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Are vegetarians Better Runners? An Evolutionary Perspective

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Abstract

Current evidence seems to be relatively straight forward that neither a beneficial nor a detrimental effect of a vegetarian diet on physical performance capacity exists, especially when carbohydrate intake is controlled. Although, from an evolutionary point of view some conflicting hints exist for running yielding to the aim of the study to analyze effects of meat versus vegetarian diet on running performance. Humans have exceptional capabilities to run long distances in hot, arid conditions which are unique among primates. Human endurance running performance capabilities compare favorably with those of other mammals emerged sometime around 2 million years ago in order to help meat-eating hominids competing with other carnivores implying that meat eating was important for the development of humans. However, recent past showed that vegetarian diet might be an advantage for running performance and for example the best German Marathon Runner Arne Gabius is vegetarian since years. Effects of meat intake on general health are relatively broadly discussed: vegetarian diets are typically lower in vitamin B12, protein, creatine, and carnitine. Furthermore iron and zinc from plant sources are less bio available than from meat sources. However, vegetarian diets are typically higher in carbohydrate and antioxidants, which may be advantageous for endurance activities. Even for the three main classes of nutrition substrates fat, protein and carbohydrates hints exist, that there is no effect on running performance. However, some protective effects of vegetarian diet e.g. in hard training periods might occur due to the fact that during hard exercises more free radicals are produced and therefore higher concentrations of antioxidants might be favorable. As general recommendation it can be concluded that due to menstrual bleeding woman have a higher risk to develop iron deficiency anemia and when performance deficit occur in woman runners, iron status should be controlled. Furthermore, some hints exist that for Ultra running races vegetarian diet might be more a problem than for shorter distances.

Keywords: Diet; Running; Meat; Vegetarian

Introduction

What is Running

Humans have exceptional capabilities to run long distances in hot, arid conditions [1-4]. These abilities, unique among primates and rare among mammals, derive from a suite of specialized features that permit running humans to store and release energy effectively in the lower limb, help keep the body's center of mass stable and overcome the thermoregulatory challenges of long distance running [1-4]. Human endurance running performance capabilities with the typical pattern of Movement compare favorably with those of other mammals probably emerged sometime around 2 million years ago in order to help meat-eating hominids compete with other carnivores [1-4]. Running is something completely natural [1-6]. It allowed humans to absolve long distances in the past and probably was an evolutionary advantage while hunting animals in order to have access to meat, which was high-quality food for our ancestors allowing a better survival [1-6].

A General Overview of the Role of Ingredients of Meat e.g. Iron: No doubt exist that physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition [7]. The body requires at least 40 nutrients that are classified into six groups: protein, carbohydrate, fat, vitamin, mineral, and water [8]. These nutrients cannot be made in the body and so they must be supplied from solid or liquid foods [8]. Some of these nutritionals may increase exercise capability e.g. Creatine supplementation improved repetitive, short-term performance [9]. In spite of well-documented health benefits of vegetarian diets, less is known regarding the effects of these diets on athletic performance and especially running [10, 11]. Human body´s health is affected by many different factors such as diet, exercise, genes and environment [12]. Interestingly, running has survival benefits and lots of positive aspects of health and adverse effects on muscle and bone were not found [13]. For Runners special diets were developed in order to increase performance such as

Saltin-Diet or general low-carb diet and /or vegetarian diets [5, 6]. Concerning meat free nutrition controversial stand points exist. Some argue that when Fe^{2+} is controlled, no negative consequences on performance are to expect [5, 6]. Generally accepted is the fact that due to menstrual bleeding some female athletes may increase their risk of iron deficiency if a restrictive vegetarian diet is adopted [5, 9, 16]. Interestingly, also the best German marathon runner Arne Gabius is also a vegetarian since years [17]. Lots of positive aspects of vegetarian diet have been associated with a reduced risk of developing coronary heart disease [18], breast cancer [19], colorectal cancers [20], prostate cancer [21], type 2 diabetes [22], insulin resistance [23], hypertension [24], cataracts [25] dementia [26] and atherosclerosis [27]. Vegetarians also typically have a lower body mass index [28-31] and an improved lipid profile [11, 28, 32].

In spite of the many health aspects of vegetarian diets some concern has been raised pertaining to the nutrient adequacy of vegetarian diets for supporting athletic performance. Vegetarian diets are typically lower in vitamin B12, protein, creatine, and carnitine, [33,34] and iron and zinc from plant sources are less bioavailable than from meat sources [11,35]. However, vegetarian diets are typically higher in carbohydrate and antioxidants [36,37] which may be advantageous for athletic performance, particularly for endurance activities [11, 38-45]. Despite these issues, little research directly examining vegetarian diets and running performance is available and for the sports regime of endurance running evidence has to be taxed as sparse.

