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The Effect of 12 Weeks of Tai Chi Exercise on IL-6 and CRP of Obese and Lean Middle-Aged Women

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Abstract: *The aim of this study was to evaluate the effect of a Tai Chi exercise on some of the inflammatory indicators of obese and lean middle-aged women. Methodology: the research sample included 40 non-athlete middle-aged women, including 20 obese and 20 lean, in Bardsir city. The subjects were purposefully selected and obese women were randomly divided into exercise obese (10 subjects) and control obese (10 subjects) groups and lean subjects were randomly divided into exercise lean (10 subjects) and control lean (10 subjects) groups.First, written consent was taken from subjects. Then, medical questionnaire were completed. Then, physical dimensions including height, weight and body mass index were measured and recorded. Then, 10ml blood sample was taken from anterior vein of the subjects at rest and fasting status and IL-6 and plasma C-reactive protein were measured and recorded. Then, obese and lean experimental groups participated in the Tai Chi exercises for 12 weeks, 3 sessions per weeks, and lasted 60 minutes per session. These exercises were performed in the form of principle of overload. Then, at the end of 12 weeks and 24 hours after the last exercise session, all variables, similar to the pre-test, were measured and recorded. Data were analyzed by paired t-test and independent t-test. Results: This study showed a significant reduction in body mass index and IL-6 and C-reactive protein in exercise obese group compared to control obese group and exercise lean group. Conclusion: Finally, this study showed that a 12-week Tai Chi exercise can be beneficial in reducing the levels of BMI, IL-6, and C-reactive protein in obese middle-aged women.*

Keywords: *IL-6, C-reactive protein, Tai Chi exercise, obese and lean middle-aged women*

INTRODUCTION

Nowadays, obesity is one of the most important concerns of healthcare professionals, since in addition to mental and psychological problems; it is associated with many metabolic disorders or chronic diseases such as liver dysfunction, hyperlipidemia, and cardiovascular disease (Paredes et al., 2016; Santilli et al., 2015). An increase in body fat associated with an increase in inflammatory cytokines such as TNF-α, IL-6 CRP, provides the conditions for prevalence or increased severity of obesity-related diseases (Vinagre et al., 2014). Low mobility and obesity are the two most common causes associated with the risk of cardiovascular disease. It has been reported that for each unit of increase in body mass index, the risk of cardiovascular disease increases by 8%, and with an increase in physical activity by one Met, the risk of cardiovascular disease decreases by 8% (Lira et al., 2010). Women, compared to men, are at higher risk for chronic inflammation or conditions, such as atherothrombosis due to having high fat tissue. Although an increased low density

lipoprotein (LDL-C) and reduced high density lipoprotein (HDL-C) are indicators for diagnosis of cardiovascular disease, reports show that people with cardiovascular disease have normal LDL-C and HDL-C. Hence, many studies have been conducted and it has been accepted that cardiovascular diseases is rooted in inflammatory and general (systemic) inflammation plays a key role in the development and progression of atherosclerosis (Belek and Reedcker, 2001). Thus, inflammatory indicators have been considered as independent predictors of cardiovascular disease in the last decade. Some of these inflammatory indicators include fibrinogen, haptoglobin, interleukin 6, and C-reactive protein (Elgharib et al. 2003). However, for two important reasons, the C-reactive protein (CRP) and IL-6 in adults are considered to be important inflammatory indicators. First, several reports have been reported on the relationship between the C-reactive protein and IL-6 and the diseases in adults (Kritchevsky et al., 2005; Aboutalebi et al., 2006). Second, in adults and elderly, compared to younger populations, the level of C-reactive protein and IL-6 in the blood has been reported higher (Grimble, 2003). In addition, several studies have shown that with the increase in age, IL-6 also increases (Grimble, 2003).

Drug therapy is one of the methods used to reduce inflammation, but in some cases, it has been shown that drug therapy may have side effects (Canvin et al., 1999). Moreover, there is evidence that regular physical activity reduces the C-reactive protein (CRP) and IL-6 levels (Nicholas et al., 2008). As the aging process can be associated with an increase in the level of inflammatory cytokines and acute phase proteins, it seems that prevention of increased C-reactive protein and IL-6 in adults and elderly people will require effective methods to control systemic inflammation. Additionally, other factors can increase body mass, clinical infections and chronic diseases, and finally, chronic inflammation.

