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Research Article

EFFECT OF RESISTANCE TRAINING AND OMEGA3 SUPPLEMENTATION ON MARKERS OF MUSCLE DAMAGE AND INFLAMMATION IN TRAINED MEN

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ABSTRACT
Physical training along with omega-3 supplementation is among one of the recommended methods for improving factors of muscle damage and inflammation. This study was aimed to investigate the effect of resistance training along with omega-3 supplementation on muscle damage and inflammatory factors among trained male subjects. Forty trained healthy male volunteers selected and randomly divided into 4 groups. The subjects (supplement+ training and training) performed resistance training for 8 weeks, 3 sessions per week. Training intensity started from 50% 1RM and reached 80% 1RM during the last two weeks. In supplement and supplement +training group subjects asked to consume 3000mg omega3 daily for 8 weeks. Before the beginning of the study (pretest), after the fourth week of training (Mid test) and end of the study (posttest) blood samples were collected. The collected data was analyzed by variance analysis test with repeated measurements.Omega-3 supplementation and resistance training along with omega-3 supplementation significantly decreased the levels of IL17, CRP, and CK, while resistance training significantly increased the levels of IL17, CRP, and CK ($P<0.5$).Results indicated that resistance training enhanced inflammatory factors and cellular damage, while omega-3 supplementation prevented such an increase.

Keywords: *Interleukin 17, C-reactive Protein, Creatine Kinase, Omega-3 Supplement, Resistance Training*

INTRODUCTION
Effect of different physical activities and training programs with medium intensity has been established on health factors and life quality. Results of several studies have shown that regular physical activities and resistance training have many advantages for musculoskeletal health (Kraemer *et al.*, 2002). People would benefit from the advantages of resistance training according to their personal goals (Kraemer & Ratamess, 2004). In spite of various benefits of resistance training, it seems that performing resistance training with high intensity and volume at heavy and repetitive level could cause inflammatory and cellular damage and consequently increase people's vulnerability and acute and chronic inflammation (Medicine, 2009). An outcome of resistance training is muscle pain, damage, and inflammation, which is called exercise-induced muscle damage (EIMD) (Gleeson, 2005). Medium-intensity physical activity enhances the function of the immune system, while intense physical activity and training deteriorate many aspects of its function (Kimura *et al.*, 2006). In addition, muscle damage and its consequent inflammation caused by intense training can increase plasma levels of cytokines such as interleukin 6 (IL6), tumor necrosis factor (TNFα), C-reactive protein (CRP), and interleukin 17 (IL17), which paves the ground for inflammation (Nieman *et al.*, 2005). Inflammation caused by resistance training is induced by two mechanisms: local inflammatory response and systemic inflammatory response (Peake *et al.*, 2005). Local inflammatory response is mostly observed in skeletal muscles as pre-inflammation after eccentric and concentric resistance training and then causes such an inflammation (Hamada *et al.*, 2005). Systemic inflammatory response is mostly generated as an inflammatory reaction (Petersen & Pedersen, 2005). Increased activity of cytokines has been observed after performing 4 times of resistance training with 12 repetitions and 70% 1RM in lower and upper extremities and core organs; after resistance training, significant increase of cytokines is 1.4, 2.7, and 2.4 times after 12, 24, and 72 h, respectively (Izquierdo *et*