The Role of Meat and its Ingredient for Physical Performance: One of the key elements relevant for human (endurance) performance and therefore running is iron. Iron is the central atom in Hemoglobin molecule in erythrocyte, a molecule most relevant for oxygen transport [5,6]. O_2 binds to the central atom of Hemoglobin the Fe^{2+} Ion allowing to transport Oxygen to periphery tissue such as skeletal muscle [5,6,46,47]. Several hints exist, that the transport of oxygen is the key relevant parameter of human performance [5,6]. Furthermore hints exist, that vegetarians are more likely to have lower iron stores compared with non-vegetarians limiting the ability to transport O_2 [44,48,49]. Performance capacity is determined by the cardiovascular system respectively its ability to transport oxygen to skeletal muscle [5,6,46,47]. In mitochondria oxidative capacity allows to use oxygen to produce the main energy substrate Adenosintriphosphate [5,6,46,47]. In endurance training we therefore see after training intervention an increase of mitochondria respectively the relevant pathways associated [5,6,12]. To sum up, for transport of oxygen Fe2+ is relevant in order to transport oxygen and hints exist, that Fe2+ from meat has a higher bioavailability than from plant sources [5,6,11,46,47].

Diet has many effects on endurance performance for example evolutionary considerations suggest that the body has been optimized to perform at a high level in the food-deprived state when fatty acids and their ketone metabolites are a major fuel source for muscle cells [50]. Furthermore, analyses of gene expression in liver and soleus tissues, and metabolomics analysis of blood suggest that the metabolic switch invoked by alternate-day food deprivation and potentiated by exercise strongly modulates molecular pathways involved in mitochondrial biogenesis, metabolism, and cellular plasticity [50]. The findings demonstrate that alternate-day food deprivation engages metabolic and cellular signaling pathways that result in increased metabolic efficiency and endurance capacity [50]. It was not tested yet for running, but in analogy to the well-known Saltin diet phases of no meat with phases of high-meat intake might be helpful to increase performance due to the fact that e.g. iron storage is emptied and refilling capacity is increased in analogy to Saltin diet were Glykogen stores are emptied and afterwards are overfilled [5,6]. However, findings from duathlets identified no differences in muscle structural composition, substrate selection, and performance capacity in highly trained endurance athletes as a consequence of consuming a high-fat or a low-fat diet [51]. In the study, eleven duathletes ingested high-fat (53% fat; HF) or high-carbohydrate diets (17% fat; LF) for 5 week in a randomized crossover design, whereby performance was not influenced by high-fat versus high-carbohydrate diets [51]. Total work output during a 20-min all-out time trial on a bicycle ergometer as well as half-marathon running time (80 min 12 s +/- 86 s vs 80 min 24 s +/- 82 s) were not different between High-Fat and Low-Fat diet [51]. Although, not on performance but on other physiological parameters effects were detected: Blood lactate concentrations and respiratory exchange ratios were significantly lower after HF than after LF at rest and during all submaximal exercise loads [51]. Muscle glycogen stores were maintained after a 5-wk high-fat diet period whereas intramyocellular lipid (IMCL) content was more than doubled and endurance performance capacity was maintained at moderate to high-exercise intensities with a significantly larger contribution of lipids to total energy turnover [51].

Running in the Past

An Evolutionary View - Long Phases of no Meat, Followed by Meat, but Meat Eating was Normal: From an evolutionary point of view it is to mention that survival of Homo sapiens during evolution was dependent on the procurement of food, which in turn was dependent on physical activity respectively running [1-4,52]. Hence, gene selection (so-called *"thrifty genes"*) in the Late-Paleolithic era was influenced by physical activity [1-4]. Furthermore, convincing evidence shows that this ancient genome has remained essentially unchanged over the past 10´000 years and certainly not changed in the past 40-100 years [1-4,52]. These *"thrifty genes"* in combination with physical activity have various effects on different organ systems [1,5,52]. During this long time of human evolution our ancestors lived as hunter and gatherer with a typical pattern of eating huge amount of meat when hunting was successful [5, 6].

