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# Fueling Sport Performance: Increasing Awareness in Female Collegiate Vegetarian Athletes

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# FUELING SPORT PERFORMANCE: INCREASING AWARENESS IN FEMALE COLLEGIATE VEGETARIAN ATHLETES

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## ABSTRACT


**FUELING SPORT PERFORMANCE: INCREASING AWARENESS IN FEMALE COLLEGIATE VEGETARIAN ATHLETES**

**Rachael Irene Marie Sofie**

Vegetarian diets, when well-planned out, have been shown to meet the needs of female athletes. Although the lifestyle provides many benefits, it does not come without risk. Women athletes, in particular, are of the greatest concern. Energy restriction is common among female collegiate athletes. Because athletes are already converting to and practicing a vegetarian lifestyle, it is necessary that athletes and related sport professionals become aware of the risks and benefits of a vegetarian lifestyle. By increasing knowledge among related personnel, athletes can use vegetarianism as a performance enhancer. Outlining possible implications of the lifestyle will allow female collegiate athletes the ability to convert to and maintain the lifestyle healthfully. The handout will provide guidelines to optimize vegetarian meal planning by eliminating risk for nutrient deficiencies and ultimately increasing sport performance

# CHAPTER 1

# INTRODUCTION

In past years, researchers have struggled to come to a conclusion regarding the substantiality of the vegetarian diet and its effects on athletic performance (Allen, 2008; Willis, Peterson, & Larson-Meyer, 2008). Recent studies have provided evidence that vegetarian diets, when planned appropriately can, in fact, provide necessary energy as well as sufficient macronutrient intakes to benefit overall health and fuel athletic performance (Borrione, Spaccamiglio, Salvo, Mastrone, Fagnani, & Pigozzi, 2009b; Larson-Meyer, 2009; Rodriguez, DiMarco, & Langley, 2009b; Tipton & Witard, 2007).Whether or not one agrees with the lifestyle, professionals in allied health care and sports science fields must become more knowledgeable in this area in order to better serve their positions as coaches, athletic trainers, personal trainers, strength and conditioning specialists, and sport nutritionists. By combining current findings and creating educated assumptions based on evidence discovered thus far, this goal can be obtained.

The number of people practicing a vegetarian lifestyle today has grown to an estimated 4.9 million adults in America alone, accounting for 2.3% of the total population (Bellows, 2012). It is probable that a number of those already practicing vegetarianism are health-conscious athletes, and that, as the population continues to increase, it will develop further in the athletic realm, as well. Compared to other ideas currently on the market regarding nutrition and performance enhancement, it seems that the risks and benefits of vegetarianism have been somewhat neglected. Athletes who are vegetarian, in particular, need more education on proper nutrient intake in order to ensure they are consuming adequate energy to reach optimal performance (Volpe, 2007). Although the research has likely been conducted, it seems that an applicable resource of combined information for college athletes to utilize would be beneficial. Like all lifestyle changes, vegetarianism is not taken on without risk, specifically in female athletes, where disordered eating to maintain a low body weight is quite common (Ducher, Turner, Kukuljan, Pantano, Carlson, Williams, & De Souza, 2011). A combination of the current findings will allow the already existing population that has taken on the lifestyle to do so as safely as possible. By safer, one can presume that it would be risk-preventative and beneficiary to athletes and coaches alike. It will also allow professionals to prepare for the possible continued increase in vegetarian athletes for the future.

The project will maintain its focus by defining lacto-ovo-vegetarianism and outlining possible implications of a vegetarian lifestyle as well as the benefits it can provide athletes. The conclusion of the literature review includes the production of an easy-to-read, reference handout on safe practices for vegetarians to follow. It can be useful for athletes with little knowledge on the subject and can serve as a set of guidelines to follow when adapting to the lifestyle as well as to safely maintain it. Concluding the review of literature, the hope is that an informative handout would be just the start of more research-based literature to come for athletes and sports professionals to use in the future. Furthermore, coaches and athletes will have the information to use vegetarianism as a performance enhancer. It is imperative that studies continue to be conducted, including, but not limited to, long-term effects of vegetarianism on sports performance, long-term effects on life outside of sports, and the specific risks and benefits to other special populations, including male athletes.

# CHAPTER 2

## A REVIEW OF LITERATURE

A typical vegetarian diet is one that excludes all types of meat and fish and tends to be designed around fruits, vegetables, nuts, whole grains and legumes (Fraser, 2009). Lacto-ovo-vegetarianism has been defined as a diet focused on plant foods but also including dairy products as well as eggs (Bellows, 2012). It is the type of vegetarianism that is most often practiced by people, most likely because it is easy to adapt to and not extremely limiting when compared to other forms of vegetarianism (Bellows, 2012). Lacto-ovo vegetarianism may be the favorite for women athletes due to the fact that it is also the version of plant-based diet that tends to have the least risk for nutrient deficiencies (Venderley & Campbell, 2006). In the past, plant-based diets have raised concern for health professionals when considering adequate levels of many different nutrients—concerns such as amenorrhea and impaired nutrient statuses with regard to iron, vitamin B12 and vitamin D deficiencies (Allen, 2008; Borrione, et al., 2009b; Willis, et al., 2008). However, when comparing lacto-ovo vegetarians to other degrees of vegetarianism, these herbivores have a more varietal selection of nutrients due to a wide array of plant foods, dairy products and eggs able to be consumed. The definition of other types will be briefly outlined, but lacto-ovo-vegetarianism will be the specific diet referred to throughout this review. Figure 1 displays different types of vegetarian diets ranging from fish consumers to the strict vegan category in which any product derived from an animal is completely avoided (Craig & Mangels, 2009)

Endurance athletes are especially attracted to the lifestyle because vegetarian diets have the potential to be loaded with necessary carbohydrates, containing higher fiber, vegetable, fruit, antioxidant and phytochemical content than the traditional American diet (Rodriguez, et al., 2009b). Furthermore, due to its high fiber content and more nutritious yet less calorically dense carbohydrate options, runners and other endurance athletes are able to manage optimal weight without risking malnutrition (Rodriguez, et al., 2009b).

**NUTRITION AND SPORT PERFORMANCE**

The purpose of nutrient intake is to supply the body with fuel needed to perform optimally. The key points to achieve this goal include proper fluid intake in order to prevent dehydration and a diet high in carbohydrate intake that provides energy, has sustainable protein levels, and is low in fat (Rodriguez, DiMarco, & Langley, 2009a). None of these requirements however, can come at the cost of maintaining a desirable body weight and proportions of lean body mass. Energy expenditure is much higher in athletes compared to the general population due to increases in physical activity as well as higher percentages of fat-free mass totaling a greater basal metabolic rate (Lee, M. G., Sedlock, Flynn, & Kamimori, 2009). Specific energy requirements are different for every individual and are determined based upon age, gender, sport, training intensity and composition (Rodriguez, et al., 2009a). In order to determine how an athlete can be vegetarian and use it to enhance their competition level, it is important that the factors that directly affect performance are clear.

According to the American College of Sports Medicine (ACSM), not only does athletic performance benefit from high quality nutrition, but general physical activity and recovery are optimized as well (Rodriguez, et al., 2009a). Just as no two females in the general population are exactly alike, some athletes may require situation-specific adjustments to accommodate their unique scenario. The following discussion will provide an outline for general recommendations for all nutrients necessary for female athletes when seeking optimal performance.

