Iran Red Crescent Med J. 2020 March; 22(3):e100227. doi: 10.5812/ircmj.100227.
Published online 2020 March 15.

Research Article

Effect of a Designed Compact Food Bar on Maximal Oxygen Uptake ($VO2_{Max}$) and Exercise Performance in Military Athletes: A Randomized, Single-Blind, Placebo-Controlled Clinical Trial

Vahid Hadi[1,2], Majid Ghayour Mobarhan[3,4], Golnaz Ranjbar[1], Mohamad Ali Sardar[5], Arasb Dabbagh Moghaddam[2], Mohsen Nematy[1], Reza Rezvani[1], Naseh Pahlavani[1], Saeid Hadi[2,6], Abdolreza Norouzy[1,*] and Mostafa Mazaheri Tehrani[7,**]

[1]Department of Nutrition, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Department of Health, AJA University of Medical Sciences, Tehran, Iran
[3]International UNESCO Center for Health-Related Basic Sciences and Human Nutrition, Department of Nutrition, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[4]Metabolic Syndrome Research Center, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[5]Department of General Courses, Mashhad University of Medical Sciences, Mashhad, Iran
[6]Department of Community Nutrition, School of Nutrition and Food Sciences, Isfahan University of Medical Sciences, Isfahan, Iran
[7]Department of Food Science and Technology, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran

[*]*Corresponding author*: Department of Nutrition, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran. Email: norouzya@mums.ac.ir
[**]*Corresponding author*: Department of Food Science and Technology, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran. Email: mmtehrani@um.ac.ir

Received 2019 December 16; **Revised** 2020 February 05; **Accepted** 2020 February 12.

Abstract

Background: Under difficult conditions, the military need high-energy macronutrients and micronutrients during intense physical activities in order to achieve optimal fitness levels.
Objectives: This randomized controlled trial aimed to assess the effects of a designed compact food bar (CFB) on the maximal oxygen uptake ($VO2_{Max}$) and physical fitness in military athletes.
Methods: This randomized controlled trial was conducted on 50 athletes aged 20 - 50 years, who were assigned into two experimental and control groups. The subjects in the compact food bar (CFB) received three packs of CFB (700 kcal each), containing functional compounds (e.g., caffeine and L-arginine), every day for 10 days. The control group consumed the regular food used in military training courses with the same daily calorie count for the same period. The exercise performance was assessed using sports tests, maximal oxygen uptake ($VO2_{Max}$) as a measure of cardio-respiratory endurance *in vitro*, cardiopulmonary exercise tests, blood pressure, and anthropometric examinations based on the participants' body composition and physical activity. The measurements were performed using a pedometer, and the data were recorded at baseline and after the intervention. The data was then analyzed in SPSS software version 16.
Results: $VO2_{Max}$ and some of the exercise tests, including push-up, sit-and-reach test, and jump pair length, revealed significant increases in CFB group, compared to the control group ($P < 0.05$). However, the concerned variable seemed to have no significant effects on the anthropometric indices (weight and body mass index) and body composition (lean body mass and body fat mass) in CFB group ($P > 0.05$).
Conclusions: According to the findings, the consumption of the proposed CFB, in comparison to regular food, could effectively improve the exercise performance in military athletes.

Keywords: Compact Food Bar, High-Energy Nutrition, Maximal Oxygen Uptake, Physical Fitness

1. Background

Appropriate nutrition is essential for health maintenance and plays a pivotal role in the physical and mental performance of athletes, especially the ones in the military (1). Fitness is of paramount importance for the athletes, and physical fitness for military men refers to physical health, the ability to perform smooth movements and return to baseline after high pressure, willingness to complete the assigned tasks, and confidence to face challenges (2). Conventionally, optimal physical fitness was an inherent element of winning or losing a war, and nutrition played a key role in this regard. Accordingly, food is of utmost importance in maintaining the capability of military troops in military missions (2).

