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Original article

Effects of vegetarian and vegan nutrition on body composition in competitive futsal athletes

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Abstract. *Background:* Plant-based diets have spread widely in the general population and among athletes too, both for well-documented health benefits and for eco-sustainability and ethical concerns. Despite appropriate nutrition is essential for satisfying training, performance, and recovery needs in athletes, little is known about the effects of plant-based diets on body composition in athletes. Appropriate training and nourishment strategies are a daily priority to arrive at victory and achieving an optimal body composition helps achieve success. Our study aimed to shed light on the adequacy of a vegetarian or vegan diet on the body composition of the athlete, in comparison with an omnivorous diet. In particular, we had tried to clarify the effects of well-structured plant-based nutrition in competitive athletes, who, previously, had never followed a diet under specialist supervision. *Methods:* The groups were followed for 8 months and subjected to a well-planned diet under medical supervision. Anthropometric parameters and body composition evaluation through Bioelectrical Impedance Analysis (BIA) were performed in each participant. *Results:* All subjects, especially vegans, showed an improvement in cellular efficiency, muscle mass, and a re-distribution of body water thanks to a better distribution of macronutrients with dietary plans. These changes demonstrate improvement in the athlete's body composition thanks to well-structured plant-based diets that meet the nutrient requirements, without a change in physical training, especially in vegan athletes. *Conclusions:* The administration of well-structured dietetic schemes for each group has reduced the differences between omnivores, vegetarians, and vegans, underling their more difficult autonomous management and the important role of the nutrition specialist. Given the evidence collected, we demonstrate that plant-based diets are sustainable for athletes and that the role of nutritionist is central to sports and food choices to achieve an optimal body composition.

Key words: Body composition, BIA, Vegan, Vegetarian, Diet, Athletes, Nutrition

Introduction

Nutrition is a fundamental factor for good health and represents one of the pillars for professional athletes both in the training and competition phases (1). In the last decades, plant-based diets are becoming most popular and diffuse in several industrialized countries both for health effects and for eco-sustainability and ethical concerns such as environmental and animal protection factors, even among athletes (2-4). While omnivores diet does not exclude any food groups, plant-based diets can be divided into two main intervention diets: vegan diet, that excludes all animal product (meat, fish, poultry, eggs, or dairy), only plant-based foods (whole grain, legumes, vegetables, and fruits), and vegetarian diet, that excludes meat and fish but contains eggs and/or dairy as well as plant-based foods. However, if well planned, vegetarian and vegan diets are able to provide adequate nutrition and health benefits, in the prevention and treatment of different diseases too (3, 5-9).

Despite all the positive effects of these diets on health, little is known about their effects on body composition and performance in athletes (3, 10-11). For all athletic competitions, training and nutritional status of the athletes are important for the success and appropriate training and nourishment strategies are a daily priority to arrive at victory (12). Sports activities, both short and long-term events, involve power development and muscular performance and require energy. Generally, many athletes are subjected to an energy imbalance risk and an inappropriate or less than ideal macro- and micronutrient intake (13). Appropriate nutrition, both in quantity and quality, is essential for satisfying training, performance, and recovery needs (9,13,14). On the other hand, several studies showed that a vegan or vegetarian diet, well-planned and balanced, is healthy and adequate to support athletic performance or training and there are no great differences between the athletic performance of vegan, vegetarian, and omnivore subjects (15,16). Especially in athletes, this is also important to ensure an adequate body composition to face the competitions. Indeed, it is known that there is also a strong association between body composition and sports performance. Achieving an optimal body composition, both in terms of lean mass, muscle mass, and fat mass, help achieve success (12, 17-18). The optimal body composition means the athlete's body composition that may be advantageous to maximize performance since it can affect an athlete's strength and agility (19-21). It is sport-specific and position-specific in team sports (21,22). This body composition must reflect the individual needs of the athlete, allowing weight and fat mass to be maintained in the appropriate body fat values for the athlete during training and competition phases to meet physiological requests. Appropriate body fat values for athletes are optimal levels of body fat (and fat-free mass) in which the player can minimize the negative effects of excess body fat without compromising skill since the body mass must be moved against gravity (19, 22). This concept takes part of the concept of an optimal body composition that may have a great effect on athletic performance (21). Furthermore, according to Gardasevic and Bjelica (2020), football players must achieve an optimal level of body fat to satisfy the requirements needed for their specific playing position.