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Current Evidence

General Hints concerning effects on performance while on a vegetarian diet: One aspect that is generally mentioned is that the time while on a vegetarian diet is relevant [11]. For example Lynch et al. [11] mention, that a considerable limitation in many of the conducted studies is the inclusion of participants who typically consume meat but subsequently adopt a vegetarian diet only for the duration of the study rather than comparing participants who have adhered to a vegetarian or meat-containing diet long-term [11]. A longer study is the one by Hanne et al. [53] which compared athletes who had maintained either a lacto-ovo vegetarian or omnivore diet for at least two years and found no group differences for aerobic or anaerobic capacity [11,53]. However, aerobic capacity was estimated using cycle ergometry and predicted VO_2 max, and strength or torque were not measured [11,53].

Furthermore, a recent study analyzing the relationship between consuming a predominately vegetarian-based diet and improved physical performance, a systematic literature review was performed [10]. Consuming a predominately vegetarian-based diet did not improve nor hinder physical performance in athletes, however, with only 8 studies identified, with substantial variability among the studies' experimental designs, aims and outcomes, further research is warranted [10]. More or less the same conclusion is derived by Nieman et al. [44]. The available evidence supports neither a beneficial nor a detrimental effect of a vegetarian diet on physical performance capacity, especially when carbohydrate intake is controlled for [44]. However, main concerns have been raised that an emphasis on plant foods to enhance carbohydrate intake and optimize body glycogen stores may lead to increases in dietary fiber and phytic acid intake to concentrations that reduce the bioavailability of several nutrients, including zinc, iron, and some other trace minerals [44]. There is no convincing evidence, however, that vegetarian athletes suffer impaired nutrient status from the interactive effect of their heavy exertion and plant-food based dietary practices to the extent that performance, health, or both are impaired [44]. Although there has been some concern about protein intake for vegetarian athletes, data indicate that all essential and nonessential amino acids can be supplied by plant food sources alone as long as a variety of foods is consumed and the energy intake is adequate [44]. To sum up, a vegetarian diet per se is not associated with improved aerobic endurance performance [44]. This fact is also supported from Evidence from animal models e.g. in dogs (sprint-racing Siberian huskies) meat free diet did not develop anemia and did not harm health of huskies [54].

One advantage that might exist is that vegetarian diet has less animal fat reducing tendency for adiposity [5]. Also recoupling effects on life style are described by running such as Runners drink less alcohol and having better lipid proteins such as high HDL [55]. But runners have to keep in mind, that vigorous exercise may mitigate diet-induced weight gain, albeit not guaranteeing protection from a general poor diet [56]. Although some concerns have been raised about the nutrient status of vegetarian athletes, a varied and well-planned vegetarian diet is compatible with successful athletic endeavor [44].

One aspect always to concern on is iron metabolism. Serum ferritin and total iron binding capacity values were significantly lower in vegetarian meat eating runners than for meat eater [49]. Dietary iron intake was comparable for the two groups but bioavailability of iron was significantly lower in vegetarian [49]. As the presence of hem iron (from meat, fish, and poultry) increases the bioavailability of dietary iron, the results suggest that vegetarian athletes have altered iron status due to the form in which their dietary iron is consumed [49]. Without doubts, this could affect performance (*see part - A general overview of the role of ingredients of meat e.g. iron*).

Concerning main substrate classes fat, carbohydrates and lipids even hints exist that the share of fat or carbohydrate is irrelevant for VO_2 max dependent performance - further implying some irrelevance of intake of main substrate classes while in consequence making general recommendations more difficult [46]. Meat consuming as well as the amount of physical activity is also culturally prone and particularly, a lack of familiarity and skill hamper the preparation of real vegetarian meals further implying a functional element of nutrition [5, 6, 57, 58]. Furthermore the beliefs of runner itself whether a special diet is favorable might have some importance on performance e.g. marathon runners often believe that they can improve performance substantially with nutrition interventions [59]. For some micro nutritional elements (e.g. for Carnosine) some evidence concerning superior performance can be found [60]. Carnosine is an abundant dipeptide in human skeletal muscle with proton buffering capacity [60]. Interestingly, Carnosine synthase mRNA expression was independent of training, but decreased significantly in the vegetarian group implying some relevance of vegetarian diet on exercise performance [60].

