

Effect of Tai Chi and Yoga Training on Oxidative Status, Physical Performance, and Cognitive Function of Military Personnel

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Abstract: Yoga, a long-established Indian philosophical system, tries to bring harmony and wellness to the physical, mental, and emotional dimensions. Tai Chi is a traditional Chinese exercise of moderate intensity. They are widely used in modern society to reduce oxidative biological alterations and enhance physical and mental performance. The main objective was to evaluate the effect of Tai Chi and Yoga exercises on oxidative stress measures, physical performance, and cognitive function of military personnel. It was a field-based pragmatic randomized control study. Military medical officers who were taking a refresher course for Military Medical Training from February to March 2020 comprised mainly 81 voluntary participants. They were divided into three groups in equal chance, with each receiving six weeks of regular, Tai Chi, and Yoga training. Blood samples were obtained before and following the six-week interventions, and measurements of the serum nitric oxide (NO) and oxidative stress index (OSI) were taken. Then assessments of cognitive function and physical fitness were conducted. Significant reductions of OSI from 0.61 ± 0.14 AU to 0.32 ± 0.12 AU ($p < 0.01$) was found in the Tai Chi group and the effect of Tai Chi on OSI level reduction was found more prominently over Yoga effects, although there were no remarkable differences in NO level among them. For physical fitness test, parameters of Yoga group (Body fat percent: 20.87 ± 3.62 to 19.84 ± 3.53 ; Sit and Reach test: 2.00 ± 1.78 to 2.89 ± 1.70 (times/minute); Crunch test: 34.07 ± 8.94 to 37.21 ± 11.89 (times/minute) were improved significantly ($p < 0.05$). In the Tai Chi group, improvements were seen in Sit and Reach test: 2.11 ± 1.66 to 2.89 ± 2.04 (times/minute); and Crunch test: 31.81 ± 7.49 to 37.85 ± 8.83 (times/minute), ($p < 0.05$). As for the cognitive function test, there were no significant changes in all groups. According to the study's outcomes, Yoga training is generally superior to Tai Chi training in terms of areas of physical fitness testing. It can be concluded that a six-week Tai Chi and Yoga exercise program has beneficial effects on antioxidant capacity and oxidative stress measurements. While the practice of Tai Chi generates a more intense antioxidant impact, Yoga produces a greater improvement in physical fitness effect.

Keywords: Tai Chi, Yoga, Oxidative Stress Index (OSI), Nitric Oxide (NO), Physical Performance, Cognitive Function

1. Introduction

Physical exercise reduces the biological alterations associated with the normal aging process, for instance, a decline in strength and mass of muscle mass, and rapid contraction of the muscle. It also has a positive effect on mitochondrial function, oxidizing enzymatic capacity, aerobic capacity, cardiac contractility, rapidity of nerve conduction, and glucose intolerance. On the other hand, moderate exercise is indicated for maintaining health and preventing chronic diseases [1]. Traditionally non-Western physical activities such as Yoga and Tai Chi therapies are beginning to receive increased research attention because these two activity practices share specific breathing exercises, physical movements, meditation, direct attention on a focus, and practice of visualization. Therefore, Tai Chi and Yoga are widely practiced among different types of physical exercises [2].

Tai Chi is a traditional Chinese conditioning moderate intensity exercise that is performed by many people in the Eastern world. Many researchers explained that Slow, deep, and diaphragmatic breathing, and integration of body movement and breathing action, are emphasized during the practice of Tai Chi. Tai Chi described the respiratory minute volume as relatively low when compared with the energy expenditure and it induced to increase in energy supplies to skeletal muscle from the immediate energy sources of ATP and phosphocreatine before other aspects of metabolism are activated [3, 4]. Moreover, Tai Chi may increase physical strength as well as relax the mind and so may be useful for alleviating stress, it is regarded as a suitable physical activity design to increase antioxidant defense function. Based on the inter-relatedness of mind, body, and spirit this form of exercise focuses on producing an inner calmness which is thought to have both physical and psychological therapeutic value [5]. In 2014, Nguyen and Dai Nguyen observed a significant decrease in blood pressure and heart rate and significant improvement in the Senior Fitness Test in 24 weeks of the Tai Chi training group, and their Body mass index and waist-hip ratio were also reduced by 1.23 and 0.04, respectively. Tai Chi is often described as “meditation in motion,” and it can be easily adapted for anyone, from the fit to people confined to wheelchairs or recovering from surgery [6]. Lu *et al* (2016) found out that Tai Chi training for 16 weeks in a randomized controlled study on older women with a sedentary lifestyle and young adults showed superior performance on a dual task cognitive exercise and better balance during the dual-task condition [7].