Aubertin-Leheudre and Adlercreutz (2009) showed a significant difference in the muscle mass between healthy omnivores and vegetarian women (either vegetarians or vegans from at least 2 years) that were sedentary or moderately physically active (3h -5h/week with moderate or low intensity). Specifically, they demonstrated a lower muscle mass in vegetarian and vegan women than in omnivorous women (23). Lynch and colleagues (2016), instead, demonstrated that vegetarian athletes had lower protein intake, lower body mass, and lower lean body mass than omnivores counterparts. Although both absolute protein intake and percent of the daily calories from proteins were lower in vegetarian athletes than in omnivores, this difference was not significant when expressed relative to body mass (3).

Given the scarce and discordant bibliography regarding the role of vegetarian and vegan diets on athletes, the purpose of our study was to add a piece to this intricate puzzle, to try to help the scientific community to dispel existing doubts and shed light on the adequacy of a vegetarian or vegan diet in the athlete and its effects on body composition, in comparison with an omnivorous diet. In particular, the study aimed to better understand the effects of well-structured vegetarian or vegan diets on the body composition of athletes, who, previously, independently managed their diet and had never followed a diet under specialist supervision. Vegetarian and vegan athletes were compared with an appropriate reference group of omnivorous athletes. The groups were followed for the same time and subjected to a well-planned diet under medical supervision. No study known to us has compared, to date, changes in body composition over medium and long-term time considering the dietary choices of the athletes. We hypothesized that thanks to a well-planned diet by a nutritionist, the differences in body composition between vegetarian and vegan athletes and omnivorous athletes might be reduced. We have evaluated possible changes after 8 months in relation to a well-planned diet to try to clarify the effects of vegetarian and vegan nutrition in competitive athletes, emphasizing their more difficult autonomous management and the important role of the nutrition specialist.

Materials and Methods

Participants

Fifteen male professional futsal players categorized as Vegans (VG) (N = 5), Vegetarians (V) (N = 5), and Omnivores (O) (N = 5) (M age 20.9 (1.53), were recruited, from the same futsal team, voluntarily and informed written consent was signed by each participant. All participants were recruited from the Department of Experimental Medicine, Section of Human Physiology and Clinical Dietetic Service of University of Campania "Luigi Vanvitelli". The experiment was approved by the ethics committee of the "Azienda Ospedaliera Universitaria, University of Campania Luigi Vanvitelli" and was performed in accordance with the 1964 Declaration of Helsinki.

The subjects recruited were interviewed about their eating habits, so as to be classified as omnivores or vegetarians or vegans, and about training protocols, to ensure that none of them followed any additional training to that of the team. General blood chemistry investigations were performed at most in the previous 2 months (that players normally do for fitness certificate for competitive sports at the start of preseason), so as to exclude subjects who present alterations. A careful pathological and physiological anamnesis has been carried out. All participants were enrolled using the following inclusion and exclusion criteria: being strictly vegan, vegetarian, or omnivorous at least for 36 months prior to the study; being adults (age ≥ 18) ; never followed a dietary plan prescribed by a practitioner; not having been hospitalized for at least 24 months prior to the study; not being prescribed medical drugs; not having pathologies (type I or type II diabetes, cardiovascular or cerebrovascular diseases, cancer, neurodegenerative disease, rheumatoid arthritis, allergies, etc.); not having haematochemical alterations; not abusing alcohol (≤ 2 drinks/week) or using drugs; being nonsmokers. All athletes were professional futsal players at a competitive level from at least 3 years. They were trained with 4 sessions of 1,5/2 hours a week and 1-2 competitions a week; no one performed any other physical activity. The start of the study coincided with the start of the season. Participants included in the study had performed the preseason regularly without suffering injuries. In the event that any participant had suffered an injury that caused him to stop for longer than 15 days during the season, he would have been discarded from the study. The main biological parameters are summarized in Table 1, for each group. No significant differences were detected at baseline (Age: $F_{2, 12}$ = 1.043 *p* .38; Height (m): $F_{2, 12}$ = .556 *p*. 58; Weight (kg): $F_{2, 12}$ = .526 *p*. 604; BMI: $F_{2, 12}$ = .909 *p*. 42). The nutritional status of all participants was evaluated according to the body mass index (BMI) and Bioelectrical Impedance Analysis (BIA).

