Review Paper

Nutrition-Related considerations for health and performance in female Volleyball: A narrative review

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ABSTRACT

Although Volleyball is one of the most widely played sports in the World, there is little scientific information on how the ergo nutritional practice of female players should be designed. Therefore, the main aim of this narrative review is to resolute concise nutritional recommendations for volleyball women who players. Research databases such as PubMed, Scielo, Scopus, Medline or Academic Search Complete summarize and synthesize the recent evidence on the role of nutrition and its relationship with health and performance in this sporting discipline. Based on a literature review, we highlight that the individual adjustment of the energy value of the diet is one of the key factors for the physical performance of female volleyball players. An adequate intake of macronutrients allows for the achievement of correct energy values. To improve training adaptation, between 1.6 and 2.2 g·(kg·day)$^{-1}$ of protein should be consumed. For optimal pre-competition muscle glycogen storage, 6-10 g·(kg·day)$^{-1}$ of carbohydrates should be consumed, and 7- 10 g·(kg·day)$^{-1}$ of carbohydrates should be consumed for adequate recovery. Micronutrients should be consumed in amounts corresponding to the recommended dietary allowances. Women volleyball players should take particular attention to the most adequate intake of these micronutrients, as well as vitamins such as iron, calcium, and vitamin D. Proper fluid intake, according to the player's needs, is crucial to maximize exercise performance. The diet of a female athlete is often characterized by low energy values, which increases the risk of various health consequences related to low energy availability. This diet of volleyball players must therefore be controlled carefully.
Keywords: Macronutrient intake; Female athletes; Nutritional recommendations; Team sports; Volleyball.

Cite this article as:
Miguel-Ortega, A., Calleja-Gonzalez, J., & Mielgo-Ayuso, J. (2023). Nutrition-Related considerations for health and performance in female Volleyball: A narrative review. *Journal of Human Sport and Exercise, 18*(2), 462-477. https://doi.org/10.14198/jhse.2023.182.16

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Submitted for publication November 18, 2022.
Accepted for publication January 13, 2023.
Published April 01, 2023 *(in press* February 10, 2023).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.182.16

INTRODUCTION

Collective sports, especially volleyball, are characterized by high intensity activities (Purkhús et al., 2016). As a team sport, this discipline is highly technical and plays on an indoor court (Anguera-Argilaga, 2005), presenting an intervallic character and involving an indirect confrontation without contact with the opponent (Tillman et al., 2004).

In addition, it is a team activity within strength and speed group of sport (Mielgo-Ayuso et al., 2012), which requires the application of the large muscles for actions such as: jumping, finishing, blocking, or recovering the ball (Valliant et al., 2012), where the management of training loads in the development of technical and tactical skills, as well as the achievement of an adequate physical condition for the competition period (Mielgo-Ayuso et al., 2012) is an aspect that should be considered.

Regarding other performance factors, the role of ergo nutrition plays a kay role, especially in female athletes (Mielgo-Ayuso et al., 2013; Mielgo-Ayuso et al., 2015), although in volleyball there is a lack of specific research on the female gender (Zapolska et al., 2014). This fact may lead us to the possibility that the findings obtained in studies carried out in the male population and extrapolated to the female population are somehow incorrect in their application to women's sport (Costello et al., 2014). Furthermore, if the female population follows the general nutritional recommendations daily, it has been found that only about 53% of the female population has an adequate caloric intake to meet their energy needs (Ackerman et al., 2019). The menstrual period must also be considered as an exclusively female physiological process, which causes predictable but inconsistent hormonal alterations in female athletes that may alter the results of the data obtained. This fact contributes to the reluctance of researchers to design specific studies for women (Elliott-Sale et al., 2021).

Related to nutritional habits, in research conducted by Szczepańska (2012), a general incorrect eating behaviour may be observed after considering the number of meals eaten in a day (Szczepańska, 2012). For example, Mielgo et al. (2017) indicated that incorrect dietary behaviours in women are associated with the incorrect concentrations and intakes of vitamin D, E and B6. Give that in team sports, two matches are different (Gregson et al., 2010), this concrete aspect creates difficulties for scientists when trying to establish individualized nutritional strategies (Jeukendrup, 2014). Always, in terms of increase the player's performance and maintain their health, being necessary to create a standard scenario in which to measure the conditions of effort (Hopkins et al., 1999). These aspects run parallel with the information obtained in team sports being drawn from laboratory studies with exercise protocols that do not resemble real competition, as stated by the American Academy of Pediatrics (2000).