al., 2009). CRP has been shown to be one of the acute phase proteins (APP) which exponentially increases with infection, inflammation, and tissue damage. CRP measurement is the best method for diagnosing tissue lesions because of its rapid increase at the beginning of tissue lesion and rapid decrease as soon as its recovery (Phillips *et al.,* 2003). Increase in inflammatory and pre-inflammatory cytokines such as IL6 and IL17 can stimulate and secrete CRP (Izquierdo *et al.,* 2009). Results of some studies have demonstrated that inflammation process increases damage caused by oxidative stress via increasing the production of reactive oxygen and nitrogen species and can cause the production of per oxidative products. Oxidative metabolites can activate NFkB (nuclear factor Kappa-light-chain-enhancer of activated B cells) pathways and increase the production of pre-inflammatory cytokines (Cho *et al.,* 2006), (De Winther *et al.,* 2005). Signal transducer and activator of transcription 3 (STAT3) can also activate most of the immune responses. These two signaling pathways can stimulate and activate pre-inflammatory and inflammatory pathways (Cho *et al.,* 2006), (Aggarwal & Gurney, 2002), (Kelley, 2001). The most considerable role of IL17 is its participation in inducing mediated pre-inflammatory response; also, as a pre-inflammatory cytokine in the immune system, IL17 responds to the destructive factors of extracellular pathogens and can upregulate inflammation; finally, it can lead to tissue and cellular inflammation and damage (Chiricozzi *et al.,* 2010). The pre-inflammatory role of IL17 via the auxiliary interaction of IL1β and TNFα, production and secretion of IL6, and subsequently increase of CRP caused by IL6 increase in muscular cells has been verified. Furthermore, in satellite cells, skeletal muscles can be secreted and produced (Duzova, 2012). IL17 has been demonstrated to induce CPR production (Kramer *et al.,* 2008). It seems that increasing CPR secretion can be finally accompanied by the increase of CK enzyme (Golzari *et al.,* 2010). In response to muscle damage and injury, their production induces stimulation and activation of anti-inflammatory cytokines including IL1, IL6, IL8, and TNFα, pre-inflammatory cytokines such as IL10, IL17, and IL23, and acute phase proteins like CRP as the inflammation factor and then upregulates them. Further, these inflammatory matters can suppress the activity of the immune system (Kelley, 2001).

Omega-3 fatty acids (EPA and DHA) have positive effects on the health of normal people as well as athletes. Existence of EPA and DHA fatty acids in the diet of athletes allows their body to change from pre-inflammatory and inflammatory to anti-inflammatory and less inflammatory states (Calder, 2013). EPA and DHA fatty acids substitute some part of arachidonic acids present in the membrane of inflammatory cells and thus reduce the biological and inflammatory activities along with inflammation (Mickleborough, 2013). Drager *et al.,* (2012) investigated the effect of eccentric and concentric resistance training in three muscular groups of upper and lower extremities and core organs on CRP inflammatory markers and CK muscle damage marker among the beginners.

The results demonstrated that serum concentration of DHA increased without any significant effect on the reduction of CRP inflammation markers; however, CK response along with muscular fatigue and damage were decreased (Drager, 2012). Santos *et al.,* (2012) studied the effect of omega-3 supplementation along with a training course of weight exercises and regular running on CRP and CK markers. They reported a significant decrease in serum concentration of CRP and CK (Santos *et al.,* 2012). Sugama *et al.,* (2012) investigated the effect of long-term endurance training on the levels of IL6, IL17, and MPO among amateur and professional athletes. Their findings indicated that IL17 increased neutrophil and myeloperoxidase (MPO) enzymatic activities via IL6 and consequently caused muscle damage and inflammation after long-term endurance training (Sugama *et al.,* 2012). Results of various studies have demonstrated that omega-3 fatty acid supplementation along with physical training can reduce the response of the immune system to muscle damage and inflammation and be used as one of the best approaches for preventing cellular damage and increase of pre-inflammatory and inflammatory markers (Drager, 2012), (Santos *et al.,* 2012), (Nieman *et al.,* 2009). This study sought to find an appropriate response to the following questions: Can a course of resistance training and omega 3 fatty acid supplementation prevent or at least reduce inflammation level? Can omega-3 fatty acid supplementation followed by a course of resistance training make significant differences in terms of IL17, CRP, and CK levels in different groups?

MATERIALS AND METHODS

Subjects: screening and selection criteria for participants:This semi-experimental four-group study was approved by the Ethical and Research Committee of the Islamic Azad University and performed in accordance with the principles outlined in the Declaration of Helsinki.Forty young athletes in the field of body-building participated as the subjects of this study. After briefing about the research subject, objectives, and stages, and the probable advantages and risks of the training protocol, the subjects voluntarily and objectively signed the consent letter and filled out the questionnaire about their health and medical, dietary, and pharmaceutical statue. The subjects were investigated in terms of lacking any diseases, especially acute inflammatory problems, muscular and joint damage, and injury in upper and lower extremities and core organs. No subjects had taken any kind of food and energy supplements, alcohol, narcotic drugs, or any other drug than can affect function of the immune system and inflammatory mechanisms during the prior three months. After ensuring the complete health of the subjects, they were randomly divided into and assigned to four groups of control (10 people), omega-3 supplementation (10 people), training (10 people), and omega-3 supplementation and training (10 people). All the subjects regularly performed resistance training three sessions per week.