Anthropometric parameters and body composition

All athletes were assessed in the morning after an overnight fast of at least 8 hours, after having slept at least 8 hours, having fed normally and at least 12 h after the last training session. Weight was measured after participants removed their clothes and they wore only underwear without shoes using a calibrated digital scale (Seca 877 Mechanical Scale, Hamburg, Germany) accurate to 0.1 kg. Height was measured using a stadiometer (SECA 213) without shoes and hats. Body mass index (BMI, in kg/m2) was calculated with the following formula: BMI = weight (kg) / height squared (m2).

The impedance survey was performed following the protocol indicated in the device manual, by 10:00 am. The room temperature was set at 24 °C. Bioelectrical impedance analysis was performed in each participant using BIA 101 ASE (Akern) device in order to estimate body composition and obtaining Resistance (R) and Capacitive Reactance (CR). Were calculated: Phase Angle (PA), Total Body Water (TBW), Extracellular (ECW) and Intracellular Water (ICW), Fat-Free-Mass (FFM), Fat Mass (FM), Muscle Mass (MM), Body Cell Mass Index (BCMI) and Basal Metabolism (BM).

Table 1. The main biological parameters for each group (St. Deviation)

Parameters	Omnivores	Vegans	Vegetarians
Mean age	20 (1.41)	21.2 (1.79)	21.2 (1.3)
Mean height (m)	1.8 (.06)	1.77 (.05)	1.8 (.05)
Mean weight (kg)	76.56 (7.02)	75.42 (6.06)	79.18 (4.46)
Mean BMI	23.54 (1.1)	23.99 (1.08)	24.32 (.37)

Nutritional Intervention

The subjects were assigned to fill in a weekly food diary, to be delivered on the day of the anthropometric assessments. The results of the food diaries study are summarized in Table 2

Personalized nutritional advice and an individual dietetic scheme were created to meet the specific needs of each athlete. In particular, the individualized dietary plan respecting the nutritional choice was prescribed for each athlete (omnivore, vegan or vegetarian diet). Energy, micronutrient, and macronutrient requirements were determined considering anthropometric characteristics of the athlete, physical activity, training, and weekly competitions to ensure that individual and sports specifics nutritional needs were met. In general, each diet included the following macronutrients distribution divided into 5-6 meals a day: carbohydrates 50-57% (6 to 10 g/kg), proteins 18-23% (1,2 to 1,6 g/kg), fats 24-29% (1,5 to 2 g/kg). The energy intake of the diets varied from 50 to 70 kcal/kg depending on the basal metabolism and the training sessions.

Table. 2 Intakes of macronutrients and energy extrapolated from weekly food diaries

Parameters	**Omnivores**	**Vegans**	**Vegetarians**
Carbohydrates	8 to 10 g/kg	9 to 15 g/kg	8 to 14 g/kg
Proteins	1.3 to 1.7 g/kg	0.9 to 1.2 g/kg	1.1 to 1.4 g/kg
Fats	1,7 to 2.1 g/kg	1.9 to 2.3 g/kg	1.6 to 2.1 g/kg
Energy intake	50 to 55 kcal/kg	50 to 58 kcal/kg	45 to 55 kcal/kg

The team protocol for supplements consists of 2 shakes, one to be consumed before and during training and the other to be consumed after training.