ENERGY DEMANDS FOR TRAINING ADAPTATION, COMPETITION, PERIODIZATION, AND RECOVERY IN WOMEN'S VOLLEYBALL

Achieving energy balance (EB) is a key determinant in meeting adequate energy requirements (Anderson, 2010) and, although classically considered a static process, EB is regulated by a series of complex dynamic interactions (Mielgo-Ayuso et al., 2013).

The EB occurs when energy intake (EI) is equal to the energy expenditure of the activity performed (EEE), which is important for athletes in maximizing performance and minimizing the adverse health effects of over-training and fatigue (Meeusen et al., 2013). It is particularly important among female athletes, as negative EB and/or low energy availability (EA) has been associated with menstrual dysfunction (Manore et al., 1996), reproductive disorders (Loucks et al., 1998), low iron intake (McKay et al., 2020), and loss of bone mineral density (Lloyd et al., 1987). Classically, an EB <30 kcal·(kg[fat-free mass (FFM)]·day)$^{-1}$ has been defined as "*low EB*" (Witard et al., 2019), although the existence of such a threshold has recently been questioned (Rehrer & McLay-Cooke, 2016).

All published studies involving elite team players in volleyball reported mainly EI or EB (EI/EB = EEE), suggesting a negative EB (Woodruff & Meloche, 2013; Peinado et al., 2013), except for Hassapidou and Manstrantoni, who indicated a neutral EB status during the competition season (but found a negative EB during training). In addition, Beals reported a negative EB of 567 ± 362 kcal/day; however, measurements of EI and EEE were based on self-reported data, limiting the information and subsequent interpretation (Meeusen et al., 2013).

These findings of low energy availability present an important nutritional determinant, since, according to the Academy of Nutrition and Dietetics, female athletes with sustained energy intakes below 2000 kcal/day over time may be prone to weight loss and endocrine dysfunction (Loucks, 2011).

Regarding periodization, training periods in team sports are generally planned in annual macrocycles (Lyakh et al., 2016). In particular, during pre-season, (training two or three times per day), athletes may achieve energy needs twice those of the off-season, whereas during the competitive period they require less (Jeukendrup, 2017). Beals (2002) concluded that female volleyball players had energy and nutrient intakes that placed them at risk for nutritional deficiencies. In addition, many provided data on alterations in body image, diet and/or menstrual dysfunction that appeared to worsen during the competitive season (Hosseini & Padhy, 2021).

Concretely, Anderson (2010) designed a comparison of dietary intake and body composition (BC) of female volleyball players with three-day dietary and BC records. The dietary feedback resulted in higher intakes of protein, vitamin C and calcium at the beginning of the season. In addition, players concluded to consume less than 90% of the DRIs for water, vitamins, and minerals. In addition, players were found to consume less than 90% of the DRIs for water, vitamins, and minerals.

Therefore, it has been recommended that the energy intake of athletes such as volleyball players -who train 2-3 h/day for 5-6 times/week- should be 50-80 g·(kg·day)$^{-1}$, with specific recommendations of 1.6-1.8 g·(kg·day)$^{-1}$ for protein (Mielgo-Ayuso et al., 2015).

In terms of recovery in team sports (Calleja-González et al., 2018), a literature review highlights specific methods used to recover after playing volleyball, where recovery strategies have been shown to enhance performance and prevent injury. Besides, specific techniques identified include nutritional strategies, adequate sleep, mental and psychological techniques, cold water immersion and laser (Closs et al., 2020) therapy to ensure adequate recovery after matches, it is necessary to know the type of fatigue induced and, if possible, its underlying mechanisms. Recovery strategies commonly used in volleyball, despite limited scientific confirmation supporting their efficacy in facilitating optimal recovery (Calleja-González et al., 2019), range from rapid glycogen replenishment after the immediate end of the match (Ashenden et al., 1998) to post-match recovery strategies (McClung, 2012). Although protein intake with 1.2 g·(kg·day)$^{-1}$ of CHO as soon as possible after the match has been shown to accelerate protein synthesis (Margolis et al., 2021), foods and/or supplements containing both macronutrients are also of benefit in aiding recovery (Haas & Brownlie, 2001).

