The relationship between dietary inflammatory index, physical performance and anthropometric indices in marines

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Research

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Abstract

Background:

Military forces can be considered in the group of active people or athletes due to their high activity and exercises. The aim of this study was to determine the relationship between dietary inflammatory index (DII) with physical function and anthropometric indices in the marine.

Methods:

This cross-sectional study was performed on 200 male aged 18 to 45 years in the Navy. Individual data were collected using a general questionnaire, exercise tests and anthropometric assessments. Food intake over the past year was assessed using a 147-item semi-quantitative food frequency questionnaire, and then the DII score was calculated for each subject. Aerobic performance was assessed using the 12 minutes cooper test. Also, the repetitions of sit up, pull up and push up in 1 minute were recorded to assess physical strength. Linear regression was used to investigate the relationship between DII with anthropometric indices and athletic performance.

Results:

The present study showed that the increase in DII is directly related to body mass index (P = 0.04) and body fat percentage (P = 0.03), and inversely related to VO2max (P = 0.001). However, after adjusting for the effect of energy intake in regression model, only the association between DII and VO_2max was statistically significant (β= -1.69, SE=0.67, P=0.01).

Conclusion:

In general, with the increase of dietary potential in causing inflammation, it may lead to an increase in BMI and body fat percentage and a decrease in aerobic capacity in military personnel. However, the observed relationship between DII and anthropometric indices seems to be influenced by the energy intake. Further well-designed studies with a prospective method are warranted to find a definitive result.

Introduction

Military personnel must be in good physical condition to perform their duties. Therefore, according to the activities they perform, they can be considered in the group of people with high physical activity or athletes. Attention to increasing athletic performance as well as having a body with lower fat mass has led to people using different methods to achieve this goal (1). In addition to the significant role of an individual's genetic characteristics in physical function (2), environmental or metabolic factors have an important role on performance. Changes in access to energy, adaptation to exercise and metabolic efficiency, secretion of various hormones, access to optimal body composition, rapidity of recovery after exercise, and planned approach to nutrition can be factors affecting physical function (3, 4). Past studies have also shown that higher military training and physical activity increase the production of inflammatory factors (5, 6). The inflammatory response to physical activity has been linked to decreased physical function (7). As a result, controlling and counteracting this effect can be more important in these people.

Studies show that dietary intake through the effects on the immune system (8), the antioxidant system (9), glycogen stores (10) as well as changes in body composition (11), can affect the physical performance of military personnel. Dietary Inflammatory Index (DII), which in recent years has been designed based on the association with the six major inflammatory factors (interleukin-1b, interleukin 6, interleukin 10, TNF-α, and C-reactive protein (CRP). In general, this index estimates the inflammatory ability of the diet based on the intake of 45 nutrients that have the most inflammatory or anti-inflammatory effect (12). The advantage of this method is that it is not limited to a specific food but all components of the diet. To the best of our knowledge, no study has been conducted to date on the relationship between physical performance and DII. However, as noted, previous studies have shown an inverse relationship between physical function and serum inflammatory factors (7). Also, intake of anti-inflammatory nutrients such as omega-3 (13), quercetin (14), selenium and vitamin C (15), has been associated with improved physical function in different groups. Moreover, a direct correlation has been observed between increased dietary inflammation and obesity in different population groups (16–18). Another study showed that dietary inflammatory index was associated with inflammatory status and metabolic syndrome in police officers (19). Due to the limited data in this regard, the present study was conducted to determine the relationship between dietary inflammatory index and physical function and anthropometric indices in the military forces.

Materials And Methods

Study population

The present cross-sectional study was conducted in 2020 on 200 members of the Navy military forces in Mazandaran Province. Included subjects were aged from 18 to 45 years old who was willing to collaborate on the study. People with diagnosed chronic diseases such as diabetes, hypertension, cardiovascular disease, kidney disease, injury and inability to perform physical assessments were not included in the study.

Demographic characteristics and physical activity

General characteristics including date of birth, educational status, use of medications and supplements, history of previous illnesses, history of chronic illness in first-degree relatives, history of surgery, and adherence to a specific diet were collected using a demographic questionnaire designed by authors.

Dietary intake assessment

In this study, a semi-quantitative food frequency questionnaire was used to estimate food intake. The validity and reliability of this questionnaire has already been confirmed in Iran. The questionnaire includes 147 food items that assess food consumption over the past year.