The physical needs of individuals under critical conditions and the military operations that are associated with short-term or long-term stress and pressure differ from the daily needs (3). The combination of these mental and physical stressors with harsh environmental conditions leads to the arousal of complexities and differences in individuals' nutritional needs; therefore, appropriate nutrition during military operations may diminish the adverse effects of psychological and physical stress (4).

Reduced energy intake and the subsequent negative energy balance in the military leads to weight loss, increased risk of various diseases, mental dysfunction, fatigue, confusion, depression, and decreased consciousness (5). Furthermore, the presence of micronutrients in the ration is essential to produce energy from macronutrients and improve the immune function and neurological/brain function. For example, the depletion of iron reserves during military activities results in reduced oxygen transfer capacity, individuals' deteriorated performance , and decreased calcium and vitamin D intake, which may increase the bone mass analysis and risk of injuries and fractures in the military members (6). Accordingly, the presence of all the micronutrients and micronutrients in the ration plays a key role in the quality of military performance (6).

Special dietary compounds could effectively improve exercise-induced changes (7). Various clinical trials have indicated that the use of beta-alanine supplements by athletes for a minimum of six weeks could increase their exercise performance ($VO2_{Max}$) and reduces their fatigue (8). In addition, amino acid supplements have been theoretically used to optimize exercise performance for several purposes such as increasing the secretion of anabolic hormones, improving fuel consumption during exercise, and preventing the adverse effects of overwork and mental fatigue (9). Dietary supplements have been mostly used to increase muscle strength during high-/low-intensity resistance training. Two examples of such supplements are hydroxymethylbutyrate and creatine monohydrate, which may have ergogenic effects on high-intensity training (10). It should also be noted that the dietary supplements increasing the athletic capacity could also maintain and improve physical fitness (10).

Under critical conditions, food selection is restricted, and compact food bars (CFBs) are made available during military missions to replace the regular food (1). CFBs are an element of the diets used in crises, maneuvers, and military operations (11, 12). The term "compact foods" encompasses a large category of dietary products such as enriched biscuits, chocolate bars, and nutrient-dense pastes (11, 12). CFBs are durable and ready-to-use, while they are logistically low in volume and weight. This is important since soldiers must be able to adhere to their diet independently (13). In addition to athletes and military personnel, compact diets could be used for humanitarian actions in the cases of crisis (e.g., emergency food products [EFP]) and disease treatments (e.g., ready-to-use therapeutic food) (12).

To date, several studies have examined the effects of functional food compounds on the improvement of exercise performance. An example of such compounds is arginine, which is one of the 20 protein-forming amino acids (13). However, few studies have investigated the effects of CFBs containing the required nutrients and functional compounds (e.g., caffeine and L-arginine) on exercise performance.

2. Objectives

The present study aimed to assess the effects of consuming a designed CFB with functional compounds (caffeine and L-arginine) on maximal oxygen uptake ($VO2_{Max}$) and exercise performance in military athletes.

3. Methods

3.1. Participants and Protocol

This randomized, single-blinded, placebo-controlled clinical trial was approved by the Ethics Committee of Mashhad University of Medical Sciences (No. 970042), and the study was registered in the Iranian Registry of Clinical Trials (IRCT20181014041336N1).

The sample population consisted of 50 athletes aged 20 - 50 years, who were assigned into two groups. The participants were military athletes in Mashhad, Iran, who were selected using simple random sampling method. This clinical trial was conducted in March 2019 on military athletes.

The inclusion criteria were as follows: (1) male military athletes, (2) no use of antioxidants and herbal supplements for a minimum of a month prior to the intervention, (3) willingness to participate and providing written informed consent after explaining the study objectives and procedures, and (4) no history of allergies to specific compounds. The exclusion criteria were as follows: (1) use of anti-inflammatory supplements/antioxidants during the intervention (four weeks), (2) adherence to a special diet, smoking habits or weight reduction diets for a minimum of six months prior to the intervention, (3) suffering from metabolic disorders (e.g., diabetes mellitus, lactose intolerance, and thyroid dysfunctions), and (4) suffering from chronic inflammatory diseases (e.g., inflammatory bowel disease).