An ancient Indian philosophical method called yoga is practiced to bring balance as well as health to one's physical, mental, and emotional aspects. Yoga contains the practice of Breathing & relaxation (Prayana), Asana (Posture), and muscle relaxation exercises, and also the practice consists of

a set of physical postures “asana”, which are maintained for a certain time. Asana is an exercise traditionally used in Yoga practices characterized by the maintenance of specific postures involving bending, standing, twisting, and balancing the body, to improve flexibility and strength. Pranayama consists of controlled breathing exercises focusing on body awareness during their execution [8]. The preliminary studies related to Yoga stated that the practice of Yoga may improve the performance of cognitive functions among potential benefits in healthy individuals. Indeed, a meta-analysis of both short- and long-term effects indicates that Yoga practice is associated with improvement in cognitive functioning generally in both long-term and short-term studies [9]. In 2012, the researcher group, Rocha *et al*, suggested practicing Yoga regularly for cognition and quality of life for individuals after six months of Yoga practice in healthy men [9]. D'souza and Avadhany (2014) investigated the effect of Yoga training and detraining on physical performance in pre-pubertal (7-9-year-old) school-going children and they reported that the efficacy of Yoga to improve strength, endurance, whole body endurance, and aerobic capacity with 3 months of training, not last after 3 months detraining [10].

The terms reactive oxygen species (ROS) and reactive nitrogen species (RNS) refer to reactive radicals and non-radical derivatives of oxygen and nitrogen, respectively [11]. Although various cells produced Nitric oxide (NO) in the body, vascular endothelium production of NO is mainly significant in blood flow regulation. Because of its importance in vascular function, abnormal production of NO is known to occur in various disease states and can adversely affect blood flow and other vascular functions [12]. Increasing production of ROS has been shown to induce damage in macromolecules, such as lipids, proteins, and DNA where oxidative stress can occur. Reactive oxygen and nitrogen species (RONS) are produced by all aerobic cells and play an important role in aging as well as in age-related diseases [13]. The antioxidant defense system includes both endogenous and exogenous molecules which protect against free radical toxicity in the body. Endogenous antioxidants include enzymatic and non-enzymatic pathways. superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) are the key antioxidant enzymes and the others are glutathione-S-transferase and glucose-6 phosphate dehydrogenase [14]. The non-enzymatic antioxidants are molecules that interact with RONS and terminate the free radical chain reactions [15]. Oxidative stress occurs when there is an imbalance between the formation and the removal of RONS because of overproduction and/or an impaired ability to neutralize them or repair the resulting damage [16]. The regular moderate extent of physical exercise has been recognized to reduce the incidence of diseases. The generation of reactive oxygen species (ROS) during regular physical exercise might be a trigger of adaptation in antioxidant capacity to prevent

extensive cellular damage with oxidative stress. In addition, studies have shown that regular exercise will improve health by boosting the immune system. In 2018, Liguori and co-workers also pointed out that oxidative stress occurs from the imbalance between RONS production and these antioxidant defenses [17].