Given its widespread and harmful effects on health, interventional and behavioral knowledge, such as exercise and food diet, is vital in reducing inflammation. Therefore, inflammatory pathways are thought to be a potential therapeutic target in interventional processes to reduce the disease and disability (Suarez et al, 1981; Hersoug and Linneberg 2007). Exercise is one of the factors affecting the immune and hormonal processes and causing a temporary change in the homeostasis of body (Blair et al. 2001; Pedersen and Hoffman-Goetz, 2000). There are consistent data available from interventional studies showing a relationship between physical activity and the level of inflammatory indicators, especially in people with chronic diseases along with increased inflammation (De Rosa et al. 2007; Samartin and Chandra al. 2001). In this regard, a lower concentration of inflammatory indicators has been reported in people with increased physical activity (Tilburgs et al. 2006).Tai Chi exercise is a regular physical exercise. Tai Chi exercise is basically among the ancient Chinese martial arts (Nguyen 2013). This exercise can be considered an activity with a low degree of difficulty. Its moderate intensity is 3.1 Met (Equivalent to metabolic) (Chan et al., 2011). This exercise is regularly associated with strengthening cardiovascular function, flexibility, muscle strength, balance, mental health, self-esteem and social interactions (Logghe et al., 2010).Investigation of the effects of factors such as regular physical activity, such as the Tai Chi exercise with ball that might reduce these factors, is very important in the health of middle-aged people. Given the role of obesity and its effect on general health and the possible role of exercise in reducing the burden of obesity such as improving the immunity and the need to compare the effect of regular physical activity in obese and lean people and given the benefits of Tai Chi exercise, this study was conducted with the aim of evaluating the effect of 12-week Tai Chi exercise on some inflammatory indicators of obese and lean middle-aged women.

Methodology

This research is considered as a quasi-experimental research. The research design was a pre-test and post-test design with control and exercise groups. A total of 350 people referred to the Health Network of Shahid Yavari in Bardsir city and they received and completed a demographic characteristics questionnaire. Out of all who were willing to participate in the research, a total of 40 people, including 20 lean people with BMI less than 19 (BMI< 19) and 20 obese people with BMI equal or more than 30 (BMI ≥30) were purposefully selected according to the inclusion criteria. The inclusion criteria of research included people aged 40 to 45 years and

the BMI at the two ends of the highest and lowest level of this indicator. Then, the lean subjects were randomly divided into two groups of control (n=10) and exercise (n=10) and the obese subjects were also randomly divided into two groups of control (n=10) and exercise (n=10). The criteria for selection of participants included lack of certain disease (no acute cardiovascular disease, lack of blood pressure disorders, no severe inflammation, lack of mental discomfort, no severe pain in the joints and low back of body, shortness of breath or asthma) and lack of participating in any regular exercise program at least 6 months prior to this exercise program, and having regular daily activities. The Tai Chi exercises program included a 12 weeks of Tai Chi exercise with ball (3 sessions per week and 55 minutes per session). These exercises were performed with the principle of overload. The Tai Chi exercise with the ball protocol at each exercise session from the first week was in this way: 1 min of Tai Chi exercise with a ball and resting for 30 seconds, and during the following sessions, 30 seconds were added to duration of the Tai Chi exercises with the ball compared to exercises of the previous week. At the beginning and end of the exercise program, 5 minutes of warm-up and 5 minutes of cool-down with stretching movements were considered. All subjects were healthy and did not have an acute disease, such as a cold, until one week before the test and they did not took any drug.