## ENERGY BALANCE

Female athletes are the focus of this review as they are more likely to practice vegetarianism as a tool to reach an optimal body weight (Ducher, et al., 2011). Many sports may not require a differentiation between females and males regarding energy intake in comparable sized athletes (Volpe, 2007). Energy restriction, however, has become a common trend among female athletes in an uneducated attempt to increase performance by reducing body fat (Volpe, 2007). Restricting caloric intake will lead to a negative energy balance, which often results in unnecessary weight loss and disruptions in normal endocrine function (Beals & Hill, 2006). One study completed in the past included female gymnasts and runners and aimed to assess lean body mass of athletes who took in less than their required calories to meet daily energy expenditure. Body composition of these athletes resulted in a higher percentage of body fat in both aerobic and anaerobic athletes (Deutz, Benardot, Martin, & Cody, 2000). More recently, researchers have continued to find evidence to support those findings. Burke et al. (2006) agreed that decreasing energy intake causes the body to use fat and lean muscle tissue for its primary fuel, decreasing overall lean mass, which will ultimately result in decreased strength, muscle endurance, immunity and musculoskeletal dysfunction. The lower threshold regarding energy availability per day for most women has been agreed to be at about 30 $kcal \cdot kg^{-1}$ of fat free mass (Rodriguez, et al., 2009b).

Achieving optimal energy balance results when an equal amount of energy is taken in to equal that which has been expended (Beals & Hill, 2006). The increase in energy expended by the athlete must be compensated for by increasing overall energy intake. Athletes can obtain energy balance by taking in energy from food, supplements and fluids equal to the sum of expended energy provided by basal metabolic rate, the thermal effect of eating and physical activity (Rodriguez, et al., 2009b). By maintaining their energy balance, athletes can better control their body composition and increase their level of performance.

Body weight has a significant impact on speed, endurance and power. Strength and agility, both just as necessary for optimal performance, are significantly impacted by body composition (Ackland, Lohman, Sundgot-Borgen, Maughan, Meyer, Stewart, & Muller, 2012). Which sport the female plays typically determines her desired physique and body composition goals. Women are estimated to need at least 12% body fat to meet general health requirements (Rodriguez, et al., 2009a). Athletes of varying sports may need the minimal or more depending on their training duration and intensities. In the case of extreme calorie restriction to obtain a certain physique or in attempt to increase performance, the opposite result typically occurs. Decreasing fat as well as muscle has not always had a positive effect on reaching goals of an ideal physique for sport performance (Heymsfield, Pietrobelli, Wang, & Saris, 2005). For at least a decade, researchers have concluded that restricting calories has been shown to have a negative impact on vitamin and mineral status in female athletes, possibly leading to greater setbacks such as amenorrhea and disordered menstrual cycles (Beals & Hill, 2006).

## MACRONUTRIENTS

Upon assuming optimal caloric intake, the next focal point in fueling for performance is macronutrient distribution. Regarding carbohydrates, it is suggested that

40-65% of calories should come from complex sources in order to maintain optimal glycogen stores as well as protect immune and antioxidant systems (Rodriguez, et al., 2009a). The main inhibitor of exercise performance is glycogen depletion because it ultimately results in fatigue (Hawley & Burke, 2010). Therefore, glycogen stores must be consistently refilled in order to obtain optimal exercise capacity.

When considering fat intake in order to achieve optimal levels for female athletes, one should consume 25-30% of one's daily caloric intake from fat (Manore, 2005). Fat is a primary energy source during rest and exercise and provides twice as much energy as carbohydrate or protein per gram (Manore, 2005). Dietary fat also provides the body with essential fatty acids imperative for metabolic processes and function (Manore, 2005).

Dietary protein, important for cell-makeup, contributes to the synthesis of muscle tissue while minimizing the loss of amino acids during oxidation (Gaine, Pikosky, Bolster, Martin, Maresh, & Rodriguez, 2007). Although all females metabolize protein at different rates in comparison to one another, it is recommended to consume at least 1.2-1.7 $g \cdot kg^{-1}$ per day, relative to body weight (Phillips, Moore, & Tang, 2007). In order to repair, maintain and synthesize skeletal muscle tissue, one must be taking in adequate amounts of protein in one's diet (Tipton & Witard, 2007).

**MICRONUTRIENTS**

All micronutrients are of equal importance. However, the vitamins and minerals that raise concern regarding the female athlete population are iron, B-complex vitamins, calcium, vitamin D and zinc (Robinson-O'Brien, Perry, Wall, Story, & Neumark-Sztainer, 2009). Vitamins and minerals are responsible for an unending list of functions such as energy production, maintaining bone health and immunity, and protecting the body from the oxidative damage resulting from physical activity (Cannell, Hollis, Sorenson, Taft, & Anderson, 2009; Strobel, Peake, Matsumoto, Marsh, Coombes, & Wadley, 2011). To detail further, micronutrients are involved with muscle synthesis during recovery and injury states (Strobel, et al., 2011). Vitamin and mineral consumption should be increased in athletes in order to decrease turnover of these vital nutrients in response to training (Strobel, et al., 2011).

## BENEFITS OF VEGETARIANISM

Studies considering vegetarian athletes are still limited, but it is no longer a question that thoroughly planned-out, plant-based diets meet the increased energy needs of athletes (Tipton & Witard, 2007). Well-balanced vegetarian diets offer many nutritional benefits when compared to carnivorous meals. Fruits, vegetables and legumes are typically high in vitamins and minerals. Fortified foods such as milk can be a good source of substantial amounts of nutrients as well (Sazawal, Dhingra, Dhingra, Hiremath, Sarkar, Dutta, Menon, & Black, 2010). Studies have shown these types of foods to be related to decreased risk for many chronic diseases including ischemic heart disease, obesity and its comorbidities, as well as many types of cancers (Craig, 2010).

Removing all meat and fish from dietary intake is positively correlated with decreased intake of saturated fat, decreased cholesterol intake and higher overall levels of carbohydrate (Fraser, 2009). By comparison, vegetarians have lower body mass index (BMI) and cholesterol levels than non-vegetarians, and tend to be less hypertensive (Fraser, 2009). They also have lower incidences of type 2 diabetes, prostate and colon cancers and a decreased mortality rate due to a lower risk for developing heart disease (Fraser, 2009). Surprisingly, even over a decade ago, research showed that, despite removing meat from their daily menu, most vegetarians were actually meeting or exceeding the protein requirements that existed for athletes (Cox, 2000). A wider variety of meat-free protein choices available today would likely allow athletes to meet their protein requirements just as easily. Vegetarian sources of protein are typically lower in calories and fat, consisting of foods like textured vegetable protein, tofu, eggs, nuts, peanut and other nut butters, as well as low-fat and/or skim dairy products such as milk, cheese and yogurt (Bellows, 2012).

Performance wise, it seems that vegetarianism is the type of diet that has the potential to take athletes to the next level. Athletes today have a wide variety of choices when it comes to meat replacement options compared to selection years ago. Accessibility to fresh fruits and vegetables and protein supplements is much more feasible today compared to what it may have been in the past; however, even then, it had not been proven that removing meat from the diet provided any negative impact on performance (Fogelholm, 2003). In fact, a recent study including over half a million people showed that those who ate more red and processed meats had a higher mortality rate, including cancer and cardiovascular disease mortalities (Sinha, Cross, Graubard, Leitzmann, & Schatzkin, 2009). Vegetarian diets are found to be high in fiber and low in fat and saturated fat--three factors that significantly predict sustained weight loss and maintenance of a lower body mass index (Craig, 2010).Typical vegetarian foods tend to be lower in overall calories when compared to the bulk of a meat-eater's diet, making it easier to get sufficient nutrients while controlling weight. Although the majority of intake tends to be low in fat, the main energy source for vegetarians is in the form of calories from complex carbohydrates (Villegas, Gao, Yang, Li, Elasy, Zheng, & Shu, 2008), which is likely the reason endurance-based athletes are drawn to the lifestyle. During training and performance, increased physical activity leads to dehydration when the glycogen stored in muscle and liver are completely depleted. As a result, energy stores are depleted, exercise capacity is diminished and athletic performance is significantly decreased (Abdel-Hamid, 2003). It is imperative that athletes constantly keep their bodies stored with glycogen. By taking in carbohydrate every single meal, they are more prepared to keep stores from reaching depletion. Meat-eaters are susceptible to practicing reduced carbohydrate diets, which can lead to dangerous results. Practicing vegetarianism for this reason alone, providing oneself with a diet rich in complex carbohydrates, can result in sustained energy beyond that of the competition.