Composition of the first shake: water 400 ml, creatine 2 g, citrulline 1.5 g, arginine 2 g, taurine 500 mg, caffeine 60 mg, acetyltyrosine 500 mg, phenylalanine 250 mg, niacin 35 mg, vit B1 0.9 mg, vit B6 1.2 mg, vit B12 50 mcg, vit C 80 mg, folic acid 120 mcg, chloride 160 mg, calcium 100 mg, potassium 100 mg, magnesium 50 mg, maltodextrin 10 mg.

Composition of the second shake: Proteins broken down into amino acids 18 g, glutamine 3.5 g, vit B1 0.3 mg, vit B2 0.4 mg, vit B6 0.7 mg, taurine 500 mg, nucleotides 50 mg.

Study Protocol

The subjects were invited to appear by 8:00 am, to perform anthropometric measurements and Bioelectrical impedance analysis (BIA). Based on all the information obtained and the training protocol provided by the team, personalized diet schemes were developed. The subjects were followed monthly for 8 months, until the end of the season, during which it was ascertained that the subjects followed the prescribed indications through the food anamnesis, a food diary, the BIA exams, and the anthropometric surveys. Monthly, if necessary, dietary plans have been modified according to new individual needs, training cycles, and bio-impedance results. After 8 months, blood chemistry analyses and anamnesis were repeated for all

Table. 3 Descriptive statistics and repeated measure analysis of variance

	Omnivores[a]'		**Vegans**[b]		**Vegetarians**[c]		**RM effects**	**RM effects • Group**	
	T1	*T2*	*T1*	*T2*	*T1*	*T2*			
BMI	23.54 (1.1)	23.72 (1.27)	23.99 (1 .1)	23.74 (.87)	24.32 (.37)	24.11 (.32)	-	-	
Body Cell Mass Index	10.32 (.18)	11 (.32)	8.86 (.25)	10.36 (.34)	9.72 (.33)	10.72 (.24)	•••	-	
ExtracellulaWater	45.04(1.41)	42.48 (1.4)	47.18 (2.46)	43.92 (1.27)	45. 76 (1.78)	42.8 (.99)	•••	-	
Fat-Free-Mass	80.6 (4)	81.1 (3.63)	71.26 (5.33)	78.38 (2.75)	74.44 (1.85)	78.16 (1.14)	•••	••	b>a
Fat Mass	19.4 (4)	18.9 (3.63)	28. 74 (5.33)	27.24 (13.65)	25.56 (1.85)	21.84 (1.14)	-	-	
lntracellular Water	54.96 (1.41)	57.52 (1.4)	52.82 (2.46)	56.08 (1.27)	54.24 (1.78)	5.2 (.99)	•••		
MuscleMass	5 3.84 (2. 13)	56.5 (1.61)	45.84 (2.32)	53.3 (1.44)	49.12 (1.48)	54.26 (1.69)	•••	•••	bc> a
Total Body Water	59 (2.93)	59.34 (2.65)	52.18 (3.89)	57.38 (2)	54.46 (1.3 5)	57.2 (.85)	•••	••	b>a

•*p* < .05; ••*p* < .01; ••• *p* < .001

subjects, to ensure that no alterations appeared. The BIA exams and the anthropometric surveys were repeated as per the protocol indicated previously.

Statistical Analysis

The differences were tested using a Mixed-design Analysis of Variance that provide a fully specified model for the multivariate distribution of the Repeatedly Measured outcome. The model includes a Within-Subjects Effects (Repeated Measures Factor derived by Bioelectrical impedance analysis at baseline (T1) and after 8 months (T2), and RM Factor * Group interactions); Between-Subject Effects was defined by group (Vegans, Vegetarians, and Omnivores). The results are shown as Mean and Standard Deviation. The assumption of sphericity was tested with Mauchly's Test for Sphericity (W), and three corrections were performed if necessary: the Greenhouse–Geisser correction, the Huynh–Feldt correction, and the lower-bound. The statistically significant differences and corresponding effect size have been highlighted. The ratio of variance explained was reported in terms of partial Eta-squared ($p\eta^2$). Post-hoc comparisons were performed according to coupled Bonferroni contrasts. Data were analyzed using the SPSS Version 20 Statistical Package.