NUTRITION

Among other variables, proper nutrition plays a crucial role in athlete's performance to maintenance or their competitive level (Guest et al., 2019), care health throughout the season and improve the BC (Heaton et al., 2017).

In team sports such as volleyball there is an intermittent activity patterns with periods of highly competitive intensity followed by rest breaks or periods of low activity (Gabbett et al., 2008). This situation requires the use of both aerobic (CHO and fats) and anaerobic (phosphagen and anaerobic glycolysis (Gastin, 2001) systems, with CHO intake being the main dietary priority as the fuel used in both energy systems (Burke et al., 2006). Besides, to promote brain activity to ensure maximum attention as well as the ability to make correct decisions during matches, it is extremely important to maintain adequate glucose levels through adequate CHO intake during matches (Winnick et al., 2005).

Specifically, volleyball requires a significant number of jumping actions and a considerable level of strength in the lower and upper body (Silva et al., 2019). In this regard, Nicolozakes et al. (2017) provided scientific evidence that high MA values negatively affect the ability to express strength in specific movements such as jumping. Moreover, Chalmers et al. (2017) suggested that FFM is closely related to muscle strength and power, and its increase one of the targets included in injury prevention programmers. Specifically, in female volleyball players, excess FFM is problematic, as it represents a "*dead weight*" that decreases the body's ability to lift repeatedly against gravity (Rico-Sanz et al., 1998), increases energy demand and accelerates the onset of fatigue (Andreoli et al., 2003), having a critical impact on athletic performance (Hallberg, 2001).

Protein recommendations for training

Protein is an essential macronutrient for immune function, tissue growth, maintenance, and repair (Rodriguez, 2013). In addition, adequate protein intake is also important for preserving lean mass if an athlete has low AD, is recovering from injury, or during short periods of intense training (Phillips & Van Loon, 2011).

A level of 2.0 g/kg body mass/day in these activity situations, has been shown to prevent loss of lean mass (Wall et al., 2015). However, female athletes playing sports such as volleyball are often at risk of low protein intake due to the presence of low AE (Hausswirth & Le Meur, 2011).

The recommended daily allowance (RDA) for protein is 0.8 g/kg body mass/day in Europe (Scientific opinion on dietary reference values for protein, 2011), but higher intakes of up to 1.6-2.2 g/kg body mass/day appear to improve training adaptation (Morton et al., 2018). These levels of protein intake can be easily achieved through a mixed diet, consisting of foods of all kinds, if energy intake is sufficient to meet the demands of training (Phillips et al., 2015). Although it has been reported that when protein supplements are consumed at a dose of 0.3-0.4 g/kg/meal, whey protein is considered a prudent choice due to its higher leucine content and digestibility (Phillips, 2016).

However, it is possible that during periods of energy deficit in a catabolic environment (Murphy et al., 2015; Longland et al., 2016), with the idea of simultaneously losing fat and gaining muscle (Costello et al., 2014), a higher protein intake (perhaps 2.0-2.4 $g \cdot (kg \cdot day)^{-1}$) may be necessary, depending on the training load and other metabolic stresses, such as recovery from injury, for example (Meeusen et al., 2013). And future studies should study metabolic relationships to improve the training load and recovery of female athletes.

Carbohydrate requirements for training

To meet the necessary energy requirements, we should look at the macronutrients that must be consumed in proportionate amounts to adequately replenish glycogen stores and glycogen storage (Thomas, 2016). An important factor affecting muscle glycogen storage is CHO (Ivy, 2004) consumption as they are the macronutrient of most valuable before, during and after exercise, although most studies looking at CHO intake strategies has been conducted in male athletes (Burke et al., 2019). Many female athletes restrict their CHO intake and, as a result, do not meet the recommended dietary allowances (RDA) for maintaining muscle glycogen stores (Jeukendrup, 2017) and given the role of muscle and liver glycogen in energy production during play, it is important to consider their contribution to training goals (Murray & Rosenbloom, 2018). Generally, female athletes are recommended to consume around 60% of energy from CHO, assuming that energy intake is adequate to meet existing needs, which translates into a range of 6 to 10 g CHO/kg body mass per day to achieve optimal muscle glycogen storage (Murray & Rosenbloom, 2018). Valliant et al. (2012) revealed that the diets of professional female volleyball players were generally inadequate to meet their daily caloric needs.