Planning meals to include these types of complex carbohydrates likely assume that it is high in fruits and vegetables--a must for any athlete. Plants are low in calories but nutrient dense providing the athlete with the essential vitamins and minerals to properly fuel their performance for the next level (Heber, 2004). Plants have been considered for years to be magical foods known to provide over 25,000 phytochemicals that cannot be provided in full capacity by any other source (Heber, 2004). It is no question the type of oxidative damage that is done through physical activity alone. Physical activity has long been shown to produce free radicals and increase the induction of oxidative stress that ultimately results in damage to tissue (Davies, Quintanilha, Brooks, & Packer, 1982). For athletes, this means damage to the body that can prevent muscle synthesis and can increase susceptibility to sickness. Oxidative stress is further defined as “an imbalance between free radical production and the antioxidant defense mechanisms of a biological organism that results directly or indirectly in cellular damage" (Jenkins, 2000). Therefore, it is not optimal for athletic performance and athletes are even susceptible to decreased immunity as a result of regular training (Venkatraman & Pendergast, 2002). The unavoidable damage to be done can be limited with increased fruit and vegetable consumption, ultimately resulting in an elevated intake of dietary antioxidants (Perez-Vizcaino, Duarte, & Andriantsitohaina, 2006). Stimulating the immune system, antioxidants are known as scavengers of oxidative enzymes, lowering oxidative stress and decreasing inflammation (Root, McGinn, Nieman, Henson, Heinz, Shanely, Knab, & Jin, 2012). One particular study suggested that athletes who regularly endure up to 40 minutes of acute high-intensity exercise likely need an increased intake of antioxidants. Examining further details of this study reveals that taking in more antioxidants in the form of fruits and vegetables would decrease oxidative stress during physical activity (Watson, Callister, Taylor, Sibbritt, MacDonald-Wicks, & Garg, 2005). Therefore, vegetarian athletes can practice and perform harder and longer than their carnivorous competition over time. Current conclusions of previous studies have provided evidence that oxidative stress not only affects athletic performance but also may play a role in the development of chronic diseases (Root, et al., 2012). This type of damage is directly linked to fatigue, once stated as the ultimate precursor for lack of motivation, energy, and ability to perform (Barclay & Hansel, 1991). Free radicals increase risk for muscle damage by overwhelming defenses of cellular antioxidants (Sachdev & Davies, 2008) which has shown in past research to drastically reduce immune function (Lee, C. Y. & Man-Fan Wan, 2000).

A strong role in avoiding the inevitable downfalls of training and the toll it takes on an athlete's body lies in the consumption of fruits and vegetables. Nutrients found in fruits and vegetables have been shown to improve oxidative stress (Perez-Vizcaino, et al., 2006) and can therefore have a positive effect on exercise performance. Vegetarians create a defensive team for their bodies by consuming various antioxidant containing plants on a regular basis to protect them from the production of free radicals. Furthermore, vegetarians consuming seeds, nuts and fruit juices create an even stronger team to defend themselves against pathological conditions related to oxidative stress (Craig, 2010).

Athletes who consume more meat generally eat fewer fruits and vegetables when compared to vegetarians (Wang & Beydoun, 2007). Assuming vegetarians implement other sources of protein in their diets, they are not missing out on anything by discarding meat from their daily intake. Meat typically tends to be not only high in fat but high in dangerous saturated fat and cholesterol as well (Micha, Wallace, & Mozaffarian, 2010). Furthermore, compared to their omnivorous competition, women who consume higher intakes of meat also take in more calories. Increased calorie intake is directly linked to a higher BMI, waist circumference, and chance of obesity (Wang & Beydoun, 2007).

One particular study showed exactly how this lifestyle was also associated with a specific 22% increase in risk of mortality from CVD when compared to a diet high in plants, legumes and whole grains (Heidemann, Schulze, Franco, van Dam, Mantzoros, & Hu, 2008). Meat consumption connected to an increased intake of calories from fat, saturated fat and excess calories overall as well as a reduced intake of vegetables link it further to an increased risk for cardiovascular disease and type 2 diabetes (Vang, Singh, Lee, Haddad, & Brinegar, 2008).The current findings have left some researchers to be advocates of the vegetarian lifestyle in preventing obesity and other chronic diseases that all impact an athlete's ability to perform (Craig, 2010).

## RISKS OF VEGETARIANISM

In order to reap the benefits of a vegetarian diet, one must be aware of the risks in order to proactively work to prevent them. A vegetarian lifestyle is not taken on without risk. Being proactive is the key to avoiding possible deficiencies and utilizing nutrition in the best way possible. Athletes as an entire population are at different risks for nutrient deficiencies than the general population, whether vegetarian or not. The most significant guideline for all athletes is that an increase in caloric expenditure must be replenished by increased energy intake to ensure the body is able to adequately adapt to exercise. Because vegetarian diets tend to contain an increased fiber content when compared to normal diets containing meat, they run a higher risk of being deficient in energy as a whole (Craig, 2010). Conclusions from Winston's study also provided evidence that a poorly planned vegetarian diet is the only type that posts the potential to provide unacceptable energy intake and/or insufficient amounts of daily nutrients (Craig, 2010). An athlete who is not getting enough energy will compromise their performance by allowing stored fat and synthesized lean mass to be used as a primary fuel source. The end result in this being a detrimental decrease in strength and endurance, and ultimately, decrease in sport performance (Burke, Loucks, & Broad, 2006).

Restrictive eating habits in female athletes raise concern for health-related professionals no matter how they originate. Researchers agree that athletes who are at the highest risk for decreased energy availability, and thus the risks that follow, are those individuals who restrict overall intake, exercise for prolonged periods, those who limit certain foods and who are vegetarian (Craig & Mangels, 2009). It seems easy for motivated female athletes to fall into those categories due to the lack of overall energy intake, leading to glycogen depletion, impaired performance followed by decreased reproductive and skeletal function (Loucks, Stachenfeld, & DiPietro, 2006).

Specifically in female athletes, decreased energy intake has the potential to turn into the Female Athlete Triad. In this serious disease state, low energy availability leads to disruptions of normal menstrual function and/or amenorrhea, or the absence of menstrual cycles for at least 3 months. These types of irregularities in the menstrual cycle can lead to decreased bone mineral density and ultimately may result in osteoporosis and a substantial increased risk for fractures (Nattiv, Loucks, Manore, Sanborn, Sundgot-Borgen, & Warren, 2007).

Low energy availability in female athletes has been found to be the key contributor to the female athlete triad with negative effects occurring with energy intake at less than 30 calories per kilogram of body weight (Nattiv, et al., 2007). Converting to a vegetarian lifestyle could further decrease energy intake due to lack of high fat energy consumption associated with consuming meat. Very low fat diets and/or avoidance of all animal protein may lead to a deficiency of essential fatty acids (Rodriguez, et al., 2009a). Athletes whose dietary habits include elimination of one or more food groups are at increased risk for micronutrient deficiency (Volpe, 2007). Requirements would be higher in athletes due to their participation in intense physical activity. If a diet is not thoroughly planned, micronutrients typically found readily available in sources of animal protein may be decreased in vegetarians. Some of these include vitamins B12 and D, calcium, iron and zinc (Rodriguez, et al., 2009b). However, non-vegetarian athletes on any low fat diet are prone to these deficiencies as well. Iron status is one specific mineral of increased concern in female vegetarian athletes due to its low bioavailability in non-heme plant sources. However, iron status seems to be low in many athletes, women in particular, whether vegetarian or not. One study involving national basketball players, male and female, and their nutrition status regarding iron found that, of 103 basketball players total, 25% of the females were iron depleted and 38% were deficient (Dubnov & Constantini, 2004). The research concluded with the recommendation of iron screening along with nutritional counseling for all athletes (Dubnov & Constantini, 2004). More recently, iron status among female athletes still seems to be an issue and may be related to disordered eating in order to reach a reduced weight and leanness (Silva, 2008). Certainly blood loss through the menstrual cycle may be one of the possible routes to anemia in women athletes. Vegetarian athletes could be at increased risk for this nutrient deficiency based on evidence that most of their iron food sources do not contain the type of iron absorbed best by the human body. Heme-iron sources, found in animal-based foods, are more readily absorbed by the body (Rodriguez, et al., 2009b). Should the mineral not be fully absorbed, certain studies have suggested that iron-depleted women have decreased endurance and energy levels (Della Valle & Haas, 2012).