The participants were randomly allocated to two experimental (n = 25) and control (n = 25) groups. Energy was estimated at 2,800 - 3,200 kilocalories per person (energy required for exercise performance). The subjects in the experimental group received three packs of the designed CFB (125 g, 700 kcal each) containing functional compounds (caffeine and L-arginine) for 10 days. In total, 2,100 kilocalories was provided daily by CFB consumption, and the remaining required energy was provided by foods such as bread, cheese, nuts, and dried fruits in order to produce the required energy.

The subjects in the control group consumed regular food used in military training courses (canned and kitchen-cooked meals) with the same daily calorie count as the intervention group during the same period. The conditions of the study were similar for all the subjects in terms of temperature, humidity, sports coverage, sleep, type of exercise, and calories. All the participants were assessed at 7:15 - 9 AM.

3.2. Properties of CFB Formulation

In the present study, the ingredients used for the production of CFBs included corn flour (Iliafactories, Kermanshah, Iran) as a carbohydrate source, whole soybean flour (Toos Soyan, Mashhad, Iran), milk protein concentrate (MPC) (Golshad, Mashhad, Iran) as the protein source, cocoa butter substitute (CBS) (Cargill, Kuala Lumpur, Malaysia) as the lipid source, granulated sugar (Iran Sugar Co., Tehran, Iran) as the source of simple sugars, lecithin and polyglycerol polyricinoleate (PGPR; Nestlé Iran, Co., Tehran, Iran), cocoa powder (Delfi Cocoa, Johor Darul Takzim, Malaysia), and vitamin and mineral premix (Osve Iran Pharm Inc., Tehran, Iran). The vitamin/mineral premix was formulated by Osve Iran Pharm to meet IOM requirements of EFPs (Table 1). Table 2 shows the macronutrients (carbohydrate, fats, and protein) of the produced CFBs.

In this clinical trial, we aimed to evaluate the effects of consuming CFB with functional compounds (caffeine and L-arginine) on $VO2_{Max}$ and exercise performance in military athletes, in comparison to the control group. To this end, CFB was designed, and the appropriate composition and amounts of macronutrients (carbohydrates, fats, and proteins) were included into the designed CFB in order to provide the required energy for exercise performance.

The carbohydrates, fats, and proteins were selected meticulously to enhance athletic performance. For example, we used MPC and soybean as the protein sources, which are abundant sources of casein protein and arginine amino acid, respectively. Furthermore, they were enriched with multivitamins, minerals, caffeine, and L-arginine, thus providing the designed CFB with properties such as adequate energy supply, increased functional capacity, reduced oxidative stress, and enhanced immune function.

Table 1. Energy, Macronutrients, Micronutrients, and Pragmatic Compounds Used in Designed CFB Based on RDA

Nutrient	RDA
Energy (kcal/day)	2,100
CHO (g/day)	230
Protein (g/day)	70
Fat (g/day)	100
Vitamin A (IU/day)	900
Vitamin C (mg/day)	60
Vitamin D (IU/day)	200
Vitamin E (IU/day)	15
Vitamin K (μg/day)	120
Thiamine (mg/day)	1.2
Riboflavin (mg/day)	1.3
Niacin (mg/day)	16
Vitamin B6 (mg/day)	1.7
Folic acid (μg/day)	400
Vitamin B12 (μg/day)	2.4
Biotin (μg/day)	30
Pantothenic acid (mg/day)	5
Calcium (mg/day)	1,200
Iron (mg/day)	8
Phosphorus (mg/day)	700
Iodine (μg/day)	150
Magnesium (mg/day)	400
Zinc (mg/day)	11
Selenium (μg/day)	50
Copper (μg/day)	50
Manganese (mg/day)	2.3
Chromium (μg/day)	30
Molybdenum (μg/day)	45
Potassium (mg/day)	4,700
Sodium (mg/day)	1,500
Caffeine (mg/day)	1,000
L-arginine (g/day)	2

Abbreviation: RDA, recommended dietary allowance.

