptive awareness. Second, all psychological measurements used in this study were self-reported. Such measurements with common method variance may lead to spurious effects since there are multiple constructs within the same survey (Podsakoff et al. 2003). In the future investigation, evaluating the potential biasing the effects of method variance and designing the study's procedure to control common method biases are needed. Additionally, comprehensive measures specific to interoceptive awareness should be used. In view of the growing concerns about the validity of heartbeat counting task, a frequently used measurements of interoception, it is a need to develop new subjective tool to measure interoceptive accuracy from both psychological and physiological approach. Third, the relationship between mindfulness level and interoceptive awareness could not be detected for a relatively small sample size. Therefore, future research should investigate the relationship between TCC practice, mindfulness, and interoceptive awareness in a larger sample. Finally, participants in the control group received no treatment. One problem with the use of a no-treatment control group is the existence of placebo effects, which enhances the effectiveness of the experimental group due

to expectation of improvement even though all participants were blinded to the aim of current study. In the future, randomized and active controlled trials should be designed to eliminate the potential placebo effects, so as to better demonstrate the TCC's effect on mindfulness level.

Author contributions

L-ZC: designed and executed the study, analyzed the data, and wrote the paper. A-YD: designed and executed the study. YY, RS, ZH, LG: executed the study. XD, AL: collaborated with the design, revised the paper. G-XW: designed the study, reviewed, edited and revised the paper, and supervised this study. All authors approved the final version of the manuscript for submission.

Declarations

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Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Approval

This study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences (CAS) and was carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Informed Consent

All participants received an explanation of the experimental processes before the study began and provided written informed consent.

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Table

Table 1. Demographic characteristics of the participants

Group	Gender	Age (years)	Education (years)
Baseline			
TCC (30)	M (8)	22.000 (4.026)	15.367 (2.141)
Control (31)	M (6)	20.548 (4.753)	14.484 (1.435)
p	0.554	0.204	0.063
Post-test			
TCC (26)	M (7)	22.650(3.919)	15.880 (2.428)
Control (30)	M (6)	20.600 (4.825)	14.530 (1.432)
p	0.541	0.089	0.013*

* $p < 0.05$

Figures

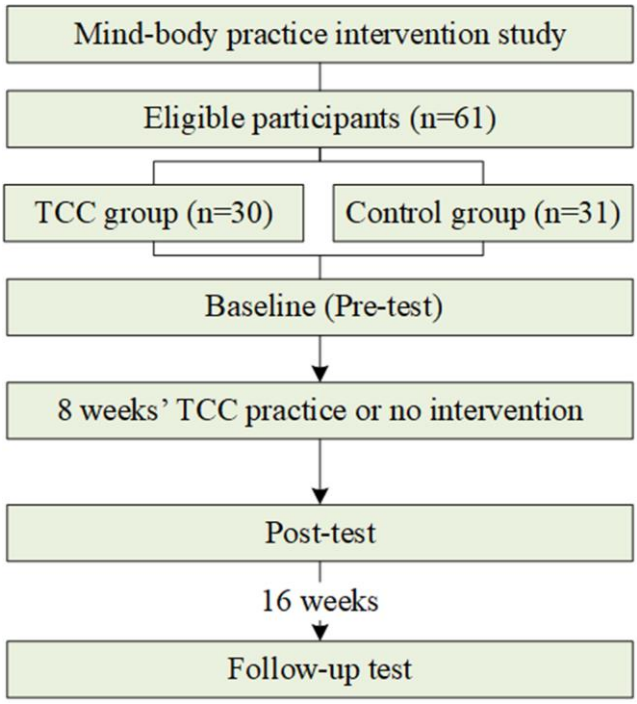

Fig. 1 Experimental procedure of the present study.

