Medicina Sportiva

Journal of the Romanian Sport Medicine Society

Vol. XI, No. 1 – 2015 **16.03.2015**

ISSN 1841-0162
***Publisher "Universitaria"*, Craiova, Romania**

Editorial Office Address: University of Craiova, Physical Education and Sports Faculty, Brestei 156, 200177, Craiova, Romania

Site adress:
http://www.medicinasportiva.ro

Technical editor
Eng. Aurora Beldiman (University of Craiova)

Medicina Sportiva (2015), vol. XI, no 1, 2477-2481
Journal of the Romanian Sports Medicine Society

Impact of energy intake and balance on the athletic performance and health of top female volleyball athletes

Sophia D Papadopoulou
Laboratory of Coaching and Sport Performance, Department of Physical Education & Sports Science, Aristotle University of Thessaloniki, Greece

Abstract. The aim of the study was to examine the impact of adequate energy intake and energy balance on the athletic performance and health of top female volleyball (VB) athletes. Female VB athletes present energy needs at an average of 50% higher than basal metabolic requirements, with a daily energy expenditure of 2400-4200 kcal (10.080-17.640 kJ). A high-level female VB player, needs about 37.5-50 kcal/kg of body weight (BW) on a daily basis, rising by 20-50% during high intensity training and competitive seasons. The athletic dietary intake should contain 58-60% carbohydrates (CHO), 15-16% proteins and 25-28% fat. More specifically, 6-10g/kg BW carbohydrates, 1.4-2g/kg BW proteins and 1.7-2.4g/kg BW fat are recommended. Even though micro-nutrients are not a source of energy, they play a significant role in its production. Studies on selected female VB athletes have demonstrated inadequate dietary energy intake, with deficiencies in macro-nutrients (CHO) and micro-nutrients (vitamins C, D, Ca, Iron, Zinc, Mg). Female athletes with long-lasting energy deficiencies are at risk for muscle mass loss, increase of injuries, reduction of basal metabolism, high fatigue, female athletic triad syndrome etc. Preventing and treating inadequate muscle fuelling through a well-balanced diet is highly significant. In conclusion, the lack of appropriate energy availability has negative consequences on female athletes' both athletic performance and health, particularly in adolescent girl athletes. Dietary guidance and further education of elite female VB athletes is imperative, in order to optimize their athletic performance and protect their overall health status.
Key words: *volleyball, top athletes, female, energy intake, energy balance, performance, health.*

Introduction

A full and well-balanced diet constitutes a substantial parameter in the training procedure for achieving the maximum athletic performance. Inadequate energy intake in relation to energy expenditure leads to a negative energy balance significantly limiting athletic performance (1).

Meeting energy needs is the first and basic nutritional priority for athletes (2). In order to secure the best possible conditions for lean tissue mass, immune and reproductive system, along with optimal sports performance, it is highly essential to achieve energy balance. According to Larson-Meyer (2003), the term 'Energy Balance' is defined as "a state when energy intake (the sum of energy from food, fluids, and supplement products) equals energy expenditure (the sum of energy expended as basal metabolism, the thermic effect of food, and any voluntary physical activity)". However, the condition when energy intake is lower than energy expenditure, clearly limits athletic performance and diminishes benefits deriving from training. The explanation for this is simple: the human body reacts by using fat and lean tissue mass as its fuel, in order to make up for the inadequate energy intake (EI). Yet, the ultimate result turns out to be completely the opposite: as muscle volume decreases, levels of strength and endurance drop.