Unfortunately, the lack of specific data on CHO utilization during typical volleyball training sessions makes it difficult to develop clear guidelines on the amount/level of CHO required for training and whether they differ from those required during matches (Peinado et al., 2013). This lack of data is the main reason why future studies should be directed in this direction to find out whether these theoretical needs are the same or like the real ones.

The CHO requirements should be personalized based on the athlete's dietary and training goals (Jeukendrup, 2017). Most evidence suggests that it may be beneficial for female athletes to focus on maintaining high CHO availability in their diet during training, resulting in power gains, increased time to fatigue and less physiological fatigue (Burke & Dziedzic, 2013). Other research found no difference in time to exhaustion or rate of perceived exertion with CHO intake, specifically during the mid-follicular phase of the menstrual cycle (Helm et al., 2021), however, participants consumed only 6.5 g/kg of CHO per day, compared to the recommended 8 g/kg (Rael et al., 2021).

After exercise, it is recommended to consume ≥ 1.2 $g\cdot(kg\cdot day)^{-1}$ of CHO during the 4-6 hours following physical activity and adding protein at a 4:1 CHO/protein ratio may aid recovery if the above CHO intake recommendation cannot be met (Margolis et al., 2021). Regarding pre-competition "*CHO loading*", it should be noted that female athletes oxidize more fat and less CHO than men at the same relative exercise intensities, which again confuses and complicates the interpretation and application of many studies conducted mainly on male athletes (Burke et al., 2001). For team sport events such as those discussed here lasting <90 minutes, a dedicated CHO load is not necessary, and glycogen stores can be replenished with regular consumption of 7-10 $g\cdot(kg\cdot day)^{-1}$ CHO (Jeukendrup, 2017).

Further research is needed to assess possible differences in the needs of female athletes compared to males, although individualization of recommendations (Guest et al., 2019) for each athlete will allow for somewhat more gender-specific recommendations (Helm et al., 2021).

Fat requirements for training

Dietary fat is an important part of an athlete's nutrition as a source of energy, a vehicle for the intake and absorption of fat-soluble vitamins and a source of essential fatty acids (Lowery, 2004). Current recommendations suggest that female athletes should consume at least 20% of their calories as fat (Holtzman & Ackerman, 2021).

In general, such recommendations are generic and not sex-specific, and therefore cannot account for a variation in substrate utilization between the sexes (Zehnder et al., 2005). These gender-specific recommendations are much needed (Bennett et al., 2018), as without such recommendations, female athletes may have an incorrect intake of the specific macronutrients they need to achieve optimal substrate utilization during the competitive season, which may subsequently lead to negative performance, poorer BC percentages and a decrease in their overall level of health (Margolis et al., 2021). Therefore, to manage the repeated stressors of a season (Kreher & Schwartz, 2012) and without diminishing the performance of athletes in a frequently fatigued state, it seems advisable to monitor nutrition along with training throughout the season, as inadequate nutrition will hinder their ability to build skeletal muscle with the necessary substrate (Heaton et al., 2017).

DIETARY INTAKE OF FEMALE VOLLEYBALL ATHLETES

To the best of authors' knowledge (Gregson et al., 2010; Kreher & Schwartz, 2012), only a few studies address the specific nutritional needs of female volleyball players (Meeusen et al., 2013).

As mentioned above, since in team sports no two matches are similar (Gregson et al., 2010), numerous drawbacks are observed when trying to evaluate nutritional strategies and to standardise effort conditions (Holway & Spriet, 2011), in a sport such as volleyball, or example.

Since so little information on volleyball exists, a starting point to analyse the dietary intake of team sports athletes could be to review all the scientific articles published in the last 30 years. On more than 100 scientific studies from 1950 onwards, including 230 groups of athletes (Burke et al., 2001), considering the limitations of such surveys (Janiczak et al., 2021).