Results

At baseline, no difference was detected in BMI ($F_{2,12}$= .909 p .409), BCMI ($F_{2,12}$= .839 p .931), ECW ($F_{2,12}$= 1.583 p .245), ICW ($F_{2,12}$= 1.583 p .245) and MM ($F_{2,12}$=.907 p .953). Significant differences, conversely, was detected in FFM ($F_{2,12}$= 7.075 p .009, Omnivores – Vegans: t = 3.699 p .009) FM ($F_{2,12}$= 7.075 p .009, Omnivores – Vegans: t = - 3.699 p .009) and TBW ($F_{2,12}$= 7.075 p .009, Omnivores – Vegans: t = 3.695 p .009).

Mixed-desi (RM) and interactions in Fat Mass (FM) and Body Mass Index (BMI) (FM: F 1, 12 = .82 p .38, - F 2, 12 = .21 p .82 - W= .827 p.12; BMI: F 1, 12 = 1.12 p .31 - F 2, 12 = 2.56 p .12 – W = .932 p. 124).

The Within-subject factor support the RM effects of Body Cell Mass Index (BCMI) (F 1, 12 = 244.26 p. < .001 $p\eta^2$ .78 W: NS), Extra Cellular Water (ECW) ($F_{1, 12}$ = 79.9 p < .001 $p\eta^2$ .84 W: NS) and Intra Cellular Water (ICW) (F 1, 12 = 79.9 p < .001 $p\eta^2$ .84 W: NS). In particular BCMI (Fig. 1) and ICW (Fig. 2) increased in all groups after 8 months, while ECW showed a significant reduction in all groups (Fig. 3).

Furthermore, the analysis revealed a significant RM effect and interaction for Free Fat Mass (FFM) (F 1, 12 = 47 p < .001 $p\eta^2$ .79; F 2, 12 = 12.02 p .002 $p\eta^2$ .63 W: NS), Muscle Mass (MM) (F 1, 12 = 349.23 p < 182 .001 $p\eta^2$ .97; F 2, 12 = 25.92 p < .001 $p\eta^2$ .85 W:

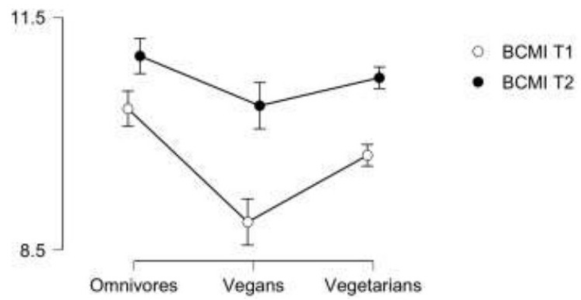

Figure 1. Descriptive Plots Body Cell Mass Index (BCMI= BCM/height²)

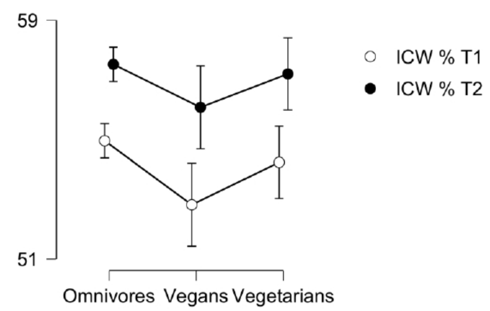

Figure 2. Descriptive Plots Intra Cellular Water (ICW)

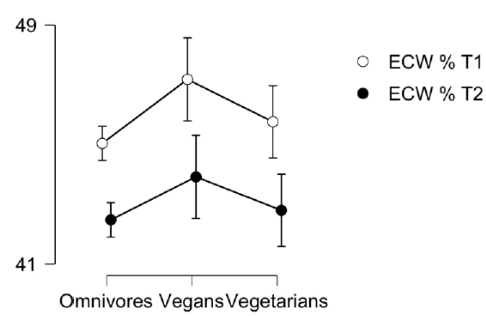

Figure 3. Descriptive Plots Extra Cellular Water (ECW)

NS) and Total Body Water (TBW) ($F_{1, 12} = 46.16$ $p < .001$ $p\eta^2$ .83; $F_{2, 12} = 11.93$ p .002 W: NS).