3.3. Test Measurement

Anthropometric indices, including weight, height, body mass index (BMI), body fat mass (BFM), and lean body

Table 2. Value and Energy Contributions of Macronutrients per 100 Grams of CFB

Macronutrients	Final Value (g)	Energy Contributions (%)
Total carbohydrates	58.59	45
Complex carbohydrates	40.71	70 (of total carbohydrates energy)
Corn flour	34.9	-
Soybean flour	5.81	-
Simple carbohydrates	17.88	30% (of total carbohydrates energy)
Powdered sugar	14.97	-
MPC	2.91	-
Fat	24.97	42
CBS	21.03	-
Corn and soybean flour	3.86	-
Protein	16.275	13
MPC	8.14	-
Soybean flour	8.13	-
Moisture	2.17	-
Rash	2.7	-

Abbreviations: CBS, cocoa butter substitute; CFB, compact food bars; MPC, milk protein concentrat.

mass (LBM), were measured in each participant at baseline and after the intervention. BMI was calculated as weight (kg) divided by height (meters squared), and LBM and BFM were measured using a body composition analyzer (model: InBody S10, InBody Co., Korea).

Cardiopulmonary endurance was evaluated using a respiratory gas analyzer (model: MetaLyzer3B, Cortex Bio Physic Co., German), which directly measured the $VO2_{Max}$ (mL/kg/min), abdominal muscle endurance in the sit-up test, shoulder belt endurance in the Barfix corrected test, upper-extremity endurance in the push-up test, flexibility in the sit-and-reach test, speed in the 45-meter running test, agility in the 4×9-meter running test, and lower-limb strength in the jump pair length test at baseline and after the intervention. In addition, physical activity was recorded using a pedometer (model: HJ-320, Omron, Japan) before and after the intervention. Exercise performance was measured and recorded at the baseline and after the intervention based on sports tests, $VO2_{Max}$ (measure of cardio-respiratory endurance) *in vitro* with cardiopulmonary exercise testing, blood pressure test, and anthropometric measurements based on body composition and physical activity using a pedometer.

3.4. Statistical Analysis

Data analysis was performed in SPSS version 16 (SPSS Inc., Chicago, IL, USA), and the significance level was set to be $P < 0.05$. The quantitative results were expressed as mean and standard deviation, and the normality of the data was evaluated using the Kolmogorov-Smirnov test. Moreover, Independent-sample *t*-test was run to compare the variables between the two groups, and Repeated Measures ANOVA was used to evaluate the variations of variables between the mean values in the study groups.

4. Results

The Kolmogorov-Smirnov test revealed the normal distribution of the data in the experimental and control groups. No significant difference was observed between the groups before the intervention in terms of age, height, weight, BMI, energy, and protein intake ($P > 0.05$) (Table 3). In addition, the participants' specifications, , including weight, BMI, BFM, LBM, physical activity (PA), and energy, were no significantly different after the intervention (Table 4).

Table 3. Baseline Characteristics of Participants in Experimental and Control Groups

Variables	CFB (N = 25)[b]	Control (N = 25)[c]	P Value
Age (y)	24.18 ± 2.9*	23.95 ± 3.23*	0.44[d]
BMI (kg/m^2)	23.35 ± 4.02*	24.01 ± 4.53*	0.57[d]
Height	175.55 ± 6.78*	176.35 ± 7.38*	0.78[d]
Weight	73.82 ± 14.02*	72.91 ± 16.32*	0.83[d]
Energy (kcal)	2359.45 ± 362.02*	2338.65 ± 341.28*	0.84[d]
Protein (g/day)	81.05 ± 13.18*	83.04 ± 8.13*	0.48[d]

[a] Values are expressed as mean ± SD.
[b] CFB: compact food bars/recipient of CFB during 10 days of the study.
[c] Recipient of regular food during 10 days of the study.
[d] Independent-student *t*-test.

Table 5 shows the intragroup and intergroup comparison of the variations in the $VO2_{Max}$ and exercise tests. Accordingly, after a 10-day intervention, there was a significant difference between the means of variations in $VO2_{Max}$, push-up, sit-and-reach test and jump pair length based on Repeated Measures ANOVA in CFB group, compared to the control group ($P < 0.05$); however, there was no significant difference in the variations of Barfix corrected test, 45-meter Run test, 4×9-meter run test, Sit-ups test ($P > 0.05$).