Another deficiency found commonly in all athletes as well as vegetarians throughout all age groups is in vitamin D (Craig, 2010). Research shows this specific vitamin is substantial for immune function and the reduction of inflammation (Craig, 2010). Furthermore, evidence indicates that a low status of vitamin D typically relates to several different chronic and autoimmune diseases (Holick, 2008). Results of studies attempting to identify the extent of this deficiency have shown that most athletes likely maintain normal levels during the months of fall and spring.

Controlling for all these risks is likely a challenge for athletes, in general, but may appear to be an even greater one for female vegetarian athletes. Making oneself aware of the risks is the first step to disease prevention. Preparing a defense against performance inhibitors is only a small part of the plan to rise above the rest of the competition. Becoming a vegetarian is no simple task, but neither are breaking individual school records and winning NCAA championships. If it were easy, every athlete would achieve it. Adopting a vegetarian lifestyle takes a great deal of thought and preparation. Like learning a new skill, performing repetition after repetition in order to perfect a new play, and training early mornings and late nights, taking on a vegetarian lifestyle takes effort and hard work. It is not a performance enhancer one can purchase at the local health store. It must be researched, prepared, adjusted and practiced every day. Great athletes train long and hard and must take the same approach to this lifestyle, if they so choose, for it to be the deciding factor to take them to the next level.

## PROACTIVE VEGETARIANISM-TAKING PERFORMANCE TO THE NEXT LEVEL

Figure 3 illustrates nutrients commonly deficient in athletes and/or vegetarians and their vegetarian sources.

Athletes considering this lifestyle change must constantly make themselves aware of daily nutrient intake, a big key to ensure athletes are getting all of the benefits of a healthy diet to improve athletic performance during training, practice, recovery and competition. Several studies have suggested the use of a food journal as a great way to manage intake (Clark, Reed, Crouse, & Armstrong, 2003; Iglesias-Gutierrez, Garcia-Roves, Rodriguez, Braga, Garcia-Zapico, & Patterson, 2005; Leblanc, Le Gall, Grandjean, & Verger, 2002; Magkos & Yannakoulia, 2003). Tracking one's daily calorie consumption as well as specific nutrient amounts can substantiate that the athlete is getting his or her goal nutrients each day, and can also be used as a reference to look back on (Volpe, 2007) Sitting down with a team sports nutritionist or athletic trainer, athletes can discuss where they need to make adjustments to be sure they are at their very best to perform when competition day arrives.

The third benefit of a food log is that it can allow athletes the opportunity to plan out their meals ahead of time and aim to meet their nutrient goals each day. By planning it out before actually consumption, athletes can ensure they are prepared for training ahead of time. They are able to recover from intense training and practices by providing fuel to their bodies with the optimal amount of every necessary nutrient.

In order to determine an accurate amount of energy to consume for each individual athlete, one must consider energy balance. Equations that estimate basal metabolic rate can be used to provide a baseline when attempting to estimate calorie intake needs. A widely accepted predictive equation includes the Harris-Benedict equation (Harris & Benedict, 1918). Female athletes often tend to take in less energy than they should, and body composition plays a key role in exercise performance but may not be easy to precisely measure (Rodriguez, et al., 2009a). Coaches should provide a range of optimal percentages for their athletes to achieve rather than encourage a specific body fat number (Rodriguez, et al., 2009b). Athletes can then be held accountable by tracking their daily intake and reporting to a team nutritionist, trainer, etc. The following will demonstrate efficient steps an athlete can take to ensure they are meeting their needs for each category of nutrients.

Athletes should direct their calorie consumption based on creating optimal energy balance. Balancing nutrition is highly important for athletes to properly condition their bodies and recover from the damages of exercise and also to prevent injury (Rodriguez, et al., 2009a). Athletes should use the Harris Benedict equation (Figure 2) to calculate their own baseline and ensure they are consuming enough energy to fuel each workout, training session and competition that they may endure (Harris & Benedict, 1918).

Over a decade ago, the most common mistake relating to energy intake in female athletes occurred when the athlete was more concerned with reaching a specific weight or "look" rather than focusing on overall body composition (Manore, 2009). Even more recently, it is still not uncommon to find female athletes not consuming enough fuel to match their energy expenditure (Beals & Hill, 2006). To compliment the Harris Benedict equation used to calculate one's basal metabolic rate including activity factors, it is recommended that athletes use well-established dietary guidelines (Manore, 2005) such as the *Dietary Guidelines for Americans 2010,* as well as the Dietary Reference Intakes, which specifically provides for women helpful tools to guide their meal planning (Volpe, 2007). It is imperative that vegetarian athletes regularly monitor their caloric and nutrient intake but, more importantly, their body composition (Rodriguez, et al., 2009b).

Another key issue with energy that vegetarians specifically face is low-calorie intake based on nutrients that are actually absorbed (Craig, 2010). When considering meat alternatives, it is important to include energy dense sources in order to achieve optimal absorption of key nutrients. Carbohydrate, protein and fat are all to be key role players in performance. By optimizing glycogen stores (carbohydrate's storage form in the human body) one can provide oneself with adequate energy to persevere through intense training (Borrione, Grasso, Quaranta, & Parisi, 2009a). So long as vegetarians are meeting their overall calorie requirements, they tend to take in a variety of both simple and complex carbohydrates by ingesting fruits, milk products, cereals and root vegetables. Whole wheat breads and pastas are also "go-to" carbohydrate sources for vegetarians due to their high content of B vitamins (Rodriguez, et al., 2009b). Vegetarian athletes should strive to reach daily carbohydrate consumption of 45-65% of daily caloric intake (Venderley & Campbell, 2006).

The remaining macronutrients likely need more attention as adequate levels are not as easily reached as carbohydrates in this population. Vegetarians should aim to get at least 20-35% of their daily caloric intake from fat (Venderley & Campbell, 2006). Considering that vegetarian diets tend to be lower in fat, it is important that female athletes take the time to include heart healthy fats in their daily nutrient plan. Typical vegetarian sources of fat include nuts and seeds, olives, avocados and heart healthy oils. Other options of fat-containing foods include full and reduced fat dairy products. However, these sources are typically high in saturated fat, something athletes and the general population should strive to avoid. Simply cooking meals with a serving of olive, sesame or canola oil can easily help a vegetarians reach their daily fat intake needs (Borrione, et al., 2009a). Small steps like these could be easily forgotten, which is why meal planning is so important.

Although widely debated and researched, acceptable protein requirements in athletes are currently suggested to be 10-35% of daily caloric intake (Venderley & Campbell, 2006). More specifically the ADA suggests that athletes intake of protein should hit at least 1.5g of protein$\cdot kg^{-1} \cdot d^{-1}$ (Rodriguez, et al., 2009b). Plant protein, such as soy, however, is not metabolized in the same way as protein derived from animals. The bioavailability of protein in meat is much greater, so vegetarians are encouraged to increase their protein intake by about 10% (J. Otten, 2006). In order for vegetarians to increase protein intake, it is suggested they consume more legumes and beans, which are both high in fiber. Other calorically-dense, low-fiber foods should be introduced to help increase overall energy absorbed of the protein they are taking in. In the past, researchers have suggested protein consumption should be at least $1.7 g \cdot kg^{-1} \cdot d^{-1}$ (Lemon, 1998). Again, all athletes have different needs according to their specific body, energy expenditure, and sport. Here, body composition as a key determinant of overall health of an athlete, comes into play and will be discussed later.

