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The Effect of Continuous Aerobic Training with Low Carbohydrate Diet on the Serum Immunoglobulins A, G and M in Overweight Adult Men

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Abstract

Introduction: The immune system is composed of several functional components that respond to a variety of stimuli such as training. The aim of training is to preserve body homeostasis at a reasonable level. The effects of carbohydrate ingestion on training-induced alterations in the immune functions have been comprehensively investigated in past. The aim of this research was to review the effect of continuous aerobic training with low carbohydrate diet on immunoglobulins A, G and M in overweight adult men.

Methods: 30 men with age range of 36-50 years and BMI between 25- 30 Kg/m^2 were selected and divided into three groups of 10 subjects randomly (control, training, training with low carbohydrate diet). Groups training and training with low carbohydrate diet performed continuous aerobic trainings 3 sessions per week for 8 weeks and low carbohydrate diet was implemented for 8 weeks with 43- 47 % of total received energy of carbohydrates and 36-40 % of lipids in the diet. The blood samples were taken before beginning the main study program and after 8 weeks of aerobic trainings. The paired sample t- test, one way ANOVA and Tukey’s post hoc tests were used to compare the pre-test and post-test data between the groups ($p \leq 0.05$).

Results: the results showed that eight weeks of training and eight weeks of training with low carbohydrate diet significantly reduced IgA, IgG and IgM ($P<0.05$).

Conclusion: It appears that performing continuous aerobic training with low carbohydrate diet causes a significant drop in plasma levels of immunoglobulins A, G and M and suppress the immune system.

Keywords: Training, Carbohydrate, Immunoglobulin

Introduction

The immune system is composed of several functional cells, proteins and compounds, which are distributed throughout the body and respond to variety of stimuli such as training (1, 2). Immunoglobulins are a group of glycoproteins that are produced by plasma cells and can be found in serum and secretions (e.g., saliva, tears). Immunoglobulins in five classes (A, M, G, E and D) have different functions (3). The aim of training is to preserve body homeostasis at a reasonable level that reduces catching diseases. One of the ways to achieve this result is improvement of immune system. Training can have both positive and negative effects on immune function and susceptibility to minor illnesses. (4) Many studies have documented a stereotypical immune response to vigorous training, consisting of an alteration in circulating immune cell numbers, reduced natural killer (NK) cell activity, reduced mitogen-induced lymphocyte proliferation, a reduced salivary immunoglobulin secretion, and elevated circulating cytokines (5). It has been reported that regular trainings have several advantageous effects on physiological, psychological and immunological functions and increase resistance against infectious agents (6- 8). Several factors such as type, duration, intensity, and program of training have also important effects on immune response to training (9). It is apparent that an adequate quantity of carbohydrate availability is a key factor for conservation of training programs and successful athletic performance (10, 11). On the other hand, altered immune cell function has been demonstrated in obesity compared with healthy weight persons (12). The preservation of the normal function of immunity system requires receiving an adequate amount of glucose besides water, proteins and electrolytes (13). The effects of carbohydrate ingestion on training-induced alterations in the immune functions were comprehensively researched during the last 15 years (14). The aim of this study was to review the effect of continuous aerobic training with low carbohydrate diet on immunoglobulins A, G and M in overweight adult men.

Methods

In present quasi- experimental study 30 men with age range of 36- 50 years and BMI (Body Mass Index) between 25- 30 Kg/m^2 were selected and randomly divided into three groups of 10 subjects randomly (control, training, training with low carbohydrate diet). The inclusion criteria of the present study included not having regular sports activities, specific diseases and specific diet. The low carbohydrate diet was implemented for 8 weeks with 43-47 % of total received energy of carbohydrates and 36-40% of lipids in the diet. Total energy expenditure was calculated according to Harris Benedict Equation (15). Protein content of diet for all groups was 15-17 % of total energy. Continuous aerobic trainings were performed 8 weeks, 3 sessions per week and 20-35 minutes with intensity of 60-75 of maximum heart rate. For evaluation of serum immunoglobulins, blood samples were collected before initiation of training and diet protocol. Blood samples (10 ml) were collected from brachial vein, 48 hours before initiation of training and 48 hours after the last training session in fasting state. The collected bloods were centrifuged at 3000 rpm for 15 minutes and then the serum was separated. The serum was stored at –80°C for later analyses. At the end using ELISA method (IgA, IgG and IgM ELISA Kit, Pars Azmon Compony, Iran), the levels of immunoglobulins A, G and M were measured. The paired sample t- test, one'way ANOVA and Tukey's post hoc tests were used to compare the pre-test and post-test data between the groups ($p \leq 0.05$).

Results

The demographic characteristics of subjects are reported in Table 1. The results of one-way ANOVA in Table 2 showed that there were significant difference in changes of IgA ($p=0.03$), IgG ($p=0.03$) and IgM ($p=0.04$) between training with low carbohydrate diet, training and control groups. The results of Tukey's post hoc test in Table 3 showed that IgA ($p=0.02$), IgG ($p=0.01$) and IgM ($p=0.03$) in training with low carbohydrate diet significantly reduced rather than control group. The results of paired sample t- test showed that the levels of IgA, IgG and IgM in training with low carbohydrate diet group in post- test significantly reduced than pre- test ($p \leq 0.05$), the levels of IgA, IgG and IgM in training group in post- test significantly reduced than pre- test ($p \leq 0.05$) nevertheless there were no significant difference in levels of IgA, IgG and IgM in post- test and post-test.

Discussion

The results of the present study showed that continuous aerobic training with limited carbohydrate diet for 8 weeks had significant effect on serum levels of immunoglobulins. Training is the strongest stress that the body experiences. The body responds to this situation as a series of physiological alterations in its metabolic, hormonal and immunological functions (16).