The dietary inflammatory index (DII)

The DII calculation was performed according to previous studies (20). First, the intake of each of the food parameters that could be estimated based on the food frequency questionnaire was subtracted from the global intake of that food parameter and divided by its global standard deviation, which obtained a Z score. The resulting number is converted to a percentile (a number between 0 and 1) and multiplied by 2 and subtracted from 1 to remove the skewness to the right. This number multiplied by each food parameter's inflammatory score and all numbers were summed to obtained overall dietary inflammatory score for each person. In general, 30 dietary parameters (including vitamin B12, vitamin B6, beta-carotene, caffeine, carbohydrate, cholesterol, energy, total fat, folic acid, garlic, iron, magnesium, mono-unsaturated fatty acids, niacin, omega-3 fatty acids, omega-6 fatty acids, onion, protein, poly-unsaturated fatty acids, riboflavin, saturated fatty acids, selenium, thiamin, trans fatty acids, vitamin A, vitamin D, vitamin E, zinc, and tea) were used in the present study to estimate the dietary inflammatory index. Finally, the subjects were divided into two groups based on median into low or high inflammation in diet.

Anthropometric measurements

Weight was assessed using a Secca scale with minimum possible cloth and an accuracy of 100 g. Height was evaluated without shoes with a Secca stadiometer. Also, waist and hip circumference were measured using a tape measure with an accuracy of 0.1 cm. Body fat percentage was estimated using the skin fold and caliper method. Body mass index (BMI) and waist to hip ratio (WHR) were calculated by dividing weight to squares of height and waist circumference to hip circumference, respectively.

Physical performance evaluation

Physical function was evaluated in two components of aerobic performance and physical strength. The 12-minute cooper test was used to measure aerobic capacity and estimate maximum oxygen uptake (VO_2max). In this regard, subjects were asked to run/walk as maximum distance as possible for 12 minutes. Two weeks before main test, a trial test was conducted for all subjects to familiarize them with the process of assessment. The covered distance for each participant was recorded and following equation was used to estimate VO_2max:

VO2 max (ml/kg/min) = (22.351 × distance covered in kilometers) -11.288

To assess physical strength, the number of repetitions for sit up, pull up, and push up in 1 minutes was recorded. They were asked to have a short warm-up and then complete their tests with a 30 minutes interval between tests.

Statistical analyses

Quantitative and qualitative variables are reported as mean ± SD or frequency (%), respectively. To assess the relationship between DII and anthropometric measures and physical performance, participants were classified into 2 groups according to DII median (high DII and low DII). The normality of quantitative variables was inspected using the Kolmogrov-Smirinov test. The independent samples t-test was used to investigate the association between DII and quantitative variables. The relationship between qualitative variables and DII was assessed by the chi-square test. The association between DII and dependent variables was evaluated by multivariate linear regression. In the crude model weight, BMI, waist circumference, hip circumference, WHR, body fat percent, VO_2max and physical strength were entered to model as response variables, and DII groups were entered as independent variables. In the adjusted model, the effect of energy intake was controlled. Data were analyzed using SPSS software version 25 (IBM Corp. IBM SPSS Statistics for Windows, Armonk, NY). P-values <0.05 considered statistically significant.

Results

Study population characteristics

Totally, 200 military personnel with 33.31 ± 4.71 of age and 24.57 ± 2.71 of BMI were participated in the present study. Forty-eight percent of subjects were university educated and 91% of them were married. The mean ± SD of energy intake in the study population were 2776.64 ± 809.93. Total dietary inflammatory index score was 0.08 ± 2.24.

Association between demographic characteristics and DII

Table 1 presents the relationship between demographic variables and energy intake with the DII. There was no significant difference between the two groups (high or low DII) in terms of age (P=0.40), level of education (P=1.00) and marital status (P=0.15). However, there was a higher energy intake in the high DII compared to the low DII intake group (P<0.001).

Association between anthropometric measures and DII

The relationship between anthropometric measures and DII is shown in Table 2. According to the independent sample t-test, a higher DII is associated with higher BMI and body fat percentage. No association was observed between weight (P=0.38), height (P=0.21), waist circumference (P=0.23), hip circumference (P=0.61), and WHR (0.19).

In multivariate linear regression (table 3), there was a direct association between BMI (β= 0.78, SE= 0.38, P=0.04), hip circumference (β= 3.33, SE=1.56, P=0.02), and body fat percent (β=1.06, SE=0.50, P=0.0.03). However, none of these relationships remained significant following adjustment of the effect of energy intake.