As a general parameter (Renard et al., 2021), the weighted averages for female volleyball players for energy intake are 8.6 MJ·day^{-1} (2064 kcal) and the mean macronutrient percentages for them are CHO ±60%, protein ±10% and fat ±30% (Manore, 2005).

Analysing the studies (Renard et al., 2021) specifically in volleyball (Valliant et al., 2012; Jeukendrup, 2014; Mielgo-Ayuso et al., 2015; Wall et al., 2015), an intake of CHO of around 49% of the total energy consumed may be observed, although this percentage is below the recommended ±60% (Baker et al., 2015). In relation to body mass, female athletes reported an average intake of 4 ± 0.7 g·(kg·day)$^{-1}$ of CHO, which is below the expert committee recommendations of 6-10 g·(kg·day)$^{-1}$ (Lloyd et al., 1987). In this regard, published studies, as well as field work with female team athletes (Valliant et al., 2012), indicate that appropriate averages are 5-7 g·(kg·day)$^{-1}$ (Kerksick et al., 2017). Results supported by other studies showing that female athletes have a low energy intake compared to energy expenditure (Tillman et al., 2004; Gregson et al., 2010).

Zapolska et al. (2014) described that the daily diet in female volleyball players had a low caloric intake compared to the recommendations for physically active people, with a very low intake of CHO and dietary fibre, an excessive proportion of saturated fatty acids and dietary cholesterol, and too low a content of monounsaturated fats and polyunsaturated acids. The current data suggest that elite female volleyball players may experience highly beneficial changes with lower total energy and CHO intake and higher protein intake than previously recommended for the increase of muscle mass and a slight reduction of body fat (Gardner et al., 1977).

At the micronutrient level Zapolska et al. (2014) observed that the supply of vitamins and minerals was alarmingly low, especially Fe and Ca; concluding that dietary supplementation was insufficient. Furthermore, female athletes have been found to be particularly at risk of ID, with an estimated 10-20% of female athletes being Fe (Ponorac et al., 2020) deficient, which has been shown to be typically more common in women than in men (Alaunyte et al., 2015), and is a particularly important problem among elite female athletes (Pedlar et al., 2018), as iron deficiency anaemia (IDA) is known to impair physical work (Johnson-Wimbley & Graham, 2011) capacity and can limit performance (Dubnov & Constantini, 2004).

Many of the studies on women included female athletes in individual sports, but the results of several studies on female athletes participating in team sports (volleyball [Calleja-González et al., 2018], basketball [Guest et al., 2019], hockey [Diehl et al., 1986] and other sports [Risser et al., 1988]) have produced contradictory results on Fe deficiency and anaemia. Consequently, to prevent ID, it is important to assess Fe status (Holway et al., 2011.

At the micronutrient level, in addition to Fe, Feillet-Coudray et al. (2002) revealed that vertical jump performance increased after Mg supplementation. This finding is explained by Mg being a cofactor of creatine kinase, a key enzyme of alactic anaerobic metabolism, the main pathway required for athletes in need of good vertical jump performance (Setaro et al., 2014). Thus, the higher the Mg supply, the more energy is produced for short-duration and high-intensity movements, such as vertical jumping.

We can observe that, in general terms, the intake of volleyball athletes (Danh et al., 2021) is below the established recommendations, both in terms of macro and micronutrients, and this will influence, in the short or medium term, the sports performance as well as the long-term health of athletes. In addition, female athletes with low energy intakes have also been reported to have poor micronutrient (Wasserfurth et al., 2020) intakes and are at risk of a diet deficient in Ca, Fe, Mg, Zinc and B-complex vitamins (Garthe & Maughan, 2018).

The nutritional needs of female athletes may differ from those of male athletes. Although extensive research has been conducted on the macronutrient, micronutrient, and fluid requirements of athletes, most of the data was obtained with male athlete subjects. Care should be taken when providing nutritional advice to female athletes, as gender and body size are factors to be considered when establishing recommendations for macro- and micronutrient intake.

Table 1. Protein and CHO requirements at sports level.