All suggestions aside, research has stated that vegetarian athletes have no problem achieving any of the various recommendations for protein intake (Barr & Rideout, 2004). Plants containing adequate amounts of protein are found among legumes, grains, nuts and seeds (Craig, 2010). Tofu, tempeh, textured vegetable protein and the wide variety of commercially prepared vegetarian “meats” are adequate sources of protein as well (Craig, 2010). Furthermore, it is possible to consume both essential and non-essential amino acids simply by consuming a diet wide in variety (Venti & Johnston, 2002). Athletes with higher training intensities and more strength and resistance training should include the higher end of protein recommendations in their daily diet (Borrione, et al., 2009a). It is safe to assume, however, that the higher end of protein recommendations is a good starting point for any new vegetarians.

Considering all macronutrients, it is possible to create a vegetarian meal plan that not only meets caloric intake needs, but establishes a well-balanced diet as well. Just as important, micronutrients must be balanced equally, which is where the athlete really needs to focus. Again, the increased need for tracking the diet daily and being aware of one's specific needs is extremely important. When omitting any particular food group from the diet, the athlete must find another source of that food's nutrients. Following the guidelines below, based on the current research, there are adequate alternatives to each deficiency risk discussed previously. Furthermore, it is possible to have a plentiful diet and increase performance without consuming meat.

The importance of consuming energy-dense food sources is stressed because high fiber diets have the potential to reduce the bioavailability of key micronutrients such as iron and zinc (Chiplonkar & Agte, 2006). Although all athletes are at risk, women athletes are the population at greatest risk because they not only lose iron through heavy sweating and haemolysis like male athletes, but they also lose iron stores due to regular menstruation (Hunt & Roughead, 1999). Vegetarian foods consist of iron in the non-heme state, which is not as readily absorbed as that of heme iron found in animal products (Chiplonkar & Agte, 2006). The key to achieving and maintaining substantial iron status in female athletes is not only to use an iron supplement, but also to focus on foods that increase iron absorption, such as those foods containing vitamin C (Peneau, Dauchet, Vergnaud, Estaquio, Kesse-Guyot, Bertrais, Latino-Martel, Hercberg, & Galan, 2008). Soy products are good vegetarian sources of iron (Tucker, Qiao, & Maras, 2010), and should be consumed with fresh fruits, fruit juices and vegetables that are high in vitamin C to ensure optimal absorption (Peneau, et al., 2008). Other foods high in iron include soy milk, "meat" substitutes and fortified juices and breakfast cereals (Craig, 2010). Iron deficiency, also known as anemia, can be prevented by routinely monitoring the athlete's iron status. Athletes should also be aware that zinc deficiencies tend to be more prevalent in women who practice vegetarianism (Rodriguez, et al., 2009a).

Zinc, imperative for immune function,  is another micronutrient raising concerns regarding all athletes due to research that has shown exercise to increases zinc excretion through sweat (Driskell, 2009) and urine (Borrione, et al., 2009a). Vegetarians especially run the risk of low zinc bioavailability (Borrione, et al., 2009a). Volpe suggested the use of zinc supplements due to evidence that they may have improved nutritional status in the athletes in this study (Volpe, 2007). This same research also suggests vegetarian athletes should include an iron supplement as part of their daily nutrient intake as well. In 2006, Maret and Sandstead found that supplementing with zinc and iron would decrease the occurrence of negative interactions regarding absorption of nutrients (Maret & Sandstead, 2006). Like iron, zinc's bioavailability increases when consumed with sources of food high in vitamin C (Venderley & Campbell, 2006).

The main sources of vitamin B12, Calcium and vitamin D are found in animal derivatives including milk and dairy products. Vegetarians can consume eggs and dairy products such as cheese, milk and yogurt to ensure optimal intake of each of these nutrients (Borrione, et al., 2009a). Other foods that are high in calcium particularly and typically fortified with vitamin D are green vegetables such as broccoli, bok choy and kale, tofu and soy dairy products (Venderley & Campbell, 2006). One can assume that, with such a variety of options, a supplement would not be necessary for vitamins B12 and D or Calcium. Current research does suggest, however, that all athletes should supplement vitamin D during the winter months in order to decrease their risk for frequent illness as a result of deficiency (Halliday, Peterson, Thomas, Kleppinger, Hollis,

& Larson-Meyer, 2011; Holick, 2008). Considerations regarding supplements for vegetarians do exist in some of the research examined throughout this review. With respect to micronutrients, it seems that, if energy intake is sufficient, balanced, and varied, and nutritional status is within normal limits, vitamin-mineral supplementation is not warranted (Volpe, 2007). Supplementation may be suggested, however, for athletes who restrict energy intake, participate in sports with weight restrictions, or limit certain foods and food groups (ACSM) and should be considered on an individualized basis (Volpe, 2007). More widely suggested creatine supplementation seems to be popular among athletes of all diet-types. Creatine supplementation aids in fueling short-term, high-intensity, repeated bouts of exercise, increases storage of synthesized creatine in the body, and aids in muscle synthesis (Borrione, et al., 2009b; Mougios, Kazaki, Christoulas, Ziogas, & Petridou, 2006). Other research suggests that creatine concentrations in vegetarian athletes are typically lower than non-vegetarian athletes, and, although long term effects are still of concern, adding creatine to the diet has been shown to improve athletic performance during short-term, intense activity (Craig & Mangels, 2009) Furthermore, vegetarians need to be aware of their potentially low body creatine pools (Borrione, et al., 2009b) Though widely accepted and practiced by many athletes, creatine supplementation vegetarian by athletes may produce the greatest response due to low creatine pools (Craig & Mangels, 2009).

It is the position of the American Dietetic Association, along with other reliable professional groups, that supplementation of any kind for athletes is not required, assuming that they are consuming a variety of foods to provide adequate energy (Rodriguez, et al., 2009b). However, a multi-vitamin/mineral supplement is appropriate for vegetarians due to the fact that they habitually eliminate a food group from their regular daily intake (Craig & Mangels, 2009).

# CHAPTER 3

# CONCLUSION

Lacto-ovo-vegetarian diets, when planned appropriately, can provide necessary energy as well as sufficient macronutrient intakes to benefit not only overall health but athletic performance as well. Female athletes especially are attracted to this type of diet because of its potential to increase athletic performance in many different ways. Vegetarian diets are high in complex carbohydrates allowing athletes to sustain their energy needs without taking in excess calories and therefore allowing them to manage an optimal weight. Low-energy intake is common in female athletes who tend to be concerned with body image and often leads to a negative energy balance.

The Harris-Benedict equation can be used as a valuable tool to estimate calorie needs based on amount of calories expended. Body composition plays a key role in exercise performance but is difficult to measure precisely. Coaches should provide a range of optimal percentages for their athletes to achieve specific to their position and sport, rather than encourage a specific body fat number. It seems to be a consensus among professionals that keeping a food journal is a great way to not only plan out meals ahead of time but also to ensure the athlete hits his or her target nutrient goals every day.

Carbohydrate intake should fall between 40-65% of daily calories. Consumption of dietary fat should be at 25-30% daily caloric intake. Typical recommendations for protein are to consume at least 1.2-1.7 g/kg of protein per day or 10-35% of total daily calories. When considering meat alternatives as sources of protein, it is important to include energy-dense sources in order to assume optimal absorption of key nutrients. Calorically dense, low-fiber protein sources include textured vegetable protein, tofu, nuts, peanut and other nut butters, as well as dairy products such as milk, cheese and yogurt. Athletes with higher training intensities and more strength and resistance training also should include the higher end of protein recommendations in their daily diet.