5. Discussion

Recently, numerous nutritional supplements have been popularized among athletes with the aim of improving the maintenance of muscle strength during high-intensity exercises and exercise performance. The present

Table 4. Anthropometric Indices and Physical Activity Before and After Intervention in Experimental and Control Groups[a]

Variables	CFB (N = 25)[b]	Control (N = 25)[c]	P Value[d]
Weight (kg)			0.67
Baseline	73.82 ± 14.02	72.91 ± 16.32	
End	73.6 ± 14.23	72.74 ± 15.17	
BMI (kg/m^2)			0.43
Baseline	23.35 ± 4.02	24.01 ± 4.53	
End	23.57 ± 3.85	23.91 ± 3.7	
BFM (%)			0.53
Baseline	19.78 ± 7.67	18.14 ± 6.97	
End	19.52 ± 7.44	18.08 ± 7.22	
LBM (%)			0.61
Baseline	58.32 ± 6.06	58.83 ± 9.97	
End	58.68 ± 6.91	58.86 ± 9.62	
PA (km/day)			0.59
Baseline	22.486 ± 0.33	22.501 ± 0.39	
End	22.389 ± 0.29	22.401 ± 0.31	
Energy (kcal)			0.51
Baseline	2742.68 ± 471.49	2889.82 ± 364.32	
End	2692.41 ± 523.30	2894.82 ± 548.17	

Abbreviation: BFM, body fat mass; LBM, lean body mass; PA, physical activity.
[a]Values are expressed as mean ± SD.
[b]CFB: compact food bars/recipient of CFB during 10 days of the study.
[c]Recipient of regular food during 10 days of the study.
[d]Repeated measures ANOVA.

Table 5. Physical Fitness Tests Before and After Intervention in Experimental and Control Groups[a]

Variables	CFB (N = 25)[b]	Control (N = 25)[c]	P Value[d]
$VO2_{Max}$ (mL/min/kg)			0.001
Baseline	41.47 ± 2.16	40.53 ± 1.85	
End	46.80 ± 3.02	41.40 ± 2.69	
Barfix corrected (repeat)			0.06
Baseline	17.95 ± 8.25	16.80 ± 11.12	
End	22.85 ± 7.13	18.80 ± 14.02	
Push-up (number/minute)			0.015
Baseline	27.37 ± 11.07	25.36 ± 4.15	
End	32.37 ± 12.59	28.86 ± 7.61	
Sit-and-reach (cm)			0.016
Baseline	33.02 ± 7.05	32.58 ± 5.07	
End	36.34 ± 7.81	34.83 ± 5.67	
45-meter run (second)			0.89
Baseline	7.43 ± 0.84	7.15 ± 0.10	
End	7.52 ± 0.51	7.98 ± 0.46	
4 × 9-meter run (second)			0.08
Baseline	10.12 ± 0.82	10.18 ± 0.90	
End	9.52 ± 0.78	10.26 ± 0.56	
Jump pair length (second)			0.008
Baseline	199.12 ± 19.82	198.18 ± 21.90	
End	211.52 ± 20.78	201.26 ± 18.56	
Sit-ups (cm)			0.72
Baseline	36.01 ± 8.01	38.58 ± 5.39	
End	40.14 ± 6.71	39.83 ± 5.93	

[a]Values are expressed as mean ± SD.
[b]CFB: compact food bars/recipient of CFB during 10 days of the study.
[c]Recipient of regular food during 10 days of the study.
[d]Repeated measures ANOVA.

study aimed to investigate the effects of consuming CFB enriched with multivitamins, minerals, L-arginine, and caffeine for 10 days on the exercise performance, $VO2_{Max}$, weight, BMI, BFM, and LBM in male military athletes, in comparison to the control group (regular food consumption).