Physiological measurements: Measuring physical and anthropometric characteristics of the subjects included height, weight, body mass index (BMI), body fat percentage, and 1 maximum repetition (1RM). A week before the beginning of the training protocol, all the subjects were invited to attend the gym and the tests were performed on two consecutive days. Weight was measured using an ELECTRONIC digital scale, made in Iran, with minimum clothing and without shoes and height was measured by a LABTRON dial height gauge, made in Iran. Then, BMI was calculated. LAFAYETTE (model 01127) caliper made in USA was used to estimate their body fat percentage using 3 skinfold method (suprailiac, thigh, and triceps). Measurement of subcutaneous fat thickness (in mm) in these sites was repeated for three times. By summing these three points using Jackson and Pollock's equation, body fat percentage of the subjects was calculated. To design the resistance training program with a percentage of 1RM, the estimated 1RM of the subjects in the resistance training was calculated using Brzycki formula (Brzycki, 1993). Resistance training included upper extremities exercises: (1) seated overhead barbell press, (2) standing barbell curl, (3) lying barbell extension, core organs exercises: (1) flat bench barbell press, (2) reserve grip pull down, (3) machine decline bench crunch, and lower extremities exercises: (1) back squat, (2) machine leg extension, and (3) machine lying leg curl. The protocol used in this study was based on the information available in the related literature, which was used as a combination protocol in this study (Baechle & Earle, 2000), (Hulmi *et al.*, 2009), (Roberts *et al.*, 2007).

***Resistance Training Protocol*:** The subjects of the training as well as training and supplementation groups performed 3 sessions of resistance training per week for 8 weeks. The overload principle was designed so that the subjects' new 1RM was determined every two weeks and the new percentages were thus adjusted and applied. Thus, in the first two weeks, resistance training was performed with 50% 1RM in 3 sessions and 12 repetitions. It the second, third, and fourth two weeks, it was done with 60% 1RM in 3 sessions and 10 repetitions, 70% 1RM in 3 sessions and 8 repetitions, and 80% 1RM in 3 sessions and 6 repetitions, respectively. All the subjects were asked to avoid any other physical activities not related to the study during the research period.

Omega-3 supplementation plan: After random assignment of the subjects to the four groups, the subjects in the omega-3 supplementation as well as omega-3 supplementation and training groups took 3000 mg omega-3 capsule (21st Century, made in USA) for 3 times per day and a 1000 mg omega-3 capsule (composed of 120 mg EPA and 120 mg DHA) after each meal for 8 weeks.

Nutrition assay: In order to control and evaluate their diet during the research, all the subjects of the four groups were asked to avoid any changes in their diet and follow their normal eating habit during the research. They were also asked to inform the researcher of any changes in their diet. Information relating to the subjects' diets was reported in self-reporting food dietary record and food frequency questionnaires for three times (two days before the pre-test, middle-test, and post-test). The recorded foods were decomposed into their constituent components and their value was calculated. Then, they were coded and

analyzed according to the instructions of Food Processor Nutritionist 4 (FPN4) software. Furthermore, the combination of intake energy from carbohydrate, fat, and protein was 55-60, 25-30, and 10-15%, respectively; frequency of meals and between-meals was monitored by FPN4 software to evaluate and control changes in the intake of nutritional factors and eliminate nutrition-disturbing factors for the studied variables (Driskell & Wolinsky, 2010), (Mahan & Escott-Stump, 2004).

Blood sampling and biochemical evaluation: In order to carefully examine the measured variables during the study, 5 cc blood sampling was done from the subjects' right antecubital vein in a seated position in three sessions by a laboratory technician and preserved in Venoject tubes. The first blood sampling was performed at the early hours of the day and while fasting, 24 h before starting the training protocol and omega-3 supplementation. Afterwards, IL17 serum level (in pg/ml), CRP (in mg/l), and CK (in unit/l) were measured using ELISA kit (sensitivity of less than 1 pg/ml) manufactured by BOSTER Company (UAS), ELISA kit (sensitivity of less than 0.01 mg/l) made by DBC Company (Canada), and ELISA kit (sensitivity of 2.2.5 unit/l) made by BIOPHARM Company (USA), respectively. To read and record the measurements, ELISA reader device with 450 nm wavelength based on optical density was applied. In order to measure the variations of plasma volume, first, the value of hemoglobin and hematocrit was measured by a cell counter device in chemical, optical, and laser flow cytometry method. Then, Dill and Costill's equation was used to determine the variations of plasma volume for the subjects (Dill & Costill, 1974).