Furthermore, it was stated, that vegetarian athletes can meet their protein needs from predominantly or exclusively plant-based sources when a variety of these foods are consumed daily and energy intake is adequate [16, 61]. Interestingly, muscle creatine stores are lower in vegetarians than non-vegetarians and Creatine supplementation provides ergogenic responses in both vegetarian and non-vegetarian athletes, with limited data supporting greater ergogenic effects on lean body mass accretion and work performance for vegetarians [61]. The potential adverse effect of a vegetarian diet on iron status is based on the bioavailability of iron from plant foods rather than the amount of total iron present in the diet [61]. Vegetarian and non-vegetarian athletes alike must consume sufficient iron to prevent deficiency, which will adversely affect performance [61]. Other nutrients of concern for vegetarian athletes include zinc, vitamin B12 (cyanocobalamin), vitamin D (cholecalciferol)

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and calcium [61]. The main sources of these nutrients are animal products; however, they can be found in many food sources suitable for vegetarians, including fortified soy milk and whole grain cereals. Vegetarians have higher antioxidant status for vitamin C (ascorbic acid), vitamin E (tocopherol), and beta-carotene than omnivores, which might help reduce exercise-induced oxidative stress, however for example for the aspect of antioxidants further research is needed for comparing antioxidant defenses in vegetarian and non-vegetarian athletes [42,43,45,61].

As a typical vegetarian diet comprises a wide range of antioxidant-rich foods, it is plausible that the consumption of these foods will result in an enhanced antioxidant system capable of reducing exercise-induced oxidative stress and being an advantage when meat is not eaten [60]. Antioxidants are often considered as one possibility of potential improvement and among the most common sport supplements used by athletes [41-43,45,60]. However, positive effects have not been conclusively proven [41]. Indeed, there is a growing body of evidence that the appearance of free radicals (the antagonists) in skeletal muscle, also fulfill important physiological functions in cells, and that the right balance between antioxidants and free radicals is necessary for the desired physiological adaptations [38,41,45,62]. Focusing back on vegetarian diet, interestingly there were also no group differences between 20 participants adopting a ovo-lacto vegetarian diet compared to maintaining the usual omnivorous diet in terms of muscle buffering capacity in conjunction with sprint training for five weeks [11,60].

During Ultra-Running - An Adequate Performance is Possible While on a Vegetarian Diet: Interestingly, a current study reported that ultra-runners were almost twice as likely to report following a vegan/vegetarian diet than half- and full-marathoners [63]. This is special due to the fact that hints exist that prevalence of vegetarians and vegans participating in running events are estimated to be less compared to the respective proportion of vegetarians and vegans to the general population [64].

Interestingly it was shown by Turner-McGrievy et al. [63] that there was no difference in diet quality between ultra and other runners but vegan and vegetarian runners had higher diet quality scores than non-vegetarian runners, whereby these findings point to an interconnectedness between long distance running, diet, and diet choice [63]. One further question that arises when addressing effects of dietary habits respectively vegetarian diet on performance is an adequate supply possible only with vegetarian diet in ultra-races? During an endurance run (1,000km in 20 days) it was investigated whether an ovo-lacto-vegetarian diet could cover the nutritional requirements of endurance athletes, whereby a regular western diet was used as reference [65]. Both diets were offered with an energy content of 18000km per day and an energy percentage of carbohydrate: fat: protein of 60: 30: 10 [65]. The runners were divided into two dietary groups according to their usual dietary habits [65]. The results of the 55 participants who completed the race show that runners from both groups had the same intake of energy, carbohydrate, fat and protein [65]. Runners of the ovo-lacto vegetarian diet group consumed more dietary fiber and polyunsaturated fatty acids as well as less cholesterol [65]. With the exception of sodium chloride and cobalamin, the intake of the calculated minerals and vitamins was higher in the vegetarian diet and exceeded the official recommendations [65]. This study shows that vegetarian with a high nutrient density is adequate to cover the nutritional requirements of endurance-athletes [65].

In 110 well-trained participants of a 1000-km running competition lasting for 20 days hematological parameters, iron metabolism, and their respective changes during the race were investigated [66]. Thirty-nine men and 11 women were accustomed to wholesome vegetarian food (ovo-lacto-vegetarian), 52 men and 8 women consumed a conventional western diet [66]. In each group 50% of the runners finished the race [66]. Before the competition started red blood cell count, hematocrit, and hemoglobin were on average below the values observed in the normal population in all groups [66]. Both male and female runners consuming the wholesome diet showed significantly lower ferritin values than those on a western diet [66]. During the first days of the competition hemolysis occurred leading to increased serum concentrations of bilirubin and iron and decreased Haptoglobin levels [66]. Hemoglobin concentrations showed a constant decrease during the race [66]. Serum ferritin concentration rose about twofold within the first days and then decreased again without reaching pre-race levels [66]. Serum iron concentrations showed a significant decrease between days 3 and 6 [66]. Iron loss was caused by hematuria (25% of all urines tested), gastrointestinal blood loss (10% of all stool specimens tested), and by sweating (4.5 micrograms iron/dl sweat) [66]. Results from Seiler et al. [66] suggest that especially in female long-distance runners it may be difficult to supply sufficient quantities of iron with a vegetarian diet [66].