Furthermore, long-lasting low energy intake commonly leads to nutrient deficiency in general, and micro-nutrient deficiency in particular (3, 4). Even though micro-nutrients (vitamins - minerals) are not energy sources themselves, they do play a significant role in energy production. In addition, they maintain bone mass, enhance hemoglobin synthesis, compose and repair muscle tissue, restore immune function and protect cells and tissues from oxidative stress (5, 2). Therefore, an adequate and energy-balanced diet - containing proper amounts of both macronutrients (carbohydrates, proteins, fat) and micronutrients (vitamins, minerals)-has the potential to maximize

the performance of team sport athletes, as opposed to inappropriate and insufficient nutrition that may seriously jeopardize their health condition (6-11).
The diet of Greek elite female athletes has been investigated by only a small number of studies that have revealed inadequate energy and nutrient intake (11-17).
The aim of the study was to examine the impact of adequate energy intake and energy balance on the athletic performance and health of top female volleyball (VB) athletes.

Energy requirements
Volleyball is a high intensity, predominantly anaerobic sport based on high aerobic endurance. High generation of aerobic energy and anaerobic energy release have to do with different metabolic pathways of energy sources. Due to the long volleyball game duration, the human body relies a lot on carbohydrates as its primary energy source (9, 13). Carbohydrate is the only fuel that can sustain high-level activity such as constant sprinting, continuous jumping, ball hitting, digging etc (2). Insufficient carbohydrate intake is likely to lead to premature muscle glycogen depletion during training or competition, as well as to inhibition of glycogen resynthesis following exercise, ultimately restricting athletic performance (18).
Nutritional and health related habits differ among different sports (17). Energy needs of Volleyball players vary depending on their competitive level, gender, age, anthropometric traits, body composition, general physical activity, environmental conditions etc (16, 4). In addition, energy expenditure is even further affected by a variety of hereditary factors and other parameters, such as body size, fat-free mass and physical activity. As far as athletes are concerned, it is recommended to analyze the intensity, frequency and duration of the type of sports activity they perform, and accordingly calculate the energy required to carry out a normal daily activity (19, 20).
Female VB athletes present energy needs at an average of 50% higher than basal metabolic needs, with a daily energy expenditure of 2400-4200 kcal (10.080-17.640 kJ) (2). A high-level female VB player needs about 37.5-50 kcal/kg of body weight (BW) on a daily basis, rising by 20-50% during high intensity training and competitive seasons (5). The athletic EI with regard to macro-nutrients diet should contain 58-60% carbohydrates (CHO), 15-16% proteins and 25-28% fat. More specifically, 6-10 g/kg BW carbohydrates, 1.4-2 g/kg BW proteins and 1.7-2.4 g/kg BW fat are recommended (5). Most VB athletes can meet their needs for vitamins - minerals (micro-nutrients), which play an important role in energy production, through a sufficient and well-balanced diet containing a variety of wholesome foods (2). A high percentage of elite female VB players (92.2%) use supplement products in order to maximize their athletic performance (17).
Surveys on top-level female VB athletes have demonstrated inadequate dietary EI, with deficiencies in macro-nutrients and micro-nutrients.
More analytically, the study of Papadopoulou et al (2008), examining the dietary intake differences between elite Greek VB and Handball (HB) women athletes, revealed that top female players in total presented insufficient energy, macro- and micro-nutrient intake. More specifically, VB athletes had significantly lower EI (1183 kcal or 15.87 kcal/Kg BW) than HB athletes (1751 kcal or 25.73 kcal/Kg BW). Also, VB athletes consumed significantly fewer CHO, proteins and fats, compared to HB athletes. Yet, with regard to fat intake, both VB and HB athletes presented higher values than the recommended ones (32.2% EI and 35.5% EI respectively). In addition, VB athletes failed to meet the Recommended Daily Allowances (RDA) for most vitamins (except vitamins A and B3) and all minerals.
Another study which evaluated and compared the nutritional intake between selected VB and basketball (BB) women athletes demonstrated -as above- showed that all athletes had energy and nutrient intake that prohibited them from achieving and maintaining a maximum athletic performance.
More specifically, VB athletes had significantly lower EI than BB athletes (1167 kcal or 15.87 kcal/Kg BW and 1344 kcal or 19.29 kcal/Kg BW respectively). Also, VB athletes consumed significantly less CHO compared to BB athletes. In addition, VB players did not meet the RDA recommended values for vitamins A, B_1, B_2, B_6, B_{12}, C, D, E, biotin, folic and pantothenic acid, and the minerals-trace elements Ca, Fe, Mn, Se and Zn (16).
Similarly, another study in a sample of high-level adolescent Greek female VB players also showed lack of proper nutrition in terms of both quantity and quality.