Association between physical performance and DII

The independent sample t-test (table 2) showed that subjects with lower DII have a higher VO2max (43.17 ± 3.93 vs. 41.53 ± 3.99; $P=0.004$). This association remained significant after adjustment for the effect of energy intake in multivariate linear regression ($\beta= -1.69$, $SE=0.67$, $P=0.01$). However, no difference was observed across DII groups regarding number of repetitions for sit up, pull up, and push up ($P>0.05$).

Discussion

The present study aimed evaluate the relationship between DII, anthropometric measures and physical function in members of the Navy military forces.

In the present study, diet with a higher potential for inflammation was associated with increased body mass index, hip circumference, and fat percentage. However, the relationship between DII and these variables lost its significance after adjusting for the effect of energy intake. In interpreting this information, it should be noted that higher energy intake is inherently a factor in increasing the body's inflammation. However, it should consider that increasing energy intake creates a positive energy balance that can increase weight and body fat percentage. There are few studies evaluating the relationship between anthropometric indices and DII. In the military, the number of these studies is much lower. As mentioned earlier, the DII is associated with 6 inflammatory biomarkers (IL-1β, IL-4, IL-6, IL-10, TNF-α and CRP) (12). A recently published study showed that BMI is directly related to hs-CRP levels in the military (21). It was observed that the level of hs-CRP in the forces sent to war zones is much higher than other forces and ordinary people in the community. Another finding of the study was the association between hs-CRP levels and a variety of nutrients, including saturated fats, carbohydrates, and protein. However, the relationship between militarism and increased hs-CRP levels did not lose its significance by modifying the effect of food intake, indicating that other factors such as job stress can also increase inflammatory markers in military personnel. This study suggests an increase in inflammatory markers due to the increase in BMI (21). In a study conducted on a civilian population (students), the dietary inflammatory index score was not associated with BMI, fat percentage, or waist circumference (22). Similarly, several other studies in different parts of the world could not find a link between dietary inflammatory index and anthropometric indices (23–25). In contrast, some other studies show an increase in BMI and abdominal obesity in subjects with high DII score (26–28). The discrepancies observed in the studies may be due to differences in the sample size, race/ethnicity, number of dietary parameters used to calculate DII, method of assessing food intake, and the range of participant’s age. Also, some conditions, such as having a specific illness, different work conditions, level of physical activity, and intensity of physical activity can change the level of inflammation.

The link between obesity and inflammation is generally unclear. Studies have shown that obesity is associated with chronic inflammation (29), but no definitive mechanism has been proposed. It appears to be a two-way relationship between obesity and inflammation. For example, in recent years, there has been a discussion about the brain-gut axis, which shows that gastrointestinal microflora can play a role in the health of the body, including obesity (30). Studies have shown that the composition of intestinal bacteria can play a role in systemic and local inflammation and obesity (31). In addition, higher adherence to a diet with a high inflammatory index is generally associated with increased intake of unhealthy foods and energy, which can lead to weight gain (27). It has also been suggested that reducing dietary inflammation can reduce the chances of obesity by affecting adipokines involved in the obesity pathway, such as chemerin (32).

According to the results, a lower DII is associated with a higher aerobic capacity. No association was found between DII and physical strength tests. To the best of our knowledge, no study has been published so far on the relationship between DII and physical performance. Moreover, studies on the components of the DII do not provide definitive results. For example, in a review, the plant-based diets (which usually reduce the inflammation) had no effect on physical performance compared to meats (which increase the DII score) (33). However, an animal study showed that inflammation in the body reduces physical function by increasing the number of neutrophils in the pulmonary ducts and impairing alveolar gas exchange (34). Inflammation has also been shown to cause cytokine cascades that are related to fatigue, which can affect athletic performance (35). In addition, inflammation increases the oxidative stress that disturbs the oxidative balance. Studies show that when a person is deficient in antioxidants, supplementation with certain antioxidants such as vitamin C, vitamin E, N-acetylcysteine can lead to increased athletic performance (36, 37). When the concentration of one of the antioxidants decreases as a result of improper diet, it may disrupt the metabolism of all antioxidants in the body. This condition disrupts redox balance and increases systemic oxidative stress (36). This condition appears to affect physical function by altering cell signaling and altering energy metabolism.

Strengths And Limitations

One of the most important strengths of the present study is that this study is one of the first studies to investigate the relationship between anthropometric indices and physical function with the inflammatory index of diet. The cross-sectional design of the study is one of the limitations, as a result of which it is not possible to determine the causality. Also, it was not possible to evaluate serum inflammatory markers to validate the collected data. An unavoidable limitation of the study was that FFQ relied on individuals' memory, which may cause recall-bias. However, authors tried to solve these problems using nutrition experts to collect data face-to-face. In addition, according to the data provided by FFQ, the DII calculation was performed with a smaller number of nutrients than the main method, which can make a difference between the studies.