Overall micronutrient needs are increased as well in athletes in order to decrease turnover of these nutrients as a result of training. Regarding micronutrients, the importance of consuming energy-dense food sources is repeated, because high fiber diets may decrease bioavailability of iron and zinc. Women athletes lose iron through heavy sweating, and they also lose iron stores due to regular menstruation.

Female athletes can maintain substantial iron and zinc status by using supplements and consuming high iron foods like soy products with fresh fruits, fruit juices and vegetables that are high in vitamin C.

The main sources of vitamin B12, Calcium and vitamin D are found in animal derivatives including milk and dairy products. Vegetarians can consume eggs and dairy products such as cheese, milk and yogurt to ensure optimal intake of each of these nutrients. Foods that are high in calcium particularly and typically fortified with vitamin D are green vegetables such as broccoli, bok choy and kale, tofu and soy dairy products. It is widely accepted that all athletes should supplement vitamin D during the winter months in order to decrease their risk for frequent illness as a result of vitamin D deficiency (Holick, 2008). Creatine supplementation is another option for vegetarians. Most research suggests that creatine concentrations in vegetarian athletes are typically lower than non-vegetarian athletes (Borrione, et al., 2009b). A multi-vitamin/mineral supplement is appropriate for vegetarians due to the fact that they habitually eliminate a food group.

More research must be conducted to broaden knowledge as a whole in the fields of Exercise Physiology and Dietetics when considering vegetarian athletes. Specific topics that still lack substantial information include implications in male athletes, long-term effects of vigorous training combined with a vegetarian diet and possibly a trial comparing sport performance in elite vegetarian athletes and elite non-vegetarian athletes.

| | |
|---|---|
| Vegetarian | Does not consume meat but may allow fish, eggs, dairy and honey. |
| Lacto-Vegetarian | Does not consume meat or fish but allows dairy. Excludes eggs. |
| Lacto-Ovo-Vegetarian | Does not consume meat or fish but allows eggs and dairy. |
| Fruitarian | Includes only fruits and seeds. |
| Vegan | Excludes consumption of all animal derived foods, including dairy and honey. |

Figure 1. Variations of vegetarian diets

| | |
|---|---|
| BMR calculation for women | BMR = 655.1 + ( 9.563 x weight in kg ) + ( 1.850 x height in cm ) – ( 4.676 x age in years ) |
| BMR calculation for women | BMR = 655 + ( 4.35 x weight in pounds ) + ( 4.7 x height in inches ) – ( 4.7 x age in years ) |

| | |
|---|---|
| Little to no exercise | Daily calories needed = BMR x 1.2 |
| Light exercise (1–3 days per week) | Daily calories needed = BMR x 1.375 |
| Moderate exercise (3–5 days per week) | Daily calories needed = BMR x 1.55 |
| Heavy exercise (6–7 days per week) | Daily calories needed = BMR x 1.725 |
| Very heavy exercise (twice per day, extra heavy workouts) | Daily calories needed = BMR x 1.9 |

Figure 2. Harris Benedict Equation (Harris Benedict Principle)

| Nutrient | Lacto-Ovo Vegetarian Sources |
|---|---|
| Carbohydrates | Fruit, vegetables, whole wheat pastas, cereals and breads, milk, cheese, yogurt |
| Fat | Avocado, olives, olive oil, canola oil, eggs, full fat dairy, nuts and nut butters |
| Protein | Tofu, tempeh, textured vegetable protein, soy, legumes, nuts, eggs, dairy |
| Iron | Soy, bread, beans, nuts, dried fruit and green leafy vegetables, fortified cereals |
| Zinc | Eggs, tofu, milk, cheese, yogurt, broccoli, pinto beans, whole grains and fortified cereals |
| Calcium | Cheese, milk and yogurt, fortified soy "dairy" products, broccoli and other dark leafy greens |
| Vitamin D | Eggs, cheese, milk and yogurt, fortified soy "dairy" products, broccoli and other dark leafy greens |
| Vitamin B12 | Eggs, milk, yogurt, cheese |

Figure 3. Vegetarian sources of commonly deficient nutrients in athletes/female vegetarians.

## BIBLIOGRAPHY

Abdel-Hamid, T. K. (2003). Exercise and diet in obesity treatment: an integrative system dynamics perspective. *Medicine and Science in Sports and Exercise, 35*(3), 400-413.

Ackland, T. R., Lohman, T. G., Sundgot-Borgen, J., Maughan, R. J., Meyer, N. L., Stewart, A. D., & Muller, W. (2012). Current status of body composition assessment in sport: review and position statement on behalf of the ad hoc research working group on body composition health and performance, under the auspices of the I.O.C. Medical Commission. *Sports Medicine, 42*(3), 227-249.

Allen, L. H. (2008). Causes of vitamin B12 and folate deficiency. *Food and Nutrition bulletin, 29*(2 Suppl), S20-34; discussion S35-27.

Barclay, J. K., & Hansel, M. (1991). Free radicals may contribute to oxidative skeletal muscle fatigue. *Canadian Journal of Physiology and Pharmacology, 69*(2), 279-284.

Barr, S. I., & Rideout, C. A. (2004). Nutritional considerations for vegetarian athletes. *Nutrition, 20*(7-8), 696-703.

Beals, K. A., & Hill, A. K. (2006). The prevalence of disordered eating, menstrual dysfunction, and low bone mineral density among US collegiate athletes. *International Journal of Sport Nutrition and Exercise Metabolism, 16*(1), 1-23.

Bellows, L. (2012). Vegetarian Diets. In C. S. University (Ed.), *Colorado State University Extension* (Vol. Fact Sheet 9.324).

Borrione, P., Grasso, L., Quaranta, F., & Parisi, A. (2009a). FIMS Position Statement 2009: Vegetarian diet and athletes. *International SportMed Journal, 10*(1), 53-60.

Borrione, P., Spaccamiglio, A., Salvo, R. A., Mastrone, A., Fagnani, F., & Pigozzi, F. (2009b). Rhabdomyolysis in a young vegetarian athlete. *American Journal of Physical Medicine & Rehabilitation / Association of Academic Physiatrists, 88*(11), 951-954.

Burke, L. M., Loucks, A. B., & Broad, N. (2006). Energy and carbohydrate for training and recovery. *Journal of Sports Sciences, 24*(7), 675-685.

Cannell, J. J., Hollis, B. W., Sorenson, M. B., Taft, T. N., & Anderson, J. J. (2009). Athletic performance and vitamin D. *Medicine and Science in Sports and Exercise, 41*(5), 1102-1110.

Chiplonkar, S. A., & Agte, V. V. (2006). Statistical model for predicting non-heme iron bioavailability from vegetarian meals. *International Journal of Food Sciences and Nutrition, 57*(7-8), 434-450.

Clark, M., Reed, D. B., Crouse, S. F., & Armstrong, R. B. (2003). Pre- and post-season dietary intake, body composition, and performance indices of NCAA division I female soccer players. *International Journal of Sport Nutrition and Exercise Metabolism, 13*(3), 303-319.

Cox, G. (2000). Special Needs: The Vegetarian Athlete. In L. a. D. Burke, V. (Ed.), *Clinical Sports Nutrition* (pp. 656-671). Sydney: McGraw-Hill.

Craig, W. J. (2010). Nutrition concerns and health effects of vegetarian diets. *Nutrition in Clinical Practice: Official Publication of the American Society for Parenteral and Enteral Nutrition, 25*(6), 613-620.

Craig, W. J., & Mangels, A. R. (2009). Position of the American Dietetic Association: vegetarian diets. *Journal of the American Dietetic Association, 109*(7), 1266-1282.