Protein	
Lean Mass Loss	2.0 g/kg
RDA Europe	0.8 g/kg
Improve training adaptation	1.6-2.2 g/kg
Simultaneous fat loss and muscle gain	2.0-2.4 $g \cdot (kg \cdot day)^{-1}$
CHO	
Optimal muscle glycogen storage	6-10 $g \cdot (kg \cdot day)^{-1}$
Post-exercise	7-10 $g \cdot (kg \cdot day)^{-1}$

Note. CHO: carbohydrates.

SUPPLEMENTS

The intake of various ergo nutritional supplements to improve sports performance has increased considerably in recent years (Close et al., 2016). However, the need for such supplementation and its effectiveness in improving performance in athletes remains somewhat questionable, although its use has become common practice among athletes worldwide (Maughan et al., 2018). For this reason, team athletes are interested in the ergogenic potential that could be obtained through sport supplements. The percentage of elite athletes using ergogenic aids has reached more than 90% (Kerksick et al., 2018) and, given the growth in demand, the supply of supplements on the market has grown exponentially, being offered in various formats for consumption, even though most of them do not have level 1A evidence (Garthe et al., 2018).

In fact, only caffeine, creatine, bicarbonate, beta alanine and nitrates have been scientifically proven (Spriet & Gibala, 2004) to have any proven results (The AIS sport supplement framework, 2019).

For example, caffeine intake, which, along with sports drinks is one of the most popular supplements (Spriet & Gibala, 2004), has been shown to improve performance in endurance (Cureton et al., 2007) or strength activities (Grgic et al., 2018). However, there are studies with similar evidence to the contrary (Guest et al., 2021). According to Burke et al. (2008), in team sports, caffeine reduces the perception of fatigue, improves endurance, fine motor skill and control, and improves cognitive function (Burke, 2005) by stimulating the central nervous system (CNS). Besides, Schneiker et al. (2006) showed that acute ingestion of a moderate dose of caffeine can improve the performance of intermittent-sprint exercise in team athletes, improvements also observed by Anselme et al. (1992). Also, Paton et al. (2001) found that the effects produced by caffeine ingestion were large enough to be of practical importance to a team sports player. Stuart et al. (2005) found that caffeine supplementation in team sports produced a 10% improvement in ability. Specifically in volleyball, it has been shown that caffeine has been shown to improve sporting performance by increasing speed, power, intermittent sprinting ability, jumping and passing accuracy (Pérez-López et al., 2015). For this reason, it may be of interest as indicated by several authors (Pfeifer et al., 2017), such a Lidor & Ziv (2010), although there is no lack of contradictory results (Kerksick et al., 2018) given that, after conducting the experiment with female volleyball players, no statistically significant differences were found between the experimental condition interaction compared to the measurements (pre and post) (Fernández-Campos et al., 2015). And although the physiological mechanism of action is not entirely clear, caffeine can improve performance in different types of sports at different exercise intensities, so the use of caffeine appears to be an effective ergogenic aid to improve physical performance in this discipline (Maughan et al., 2018). Nonetheless, Fernández-Campos et al. (2015) did not find an improvement in physical performance in volleyball players with caffeine intake, so more field studies are required to establish a clear and direct relationship between caffeine and sports performance (Chen, 2019).

In turn, creatine, commonly used in team sports, has also been the subject of extensive research in relation to these sports given that its supposed ergogenic action -enhanced recovery of PC- coincides with the activity profile of these sports (Schneiker et al., 2006), and various investigations indicate that both acute and chronic creatine supplementation can contribute to improved performance in this type of sport (Bird et al., 2003). Although specific studies on volleyball are needed to determinate its effectiveness in this discipline, as there does not appear to be any specific studies on this discipline at the female level (Lamontagne-Lacasse, 2011).