The FFM was statistically enhanced in all subjects after 8 months. In addition, multiple comparisons test showed that vegan athletes (71,4% vs. 78,2 %) displayed a greater increase when compared to omnivores (80,6% vs. 81,2%) (p .002) (Fig.4). The Muscle Mass (MM) showed a statistically significant increase in all groups after 8 months, and the rise was greater in vegan ($p < .001$) and vegetarian ($p < .001$) athletes when compared to omnivores (Fig.5).

Although TBW was significantly increased in all groups, and interaction effects showed a significant increase in vegan subjects when compared to omnivores (p .002) (Fig. 6).

Discussion

Vegan and vegetarian diets can be healthy strategies to weight loss, improve nutrition profile and prevent diseases (such as the reduction in risk of coronary diseases, several cancer types, type 2 diabetes, and hypertension, and are useful for weight management) (3, 5, 8). In general, plant-based diets are associated with lower body weight and lower weight gain over time compared with an omnivorous diet that could be due to the increase in fiber intakes and a decrease in saturated fat intakes (8). Vegetarians and vegans had higher dietary carbohydrate and fiber intake, while omnivores more dietary protein, cholesterol, and vitamin B12 (3, 9, 11, 24, 25). Despite vegetarian and vegan diets in sport offer several benefits to performance, such as a great antioxidants intake and carbohydrate-rich foods who help training and enhance recovery, little is known as concern these diets in sports in general and on body composition (3, 11, 26, 27). For sports nutrition is it important to understand if these diets can ensure healthy and adequate nutritional needs to sports performance and respond to sport-specific needs (11). Macro- and micronutrient availability can modulate skeletal muscle adaptations to training by regulating their signaling pathways (23, 28). A vegan diet can act synergistically with physical exercise to improve physical performance thanks to the increased intake of antioxidants, polyunsaturated fat, and carbohydrate-rich foods (2-3). Plant-based protein sources are often incomplete in essential amino acids (leucine, methionine, lysine, and tryptophan) leading to a reduction in muscle protein anabolism (2). Proteins play a key role for health and athletic performance since they are involved in protein synthesis, body composition, and energy metabolism (12). Several studies demonstrated that it is important to balance plant-based foods and counteract this deficit by varying protein sources on the diet to satisfy and ensure proteins and amino acids needs, especially for athletes (2, 11, 29-31). Starting from evidence, our nu-

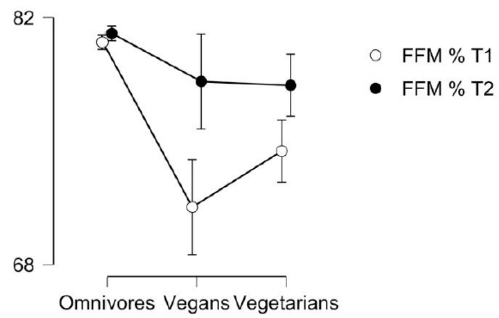

Figure 4. Descriptive Plots Free Fat Mass (FFM)

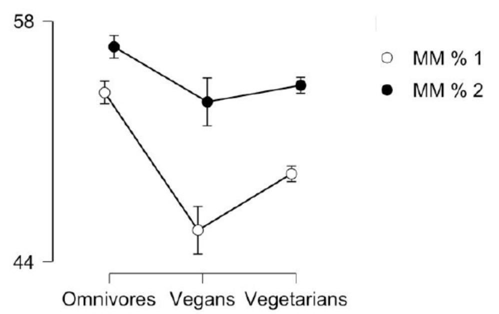

Figure 5. Descriptive Plots Muscle Mass (MM)