Exclusion criteria of research included participating in heavy exercises, infectious diseases, and hospitalization. One week before the exercise program, they were invited and information on their age, height, weight and BMI was recorded. In addition, using a medical history questionnaire, information such as age, medical, sports and therapy history, fracture, and drug use was obtained. Height meter with a precision of 1 mm (SECA, manufactured by Germany) was used to measure the height of the subjects in a standing position without shoes and socks based on cm. The SECA digital scale (made in Germany) was used to measure weight in two stages of before exercise and after 12 weeks of exercise in light cloth and no shoe. BMI of each subject was calculated in two stages of before the beginning of the exercises and after 12 weeks of exercises by dividing the weight (kg) by height (m). To examine the biochemical variables, blood sampling was performed after 12-14 hours of fasting in two stages of before beginning of exercises and after 12 weeks of exercises.In the first stage, to take the blood samples from all subjects, 2 days before the test, they were asked not to have hard activity. Then, the subjects were asked to refer to Shahid Yavari Health Center from 10 to 8 am. Then, 10 ml of blood sample was taken from the right vein of each subject in sitting position and after five minutes of rest on a chair. The temperature and time of blood sampling were recorded to maintain these conditions in the next stage. The taken blood was injected into sterile tubes and serum was separated from plasma using centrifuge method (for 10 min with 3000 rpm) and frozen at a temperature of -70 up to the measurement time. After this stage, the subjects received the exercise protocol for 12 weeks. After this period and 24 hours after the last session, the blood samples were re-taken form subjects. The subjects of experimental group were asked not to have exercise or long-term walking 24 hours after the completion of exercises. After collecting samples in the post-test and pre-test, all blood samples were removed from the freeze in one day and the tests were performed according to the relevant protocol. ELISA laboratory kits (Boster Human ElisaKit, manufactured by United States) were used for measuring the values of IL-6 based onPg/ml. and Diagnostics Biochem Canada kit (manufactured by Kanda) based on µg/ml to measure the CRO.

Statistical analysis

The collected data were analyzed by descriptive and inferential statistical methods and the results were presented in the form of tables. Descriptive statistics were used for anthropometric characteristics of the subjects including age, height, weight, BMI. In the inferential statistic, the Levene test was used to examine the normal distribution of the data. For intra-group comparisons, paired t-test was used, and for inter-group comparisons, independent t-test was used. It should be noted that spss 18 was used to interpret the data. Other statistical operations such as drawing charts were done with Excel software (minimum significance level for the research was considered as $P \leq 0.05$).

Results

Anthropometric characteristics of the subjects in obese and lean control and experimental groups are

presented in Table (1)

Table 1: Anthropometric characteristics of the subjects in obese and lean control and experimental groups

groups	n	Mean age (year)	Mean height (cm)	Mean weight (kg)	Body mass index (kg / m 2)
Experimental obese Control	10	1.1±2.42	5.9±8.158	2.1± 7.86	08.3 4±.34
	10	8.1±1.43	6.7± 4.158	7.3±8.84	28.3±52.33
Experimental lean Control	10	5.1±4.43	7.±6 7.156	7.5±4.45	69.0±44.18
	10	1.2±8.42	6.6±3.156	5±2.45	71.0±47.18

Table 2: Descriptive statistics of research variables in the experimental and control obese and lean groups

Variable	Experimental group	Experimental obesecontrol obese		Experimental leancontrol lean	
		Mean and SD	Mean and SD	Mean and SD	Mean and SD
Weight (kg)	pretest	24.7±1.86	7.8±30.84	7.5±41.45	06.5±23.45
	posttest	57.7±69.83	81.8±34.84	82.5±98.45	08.5±28.45
Body mass index (kg / m 2)	pretest	08.4±30.34	28.3±52.33	69.0±44.18	71.0±47.18
	posttest	82.3±30.33	25.3±56.33	68.18±73 .0	71.0±48.18
IL-6 (pg/ml)	pretest	02.2±25.7	57.1±08.7	28.0±68.2	24.0±7.2
	posttest	66.1±05.6	56.1±14.7	35.0±62.2	24.0±7.2
CRP (µg/ml)	pretest	53.0±13.3	39.0±03.3	17.0±13.1	30.0±27.1
	posttest	49.0±42.2	39.0±05.3	17.0±12.1	31.0±28.1

Table 3: results of paired t test and independent t test for the measured variables in experimental and control obese and lean subjects