In a further cross-sectional study, elite vegetarian and omnivore adult endurance athletes for maximal oxygen uptake (VO_2 max) were compared [11]. Although total protein intake was lower among vegetarians in comparison to omnivores, protein intake as a function of body mass did not significantly differ by group) [11]. VO_2 max differed for females by diet group (vegetarian versus not) but not for males [11]. These data for normal running performance in contrast to findings from ultra-races suggest that vegetarian diets do not compromise performance outcomes and may even facilitate aerobic capacity in athletes [11].

In principle, it has been shown by Veleba et al. [67] that it is possible to increase mitochondrial oxidation significantly by a diet with a low glycemic index [67]. In a trial effects of a vegetarian and conventional diet with the same caloric

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restriction on physical fitness and after 12 weeks of diet plus aerobic exercise in 74 patients with type 2 diabetes different parameters were compared [67]. An individualized exercise program was prescribed to the participants and was conducted under supervision, while physical fitness was measured by spiroergometry and indirect calorimetry was performed at the start and after 12 weeks [67]. Maximal oxygen consumption (VO_2 max) significantly increased by 12% in vegetarian group, whereas no significant change was observed in Control groups [67]. Maximal performance (Watt max) increased significantly by 21% in vegetarian whereas it did not change in Control [67]. Results indicate that vegetarian diet yield more effectively to improvement in physical fitness than only aerobic exercise programs [67]. Concerning whole caloric intake it is to mention that Athletes consuming less than 2000 calories a day may have difficulty meeting nutrient needs, particularly for iron and calcium [40,68]. Interestingly also on muscle cell level different adaptions are described how muscle cells can adapt to fat as fuel [47]. Furthermore following 2h of exercise, subjects were fed one of three diets (15%, 40% or 70% fat energy) directly influencing proper restoring [69]. Initial IMCL concentration was reduced to 70% after exercise and the rate of replenishment was minimal with the low-fat and much higher with both higher fat diets whereby Glycogen and IMCL replenishments were inversely correlated [69]. Furthermore, focusing back on hemostatic parameters influences of vegetarian diet on acid-base metabolism can be mentioned for example no clear effects was detected when investigating effects of low-protein vegetarian diet on blood acid-base status and performance during submaximal and maximal aerobic cycling [70]. Focusing on laboratory parameters plasma concentrations of lipids, lipoproteins, glucose, insulin, C-reactive protein, blood pressure (BP), and carotid artery intima-media thickness were significantly lower in the low-calorie low-protein vegan diet and runner groups than in a group following a Western diet [29]. Also concerning hypertonia good effects are described e.g. both systolic and diastolic BP were significantly lower in the low-calorie low-protein vegan diet group than in BMI-matched endurance runners and Western diet group; BP values were directly associated with sodium intake and inversely associated with potassium and fiber intake [29].

Trying to come to general recommendations effects of a vegetarian diet were analyzed and it was mentioned than when well-planned, appropriately supplemented vegetarian diets appear to effectively support athletic performance; provided protein intakes are adequate to meet needs for total nitrogen and the essential amino acids, plant and animal protein sources appear to provide equivalent support to athletic training and performance; but particularly women vegetarians are at increased risk for iron deficiency, which may limit endurance performance; and vegetarians in general have lower mean muscle creatine concentrations than do omnivores, and this may affect supramaximal exercise performance [71]. Because their initial muscle creatine concentrations are lower, vegetarians are likely to experience greater performance increments after creatine loading in activities that rely on the adenosine triphosphate/phosphocreatine system and a supplementation might be helpful [33,71].

Further hints can be derived by the study of Haider et al. [48]. The meta-analysis which combined data of 24 cross-sectional studies showed that adult vegetarians have significantly lower serum ferritin levels than their non-vegetarian controls [48]. Inclusion of semi-vegetarian diets did not change the results considerably [48]. The effects were more pronounced in men than in both premenopausal women and all women, respectively [48]. To sum up results showed that vegetarians are more likely to have lower iron stores compared with non-vegetarians [48]. However, to make general recommendation for all to increase iron intake is probably worse, since high iron stores are also a risk factor for certain non-communicable diseases, such as type 2 diabetes [48].