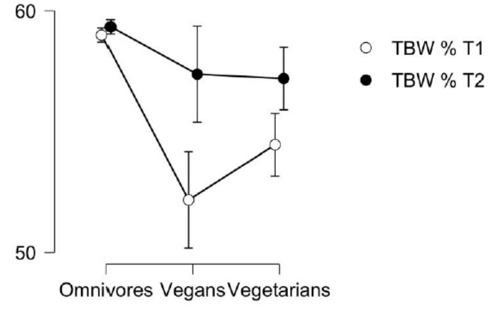

Figure 6. Descriptive Plots Total Body Water (TBW)

tritional assessment evaluated all macronutrients intake and we ensure the correct macronutrients intake thanks to the variation of plant-based protein sources, selecting food sources to compensate animal proteins lack in the plant-based diets (i.e. soya, beans, whole grains, and nuts). The International Society of Sports Nutrition (ISSN) recommends adapting energy requirements according to body mass, muscular mass, sport type, training, and competition level, to ensure that individual and sports specifics nutritional needs are met (11).

To clarify this, our study aimed to analyze the effects of prescribed vegetarian and vegan diets on the body composition of competitive athletes, compared with a prescribed omnivorous Mediterranean diet. During the study, the training program remained unchanged while each participant was provided with a personalized diet plan.

From our results, the prescribed diets have maintained the body weight, showing that athletes were in energy balance for their sport activity already at the beginning of the study. In addition, this allows us to show changes in body composition on unchanged weights, making our data more significant. In fact, a bodyweight suitable for physical activity is important for the performance itself (11). Rather, the changes that emerged from the study concern variations in body composition. These results reflect the need for an improvement in body composition in order to obtain the best performance while maintaining the weight of the subject.

All subjects showed an increase in PA, especially vegans (5,6° vs. 6.4°). This increase in PA supports the hypothesis that their body composition was improved thanks to a well-structured diet that satisfied nutrient requirements. PA alterations are associated with FFM loss or ECW expansion due to disease or malnutrition (32). The PA is considered as a marker of nutritional status or a general health marker (32, 33). An increase in it indicates a better cellular efficiency (cellular activity, cell membrane integrity, and related permeability), as shown in our results. High PA values indicate high levels of BCM too and are associated with good physical activity (32). Therefore, PA and BCM are valuable tools to assess the training program and dietary interventions (33). In our study, also BCMI is increased in all athletes regardless of the type of diet. BCMI is calculated starting from BCM (Body Cell Mass, it reflects the metabolically active mass of FFM) with the following formula: BCMI = BCM/height^2. BMCI allows us to compare the metabolically active mass with the height of the subject. It is more sensitive than BMI in evaluating changes in the muscle mass of the subject under examination as demonstrated by some studies (34, 35). So, it is an index that also reflects the state of muscle mass and in our case underlines the increase in muscle mass in all athletes. BCM is also is related to ICW since it is an expression of ICW itself (33). Meleleo and colleagues (2017), comparing competitive and non-competitive athletes after six and twelve months thanks to BIA, demonstrated an improvement in body composition associated with unvaried TBW value due to a re-distribution of body water with an increase in ICW and a decline in ECW (36). In our case, BIA value showed an increase in TBW, especially in vegans compared to omnivores athletes (52 ± 3,74 t_0 vs. 57,36 ± 2,1 t_1), and an increase in ICW and decrease in ECW. We assist to a re-distribution of body water thanks to a better distribution of macronutrients with dietary plans. In our body, water is bounded to proteins and other biomacromolecules (bound water) and carbohydrates loading leads to an increase in TBW because water binds glycogen (37). Our hypothesis is that the increase in TBW with the increase in ICW but not in ECW can be associated, on a side, to an increase in protein-bound water due to an increase in muscle mass, and, on the other side, to an improvement in muscle glycogen due to optimal carbohydrates loading with our diets.