Regarding ß-alanine, the evidence is mixed: it may improve high-intensity exercise (Milioni et al., 2019), and sprint repetition (Sweeney et al., 2010). It may also provide benefits (Lindinger et al., 1996) by increasing muscle stores of carnosine as an intracellular buffer, but further studies are required using protocols suitable for team sports (Danh et al., 2021). In reference to this point, we can note that most data with ß-Alanine supplementation indicate that women have lower initial muscle carnosine levels, which could lead to greater benefits from ß-Alanine supplementation (Stegen et al., 2014). Varanoske et al. (2017) reported that ß-Alanine supplementation was more effective in women than in men, although the attenuation of fatigue was similar for both, but according to our criteria it is necessary to continue research on supplementation (Trexler et al., 2015), and specifically in volleyball to summaries its effectiveness in this discipline. To date, there are no studies on the effects of beta alanine in volleyball.

In respect of nitrates, Peeling et al. (2018) reported that nitrate supplementation produces an improvement in exercise economy and endurance (Jones, 2014), presenting a new approach that may hold promise for improving aspects of the physiological response to exercise, such as efficiency and muscle oxygenation, which could enhance performance, although the conditions under which nitrate may be ergogenic have not yet been precisely established. So far, in volleyball, no evidence has been found on the results of this supplement and this means that more intervention studies are needed to establish its effects on health and sports performance.

Sodium bicarbonate increases the extracellular buffering capacity, which may have beneficial effects on sustained high-intensity exercise performance (Hadzic et al., 2019). Bicarbonate also has fatigue-reducing effects during competition although, yet these effects do not have scientifically proven results (Hogervorst et al., 1999).

Apart from the substances reviewed that actually present scientific evidence (Spriet & Gibala, 2004) as well as some kind of proven results (The AIS sport supplement framework, 2019), in recent times, ß-hydroxy-ß-methyl butyric acid (HMB) has become a popular supplement in promoting the increase of fat-free mass and strength as Porta et al. (2011) also indicated an increase in anaerobic and aerobic capacity, accompanied with an increase in anabolic hormonal response and a reduction in catabolic and inflammatory response in elite volleyball players. And although HMB supplementation in elite male and female volleyball players was associated with greater increases in muscle mass, muscle strength and anaerobic properties, further studies are needed to determine the effect of HMB supplementation over longer periods of training (Milioni et al., 2019).

Among the nutritional strategies that can prevent damage and improve athletic performance, grapes, and grape derivatives, such as grape juice, are recognized for their health benefits (Dani et al., 2007) due to high levels of phenolic compounds, which have antioxidant, anti- inflammatory and antimutagenic properties (Xia et al., 2010), and have therefore become a target for study. These grape derivatives are a source of CHO, a macronutrient essential for glycogen replenishment and optimization of training and regeneration during exercise (Beelen et al., 2010). Gonçalves et al. (2011) observed that their use leads to improvements in glucose homeostasis, microvascular function, and antioxidant capacity (Gonçalves et al., 2011). Similarly, Toscano et al. (2015) showed that consumption of purple grape juice significantly attenuated inflammatory markers and increased total antioxidant capacity (Toscano et al., 2015). So far, only one study has evaluated the effects of grape derivatives on the metabolic status of volleyball players (Taghizadeh et al., 2016), attributing to them antioxidant and anti-inflammatory effects. Martins et al. (2020) concluded that ingestion of grape juice for two weeks appears to alleviate oxidative stress (reducing levels of lipid peroxidation) and DNA damage generated by intermittent physical exercise (Martins et al., 2020) in line with those published by Taghizadeh et al. (2016) and Martinovic et al. (2009) regarding sulfhydryl's and their relationship to the level of endogenous antioxidant defences in volleyball players (Martinovic et al., 2009).

Related to performance level, several studies have established a distinct relationship between physical performance and magnesium (Mg) concentrations (Cinar et al., 2006; Cinar et al., 2008; Lukaski et al., 1983), while others demonstrated that compartmental changes in plasma and serum Mg levels are associated with the type of exercise performed (Bohl & Volpe, 2002; Nielsen & Lukaski, 2006). Therefore, Mg supplementation has been recommended to improve physical performance. Although most studies do not provide data on Mg intake, it is difficult to draw conclusions as the effects of supplementation may vary between individuals with different dietary profiles (Workinger et al., 2018). Specifically, in volleyball, efficient vertical jump performance is considered one of the key attributes required of elite players (Thissen-Milder & Mayhew, 1990), as this activity is involved in most offensive and defensive movements. Santos et al. (2011) reported that Mg intake was positively associated with plyometric and isokinetic performances of volleyball players, thus confirming that Mg supplementation exerts a positive influence on this type of activity. Thus, the higher the Mg intake, the more energy is produced for short-duration, high-intensity movements such as vertical jumps (Cheng et al., 2010).