Tai Chi training and Yoga meditation can lead to lower oxidative stress through mood-related signaling. Stress can also be reduced through various mechanisms, especially via parasympathetic activation in Yoga exercises [18–20]. Due to the effect of inflammation, immune cells tend to produce various cytokines and enhance ROS generation [18]. Tai Chi exercise, the effect is responsible for decreasing pro-inflammatory cytokines such as TNF-alpha, and IL-2 which enhances the lower function of the immune cells and ROS generation [21]. As for Yoga exercise, parasympathetic activation mainly through the Vagus nerve creates secretion of acetylcholine which binds to its receptor on immune cells leading to blocking proinflammatory cytokines [22].

Therefore, many reviewers stated that Tai Chi and Yoga programs are not serious training, and they are just comfortable relaxation techniques so these types of interventions have a lot of advantages for mankind. Many researchers had already proved that Tai Chi & Yoga can reduce oxidative stress and these exercises have been suggested as popular exercises that are accessible, can be performed without restrictions, and can be attained in daily life activities. However, it is unknown whether Tai Chi or Yoga produces a more efficient antioxidant effect. This study wished to prove that meaningful improvements in both Tai Chi and Yoga groups in physical performances (BMI, blood pressure, body fat percentage, three-minute step test heart rate, sit and reach test, crunch test) and cognitive function (revised Hasegawa's dementia score (HDS-R)). Therefore, it is an interesting point to the effect of Tai Chi and Yoga Training on oxidative status, physical performance, and cognitive function of military personnel and a lot of benefits will be obtained from this study. This study aims to evaluate the effect of two exercise programs, Yoga and Tai Chi exercises, on antioxidant capacity and oxidative stress measures as well as physical performance, and cognitive function of military personnel.

2. Materials and Method

It is a field-based pragmatic randomized control study. Participants in the present study included 81 voluntary healthy adults (30 to 40 years) males who were attending the Defence Services Medical School, Hmawbe, for the Medical Company Commander Course. By using the block randomization method, all participants went into three groups (Control group $n = 27$, Tai Chi group $n = 27$; Yoga group $n = 27$) in equal chance throughout the whole study period from January 2020 to June 2020. The study was approved by DSMA Ethical Review Committee according to the CIOMS Guidelines, with informed consent. In the Tai Chi group, the program was a 24-movement style taught by an experienced

instructor, one movement was taught each day five days per week for six weeks. During the same period, participants in the Yoga program were taught by an experienced instructor with 7 styles. In the control group, participants had no regular training. This study excluded the participants who were recent infections and injuries that could impact training performance. No participants had previous experience with any extensive exercise training. Alcohol drinking and smoking were not allowed during the study period. Their fasting blood sample collection for biochemical parameters was collected before and after the exercise intervention procedure for six weeks. Total Oxidant ELISA kit (E1599HU), Total Anti-oxidant ELISA kit (E2199HU), and Human Nitric Oxide ELISA kit (E1510HU) were used to determine the blood TOS, TAS, and Nitric Oxide levels. The oxidative stress index (OSI) can be calculated as the ratio of the TOS level to the TAS level.

Specifically, $OSI \text{ (Arbitrary unit)} = TOS \text{ (U/L)} / TAS \text{ (U/L)}$

Source: [23]

Their Physical fitness test (Standard measurements, Body composition, Cardiorespiratory Endurance, Flexibility test, Muscular strength, and endurance) and Cognitive function test were noted in their proforma, and Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) software version v.25.0. Results are expressed as means, SD (standard deviation) & Independent student *t*-test, one-way ANOVA methods were applied to calculate the significance of the difference between the means on 95% confidence interval of results.

