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The question of ergogenic potential of the Paleolithic diet

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The Paleolithic diet is a modern nutritional diet developed on the basis of human and primate evolution. There is a growing body of evidence suggesting the Paleolithic diet may have beneficial effects on risk factors of cardiovascular diseases and type 2 diabetes. Some authors claim the modern model of Paleolithic diet has an ergogenic potential (i.e. it may enhance physical performance), especially with regard to its high content of branched-chain amino acids, alkalizing properties as well as limited amount of antinutrients, and the appropriate omega-6/omega-3 fatty acids ratio. Gaining the benefits regarded as unique for the Paleolithic diet may not always be associated with complete exclusion of cereals, milk, dairy products and legumes. The diet is particularly recommended for endurance athletes and athletes for whom maintaining low adiposity is priority. Moreover, periodical adherence to the Paleolithic diet may enhance the flexibility of utilization of energy substrates in endurance sports. More extensive research on physically active individuals may provide more solid evidence on the ergogenic potential of the Paleolithic diet.

KEYWORDS: physical exercise, performance improvement, nutrition, paleolithic diet, health promotion.

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What is already known on this topic?
Modern nutrition not always ensures optimal health outcomes. This problem can be illustrated by the increasing prevalence of diet-dependent metabolic disorders such as obesity, type 2 diabetes, cardiovascular diseases, and food intolerance. Dietary errors in physically active individuals can have a detrimental impact on their physical fitness and sport performance. One of multiple dietary models for prevention of the above is the modern model of Paleolithic diet based on the nutritional diet from the prehistoric period in which the most profound development of human physiology and metabolism took place. Experimental studies confirm health benefits the Paleolithic diet, whose nutritional qualities may enhance physical fitness and performance of athletes of a least a few sports.

Introduction

There is a growing body of evidence that the profound changes in dietary and lifestyle conditions that began with the advent of agriculture (about 11×10^3 years ago), and than after the industrial revolution (about 200 years ago), occurred too recently on an evolutionary time scale for the human genome to adjust [1, 2].

Most of human genes associated with biochemical processes and anatomy were developed in the Paleolithic era about $2.6 – 0.01 \times 10^6$ years ago, and the human genome has hardly changed since the emergence of behaviorally-modern humans in East Africa about

100-50 × 10^3 years ago [3]. In consideration of the above it can be assumed that a reconstruction of Paleolithic hunter-gatherer dietary habits may help understand the nutritional needs of modern people as well as the causes of common chronic nutritional disorders [4].

The Paleolithic diet is a modern nutritional diet developed on the basis of human and primate evolution. It emulates foods presumably eaten regularly by humans during the Paleolithic era, e.g. lean meat, fish, shellfish, fruits, vegetables, eggs and nuts, but not grains, milk and dairy products, refined fats and sugar and highly processed products, which became staple foods long after the appearance of fully modern humans [5].

Intervention studies using the modern model of Paleolithic diet revealed an improvement in the risk factors of cardiovascular diseases and type 2 diabetes [5, 6]. This was confirmed by studies on animals [7], and by short-term [8, 9] and long-term studies on humans [10]. One interesting study revealed that a Paleolithic diet was as much satiating as a Mediterranean-like diet, with lower daily energy intake. Beneficial effects of the Paleolithic diet on glucose tolerance and waist circumference were also noted [11]. In turn, other authors observed that the incidence of diet-dependent disorders (e.g. obesity, metabolic syndrome, type 2 diabetes, cardiovascular diseases and tumors) in ancestral hunter-gatherer communities had been very low [12]. Furthermore, studies carried out among present-day communities of hunter-gatherers showed that their levels of physical activity and aerobic capacity were significantly higher than the levels of their westernized counterparts [13]. On the other hand, the fasting insulin and leptin levels in those groups were much lower [14, 15]. Also, the skeletal frame sizes of late Paleolithic humans found by physical anthropologists were comparable to the skeletal frame sizes of present-day athletes [16].