Statistical analysis: First, normality of the data was determined by Kolmogorov–Smirnov test. Then, inferential statistical method of repeated-measures Analysis of Variance was applied to compare changes over 8 weeks of intervention. Bonferroni's post-hoc test was performed to determined pair wise differences. To compare anthropometric characteristics and 1MR at the beginning of the training protocol, one-way Analysis of Variance was applied; in addition, Pearson's correlation coefficient was used to investigate the relationships between IL17, CRP, and CK. All the statistical calculations were performed in SPSS 18 software and at the significance level of ($p \leq 0.05$).

RESULTS AND DISCUTION

Baseline characteristics: The subjects' physical and anthropometric characteristics for the separate groups are presented in Table 1 and showed that there was no significant difference between the groups in terms of body fat percentage, BMI, weight, height, age and one repetition maximal at the beginning of the study and the groups were homogeneous in these markers ($p \geq 0.05$).

Table 1: Subjects characteristics of four groups at the beginning of the study

Variable Groups	Control n=10	Supplementation n=10	Resistance training n=10	Resistance training and Supplementation n=10	P
Age (year)	20.20 (2.20)	19.90 (1.91)	21.50(2.06)	20.50 (1.58)	0.149
Height (cm)	175.30 (3.40)	174.40 (3.20)	173.30 (3.77)	173.70 (2.75)	0.754
Weight (kg)	72.60 (2.91)	72.80 (2.04)	72.70 (2.26)	72.90 (1.72)	0.369
BMI ($kg/m^{2)}$	23.65 (0.61)	23.97 (0.59)	24.17 (0.61)	24.20 (0.45)	0.644
Body fat (%)	12.74(1.10)	13.49 (0.87)	13.47 (0.57)	13.25 (0.67)	0.366
1RM Seated Overhead Barbell	____	____	55.67 (2.16)	56.09 (1.33)	0.67

Press					8
Standing Barbell Curl	____	____	45.11(1.46)	47.86 (1.43)	0.919
Lying Barbell Extension	____	____	45.08 (1.49)	43.06 (1.43)	0.824
Flat Bench Barbell Press	____	____	83.03 (1.91)	81.68 (1.65)	0.972
Reserve Grip Pull Down	____	____	48.12 (1.06)	43.69 (1.27)	0.948
Machine Decline Bench Crunch	____	____	33.69 (1.30)	37.63 (1.11)	0.868
Back Squat	____	____	92.28 (1.52)	88.07 (1.41)	0.820
Machine Leg Extension	____	____	47.05 (1.07)	48.06 (2.22)	0.637
Machine Lying Leg Curl	____	____	44.03 (1.35)	46.46 (1.63)	0.873

Values are expressed as mean (SD).

***Hematological analysis*:** Hematological markers such as hemoglobin and hematocrit and variations of plasma volume for the middle- and post-test measurements compared with the pre-test were assessed and determined that there was no significant difference in the variations of plasma volume between the groups and they were homogenous (Table 2).

Table 2: Subjects hematological characteristics and plasma volume changes of four groups

Variable Groups	Control n=10	Supplementation n=10	Resistance training n=10	Resistance training and Supplementation n=10	P
HB (gr/dl)	15.22(0.05)	15.07(0.01)	15.32(0.01)	15.09(0.02)	0.780
HTC (%)	48.06(0.01)	46.33(0.02)	46.07(0.02)	46.33(0.01)	0.870
ΔPV (%) Mid test	-0.06(0.29)	0.04(0.10)	0.10(0.10)	-0.03(0.13)	0.751
ΔPV (%) Post test	0.05(0.27)	0.03(0.07)	-0.03(0.09)	0.05(0.07)	0.621

Values are expressed as mean (SD).ΔPV, plasma volume changes. HB, Hemoglobin. HTC, Hematocrit.

Diet analysis: Results obtained from the subjects' food intake are presented in Table 3, indicating that there was no significant difference between the groups for three pre-, middle-, and post-tests in food factors such as daily energy intake; daily carbohydrate, fat, and protein intake; and their respective energy intake percentage, fish consumption per day, nuts consumption, and mega-3 supplementation; so, the groups were homogenous in terms of nutritional factors ($p \geq 0.05$).