3. Results

In this study, Age and physical characteristics (Height, Weight, and BMI) and blood pressure are not significantly different changes before and after training in Control, Tai Chi & Yoga groups apart from decreasing trend of BMI after the intervention period (Table 1). Intervention effect can be seen in Tai Chi and Yoga group in serum oxidative stress level; however, there was no significant effect in Control group. Nitric oxide level was significantly decreased after six weeks of training for all groups. Index of oxidative stress and TOS level were also significantly reduced in Tai Chi and Yoga Group in which intervention effect was prominently found in the Tai Chi group (Table 2). Before and after the intervention, three minutes step test of heart rate, Sit and reach test, and body fat percentage were highly significant, without intervention (Table 3). Sit and reach test and crunch test were significantly better in Tai Chi group. Intervention effects were seen only in these two tests but also in three minutes step test heart rate and body fat percent are somewhat decreased without significance. Among five parameters of physical functions, sit and reach test as well as the crunch test had significant improvement in the Tai Chi group ($p < 0.05$) (Table 4). Before and after the intervention, sit and reach test and body fat percentage were highly significant and crunch tests are significantly better in the Yoga group. Intervention

effect is seen only in these two tests but also in three minutes step test heart rate is somewhat decreased without significance. HDS-R is also increased after yoga but not significant (Table 5).

Table 1. Baseline characteristic of the study population.

Characteristics		Control group (n = 27)		Tai chi group (n = 27)		Yoga group (n = 27)	
Age (years)		33.09 ± 1.89		32.48 ± 1.66		35.00 ± 1.78	
		Before	After	Before	After	Before	After
Height (m)		1.68 ± 0.06		1.66 ± 0.07		1.69 ± 0.04	
Weight (kg)		68.86 ± 10.81		68.94 ± 9.78		68.91 ± 9.18	
BMI		24.13 ± 2.91		24.86 ± 4.31		24.08 ± 3.00	
Blood Pressure		Systolic	122.72 ± 14.20	122.93±13.15	116.66 ± 9.6	117.33 ± 9.26	121.07 ± 13.14
(mmHg)		Diastolic	83.93 ± 6.81	86.06 ±10.87	78.14 ± 10.28	79.07 ± 6.79	81.78 ± 8.18
							80.89 ± 7.20

Values are Mean ± SD.

Table 2. Distribution of biochemical parameters in three groups before and after intervention.

Parameters	Control (n = 27)		Tai Chi (n = 27)		Yoga (n = 27)	
	Before	After	Before	After	Before	After
TOS (U/L)	11.72 ± 3.36	10.12 ± 3.1	17.78 ± 3.68	9.03 ± 3.18 **	13.24 ± 3.27	10.54 ± 3.01 *
TAS (U/L)	28.42 ± 6.25	29.59 ± 5.32	30.08 ± 5.27	28.94 ± 3.11	29.44 ± 4.2	29.41 ± 3.88
OSI (AU)	0.43 ± 0.14	0.35 ± 0.12	0.61 ± 0.14	0.32 ± 0.12 **	0.46 ± 0.13	0.36 ± 0.11 *
NO (μmol/L)	308.06 ± 46.03	248.28 ± 28.19 **	361.33 ± 29.96	189.38 ± 55.93 **	316.40 ± 53.55	187.36 ± 48.63 **

Values are Mean ± SD, * $p < 0.05$, ** $p < 0.01$.

Table 3. Physical fitness test and HDS-R result of control group before and after intervention.

Control Group Parameters	Pre-Intervention Program	Post-Intervention Program
Body Fat Percent	21.40 ± 3.09	20.33 ± 3.28 **
3 minutes step test heart rate (Beats/minute)	95.33 ± 17.17	86.90 ± 14.32 **
Sit and reach test (Times/minute)	2.38 ± 1.89	2.27 ± 2.02
Crunch test (Times/minute)	28.84 ± 5.67	32.15 ± 7.26 **
HDS-R (Score)	27.70 ± 2.03	27.93 ± 2.26

Values are Mean ± SD, * $p < 0.05$, ** $p < 0.01$, HDS-R = revised Hasegawa's dementia score.

Table 4. Physical fitness test and HDS-R result of Tai Chi group before and after intervention.