An increase in muscle mass is associated with ICW increased and, in turn, PA increased (38). Our results are in line with these variations in body composition showing an increase in ICW and Muscular Mass thanks to adequate nutrition in athletes, without a change in physical training. Major improvement in vegans reflects their improvement in body composition showed by other parameters. As concerned FFM, it increased in all groups, in particular in vegan athletes there was an increase of 7% around and a decrease in FM of the same percentage. The increase in FFM reflects an increase in MM since they are related. MM was increased especially in vegan and vegetarian athletes compared to omnivores. However, we must note that at time T1, muscle mass was significantly greater in the omnivore group than in the other groups. It is conceivable that, despite the absence of a specialist, the omnivorous diet was better structured and guaranteed a good supply of macro- and micro-nutrients, useful for a better body composition. The action of a specific diet has improved this condition in omnivores while in vegans and vegetarians it has allowed them to obtain MM, FFM, and FM values such as to reduce the differences between the groups. The increase in factors related to the metabolically active mass also had their effect on the basal metabolism. Basal metabolism was significantly increased, especially in vegans. This supports the greater improvement of the metabolically active mass in the vegan group which is associated with an increase in basal metabolic rate. BMC is related to O2 consumption and energy expenditure, factors that are reflected in the MB (33). The positive effect of a well-balanced diet is demonstrated by this study. This could be the way to ensure the health and better performance of these athletes considering also the new evidence in sports nutrition.

Conclusions

In the last decades, there is a growing number of vegetarian and vegan athletes, therefore, it is important for sports nutrition knowledge to elucidate and understand the effects (beneficial or not) of these diets on their body composition and physical performance. An adequate body mass, with optimal relative values of muscular mass and fat mass, is important in sports activities and it could be reached thanks to a combination of a balanced diet and a well-planned training program. There is not a particular diet to reach the perfect performance in sports. Nutritional strategies for athletes must be well-planned by evaluating energy demands (that can change during the season and between training and competition), macro- and micronutrient needs, and food intake to achieve better body composition and performance to reach success. Vegan and vegetarian diets can be planned to meet the nutritional needs of athletes via the management of foods and a well-planned program diet. A varied vegetarian food consumption and a correct nutritional guidance seem to be able to ensure an adequate intake of all nutrients. In this way, vegan and vegetarian diets can meet the nutrient and energy needs of athletes, elite athletes too. This study supports the key role of a healthy and balanced diet in improving body composition in athletes independently by the type of diet. The 8-month dietary intervention program applied in this study improved nutritional habits, nutrient intake, and body composition of athletes. Achievement of optimal body composition is an important objective of many athletes to improve their performance. It could be possible via training and nutritional programs. These findings highlight the importance of macronutrient composition during exercise training to improve body composition in presence of specific dietary restrictions. The improvement in body composition, especially in vegan subjects, indicates that these subjects did not follow a diet completely suitable for their nutrition, both compared to the group of vegetarians and omnivores. Besides, vegetarians had a greater active component than vegans and more similar to that of omnivores. The administration of a well-structured dietetic scheme for each group has improved the active component in each group, giving an important effect and, at the same time, has reduced the differences between omnivores, vegetarians, and vegans. This study demonstrates the sustainability of plant-based diets for athletes but also highlights the importance of the role of the nutritionist in both sports and food choices. The initial differences were due to a more difficult self-management of vegetarian and (especially) vegan diets by athletes. In this way, we can assist our athletes with food strategies to attain optimal health and performance thanks to personalized dietetic strategies. Certainly, food choices education is an optimal, simple and inexpensive intervention to improve and optimize health and athletes' performance, especially vegan and vegetarian ones. Thanks to nutrition, we can help athletes attain their dreams, maintain optimal health and performance and follow their nutritional choice, independently if that is made for ethic or healthy reason.

Limitations

Limitations to the study include that long time effects of diets could be studied thanks to a longer intervention. There was also a small sample size in this study, due to the difficulty in finding athletes willing to follow the study. This small champion, however, has an advantage: coming all the subjects from the same team, the training regimes were the same for all the athletes; this eliminates the confounding factor of training on changing in body composition, reinforcing the value of nutrition on changing in all studied parameters. A wider sample size could be useful to have clearer results in the different sports. This factor and a longer intervention program could be taken into account by future research to compare the improvement degree.

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