Some authors are convinced that adherence to a Paleolithic diet may greatly improve sport performance, especially in endurance sports and for athletes for whom maintaining low fat mass is priority [17]. According to those authors the ergogenic potential of the Paleolithic diet comprises four components:

1) high protein content, in particular, of branched-chain amino acids;
2) high nutrient density;
3) alkalizing properties;
4) sufficient carbohydrate content.

The Paleolithic diet also lacked cereals and legumes with their considerable content of antinutrients (e.g. gluten, phytic acid, lectins and saponins), dominance of omega-6 over omega-3 fats, and milk and dairy products with their strong insulinotropic properties.

The aim of the present paper is to discuss the arguments for beneficial effects of the Paleolithic diet on physical fitness and sport performance.

High content of branched-chain amino acids

Authors of review papers [18, 19] indicate that protein recommendations for endurance and strength trained athletes range from 1.2 to 1.7 g per kg of body mass. Protein requirements probably decrease with training experience but increase with greater exercise volume and intensity [19]. Helms et al. (2013) note that following calorically restricted diets requires higher protein intake [20]. Their meta-analysis showed that protein needs for strength-trained athletes were likely 2.3-3.1 g/kg of fat-free mass scaled upwards with severity of caloric restriction and leanness. Dietary proteins stimulate thermogenesis and satiety more than carbohydrates or fats [21] and they feature the lowest energy efficiency [22]. For this reason a high-protein diet is recommended for athletes to maintain low adiposity. Leucine, and most likely other branched-chain amino acids, are crucial for maximizing muscle protein synthesis [23]. Joy et al. 2013 found no differences in the body composition and exercise performance in young men who trained 3 times per week, after an 8-week 48 g whey or rice protein isolate supplementation. Joy et al. also noted that the lack of differences could be the result of crossing the leucine threshold necessary for maximizing muscle protein synthesis (2-3 g or 0.05 g per kg of body mass) [23, 24]. It should also be emphasized that in physically active, healthy persons a nutrient-rich well-balanced diet (protein intake of 1.4-2.0 g per kg of body mass) does not increase the risk of chronic kidney disease and osteoporosis [25].

A Paleolithic diet rich in animal protein (lean meat, fish, shellfish, eggs) can also augment the supplementation of the appropriate amount of branched-chain amino acids during exercise of high volume and intensity. However, it must be stressed that milk and dairy products (whey protein, in particular), which are absent in the Paleolithic diet, are also rich sources of high-quality protein and branched-chain amino acids [26].

High nutrient density

The optimal intake of vitamins and minerals is determined by total energy and the amounts of energy from particular macronutrients supplied to the human body as well as by the volume and intensity of physical exercise [26]. Most research studies failed to reveal any additional benefits from vitamin and mineral supplementation. However, an insufficient supply of nutrients in a diet can greatly contribute to the decline of physical performance [27, 28].

According to some authors the mean nutrient density of milk and whole grain cereals is lower that of vegetables, fruits, lean meat and shellfish [1]. It can be concluded therefore that following a Paleolithic diet involves a high intake of vitamins, especially antioxidant vitamins, and minerals such as iron, zinc, or copper, which are crucial in conditions of intensified metabolism. On the other hand, the exclusion of milk and dairy products from the Paleolithic diet may be a factor risk for calcium deficit [5]. Literature lacks solid evidence behind the premise that athletes adhering to the Paleolithic diet more seldom contract infections of the upper airways [17].