Tai Chi Group Parameters	Pre-Intervention Program	Post-Intervention Program
Body Fat Percent	21.01 ± 3.71	20.68 ± 3.82
3 minutes step test heart rate (Beats/minute)	91.29 ± 11.26	89.18 ± 15.03
Sit and reach test (Times/minute)	2.11 ± 1.66	2.89 ± 2.04 *
Crunch test (Times/minute)	31.81 ± 7.49	37.85 ± 8.83 *
HDS-R (Score)	27.70 ± 2.43	27.81 ± 1.92

Values are Mean ± SD, * $p < 0.05$, ** $p < 0.01$, HDS-R = revised Hasegawa's dementia score.

Table 5. Physical fitness test and HDS-R result of Yoga group before and after intervention.

Yoga Group Parameters	Pre-Intervention Program	Post-Intervention Program
Body Fat Percent	20.87 ± 3.62	19.84 ± 3.53 **
3 minutes step test heart rate (Beats/minute)	96.50 ± 8.95	90.60 ± 15.00
Sit and reach test (Times/minute)	2.00 ± 1.78	2.89 ± 1.70 **
Crunch test (Times/minute)	34.07 ± 8.94	37.21 ± 11.89 *
HDS-R (Score)	27.93 ± 2.65	28.39 ± 2.24

Values are Mean ± SD, * $p < 0.05$, ** $p < 0.01$, HDS-R = revised Hasegawa's dementia score.

4. Discussion

The impact of the activity of moderate-intensity physical exercise on various aspects of aging, including the prominent development of an antioxidant response accomplished by an adaptive process had been established. In this study, the distribution of participants of three groups distribution was selected by block randomization method because it can

overcome the confounding factors differences between these groups such as BMI, blood pressure, lifestyle differences with cigarette smoking, alcohol drinking, nutrient intake, etc. According to the biological characteristics of the study population, the mean age was 33.09, 32.48, and 35 years in control, Tai Chi, Yoga respectively (Table 1). (Apart from the Yoga group), their mean BMI and blood pressure were not significantly changed after six weeks training period.

After the intervention period, a decline in nitric oxide

levels was seen in all three groups. Apart from the control group, Tai Chi and Yoga groups had decreasing trends in TOS, and OSI indicating that their oxidative status became reduced after Tai Chi and Yoga training (Table 2). In the control group, serum TOS, TAS, and OSI levels were not different between pre- and post-exercise conditions. But NO level was seen lower after six weeks of intervention. This may be due to the effect of baseline activities of the training course. Even regular exercise training blocks the production of pro-inflammatory cytokines which leads to anti-inflammation and reduces ROS generation [21]. Therefore, there is relatively a lower amount of NO level was found in the control group.

In Tai Chi group, the main findings of the present study were reduction of serum biochemical parameters in post-exercise condition compared with pre-exercise condition (TOS: 17.78 ± 3.68 to 9.03 ± 3.18 (U/L); OSI: 0.61 ± 0.14 to 0.32 ± 0.12 (AU); and NO: 361.33 ± 29.9 to 189.38 ± 55.93 ($\mu\text{mol/L}$) ($p < 0.0001$) but not in TAS. Interestingly, the Tai Chi group had reduced TOS and OSI levels to half of the baseline amount. This can be due to the stress-reducing effect of Tai Chi because of intracellular signaling pathways [24]. Yoga therapy can reduce stress in many ways via parasympathetic activation, and many cytokines that can interact and reduce oxidative stress. Tai Chi training and Yoga meditation can affect mood-related networks in the brain, and then it leads to increased expression of a lot of anti-inflammatory cytokines directly reducing oxidative stress [18–20]. Due to the effect of inflammation, immune cells tend to produce various cytokines and enhance ROS generation [18]. But in the Tai Chi intervention group, its effect is responsible for reducing pro-inflammatory cytokines such as TNF- α , and IL-2 which can lead to decreased inflammation. And it enhances reduces the activity of the immune cells and ROS generation becomes lower in the body [21].