According to the findings of the present study, the consumption of CFB increased $VO2_{Max}$ and physical performance; however, no significant difference was observed between the experimental and control groups in terms of the mean weight, BMI, BFM, and LBM before and after the intervention. This could be attributed to the short period of the study, implementation of a joint exercise program (long days and night walks), military maneuvers, and same exercise in the study groups.

According to the study findings, the effects of CFB consumption more favorably increased cardiopulmonary endurance ($VO2_{Max}$), Upper-limb strength (push-up), flexibility (sit-and-reach test), and lower-limb strength (jump pair length test) in the experimental group, compared to the control group.

The protein used in the CFB was an abundant source of L-arginine, which is an essential amino acid found in soybean protein, and branched amino acids (casein protein in the MCP) as well as multivitamins, minerals, and caffeine. These compounds increase oxygen delivery to the active muscles, thereby enhancing the oxygen uptake in the muscles to effectively improve exercise performance. Several studies have focused on the effects of these nutritional compounds on exercise performance (14, 15).

Our findings are consistent with the previous studies conducted in this regard. According to a similar study, arginine amino acids improve muscle strength and function during exercise, thereby leading to delayed muscle fatigue during physical activity (16). In another study, the consumption of L-arginine (3 g/day) for 15 days by men reduced muscle fatigue and increased oxygen uptake during exercise (17). L-arginine was used in another study for 45 days at the concentration of 2 g/day, enhancing the agility and performance of skeletal muscles during exercise in male athletes (18).

The suggested mechanism is that L-arginine may affect $VO2_{Max}$ and exercise performance through increasing oxygen delivery to the active muscles, which in turn increases oxygen uptake in muscles (18). L-arginine is the precursor of nitric oxide, which has vasodilatory effects on increasing the blood flow and improving cardiopulmonary endurance (19, 20). Theoretically, increased blood flow could enhance physical performance through enhancing oxygen and nutrient delivery and waste product removal from the skeletal muscles during exercise (18, 19). In terms of cardiopulmonary endurance, the Krebs cycle is considered to be the dominant energy supply system for the body. This cycle requires oxygen to produce adenosine triphosphate (ATP), and the activities that increase the capacity of the circulatory and pulmonary tracts to increase the capacity of oxygen delivery to the cells in the body, result in continuous ATP remodeling to improve performance and regular activity (20). Therefore, compounds such as L-arginine in the designed CFB in the current research could be highly effective in increasing the oxygen delivery capacity.

The other potential effects of a CFB might be caused by the constituents such as caffeine. This finding is in line with previous studies that examined the effect of caffeine on exercise performance (21-23). The results of a study showed that 5 mg/kg of caffeine enhanced the endurance, agility, and performance of muscle strength at various intensity levels of practice (21). One study showed that caffeine intake in the Ergometer test increased the time to reach exhaustion (20). Another study showed that caffeine intake of 5 mg/kg increased exercise performance and $VO2_{Max}$ (23).

The possible mechanisms explaining the effects of the caffeine content for the designed CFB include increased energy intake, stimulation of fatty acid release from the adipose tissue (14, 15), faster regeneration of energy sources, and delayed fatigue threshold, which is possible through the preventing disturbances in the acid-base balance and reduction of glycolysis and lactic acid accumulation in the muscles (24, 25). Caffeine is an ergogenic agent, which influences the release of catecholamines and prevents cellular damage through its antioxidant effects (14). Moreover, caffeine improves cardiopulmonary endurance and exercise performance during high-intensity exercises and long-term activities and could be effective in prolonging the time to reach fatigue by glycogen storage through increasing lipolysis and consumption of fatty acids as the main energy supply during high-intensity exercises (15). Therefore, compounds such as L-arginine and caffeine in the CFB designed in the present study could increase oxygen delivery capacity and enhance exercise performance.

5.1. Conclusions

According to the findings of the present study, the consumption of the designed CFB with functional compounds (caffeine and L-arginine) by military athletes under severe conditions and intense exercise activity positively affected $VO2_{Max}$ and exercise performance. However, there was no significant effect on the anthropometric indices and body composition.

Acknowledgments

Hereby, we extend our gratitude to those who assisted us in this research project. We would also like to thank all the participants for their cooperation.