Conclusion

In general, the present study showed that the physical performance and anthropometric measures of military personnel can be affected by diet. As the diet's potential for inflammation increased, we observed a decrease in aerobic capacity. These findings suggest that modifying the military diet and eliminating foods that have the potential to cause inflammation can help these individuals to achieve an optimal physical function. However, investigating the effect of DII on anthropometric measures needs more studies. Further well-designed studies are warranted to obtain more definitive results in the association between DII, physical performance and anthropometric measures.

Declarations

Ethics approval and consent to participate

The protocol of the study was approved by the ethical committee of Baqiyatallah University of Medical Sciences Research Center, Tehran, Iran (ethic code: 97000613). All subjects signed a consent to participate in the study.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AR collected data, prepared data for analyzing and contributed in writing manuscript. KP collaborated in the design of the study and analysis of data. MD contributed in preparing the manuscript and interpreting the results of the study. HR was a major contributor in designing the study and writing the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Demographic characteristics of the participants according to the DII status

Variable [1]		DII				P-value[2]
		Low		High		
		Mean or frequency	SD or %	Mean or frequency	SD or %	
Age (years)		33.03	4.39	33.59	5.015	0.402
Education status	Diploma	52	52	48	48	1.000
	University educated	52	52	48	48	
Marriage status	Married	91	91	96	96	0.152
	Single or divorced	9	9	4	4	
Calorie intake (kcal/day)		2173.87	426.75	3379.40	634.42	<0.001

[1] Quantitative variables are presented as mean ± SD and qualitative variables are presented as frequency (%)

[2] P-value is calculated using independent sample t-test or chi-square for quantitative or qualitative variables, respectively

Table 2. Anthropometric measures and physical performance across the DII status

Variable[1]	DII				P-value[2]
	Low		High		
	Mean	SD	Mean	SD	
Weight (Kg)	75.81	9.353	77.10	11.605	0.388
Height (cm)	176.91	7.392	175.55	8.125	0.217
BMI (Kg/m^2)	24.18	2.26	24.9681	3.06	0.042
Waist circumference (cm)	89.06	9.05	90.685	10.37	0.239
Hip circumference (cm)	97.45	9.25	100.08	10.42	0.061
WHR	0.91	0.04	0.90	0.05	0196
Body fat percent	20.42	3.11	21.4874	4.00	0.037
VO2max (mL/kg/min)	43.17	3.93	41.5320	3.99	0.004
Sit up repetition	46.60	5.25	46.66	5.43	0.937
Pull up repetition	8.12	3.12	7.89	3.10	0.602
Push up repetition	38.49	4.77	37.46	4.57	0.121

[1] Quantitative variables are presented as mean ± SD

[2] P-value is calculated using independent sample t-test

Table 3. The relationship between anthropometric measures and physical performance with DII status using multivariate linear regression

Variable	Model[1]	DII	
		β (SE)	p-value
Weight	**Crude**	1.29 (1.49)	0.388
	Energy adjusted	-0.28 (2.23)	0.900
BMI	**Crude**	0.78 (0.38)	**0.042**
	Energy adjusted	0.54 (0.57)	0.346
Waist circumference	**Crude**	1.62 (1.37)	0.239
	Energy adjusted	-0.73 (2.06)	0.722
Hip circumference	**Crude**	3.33 (1.56)	**0.023**
	Energy adjusted	0.29 (2.33)	0.391
WHR	**Crude**	-0.01 (0.01)	0.156
	Energy adjusted	-0.01 (0.01)	0.475
Body fat percent	**Crude**	1.06 (0.50)	**0.037**
	Energy adjusted	0.84 (0.76)	0.268
VO2 max	**Crude**	-1.44 (0.44)	**0.001**
	Energy adjusted	-1.69 (0.67)	**0.013**
Sit up repetition	**Crude**	0.06 (0.75)	0.937
	Energy adjusted	0.37 (1.13)	0.743
Pull up repetition	**Crude**	-0.23 (0.44)	0.602
	Energy adjusted	-0.04 (0.66)	0.945
Push up repetition	**Crude**	-1.03 (0.66)	0.121
	Energy adjusted	-0.20 (0.99)	0.834

[1] crude model: anthropometric measures or physical function as dependent variable and DII group as independent variable

Energy adjusted: previous model adjusted for the effect of energy intake