Alkalizing properties

According to some researchers following a typical western diet with its acid-producing characteristics may lead to mild chronic metabolic acidosis, and – in consequence to – osteoporosis and sarcopenia [12, 29]. This is possible because bone mineral compounds can be used for neutralizing hydrogen ions, which leads to intensified renal calcium clearance. Glutamine released to the blood with the breakdown of skeletal muscles, as well as glutamine synthesized by the liver with other amino acids, is utilized for renal synthesis of ammonia. Ammonia compounds become spontaneously protonated and excreted as ammonium. This alleviates metabolic acidosis but also enhances the loss of muscle mass [29, 30]. Some findings on the harmful effects of diets with acid-producing properties have been questioned in recent research studies [31, 32]. According to Fenton et al. 2009, hypercalciuria does not have to reflect negative changes in the body's calcium balance and the loss of bone mass [31]. At the same time, reduced losses of muscle mass thanks to ingestion of alkaline diets (fruits and vegetables) were found only in elderly subjects [33].

According to literature, diet-dependent mild chronic metabolic acidosis may be a factor contributing to a number of metabolic and endocrine disturbances such as mild forms of hypothyroidism and hyperglucocorticoidism [30].

Recent studies show that the diet of East African Paleolithic hunter-gatherers was predominantly net base-producing [29]. Considering the observed beneficial impact of exogenous administration of buffer substances (e.g. sodium bicarbonate and sodium citrate) on physical performance [34], one can expect similar effects following the adherence to a model Paleolithic diet by present-day athletes. Thus the need for more extensive research on possible use of alkaline diets by physically active individuals as well as on effects of such diets on body composition and exercise performance seems justified.

Sufficient carbohydrate content

Training with low muscle glycogen enhances transcription of a number of genes involved in training adaptation [35, 36], fat metabolism during exercise performance, and accumulation of intramyocellular triacylglycerol as a substrate source during exercise (IMTG) [37]. In order to attain the above goals different dietary variants have been examined. Van Proeyen et al. 2011 found that endurance training in the fasted state may facilitate fat oxidation during exercise and prevent an exercise-induced drop in blood glucose concentration [38]. On the other hand, Vogt et al. 2003 showed that IMTG content could be doubled without a significant decrease in muscle glycogen stores. In their experiment endurance athletes followed a moderate-carbohydrate and high-fat diet for 5 weeks (14%, 31% and 53% of total energy from proteins, carbohydrates and fats, respectively) [39]. They also determined the proportion of used energy substrates and noted higher respiratory exchange ratios (RER) at rest and during submaximal exercise in participants consuming the experimental diet. These results suggest that the greater part of energy used by the human body came from oxidation of free fatty acids. Moreover, they did found no differences in performance levels during exercise of moderate and high intensity in participants following the experimental diet compared with the controls adhering to a high-carb diet. Periodical adherence to a Paleolithic diet can be an interesting way of improving the flexibility of utilization of energy substrates during endurance exercise. This requires, however, more extensive studies on high-performance athletes. It should be stressed that a Paleolithic diet does not have to be a low-carb diet. Kuipers et al., 2010, claim that the diet of Paleolithic East African hunter-gatherers could have included considerable amounts of carbohydrates (median and total: 39-40% and 19-48% of energy intake). This, in many sports, can ensure the maintenance of appropriate muscle glycogen levels with the increasing possibility of utilization of fatty acids [40].

Other beneficial effects of the Paleolithic diet

The Paleolithic diet is gluten-free, which is considered by some a nutritional advantage [17]. However, today, the prevalence of autoimmune gluten intolerance in the general population is estimated at 0.3-1.2%, whereas non-celiac gluten sensitivity (NCGS), which is probably 10 times more prevalent, still lacks any accurate diagnostic criteria [41]. Vojdani and Tarash, 2013 also noted strong cross-reactions between antibodies against gliadin and antigens of foods absent in the Paleolithic diet: cow's milk, milk chocolate, milk butyrophilin, whey protein, casein, yeast, oats, corn, millet, instant coffee and rice. The elimination of these foods may have a beneficial effect on the health and exercise performance of athletes with coeliac disease or with NCGS, for whom gluten-free diet fails [42].