Another finding of the present study was in the Yoga group which has some significant results (TOS: 13.24 ± 3.27 to 10.54 ± 3.01 (U/L); and NO: 316.40 ± 53.55 to 187.36 ± 48.63 ($\mu\text{mol/L}$) and p -values are statistically significant ($p < 0.01$ for TOS and $p < 0.0001$ for NO) but not in OSI and TAS. In this

group, both TOS and OSI levels were reduced. This can be because of the stress-reducing effect of Yoga due to intracellular signaling pathways. This agrees with the previous study [25]. Yoga therapy can reduce stress in many ways via parasympathetic activation, and many cytokines that can interact and reduce oxidative stress. An increased parasympathetic state can lower inflammation [18–20]. The main component of parasympathetic activation is the Vagus nerve, and it secretes acetylcholine which binds to its receptor on immune cells leading to inhibiting the inflammatory cytokines [22]. Moreover, anti-inflammatory effects can lower the production of pro-inflammatory cytokines from immune cells which can decrease ROS production [18].

When changes in biochemical parameters among 3 groups were compared, the effect of Tai Chi on reducing OSI levels was found more prominently over Yoga effects, although there were no remarkable differences in reduced NO levels among them (Figure 1). Tai Chi is one kind of martial art and its exercise and according to the Nguyen and Dai Nguyens' study (2014) in 24 weeks body mass index and waist-hip ratio were also reduced by 1.23 and 0.04, respectively [26]. Not the same as the present study changes only occur in flexibility tests such as sit and reach test and crunch test due to the fact of our Tai Chi program is only 6 weeks and uses 24 movements sequentially to do slow flexion and extension movements powerfully with high ATP consumption under low cardiovascular activity [27]. For the Yoga group, this study used a six weeks program of low-intensity yoga practice. This practice contained breathing and relaxation for 15 min, then sequentially rotated 7 asanas (postures) for 30 min and muscle relaxation for 15 min procedure for 1 hour each weekday (5 days/week). Our program did not allow intense to moderate-intensity and tended to low-intensity exercises. According to the program, only flexibility tests were improved after the intervention. These findings did not follow the improvement of the Senior Fitness Test in Nguyen's paper [26]. For control group can easily imagine the effect of military training like ordinary running exercise for 45 minutes. High-intensity exercise, body fat percentage, three minutes step test heart rate, and crunch test were highly significant but no more flexibility tests were improved.

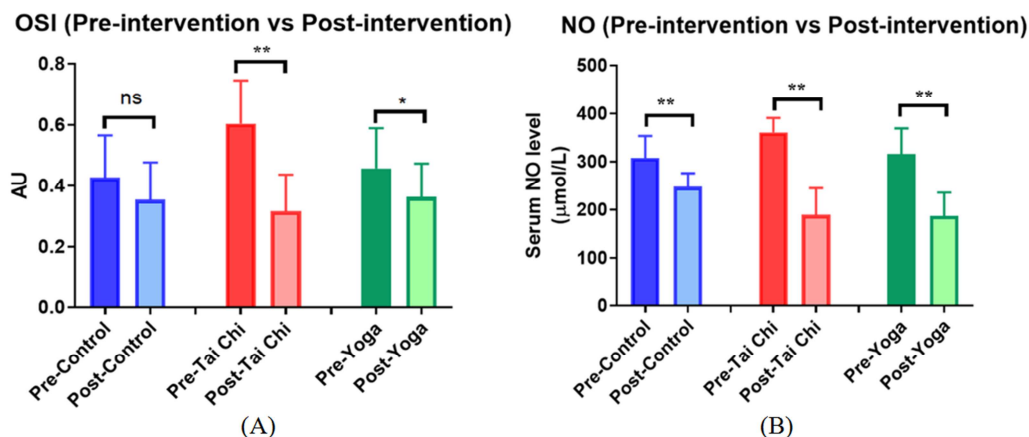


Figure 1. Comparison of Pre- and Post-intervention of (A) oxidative stress index and (B) nitric oxide level of three groups (ns = not significant, * $p < 0.05$, ** $p < 0.01$).