Davies, K. J., Quintanilha, A. T., Brooks, G. A., & Packer, L. (1982). Free radicals and tissue damage produced by exercise. *Biochemical and Biophysical Research Communications, 107*(4), 1198-1205.

Della Valle, D. M., & Haas, J. D. (2012). Iron Status Is Associated With Endurance Performance and Training in Female Rowers. *Medicine and Science in Sports and Exercise*.

Deutz, R. C., Benardot, D., Martin, D. E., & Cody, M. M. (2000). Relationship between energy deficits and body composition in elite female gymnasts and runners. *Medicine and Science in Sports and Exercise, 32*(3), 659-668.

Driskell, J. A. (2009). *Nutrition and Exercise Concerns of Middle Age*: CRC Press.

Dubnov, G., & Constantini, N. W. (2004). Prevalence of iron depletion and anemia in top-level basketball players. *International Journal of Sport Nutrition and Exercise Metabolism, 14*(1), 30-37.

Ducher, G., Turner, A. I., Kukuljan, S., Pantano, K. J., Carlson, J. L., Williams, N. I., & De Souza, M. J. (2011). Obstacles in the optimization of bone health outcomes in the female athlete triad. *Sports Medicine, 41*(7), 587-607.

Fogelholm, M. (2003). Dairy products, meat and sports performance. *Sports Medicine, 33*(8), 615-631.

Fraser, G. E. (2009). Vegetarian diets: what do we know of their effects on common chronic diseases? *The American Journal of Clinical Nutrition, 89*(5), 1607S-1612S.

Gaine, P. C., Pikosky, M. A., Bolster, D. R., Martin, W. F., Maresh, C. M., & Rodriguez, N. R. (2007). Postexercise whole-body protein turnover response to three levels of protein intake. *Medicine and Science in Sports and Exercise, 39*(3), 480-486.

Halliday, T. M., Peterson, N. J., Thomas, J. J., Kleppinger, K., Hollis, B. W., & Larson-Meyer, D. E. (2011). Vitamin D status relative to diet, lifestyle, injury, and illness in college athletes. *Medicine and Science in Sports and Exercise, 43*(2), 335-343.

Harris, J. A., & Benedict, F. G. (1918). A Biometric Study of Human Basal Metabolism. *Proceedings of the National Academy of Sciences of the United States of America, 4*(12), 370-373.

Hawley, J. A., & Burke, L. M. (2010). Carbohydrate availability and training adaptation: effects on cell metabolism. *Exercise and Sport Sciences Reviews, 38*(4), 152-160.

Heber, D. (2004). Vegetables, fruits and phytoestrogens in the prevention of diseases. *Journal of Postgraduate Medicine, 50*(2), 145-149.

Heidemann, C., Schulze, M. B., Franco, O. H., van Dam, R. M., Mantzoros, C. S., & Hu, F. B. (2008). Dietary patterns and risk of mortality from cardiovascular disease, cancer, and all causes in a prospective cohort of women. *Circulation, 118*(3), 230-237.

Heymsfield, S. B., Pietrobelli, A., Wang, Z., & Saris, W. H. (2005). The end of body composition methodology research? *Current Opinion in Clinical Nutrition and Metabolic care, 8*(6), 591-594.

Holick, M. F. (2008). The vitamin D deficiency pandemic and consequences for nonskeletal health: mechanisms of action. *Molecular Aspects of Medicine, 29*(6), 361-368.

Hunt, J. R., & Roughead, Z. K. (1999). Nonheme-iron absorption, fecal ferritin excretion, and blood indexes of iron status in women consuming controlled lacto-ovo-vegetarian diets for 8 wk. *The American Journal of Clinical Nutrition, 69*(5), 944-952.

Iglesias-Gutierrez, E., Garcia-Roves, P. M., Rodriguez, C., Braga, S., Garcia-Zapico, P., & Patterson, A. M. (2005). Food habits and nutritional status assessment of adolescent soccer players. A necessary and accurate approach. *Canadian journal of Applied Physiology - Revue Canadienne de Physiologie Appliquee, 30*(1), 18-32.

Jenkins, R. R. (2000). Exercise and oxidative stress methodology: a critique. *The American Journal of Clinical Nutrition, 72*(2 Suppl), 670S-674S.

Larson-Meyer, D. (2009). *Vegetarian Sports Nutrition: Food Choices and Eating Plans for Fitness and Performance*. Champaign: Human Kinetics.

Leblanc, J., Le Gall, F., Grandjean, V., & Verger, P. (2002). Nutritional intake of French soccer players at the clairefontaine training center. *International Journal of Sport Nutrition and Exercise Metabolism, 12*(3), 268-280.

Lee, C. Y., & Man-Fan Wan, J. (2000). Vitamin E supplementation improves cell-mediated immunity and oxidative stress of Asian men and women. *The Journal of Nutrition, 130*(12), 2932-2937.

Lee, M. G., Sedlock, D. A., Flynn, M. G., & Kamimori, G. H. (2009). Resting metabolic rate after endurance exercise training. *Medicine and Science in Sports and Exercise, 41*(7), 1444-1451.

Lemon, P. W. (1998). Effects of exercise on dietary protein requirements. *International Journal of Sport Nutrition, 8*(4), 426-447.

Loucks, A. B., Stachenfeld, N. S., & DiPietro, L. (2006). The female athlete triad: do female athletes need to take special care to avoid low energy availability? *Medicine and Science in Sports and Exercise, 38*(10), 1694-1700.

Magkos, F., & Yannakoulia, M. (2003). Methodology of dietary assessment in athletes: concepts and pitfalls. *Current Opinion in Clinical Nutrition and Metabolic Care, 6*(5), 539-549.

Manore, M. M. (2005). Exercise and the Institute of Medicine recommendations for nutrition. *Current Sports Medicine Reports, 4*(4), 193-198.

Maret, W., & Sandstead, H. H. (2006). Zinc requirements and the risks and benefits of zinc supplementation. *Journal of Trace Elements in Medicine and Biology: Organ of the Society for Minerals and Trace Elements, 20*(1), 3-18.

Manore, M., & Thompson, J. (2009). *Sport Nutrition for Health and Performance* (2nd ed.). Champaign: Human Kinetics.

Micha, R., Wallace, S. K., & Mozaffarian, D. (2010). Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: a systematic review and meta-analysis. *Circulation, 121*(21), 2271-2283.

Mougios, V., Kazaki, M., Christoulas, K., Ziogas, G., & Petridou, A. (2006). Does the intensity of an exercise programme modulate body composition changes? *International Journal of Sports Medicine, 27*(3), 178-181.

Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., & Warren, M. P. (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and Science in Sports and Exercise, 39*(10), 1867-1882.

Otten, J. H., et al. . (2006). *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Washington, DC: National Academies Press.

Peneau, S., Dauchet, L., Vergnaud, A. C., Estaquio, C., Kesse-Guyot, E., Bertrais, S., Galan, P. (2008). Relationship between iron status and dietary fruit and vegetables based on their vitamin C and fiber content. *The American Journal of Clinical Nutrition, 87*(5), 1298-1305.

Perez-Vizcaino, F., Duarte, J., & Andriantsitohaina, R. (2006). Endothelial function and cardiovascular disease: effects of quercetin and wine polyphenols. *Free Radical Research, 40*(10), 1054-1065.

Phillips, S. M., Moore, D. R., & Tang, J. E. (2007). A critical examination of dietary protein requirements, benefits, and excesses in athletes. *International Journal of Sport Nutrition and Exercise Metabolism, 17 Suppl*, S58-76.

Robinson-O'Brien, R., Perry, C. L., Wall, M. M., Story, M., & Neumark-Sztainer, D. (2009). Adolescent and young adult vegetarianism: better dietary intake and weight outcomes but increased risk of disordered eating behaviors. *Journal of the American Dietetic Association, 109*(4), 648-655.