			Mean difference	T	P	Mean difference	t	P
BMI of obese women	Experimental group	pretest	0.99800	6.521	0.001	0.98300	6.418	0.001
		posttest						
	Control group	pretest	-11500.0	-167.1	0.273			
		posttest						
BMI of lean women	Experimental group	pretest	-23400.0	-080.3	0.113	-37600.0	-698.4	0.123
		posttest						
	Control group	pretest	0.01500-	-830.1	0.101			
		posttest						
IL-6 of obese women	Experimental group	pretest	1.20000	7.746	0.001	0.13350	8.539	0.001
		posttest						
	Control group	pretest	-0.06000	-2.714	0.243			
		posttest						
C-reactive protein of obese women	Experimental group	pretest	0.71200	9.973	0.001	0.67600	8.82*0*	0.001
		posttest						
	Control group	pretest	-9.02000	-2.798	0.221			
		posttest						
C-reactive protein of lean women	Experimental group	pretest	01100.0	905.2	117.0	-10300.0	-814.1	0.186
		posttest						
	Control group	pretest	-00700.0	-165.0	872.0			
		posttest						

Table (2) presents a summary of descriptive statistics for the main variables including weight, body mass index (BMI), IL-6, and C-reactive protein in two groups of experimental and control for obese and lean subjects and the two groups of experimental and control for lean subjects in the pre-test and post-test stages. The Levene test was used to examine the equality of variance of the groups and the paired t-test was used to examine the intra-group design and the independent t-test was used for the inter-group comparisons (minimum significance level for the research hypothesis test was considered as $P \leq 0.05$).

As shown in Table (3), 12-week Tai Chi exercise had significant effect on BMI, IL-6 and CRP in obese middle-aged women. Based on paired t-test and according to significance level of the test for BMI, IL-6 and CRP (sig = 0.001, t = 6.52) (sig = 0.001, t = 7.746) (sig = 0.001, t = 9.973), respectively, Tai Chi exercises had an effect on body mass index, IL-6 and CRP in the experimental obese group.In addition, based on independent t-test, given the significance level of the test for BMI, IL-6 and CRP (sig = 0.001, t = 6.41) (sig = 0.001, t=8.539) (sig = 0.001 = 8.820), respectively, there is a significant difference between the BMI, IL-6 and CRP in obese middle-aged women before and after 12weeks of Tai Chi exercise. In addition, as shown in Table 3, 12-week Tai Chi exercise had no significant effect on BMI, IL-6, and CRP in middle-aged lean women. Based on paired t-test and according to the significance level of the test for BMI, IL-6 and CRP (sig = 0.113, t=- 3.080) (sig=0.208, t=1.356), and (sig=0.117, t=2.905), respectively, Tai Chi exercises had no significant effect on BMI, IL-6 and CRP in the experimental group. Additionally, based on independent t-test, given the significance level of the test for body mass index, IL-6 and CRP (sig = 0.123, t =-4.698), (sig=0.123, t=-2.728) and (sigb0.186, t= -1.817), respectively, no significant difference was found between the BMI, IL-6 and CRP of lean middle-aged women before and after 12 weeks of Tai Chi exercises.

Table 4: Independent test results for measured variables in obese and lean groups

	groups		Difference between mean pretest and mean posttest	Mean difference of experimental and control groups	T	P
BMI	obese	Experimental	0.998	0-983	8.03	0.001
		control	0.0150			
	Lean	Experimental	-0.0387	-0.398		
		control	-0.0110			
IL-6	obese	Experimental	1.20000	0.13350	6.35	0.001
		control	0.-06000			
	Lean	Experimental	0.05900	-.23300		
		control	0.-01600			
C-reactive protein	obese	Experimental	0.71200	0.67600	3.35	0.001
		control	-0.02000			
	Lean	Experimental	0.01100	-0.10300		
		control	-0.00700			

As shown in Table (4), there is a significant difference between the obese group and lean group in terms of mean BMI, IL-6 and CRP. With regard to the significance level of the test for BMI, IL-6 and CRP (sig = 0.001, t = 8.03), (sig = 0.001, t = 6.35), and (t=3.35, sig=0.001), respectively, we conclude that the values of BMI, IL-6, and CRP decreased significantly in obese group. Therefore, there was a significant difference between obese middle-aged women and lean middle-aged women in terms of the effect of 12 weeks of Tai Chi exercise on body mass index, IL-6 and CRP.