Footnotes

Authors' Contribution: Study proposal and development as well as the analysis and interpretation of the data: Vahid Hadi, Majid Ghayour-Mobarhan, Mohamad Ali Sardar, Arasb Dabbagh Moghaddam, Abdolreza Norouzi, and Mostafa Mazaheri Tehrani; drafting the manuscript: Vahid Hadi, Abdolreza Norouzi and Mostafa Mazaheri Tehrani; in-depth revision of the manuscript for important intellectual content: Saeid Hadi, Mohsen Nematy, Golnaz Ranjbar, and Nasrin Borumandnia; statistical analysis: Reza Rezvani and Naseh Pahlavani.

Clinical Trial Registration Code: IRCT20181014041336N1.

Conflict of Interests: The authors declare that they have no conflict of interests.

Ethical Approval: IR.MUMS.MEDICAL.REC.1397.276.

Funding/Support: The present study was funded by the vice chancellor for research of Mashhad University of Medical Sciences.

References

1. Farajzadeh D, Golmakani M. Formulation and experimental production of energy bar and evaluating its shelf-life and qualitative properties. *J Mil Med*. 2011;**13**(3):181–7.
2. McArdle WD, Katch FI, Katch VL. *Exercise physiology: Nutrition, energy, and human performance*. Lippincott Williams & Wilkins; 2010.