Rodriguez, N. R., DiMarco, N. M., & Langley, S. (2009a). American College of Sports Medicine position stand. Nutrition and athletic performance. *Medicine and Science in Sports and Exercise, 41*(3), 709-731.

Rodriguez, N. R., DiMarco, N. M., & Langley, S. (2009b). Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *Journal of the American Dietetic Association, 109*(3), 509-527.

Root, M. M., McGinn, M. C., Nieman, D. C., Henson, D. A., Heinz, S. A., Shanely, R. A., Jin, F. (2012). Combined fruit and vegetable intake is correlated with improved inflammatory and oxidant status from a cross-sectional study in a community setting. *Nutrients, 4*(1), 29-41.

Sachdev, S., & Davies, K. J. (2008). Production, detection, and adaptive responses to free radicals in exercise. *Free Radical Biology & Medicine, 44*(2), 215-223.

Sazawal, S., Dhingra, U., Dhingra, P., Hiremath, G., Sarkar, A., Dutta, A., Black, R. E. (2010). Micronutrient fortified milk improves iron status, anemia and growth among children 1-4 years: a double masked, randomized, controlled trial. *PloS one, 5*(8), e12167.

Silva, C. M. (2008). Eating Disorders in Female Athletes. *Medicine and Science in Sports and Exercise, 40*(5).

Sinha, R., Cross, A. J., Graubard, B. I., Leitzmann, M. F., & Schatzkin, A. (2009). Meat intake and mortality: a prospective study of over half a million people. *Archives of Internal Medicine, 169*(6), 562-571.

Strobel, N. A., Peake, J. M., Matsumoto, A., Marsh, S. A., Coombes, J. S., & Wadley, G. D. (2011). Antioxidant supplementation reduces skeletal muscle mitochondrial biogenesis. *Medicine and Science in Sports and Exercise, 43*(6), 1017-1024.

Tipton, K. D., & Witard, O. C. (2007). Protein requirements and recommendations for athletes: relevance of ivory tower arguments for practical recommendations. *Clinics in Sports Medicine, 26*(1), 17-36.

Tucker, K. L., Qiao, N., & Maras, J. E. (2010). Simulation with soy replacement showed that increased soy intake could contribute to improved nutrient intake profiles in the U.S. population. *The Journal of Nutrition, 140*(12), 2296S-2301S.

Vang, A., Singh, P. N., Lee, J. W., Haddad, E. H., & Brinegar, C. H. (2008). Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Annals of Nutrition & Metabolism, 52*(2), 96-104.

Venderley, A. M., & Campbell, W. W. (2006). Vegetarian diets : nutritional considerations for athletes. *Sports Medicine, 36*(4), 293-305.

Venkatraman, J. T., & Pendergast, D. R. (2002). Effect of dietary intake on immune function in athletes. *Sports Medicine, 32*(5), 323-337.

Venti, C. A., & Johnston, C. S. (2002). Modified food guide pyramid for lactovegetarians and vegans. *The Journal of Nutrition, 132*(5), 1050-1054.

Villegas, R., Gao, Y. T., Yang, G., Li, H. L., Elasy, T. A., Zheng, W., & Shu, X. O. (2008). Legume and soy food intake and the incidence of type 2 diabetes in the Shanghai Women's Health Study. *The AmericanJournal of Clinical Nutrition, 87*(1), 162-167.

Volpe, S. L. (2007). Micronutrient requirements for athletes. *Clinics in Sports Medicine, 26*(1), 119-130.

Wang, Y., & Beydoun, M. A. (2007). The obesity epidemic in the United States--gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiologic Reviews, 29*, 6-28.

Watson, T. A., Callister, R., Taylor, R. D., Sibbritt, D. W., MacDonald-Wicks, L. K., & Garg, M. L. (2005). Antioxidant restriction and oxidative stress in short-duration exhaustive exercise. *Medicine and Science in Sports and Exercise, 37*(1), 63-71.

Willis, K. S., Peterson, N. J., & Larson-Meyer, D. E. (2008). Should we be concerned about the vitamin D status of athletes? *International Journal of Sport Nutrition and Exercise Metabolism, 18*(2), 204-224.

Appendix A

Presentation Handout

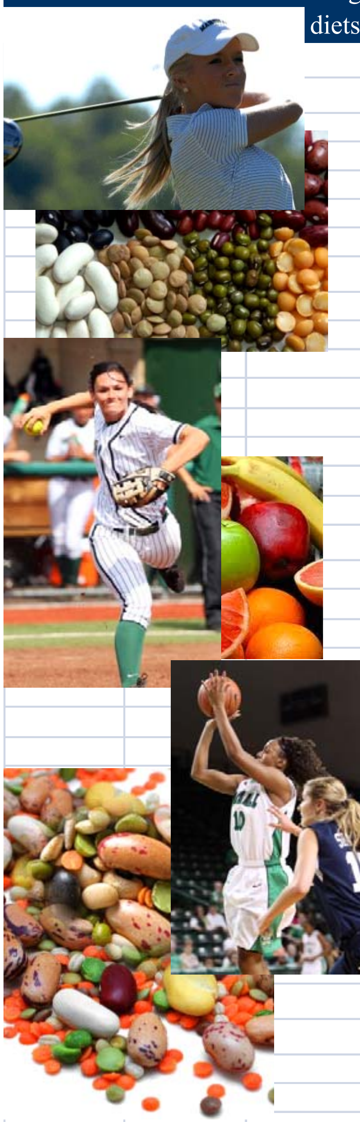
# FUEL

## for VEGETARIAN ATHLETES

**LACTO-OVO-VEGETARIANISM**

**A Practical Guide to Increasing Performance with Optimal Nutrition**

Thoroughly planned-out, plant based diets meet the increased needs of athletes



### Utilize a food journal

**Design meals beforehand to meet goals**

**Carefully plan ahead to ensure adequate intake. of key nutrients. Record actual intake and make detailed comments to refer to with a team**

### Aim to reach daily energy goals

**Understand energy balance to ensure adequate intake**

**As training intensity and duration increase, energy intake should increase as well. Calculate individual energy needs.**

**[BMR= 655+(4.32 x lbs)+(4.7 x in)-(4.7 x yrs)]**

| | |
|---|---|
| Moderate exercise (3–5 days/wk) | BMR x 1.55 |
| Heavy exercise (6–7 days/ wk) | BMR x 1.725 |
| Very heavy exercise (2x/day, heavy) | BMR x 1.9 |

### Focus on variety

**Ensure a well balanced intake of nutrients by incorporating a wide variety of foods**

| | |
|---|---|
| **Carbohydrates** | Fruits, vegetables, whole wheat cereals, pastas & breads, dairy |
| 45-65% of daily intake | Consume often to avoid fatigue due to glycogen depletion |
| **Fat** | Nuts, nut butters, olives, olive oil, avocado |
| 20-35% of daily intake | Focus on heart healthy sources, low saturated fat |
| **Protein** | Beans, dairy, eggs, tofu, tempeh, soy |
| 20-35% of daily intake | Focus on lean sources, supplement if desired |
| **Iron** | Soy products, "meat" substitutes, fortified cereals and juice, supplement |
| **Zinc** | Eggs, tofu, dairy, broccoli, pinto beans, whole grains and fortified cereals |
| **Calcium** | Dark green leafy veggies, milk, yogurt, cheese |
| **Vitamin D** | Milk, yogurt, cheese, tofu, soy products |
| **Vitamin B12** | Eggs, milk, yogurt, cheese |

### Supplement when necessary

**Regularly check status of key micronutrients**

**Vegetarians may need to incorporate supplements into daily intake due to absorption issues. Check iron, zinc, vitamin d, calcium and vitamin b12 levels often.**

### Meet with a Team Professional

**Monitor progress on a regular basis**

**Whether it be a team dietitian, athletic trainer or an assistant coach, monitor progress on a regular basis. Focus on a body fat range rather than a specific percentage or weight.**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**Thesis Presentation**

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