Discussion

As stated, the Tai Chi exercise with the ball has had a significant effect on the reduction of BMI in the

experimental obese group. This result was not consistent with the result of the studies conducted by Wan-An and Cheng-Deng Kuo (2012) and Jing Liu et al (2012). In addition, Tai Chi exercise with ball did not have a significant effect on the reduction of BMI in the experimental lean group. It was consistent with the results of the studies conducted by Wan-An and Cheng-Deng Kuo (2012) and Jing Liu et al (2012). Wan-An and Cheng-Deng Kuo (2012) examined the effect of three months of Tai Chi exercises on middle-aged and elderly men and women and they reported lack of significant reduction in BMI in this group of people. Jing Liu et al (2012) did not observe a significant reduction in BMI in a study conducted to evaluate the effect of Tai Chi exercises on immune system function in middle-aged and elderly women. The inconsistency results in the mentioned studies and the present might be attributed to differences in the gender, age, primary levels of BMI, type of exercise, and intensity of exercise. Different experimental studies suggest that physical activities play a major role in controlling weight. The effects of exercises in controlling weight become evident increasingly, and even, low-intensity exercises performed for a long time will have a significant impact on weight control. In the late 1980s, various professional sports associations suggested low-intensity aerobic exercise to decrease body fat. These associations believed that low-intensity aerobic exercise leads to increased use of body fat as an energy source, so it accelerates the fat reduction. In fact, the body uses more fat to produce energy in low-intensity exercises. The designed Tai Chi exercises with ball in the present study are considered as a low-intensity exercise, so weight loss and reduced BMI are expected at the end of the study. The reason for lack of significant effects of physical activity on BMI of lean people can be attributed to the fact that lean people have lower fat tissue compared to obese people, so reduction in BMI of obese people will be more evident. In addition, a positive and significant correlation has been reported between BMI and obesity indicators in previous studies.

As shown, presentation of Tai Chi exercises with the ball had a positive impact on the reduction of CRP and IL-6 levels in the experimental obese group. It was not consistent with the results of the research conducted by Wan-An and Cheng-Deng Kuo (2012) 2012 and was consistent with the results of the research conducted by Jiang Juan et al (2009), Jing Liu et al (2012), Wang and An (2011) and Victor Manuel et al (2014). The presentation of Tai Chi exercise with the ball did not reduce the levels of CRP and IL-6 significantly in the experimental lean group. It was in line with the research conducted by Wan-An, Cheng-Deng Kuo (2012), but it was not consistent with the results of research conducted by Jiang Juan et al (2009), Jing Liu et al (2012), Wang-An (2011), and Victor Manuel et al (2014). In a study entitled "examining the effect of tea extract polysaccharide and Tai Chi exercise in production of free radicals and peroxidation and its moderating effect on the safety of middle-aged women", Jiang Juan et al (2009) found that inflammatory indicators in the Tai Chi exercise group were significantly reduced compared to the control group and Tai Chi exercise improved the immune system.

In a study conducted with the aim of investigating the effect of Tai Chi on the immune system function of middle-aged and elderly women, Jing Liu et al (2012) found that the percentage of CD4+ lymphocytes compared to CD 8+ increased, and IFN-α and IL-4 also significantly increased in the experimental group. In a study entitled "the effects of three months of Tai Chi exercises on the rate of Cytokines in middle-aged and the elderly people", Wang-An , Cheng-Deng Kuo (2012) concluded that three months of Tai Chi exercise in middle-aged and elderly people increased the production of IFN-γ and TNF-α cytokines. In study entitled "The effects of a 12-week Tai Chi exercise on the immune system function of girls who had no physical activity, Wang-An (2011) found that there was a significant difference in the concentration of IL-4 and IL-12 and IFN-Y and CD 3. IFN-Y level increased and IL-12 level decreased to a normal level. Various mechanisms might be involved in the pathways through which regular aerobic exercise can reduce and improve serum levels of IL-6 and CRP. A major potential pathway could be the production of interleukins. IL-6 and TNF- α are significantly secreted from fat tissue, especially visceral fat tissue. Their release increase sympathetically. As regular physical activity causes a decreasing regulation in sympathetic stimulation, it is likely to reduce TNF-α, that is a potent stimulus of IL-6 production and IL-6 is a potent stimulus of CRP production.