Antinutrients absent in the Paleolithic diet include some lectins contained in cereals and legumes, e.g. wheat germ agglutinin (WGA). They enhance intestinal permeability, affect the autoimmune, allergic and inflammatory responses, and bind to insulin and leptin receptors and insulin-like growth factor-1 [12, 43]. They can thus facilitate chronic inflammations and the levels of glucose and fatty acids, i.e. the main energy sources during exercise. However, little is known about the effects of dietary plant lectins contained in a typical diet, in thermally processed foods, on the human body [12, 44].

The Paleolithic diet also excluded cereal grains and legumes with their high content of phytic acid, which has the ability to chelate multivalent metals (in particular, zinc, calcium and iron), but also exhibits antioxidant and antitumor properties [45].

A recent comparative analysis between Paleolithic East African diet and modern western diet showed that the former was rich in long-chain omega-3 and omega-6 fatty acids and poor in linolenic acid [40]. The same study also showed that the linoleic/linolenic acid ratios and omega-3/omega-6 fatty acids ratios were relatively low and amounted to 1.12-1.64 g and 0.84-1.92 g, respectively. A similarly low ratio of these fatty acids was found in populations characterized by longevity and low prevalence of cardiovascular diseases, tumors, and type 2 diabetes (e.g. in Japan: 4/1, and in pre-1960 Greece: 1-2/1) [46]. However, the significance of the omega-6/omega-3 ratio has been questioned by some other researchers [47] for whom more important is the appropriate intake of long-chain omega-3 fatty acids (eicosapentaenoic and docosahexaenoic acids) and avoidance of extensive consumption of linoleic acid from highly processed food products, e.g. refined plant oils, sweets, or confectionery.

The Paleolithic diet is deprived of milk and dairy products. The insulin response to intake of milk fermented dairy products and ice cream – despite low glycemic index – is close to the response to white bread consumption [48, 49, 50]. Data from literature indicate that the insulinotropic properties of milk and dairy products may be associated with increased concentrations of highly insulinogenic branched-chain amino acids, whey bioactive peptides, *or bioactive peptides* formed during gastrointestinal *digestion* of milk proteins. The insulin response to milk and dairy products also seems to involve incretin hormones, in particular, glucose-dependent insulinotropic polypeptide (GIP), whose concentration rises significantly after whey consumption [51]. Due to their strong insulinotropic properties the role of milk and dairy products in prevention and treatment of diseases of civilization remains unclear [50]. Hoppe et al. 2005 found that high milk intake increased fasting insulin resistance and serum concentration in young boys [48]. On the other hand, some observation studies suggest that the consumption of dairy products reduces the risk of diseases related to insulin resistance [52]. Moreover, benefits of milk consumption during recovery from resistance training and endurance sports have also been discussed. The high content of proteins with various absorption rates, branched-chain amino acids, and nutrients in milk as well as milk's insulinotropic properties may also enhance the synthesis of muscle proteins, minimization of their breakdown, and resynthesis of muscle and liver glycogen [53].

Conclusion

Results of intervention studies indicate that certain nutritional aspects of the Paleolithic diet have a beneficial effect on a number of risk factors of cardiovascular diseases and type 2 diabetes.

The ergogenic potential of the Paleolithic diet is a promising prospect for athletes of sports in which maintaining low adiposity is priority. Periodical adherence to the Paleolithic diet may enhance the flexibility of utilization of energy substrates in endurance sports.

Gaining the benefits regarded as unique for the Paleolithic diet may not always be associated with complete exclusion of cereals, milk, dairy products and legumes.

More extensive research on physically active individuals may provide more solid evidence on the ergogenic potential of the Paleolithic diet.

What this paper adds?
The present review paper addresses benefits of the Paleolithic diet for prevention and treatment of diseases of civilization and metabolic disorders. The authors discuss the nutritional aspects of the diet that may influence physical fitness and sport performance. Areas for further research into the usability of the Paleolithic diet for high-performance athletes are suggested.

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