3. Ashtary-Larky D, Lamuchi-Deli N, Milajerdi A, Bakhtiar Salehi M, Alipour M, Kooti W, et al. Inflammatory and biochemical biomarkers in response to high intensity resistance training in trained and untrained men. *Asian J Sport Med*. 2017;**8**(2). e13739. doi: 10.5812/asjsm.13739.
4. Jaeger SR, Cardello AV. A construct analysis of meal convenience applied to military foods. *Appetite*. 2007;**49**(1):231–9. doi: 10.1016/j.appet.2007.02.001. [PubMed: 17399852].
5. Shay LE, Seibert D, Watts D, Sbrocco T, Pagliara C. Adherence and weight loss outcomes associated with food-exercise diary preference in a military weight management program. *Eat Behav*. 2009;**10**(4):220–7. doi: 10.1016/j.eatbeh.2009.07.004. [PubMed: 19778751]. [PubMed Central: PMC3936599].
6. Hennigar SR, Gaffney-Stomberg E, Lutz LJ, Cable SJ, Pasiakos SM, Young AJ, et al. Consumption of a calcium and vitamin D-fortified food product does not affect iron status during initial military training: A randomised, double-blind, placebo-controlled trial. *Br J Nutr*. 2016;**115**(4):637–43. doi: 10.1017/S0007114515004766. [PubMed: 26625709].
7. Bagheri R, Rashidlamir A, Ashtary-Larky D, Wong A, Alipour M, Motevalli MS, et al. Does green tea extract enhance the anti-inflammatory effects of exercise on fat loss? *Br J Clin Pharmacol*. 2019. doi: 10.1111/bcp.14176. [PubMed: 31747468].
8. Ghiasvand R, Askari G, Malekzadeh J, Hajishafiee M, Daneshvar P, Akbari F, et al. Effects of six weeks of beta-alanine administration on VO(2) max, time to exhaustion and lactate concentrations in physical education students. *Int J Prev Med*. 2012;**3**(8):559–63. [PubMed: 22973486]. [PubMed Central: PMC3429803].
9. Williams M. Dietary supplements and sports performance: Amino acids. *J Int Soc Sports Nutr*. 2005;**2**:63–7. doi: 10.1186/1550-2783-2-2-63. [PubMed: 18500957]. [PubMed Central: PMC2129148].
10. Nissen SL, Sharp RL. Effect of dietary supplements on lean mass and strength gains with resistance exercise: A meta-analysis. *J Appl Physiol (1985)*. 2003;**94**(2):651–9. doi: 10.1152/japplphysiol.00755.2002. [PubMed: 12433852].
11. Barrett AH, Cardello AV. *Military food engineering and ration technology*. DEStech Publications, Inc; 2012.
12. Hadi V, Norouzy A, Mazaheri Tehrani M, Nematy M, Hadi S. Characteristics of compact food bars. *J Nutr Fast Health*. 2018;**6**(3):125–31.
13. Sheibani E, Dabbagh Moghaddam A, Sharifan A, Afshari Z. Linear programming: an alternative approach for developing formulations for emergency food products. *J Sci Food Agric*. 2018;**98**(4):1444–52. doi: 10.1002/jsfa.8612. [PubMed: 28776694].
14. Jafari A, Nik KJ, Malekirad A. Effect of short-term caffeine supplementation on downhill running induced inflammatory response in non-athletes males. *J Cell Tissue*. 2012;**2**(4):377–85.
15. Davis JK, Green JM. Caffeine and anaerobic performance: ergogenic value and mechanisms of action. *Sports Med*. 2009;**39**(10):813–32. doi: 10.2165/11317770-000000000-00000. [PubMed: 19757860].
16. Stipanuk MH. Sulfur amino acid metabolism: Pathways for production and removal of homocysteine and cysteine. *Annu Rev Nutr*. 2004;**24**:539–77. doi: 10.1146/annurev.nutr.24.012003.132418. [PubMed: 15189131].
17. Santos RS, Pacheco MTT, Martins RABL, Villaverde AB, Giana HE, Baptista F, et al. Study of the effect of oral administration of L-arginine on muscular performance in healthy volunteers: An isokinetic study. *Isokinet Exerc Sci*. 2002;**10**(3):153–8. doi: 10.3233/ies-2002-0096.
18. Pahlavani N, Entezari MH, Nasiri M, Miri A, Rezaie M, Bagheri-Bidakhavidi M, et al. The effect of l-arginine supplementation on body composition and performance in male athletes: A double-blinded randomized clinical trial. *Eur J Clin Nutr*. 2017;**71**(4):544–8. doi: 10.1038/ejcn.2016.266. [PubMed: 28120856].
19. Laursen PB, Jenkins DG. The scientific basis for high-intensity interval training: Optimising training programmes and maximising performance in highly trained endurance athletes. *Sports Med*. 2002;**32**(1):53–73. doi: 10.2165/00007256-200232010-00003. [PubMed: 11772161].
20. Baker JS, McCormick MC, Robergs RA. Interaction among skeletal muscle metabolic energy systems during intense exercise. *J Nutr Metab*. 2010;**2010**:905612. doi: 10.1155/2010/905612. [PubMed: 21188163]. [PubMed Central: PMC3005844].
21. Wiles JD, Coleman D, Tegerdine M, Swaine IL. The effects of caffeine ingestion on performance time, speed and power during a laboratory-based 1 km cycling time-trial. *J Sports Sci*. 2006;**24**(11):1165–71. doi: 10.1080/02640410500457687. [PubMed: 17035165].
22. Bell DG, Jacobs I, Ellerington K. Effect of caffeine and ephedrine ingestion on anaerobic exercise performance. *Med Sci Sports Exerc*. 2001;**33**(8):1399–403. doi: 10.1097/00005768-200108000-00024. [PubMed: 11474345].
23. Doherty M. The effects of caffeine on the maximal accumulated oxygen deficit and short-term running performance. *Int J Sport Nutr*. 1998;**8**(2):95–104. doi: 10.1123/ijsn.8.2.95. [PubMed: 9637189].
24. Cerretelli P, Samaja M. Acid-base balance at exercise in normoxia and in chronic hypoxia. Revisiting the "lactate paradox". *Eur J Appl Physiol*. 2003;**90**(5-6):431–48. doi: 10.1007/s00421-003-0928-x. [PubMed: 14504942].
25. Shahmohammadi HA, Hosseini SA, Hajiani E, Malehi AS, Alipour M. Effects of green coffee bean extract supplementation on patients with non-alcoholic fatty liver disease: A randomized clinical trial. *Hepat Mon*. 2017;**17**(4). en. e12299. doi: 10.5812/hepatmon.45609.