Pro-inflamatory, inflamatory and enzymatic markers analysis: By comparing values of pre-test variables in the groups, no significant difference was found in IL17, CRP, and CK pre-test among the groups and all of them were at normal levels. Considering that the variations of variables were studied in three sessions of pre-, middle-, and post-tests, findings of the study indicated that there was a significant difference in terms of IL17 level between the groups ($p \leq 0.05$). The post-hoc test demonstrated that there was a significant decrease in cytokine levels after four weeks of supplementation (supplementation group); however, the resistance training following this period significantly increased its levels (training group). In contrast, simultaneous effect of supplementation and resistance training significantly decreased this cytokine (supplementation and training group) ($p=0.001$).

Table 3: Energy intake characteristics and nutrients analysis of the dietary records of subjects of four groups

Variable Groups	Control n=10	Supplementation n=10	Resistance training n=10	Resistance training and Supplementation n=10	P
Dairy Energy Intake (kcal)	3269.50(21.60)	3277.60(7.86)	3284.66(10.51)	3279.90(10.79)	0.748
Dairy CHO Intake (gr)	473.81(3.32)	476.48(2.81)	476.04(3.48)	476.07(3.43)	0.779
Dairy FAT Intake (gr)	99.31(1.16)	99.70(0.96)	100.41(0.82)	100.10(1.06)	0.922
Dairy PRO Intake (gr)	118.42(2.92)	118.34(1.99)	118.95(2.14)	118.40(2.02)	0.852
CHO Intake (%)	58.08(0.38)	58.15(0.34)	58.79(0.32)	58.08(0.34)	0.942
FAT Intake (%)	27.51(0.25)	27.39(0.24)	27.53(0.22)	27.48(0.23)	0.949
PRO Intake (%)	14.53(0.25)	14.45(0.24)	14.51(0.24)	14.45(0.24)	0.882
Fish Meat Intake (gr)	96.53(1.99)	97.16(1.46)	97.73(1.34)	96.70(1.17)	0.826
Grains Intake (gr)	31.85(0.71)	31.93(0.80)	32.01(0.62)	31.96(0.59)	0.799

Values are expressed as mean (SD).CHO, carbohydrate. PRO, protein.

Maximum amount of IL17 was related to the training group in the post-test (2.58 pg/ml), while the minimum value was related to supplementation group in the post-test (0.87 pg/ml). In addition, a significant difference was observed between the groups in terms of CRP level (p=0.001). The post-hoc test showed that, at the end of the fourth week, there was a decrease in CRP level in the supplementation group, which was not statistically significant. However, at the end of the eighth week, a significant decrease was observed in this protein. Furthermore, a significant increase was found in CRP level for the training group and supplementation along with resistance training decreased the incremental slope of CRP level (p=0.001). Maximum level of CRP was related to the training in the post-test (2.16 mg/l), while the minimum was related to the supplementation group in the post-test (0.25 mg/l). In addition, after four weeks of supplementation, CK level was decreased, which was not statistically significant. However, by continuing the supplementation by the end of the eighth week, there was a significant decrease in CK level (supplementation group). Furthermore, a significant increase was observed in CK level for the training group in the middle- and post-test measurements. Also, there was a significant decrease in CK level in the training and supplementation groups for the post-test measurement (p=0.001). Maximum level of CK was related to the training group for the post-test measurement (188.50 unit/l), while the minimum was related to the supplementation group for post-test measurement (41.60 unit/l) (Table 4).

Table 4: Comparison of three time of concentration IL17, CRP, CK of subjects of four groups