It has been observed that mouth guards (MG), another possible type of physiotherapeutic aid, may have ergogenic effects (Ebben et al., 2010). Thus, there are three main theories in scientific literature on the improvement of athletic performance due to the improvement of jaw kinetics with an MG: 1) reduction of afferent reflex afferents C3/4 economies cardiac workload, ventilation, and metabolism; 2) coactivation of the main sport-related muscles and potentiation of concurrent activation: 3) improvement of muscular imbalances.

In this regard, Shulze et al. (2019), concluded that aiming accuracy in volleyball players was significantly better when using a mouthguard. Thus, when ergogenic effects are expected, the use of a mouthguard can be recommended in case of intercuspal disorders, muscle weakness or imbalance. However, this pilot trial needs further studies to clarify the hypothesis and expected results (Schulze y Busse, 2019).

Table 2. Effects of supplements in volleyball.

Caffeine	
Speed	⇧
Power	⇧
Intermittent sprinting capacity	⇧
Jumping	⇧
Passing accuracy	++
HMB	
Fat free mass	⇧
Strength	⇧
Anaerobic and aerobic capacity	⇧
Anabolic hormone response	⇧
Catabolic response	⇩
Inflammatory response	⇩
Mg	
Plyometric performance	⇧
Isokinetic performance	⇧
MG	
Aiming	++

Note. HMB: β-hydroxy-β-metilbutirato; Mg: magnesium; MG: mouth guard; Improved: ++; Increased:⇧; Reduced:⇩

CONCLUSIONS

Several reasons associated with low energy availability have been identified, such as body image issues and social influences to stay slim, for which female athletes restrict their energy intake and may manifest eating disorders, and more specifically in female volleyball players.

Specifically in volleyball, disorders have been identified in the eating behaviour of sportswomen associated with a conscious restriction of calorie intake for reasons of body image and aesthetics, which leads to low energy availability. Thus, it has been found that they do not even meet the current energy recommendations for physically active women, with the reduction in CHO intake being responsible for these imbalances, and moreover, protein and fat intake tend to be higher than recommended.

The results reveal a large heterogeneity in supplementation habits. A pragmatic approach to supplements and sports foods is needed in the face of evidence that some products can make a useful contribution to improving performance.

Finally, it can be concluded that the intake of Fe is generally low in these sportswomen.

Practical recommendations

It is recommended that more attention be paid to the nutrient intake (especially calories and micronutrients) of female volleyball athletes give that, although theoretically the increase in the levels of micronutrients and vitamins through supplementation does not result in an improvement in sporting performance, failure to reach these theoretical levels leads to a decrease in sporting performance, as it seems to be directly related to a decrease in the general health of the athlete and the possible occurrence of various disorders and injuries.

In volleyball, the use of a balanced diet in terms of quality and quantity is essential for the proper functioning of the nervous system and its consequences on muscle strength. In view of the scientific evidence, the supplements that appear to be useful in this discipline are caffeine, HMB and Mg.

Future research lines

Future research should measure and report on the reliability, validity and sensitivity of sport specific protocols and skill tests, directing these investigations towards the identification of the most important motor performance skills specifically related to the actual demands of volleyball play. There is also a need for further research to evaluate specific nutritional strategies for female volleyball players, collecting data on the dietary intake of female athletes on match days as most of the published data refer to training days, and thus establishing a comparison between the two situations. Equally, more interventions design re necessary to understand better the most adequate recovery protocols in volleyball.

Finally, studies are needed to assess specific nutritional strategies for health, performance, and body composition in female volleyball players.

AUTHOR CONTRIBUTIONS

All authors whose names appear in the submission:

1) Made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work;
2) Drafted the work or critically reviewed it for important intellectual content;

3) Approved the version to be published; and
4) Agreed to be responsible for all aspects of the work to ensure that questions regarding the accuracy or completeness of any part of the work are properly investigated and resolved.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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