Table 1. The demographic characteristics of subjects in three groups

Group Variable	Control	Training	Training with low carbohydrate diet
Age (year)	46.17±1.62	44.91±1.05	45.91±1.36
Height (cm)	170.88±11.21	173.24±5.52	171.72±6.38
Weight (g)	83.89±12.18	84.64±8.45	82.75±8.57

Table 2. The results of one way ANOVA for compare the changes of IgA, IgG, and IgM between research groups

Variable	Group	Time	Mean ± SD	One way ANOVA
IgA (mg/dl)	Control	Pre- test	265.59± 25.14	F=2.250, p=0.03*
		Post- test	262.26±23.43	
	Training	Pre- test	263.11±24.36	
		Post- test	246.51±22.89	
	Training with low carbohydrate diet	Pre- test	264.23±23.78	
		Post- test	218.47±24.49	
IgG (mg/dl)	Control	Pre- test	1187.14±368.73	F=3.01, p=0.03*
		Post- test	1183.54±559.41	
	Training	Pre- test	1192.11±489.09	
		Post- test	1159.16±476.27	
	Training with low carbohydrate diet	Pre- test	1201.23±682.37	
		Post- test	1089.67±681.07	
IgM (mg/dl)	Control	Pre- test	143.25±34.28	F=1.93, p=0.04*
		Post- test	141.62±42.09	
	Training	Pre- test	141.14±37.23	
		Post- test	136.78±3374	
	Training with low carbohydrate diet	Pre- test	140.23±44.11	
		Post- test	129.81±43.52	

* Significant difference at p≤0.05

Table 3. The results of Tukey's post hoc test for compare the IgA, IgG, and IgM between research groups

Variable	group		Tukey' s post hoc test
IgA	Control	Training	M=4.29, p=0.08
		Training with low carbohydrate diet	M=8.11, p=0.02*
	Training	Training with low carbohydrate diet	M=3.17, p=0.23
IgG	Control	Training	M=5.32, p=0.07
		Training with low carbohydrate diet	M=9.02, p=0.01*
	Training	Training with low carbohydrate diet	M=3.27, p=0.35
IgM	Control	Training	M=2.17, p=0.26
		Training with low carbohydrate diet	M=7.08, p=0.03*
	Training	Training with low carbohydrate diet	M=1.02, p=0.68

* Significant difference at p≤0.05

In most conditions, performing moderate, regular physical trainings improve functions of physiological systems of the body (17). However, sport activities have double-sided effects on the immune system (18). Moderate sport activities cause strength of immunity system (9). Prolonged and intense training resulted in damage to the immune functions (14, 19, 20). Training produces temporary distresses in immunity, including alterations in circulating leukocyte numbers, cytokine concentration, and some measures of cell function (7). Most research has emphasized that moderate regular trainings improve immune cell functions and increase production of immunoglobulins in the body (2, 8). On the other hand, there are studies that indicate moderate physical activities not only have any effect on immune functions but also decrease production of some immunoglobulins (21- 23). Imanipour *et al.* (2009) studied the effect of physical activities on humoral immune system (IgA, IgG and IgM) and reported that training decline serum immunoglobulins. Therefore, training may have negative effects on immune system (23). Hu *et al.* (2015) reported that a low-carbohydrate diet resulted in similar or greater improvement in inflammatory response, adipocyte malfunction, and endothelial cell dysfunction than a standard low-fat diet among fat persons (24). There are considerable experimental evidences that support beneficial effects of carbohydrate feeding during training (25, 26). Consumption of carbohydrate during training induces increase in plasma catecholamines, growth hormone, adrenocorticotrophic hormone, cortisol and cytokines (25). Carbohydrate intake during training also reduces the trafficking of most leukocyte and lymphocyte subsets, including the rise in the neutrophil to lymphocyte ratio, prevents the training-induced decrease in neutrophil function, and lessens the extent of the reduction of mitogen stimulated T-lymphocyte proliferation following prolonged training (25, 27, 28). Mitchell *et al.* (1998) observed that exercising (1 h at 75% VO_{2max}) in a glycogen-depleted state (induced by prior training and 2 days on a low-carbohydrate diet) resulted in a greater decrease in circulating lymphocyte numbers at 2 hours after training in comparison with the same training performed after 2 days on a high-carbohydrate diet. In addition, the handling of carbohydrate station did not affect the decrease in mitogen stimulated lymphocyte proliferation that occurred after training (29). It has been suggested that athletes with carbohydrate deficiency are at risk for the prominent immunosuppressive effects of cortisol, including the suppression of immunoglobulin production, lymphocyte proliferation, and NK cell cytotoxic activity (30). The immunosuppressive effects of stress and high serum levels of stress hormones such as cortisol have been well-established (31). Carbohydrates as a source of energy are important substances for lymphocytes, neutrophils and macrophages, because metabolic levels of immune cells are extremely high (32). It has been shown that the levels of stress hormones such as cortisol and catecholamines (epinephrine, norepinephrine) not only increase during high intensity training but also depend on carbohydrate accessibility (14). A low level of blood glucose concentration during prolonged physical trainings results in greater levels of cortisol and epinephrine (33, 34). Therefore, the supply of adequate carbohydrate availability and steady blood sugar concentration may decrease stress hormone levels, provide energy substrate for immune cells and help to maintain immunity functions (14).

Conclusion

It appears that carbohydrates in the diet for 8 weeks may induce suppression of immunoglobulins production and influences the immune system functions and continuous aerobic training with low carbohydrate diet, by reduction of serum immunoglobulins may cause humoral immunity suppression in adult men with overweight.

Ethical issues

Not applicable.

Authors' contributions

All authors equally contributed to the writing and revision of this paper.

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