Variable	Test time	Control n=10	Supplementation n=10	Resistance training n=10	Resistance training and Supplementation n=10	P value time	P value group	P value time × group
IL17(pg/ml)	Pre test	1.52(0.26)	1.57(0.23)	1.48(0.25)	1.44(0.27)	0.001*	0.001*	0.001*
	Mid test	1.54(0.25)	1.35(0.21)*	1.80(0.23)*	1.81(0.25)*			
	Post test	1.53(0.27)	0.87(0.14)*	2.58(0.30)*	0.90(0.16)*			
CRP(mg/l)	Pre test	0.77(0.31)	0.68(0.30)	0.71(0.32)	0.68(0.26)	0.001*	0.001*	0.001*
	Mid test	0.91(0.28)	0.55(0.27)	1.43(0.16)*	1.42(0.37)*			
	Post test	0.86(0.19)	0.25(0.17)*	2.16(0.13)*	0.85(0.32)*			
CK(U/l)	Pre test	62.60(13.04)	57.80(10.10)	59.80(12.47)	67.20(11.53)	0.001*	0.001*	0.001*
	Mid test	65.20(12.71)	52.70(9.90)	123.60(12.98)*	95.80(7.02)*			
	Post test	63.30(12.74)	41.60(7.04)*	188.50(8.18)*	79.60(5.72)*			

**Significant at (P<0.05).IL17, Interleukin 17. CRP, C Reactive protein. CK, Creatine kinase*

Results of between groups of the research data showed that there was significant difference in levels of IL17, CRP and CK between resistance training group and resistance training – supplement group and supplement group in the posttest stage, Furthermore resistance training group significantly increased the levels of IL17, CRP, and CK, while resistance training –group along with omega-3 supplementation and supplement group significantly decreased the levels of IL17, CRP, and CK (Table 5).

Table 5: Bonferroni test results to determine difference between groups

Group	Difference between groups	IL17 (pg/ml)	CRP (mg/l)	CK (U/l)
Resistance training and supplementation	Resistance training	- 0.570*	- 0.450*	- 42.90*
	supplementation	0.120	- 0.490*	30.17*
	control	- 0.147	0.137	17.17
Resistance training	Resistance training and supplementation	0.570*	0.450*	42.90*
	supplementation	0.690*	0.940*	73.07*
	control	0.420*	0.587*	60.07*
supplementation	Resistance training and supplementation	- 0.120	- 0.490*	- 30.17*
	Resistance training	- 0.690*	- 0.940*	- 73.07*
	control	- 0.267	- 0.345*	13.00*

Significant at (P<0.05).IL17, Interleukin 17. CRP, C Reactive protein. CK, Creatine kinase.

Results of the present study showed that omega-3 supplementation in both supplementation group and supplementation and training group decreased IL17, CRP, and CK levels, while resistance training increased these levels. Muscle damage and inflammation stimulate the regeneration process and lead neutrophils and macrophages to skeletal muscle while doing sports (Izquierdo *et al.,* 2009). As a result of the entry of neutrophils and macrophages into the muscles during physical activity, IL17 is produced and subsequently CRP secretion is increased; increased secretion of CRP can also increase CK secretion (Golzari *et al.,* 2010). In the present study, IL17 level increased in the training group; previous studies have considered training intensity as a key factor (Duzova, 2012), (Duzova *et al.,* 2009). Intense physical activities increased IL17 level; but, reducing the intensity did not increase IL17; even in some people, it was decreased, which has been attributed to lower level of training intensity (Duzova, 2012) , (Sugama *et al.,* 2012). It seems that muscle damage and injury activate NFkB and STAT3 signaling pathways, which can stimulate and activate pre-inflammatory and inflammatory cytokines and consequently cause cellular and tissue inflammation (Cho *et al.,* 2006),(Chiricozzi *et al.,* 2010). On the other hand, IL17 was reduced in omega-3 supplementation group and omega-3 supplementation and training group at the end of the fourth and eighth weeks and the end of the eighth week, respectively. In addition, IL17 level followed a consistent reduction trend from the beginning to the end of the research period in the supplementation group; however, it had a decreasing tend in the supplementation and training group only after 4 weeks. This issue could be probably attributed to the time required for the effect of supplementation during the resistance training, since IL17 increase was not prevented until the end of the fourth week. It seems that the mechanism related to this issue is that intense physical activity releases pre-inflammatory cytokines which produce inflammatory cytokines and could finally increase CRP and CK and cause inflammatory and cellular damage (Duzova, 2012) , (Duzova *et al.,* 2009). According to the above-mentioned results, it can be concluded that intensity and duration of resistance training can be the key factors in increasing IL17 level; however, supplementation can change this pattern. As a result of tissue, muscle, and cellular damage caused by intense, repetitive, and long-term sport activity, CRP can generate acute phase response and therefore quickly increase after the sport activity (Singh *et al.,* 2008). Increase in pre-inflammatory cytokines including IL17 and inflammatory ones such as IL6 can stimulate CRP secretion;