Furthermore one aspect to focus is serum lipid concentrations, including apolipoproteins A-I and B, in different diet groups [28]. Serum concentrations of total, and high-density lipoprotein cholesterol, as well as apolipoproteins A-I and B were measured, and serum non-HDL cholesterol was calculated [28]. Vegans had the lowest body mass index and the highest and lowest intakes of polyunsaturated and saturated fat, respectively [28]. After adjustment for age, alcohol and physical activity, compared with meat-eaters, fish-eaters and vegetarians, serum concentrations of total and non-HDL cholesterol and apolipoprotein B were significantly lower in vegans [28]. Serum apolipoprotein A-I concentrations did not differ between the diet groups [28]. In this study, which included a large number of vegans, serum total cholesterol and apolipoprotein B concentrations were lower in vegans compared with meat-eaters, fish-eaters and vegetarians [28]. A small proportion of the observed differences in serum lipid concentrations were explained by differences in BMI, but a large proportion is most likely due to diet [28].

The current evidence focuses on aspects of different nutritional styles - e.g. iron or other trace elements homeostasis. Encompassing analyses with longitudinal focuses analyzing longer times periods with effects of different nutritional styles are missed or sparse. As a consequence clear and straight forward evidence is based on the current literature to be taxed as fragmented.

Evidence from Meat Eating on Steroids and Immune System: Interestingly, adoption of an ovo-lacto vegetarian diet for six weeks did not significantly affect endurance performance among a group of trained, male endurance athletes, in spite of a decrease in total testosterone while on vegetarian diet [72]. The vegetarian diet resulted in a lower total Testosterone level compared with the Meat diet [72]. However findings are relativized due to that Serum free testosterone, however, did

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not differ significantly during the 6 week dietary intervention periods and neither did serum concentrations of sex hormone binding globulin, dihydrotestosterone, dehydroepiandrosterone sulphate, 4-androstenedione, estrone, estradiol, estrone sulphate, or gonadotropins did not significantly change [72]. In conclusion, 6 week on a ovo-lacto vegetarian diet caused a minor decrease in total testosterone and no significant changes in physical performance in male endurance athletes compared with 6 week on a mixed, meat rich diet [72].

Furthermore, steroids such as Cortisol influence immune system activity such as T-cell regulation. The influence of a vegetarian diet versus a meat-rich Western diet on in vitro measures of immune function was studied in endurance athletes [73]. One diet was a mixed meat-rich diet (M) prepared with 69% animal protein sources, whereas the other diet (V) was a lacto-ovo vegetarian diet prepared with 82% vegetable protein sources [73]. Interestingly, the number of specific immune cells such as CD3+ (pan T-cells), CD8+ (mainly T suppressor cells), CD4+ (mainly T helper cells), CD16+ (natural killer cells), and CD14+ (monocytes) was similar after the two different diets [73]. Furthermore, positive aspects of exercise on inflammation in general were described [74].

Conclusion

The evidence concerning the direct relationship on running performance between vegetarian diet or omnivore diet is sparse. However, some hints can be found in the evolution of the early homo, where it was normal to eat meat. As a consequence, humans should be adapted for meat eating and meat eater should not have a disadvantage compared to runners on a vegetarian diet. As the great Dobazionous Theodazski once impressively mentioned: '*Nothing in biology makes sense except in the light of evolution'* this probably also counts for meat eating [1-4,75]. Therefore it becomes clear, that humans evoked as hunters and gatherers with the necessity to eat meat [1-4, 75]. Times of successful hunting were followed by unsuccessful times with no meat [1-4, 75]. To make recommendations based on the prior mentioned it becomes clear, that meat eating versus not eating is first only one element determining running performance, second other elements such as training regime or genes are as important and third other nutritional habits (junk food versus high-quality diet) are also important. For example higher intake of fruit and lower intake of meat was further associated with lower BMI and more walking activity in a large sample of humans maybe implying feedback effects of physical activity on nutritional habits implying the underlying complex mechanism [31]. Although meat eating was normal, it becomes evident, that this does not count anymore today with for most of the population of Western societies always having adequate access to all classes of nutritionals [1-4, 76]. Access to nutrition from all continents is today possible due to global markets and international trade. The increased access to different food classes such as e.g. Soy Beans or Tofu allows covering especially the often mentioned insufficient protein intake when on vegetarian diet.

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