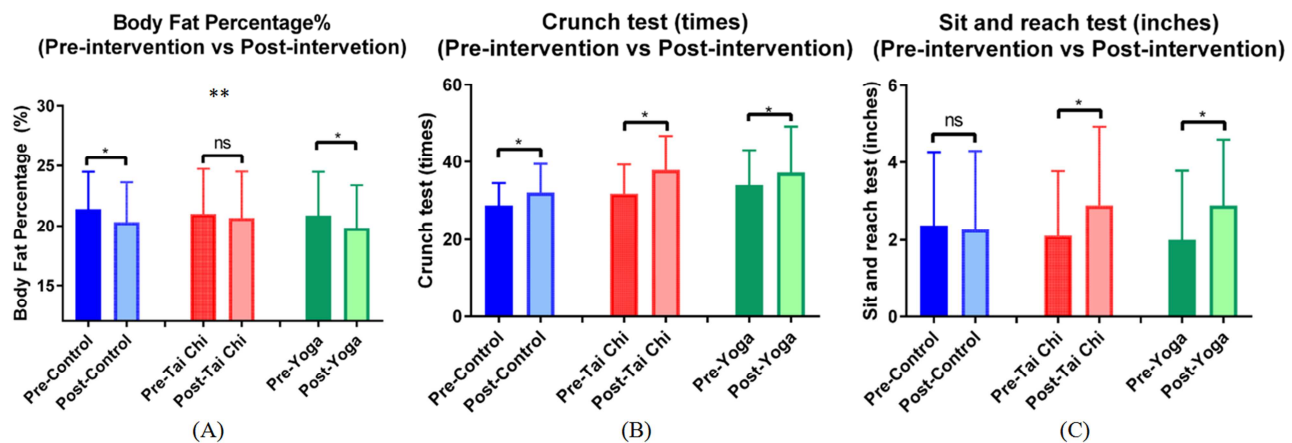


Figure 2. Comparison of Pre- and Post-intervention of (A) Body Fat Percent (B) Sit & reach test (C) Crunch test of three groups (ns = not significant, * $p < 0.05$, ** $p < 0.01$).

In the present study, the baseline characteristics of the study population have been analyzed. The same age group was selected for the training and height, weight and BMI were not significantly different even after training in all three groups. Another characteristic is blood pressure and it is also not significantly different in both systolic and diastolic. This is not in line with Bharshankar's study in 2003, he mentioned for 5 years of training in Yoga had significantly reduced heart rate and blood pressure in both systolic and diastolic pressures [28]. This might be explained by the study duration that we had a very short period. Before the intervention, there is no significant difference in physical fitness and cognitive function tests except for crunch tests. This can be explained by all the participants having done much military training and that kind of test can be normalized in the non-exercise population. Every military training had relaxation exercises and this was used for every participant with a slightly reduced control group.

After the intervention, the same as pre-intervention, only crunch tests were significantly different in Tai Chi and Yoga groups. From the physical performance test aspects, Tai Chi training effects were significantly seen in sit and reach test and crunch test, 2 parameters (flexibility tests) and Yoga training effects were absolute significantly seen in body fat percentage and sit and reach test and significantly seen in crunch tests. So, there may be 2 significant parameters from Tai Chi training and 2 absolute significant parameters, and 1 significant parameter from Yoga training. No more differences in cognitive function as HDS-R for short-term training, not enough to change synaptic plasticity. In fact, according to the results of this study, Yoga training is preferable to Tai Chi training in physical fitness test aspects.

5. Conclusion

The findings of the present study suggest that the practice of Tai Chi generates a more intense antioxidant effect than Yoga while the Yoga practice generates a more improvement in physical fitness effect than Tai Chi although obvious improvement of cognitive function was not observed in both

groups of the present study. However, these results need to be collaborated by long-term cohort studies. It can be concluded that a six-week Tai Chi and Yoga exercise training program has a positive influence on antioxidant capacity and oxidative stress measures and is effective for improving health and physical fitness for adult males.

Conflict of Interest

All the authors do not have any possible conflicts of interest.

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