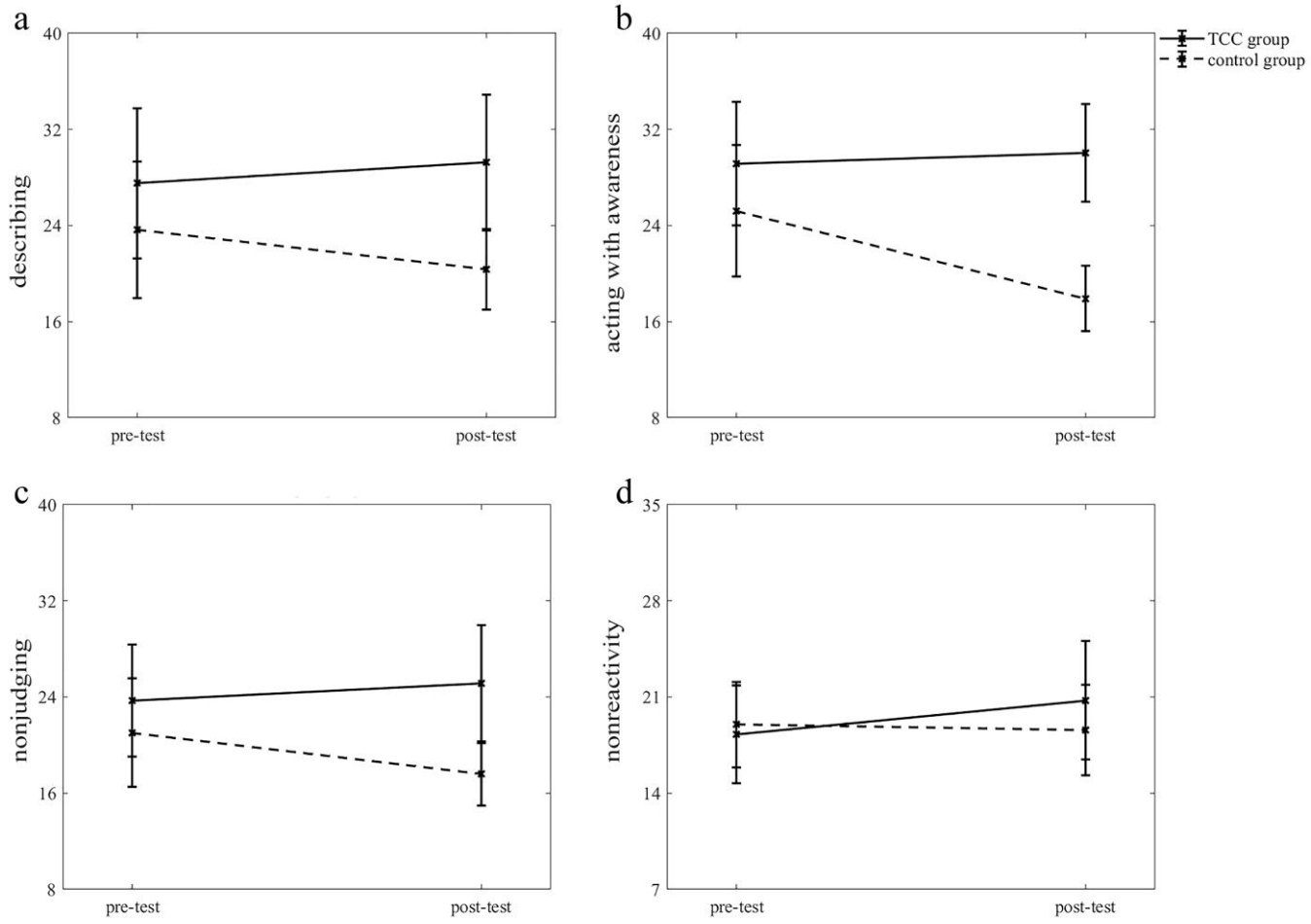

Fig. 2 Results of the FFMQ-C. Significant changes in the (a) describing, (b) acting with awareness, (c) nonjudging, and (d) nonreactivity dimensions of the FFMQ-C at baseline and post-test (the end of the 8th week) in the TCC group compared with the control group.

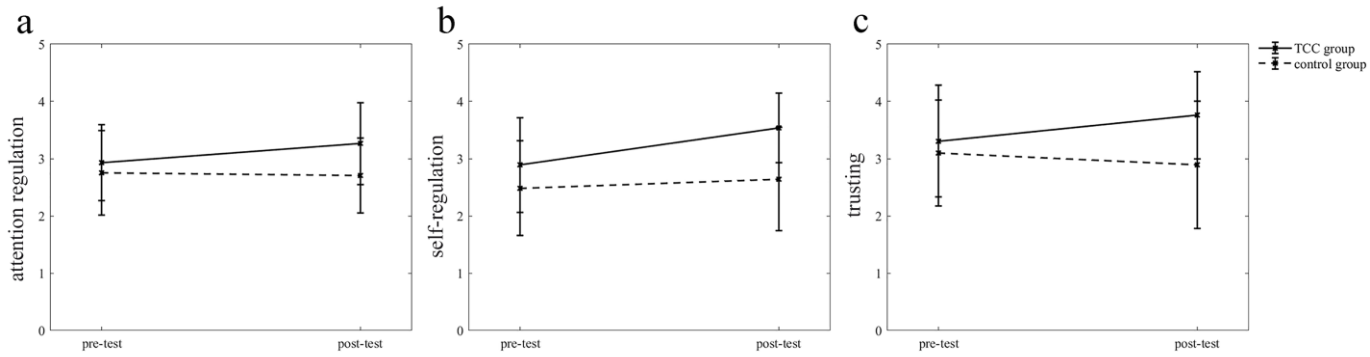

Fig. 3 Results of the MAIA-C. Significant changes in the (a) attention regulation, (b) self-regulation, and (c) trusting dimensions of the MAIA-C at baseline and post-test (the end of the 8th week) in the TCC group compared with the control group.