on the other hand, CRP can also increase the production of pre-inflammatory and inflammatory cytokines (Izquierdo *et al.*, 2009), (MacIntyre *et al.*, 2001). In the present study, it was shown that performing resistance training for 8 weeks can increase CRP level; but, taking omega-3 supplement during the resistance training reduces the incremental slope of this reactive protein. The amount of this reactive protein was increased in the training group and decreased in the supplementation group and supplementation and training group. Time of supplement intake is also an important factor and several studies have reported that, if duration of omega-3 supplement intake increases from one to two weeks, the results might vary (Niebauer, 2008). Another study demonstrated a direct relationship between CRP level and intensity of physical activity (Tsao *et al.*, 2009). Therefore, the present study demonstrated that CRP level was related to the training intensity. Also, another study showed that training duration can have a significant effect on the variation of CRP level (Niebauer, 2008). Comparison of the results showed that omega-3 supplementation could decrease CRP secretion and prevent inflammation increase. In particular, CK is among the most sensitive enzymes for the diagnosis of cellular and tissue damage and its activity decreases shortly after resistance training. Membrane permeability of muscular cells increases as a result of damage to the membrane of muscular cells caused by resistance training, which causes CK to leak to intracellular fluid and enter the blood circulation system via lymphatic system and thus increase (Koch *et al.*, 2014). With increasing the intensity and duration of sport activity, level of this enzyme increases; in fact, there is a direct relationship between the intensity and duration of sport activity and CK level (Mickleborough, 2013). In the present study, minimum level of CK was observed in the supplementation group, which only took the supplement. Probably, it can be concluded that minimum muscle damage was observed in this group; in the training group, CK level had a significant increase, while in the training and supplementation group, CK level had a significant decrease after 4 weeks. Since the training protocol of both training as well as training and supplementation groups was equal, it can be suggested that supplementation in the training and supplementation group could prevent CK increase. In the present study, a correlation was observed between the following variables: IL17 and CRP (r=0.71), IL17 and CK (r=0.66), and CRP and CK (r=0.79). Therefore, it can be concluded that the entry of neutrophils and macrophages into the skeletal muscles during the sport activity due to IL17 activity causes an interaction between IL17 and IL6, which leads to more secretion of both IL17 and IL6 cytokines and consequently increasing CPR secretion; i.e. IL17 can induce the production of CRP, which is conventionally accompanied by CK increase (Kramer *et al.*, 2008), (Golzari *et al.*, 2010). Results of various studies have demonstrated that omega-3 fatty acid supplementation (DHA and EPA) simultaneous with training activities can reduce the response of the immune system to inflammation and muscle damage and be related to the health of the athletes' immune system and skeletal muscle (Drager, 2012), (Santos *et al.*, 2012), (Nieman *et al.*, 2009). Omega-3 fatty acids (EPA and DHA) can bond with peroxisome proliferator-activated receptors (PPARs) that adjust transcription factors related to inflammatory signaling pathways during pre-inflammatory, inflammatory, and metabolic processes. Via bonding, NFkB and STAT3 signaling pathways are suppressed, production of pre-inflammatory and inflammatory cytokines are reduced, and thus a general effect as an anti-inflammatory or inflammation-reducing agent can be induced (Calder, 2013). Furthermore, omega-3 fatty acids (DHA and EPA) can substitute a part of arachidonic acid present in inflamed cells. Also, they can convert the resulting prostaglandin E2 metabolites on cyclooxygenase pathway into prostaglandin E3 and leukotriene L4 on lipoxygenase pathway into leukotriene L5 with less biological activity and inflammatory effect (Calder, 2011). Therefore, it seems that taking omega-3 fatty acids (EPA and DHA) can move the balance of inflammatory eicosanoids toward anti-inflammatory or less inflammatory states and thus reduce the production of inflammatory and pre-inflammatory cytokines (Calder, 2013; Calder, 2011).

Conclusion

Generally, results of this study showed that resistance training reduced levels of IL17, CRP, and CK among young athletes. It seems that omega-3 supplementation can significantly decrease pre-inflammatory (IL17), inflammatory (CRP), and enzymatic (CK) markers. Therefore, it can be an appropriate method for preventing muscle, inflammatory, and cellular damage among young athletes.

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