Thus, regular exercise on reducing sympathetic stimulation and as a result reduced levels of TNF and IL-6 might responsible for reducing CRP in people with high levels of physical fitness. Long-term exercise can change the regulation of inflammation. The first mechanism is that the aerobic exercise can reduce the gene expression and serum levels of the leukocytes molecules, and thus, inhibit the response of the endothelial cell monocyte, and ultimately, leads to a reduction in the production of cytokines. Strakskoski et al. (2005) also examined the effect of a regular physical activity program on CRP levels of obese women and showed that aerobic exercise reduces serum CRP levels. Moreover, Michael Ji Lamonthe et al (2002) examined cardio respiratory readiness and CRP in three of the women. An important aspect of this study was the effect of race of people on the levels of CRP. This study showed that CRP varies in different races and it decreases with increasing physical fitness and increases with increasing BMI and waist circumference. The antioxidant effect of exercise is another mechanism that reduces inflammation. There is some evidence on animal and human studies that suggests that aerobic exercises can significantly reduce oxidative stress by increasing the body antioxidant defense capacity and accordingly reduce inflammation and CRP. Moreover, aerobic exercises increase the anti-inflammatory cytokines.

In this regard, Victor Manuel et al (2014) conducted a study to evaluate the effect of Tai Chi exercise on the biological indices of oxidative stress in saliva and its relationship with dental and gum diseases in elderly people with measuring IL-8 and IL-10 and IL-10 IL-1 and TNF-α. They found that IL-1 levels were significantly reduced and these findings show that Tai Chi exercises improve teeth and gum disease in the elderly with their anti-inflammatory and anti-oxidant effects. Lack of effect of this type of physical activity on IL-6 and CRP in lean subjects might be due to their low or normal BMI, since baseline concentration of serum IL-6 and CRP might be associated with obesity, in the sense that IL-6 and CRP levels in obese people are significantly higher than those of lean people. In this study, it was revealed that baseline IL-6 and CRP levels were significantly higher in both obese groups compared to lean groups before starting of the exercises. In healthy people, about 30% of circulating interleukin is released from fat tissue (Mohamed Ali et al, 1997).IL-6 is one of the pre-inflammatory cytokines secreted from fat tissue and its circulating levels are directly associated with obesity (Rudin and Barzilai, 2005).Obese people with higher fat tissue have more interleukin than lean people (Mohamed Ali et al, 1997). IL-6 released from fat tissue stimulates the liver cells to release more CRP in the blood circulation (Heinrich et al, 1990). This suggests that the levels of IL-6 and CRP are lower in the lower weights (Rudin and Barzilai, 2005). Thus, reduced body mass index in obese group exercise groups in the sense of reduced body fat during physical activities leads to reduced TNF-α. It means that potent stimulant of IL-6 production and reduced IL-6 that is potent CRP stimulant reduces the CRP. Hence, by exercising, reduction of IL-6 and CRP in obese people will be more significant. Moreover, there is a positive and significant correlation between IL-6 and CRP and obesity indicators in previous studies. Although physical activity causes many changes in immune function parameters, the nature and level of such changes depend on various factors such as the studied immune parameters, type, intensity and duration of exercise, physical fitness and exercise history of subjects, environmental factors such as environment temperature, and time of blood sampling (Mackinnon and Hopper, 1996). In general, the rate of change in each immunity parameter is a function of the dose or the intensity of exercise or physical activity (intensity and duration) (Mackinnon and Hopper, 1996). In general, the results of the present study are consistent with results of the above-mentioned studies and inconsistent with some others. The reason might be lack of use of the control group, non-randomized methods, the use of different designs and methods, the use of the different subjects or non-homogeneity of subjects in terms of age and gender. In general, the findings show that regular and long-term regular exercise of Tai Chi as a low-intensity exercise without the need for specific equipment can be used to improve the function of the immune system in people who have no physical activity. However, further studies are required on other immunity aspects.

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