Their mean daily EI was 1648 kcal/day -an amount which was below the RDA- while the consumption of CHO was 45.9% EI, which is far less than the suggested 60% EI. Young female VB athletes consumed higher quantities of fat (37.5% EI) at the expense of carbohydrates. In addition, they did not meet the RDA values regarding vitamins A, B1, B2, B6, Ca, Fe, folic acid, Mn, and Zn (13).

Other studies investigating female VB athletes - either individually or in comparison with respective athletes of other sports - have demonstrated findings similar to the above (12, 21, 22, 15, 11, 23, 24, 25).

It should be noted that energy deprivation is induced purposefully by VB female athletes, often due to their desire to lose weight or maintain low body weight, or even because of their body image dissatisfaction, something which is commonly seen in other sports, as well (21, 26, 17, 23, 27). The study by Frideres and Palao Andres (2005) showed that some women VB players consume inappropriate diets of low density food concerning both nutrients and kilocalories; this is actually attributed to lack of nutritional knowledge. Nutritional education should be provided to athletes and their families for promoting a healthy, balanced, nutrient-dense dietary intake (11, 27).

Negative effects of inadequate energy intake

When levels of energy intake are low compared to the high energy requirements of elite female VB athletes, they turn out to be insufficient to maintain their intense physical activity and proper metabolic functions. The human body recruits its energy ‘reserves' in order to make up for the unfulfilled energy.

Energy deficiency caused by inadequate food intake is then tried to be covered by the catabolism of glycogen, proteins and body fat (28). Furthermore, in a given energy expenditure, the high intensity rates during volleyball training sessions and games may lead to increase of the negative energy balance and further loss of even higher amounts of fat mass (29, 30).

The athletic performance is clearly reduced in female athletes with chronic energy deficiency, which actually presents a real risk for health complications. More specifically, there is high risk for decline of the players’ physical and mental abilities required for the effective implementation of technical-tactical volleyball skills (9, 21, 4), increase of fatigue and recovery time (4), reduction of the basic metabolism rate (8, 4), loss of muscle mass and bone density (2, 4, 31, 4), undesirable body weight loss (4), as well as increase of injuries and various other diseases (7, 4).

Furthermore, there is always the risk for nutritional disorders (31-33, 4), and hormonal and menstrual irregularities (32, 34, 8, 10, 31), that are correlated with the occurrence of the Female Athlete Triad Syndrome (nutritional disorders, amenorrhoea, osteoporosis) (21, 33, 4).

The unmet energy requirements, in combination with the heavy training and competition burdening, are factors responsible also for skeletal growth abnormalities that may occur in the elite female preadolescent and adolescent athletes (8, 10).

The sufficient fulfillment of dietary needs of female athletes that are in their growing process requires good knowledge concerning the different stages of natural growth. Particularly, during adolescence, the demand in energy intake is higher than in any other phase of human life (35). Thus, it is highly significant for elite VB female athletes during the period of pubertal development to receive through nutrition the required energy and essential nutrients supporting their growth and intense sports activity.

Prevention and treatment

Preventing and treating inadequate muscle fuelling through a well-balanced diet is highly significant. In female VB athletes, this can be successfully achieved by implementing daily energy intake that meets the human body basic energy requirements in connection with the respective needs of the specific sport (4). In addition, the quality of dietary energy intake is provided by establishing a balanced diet containing sufficient amounts of all macro- and micro-nutrients (4, 36). It is also considered to be important that the nutritional options established are adjusted to the athletes’ taste preferences (36). Lastly, energy needs are covered with the consumption of frequent meals or snacks (6-8) throughout the day (2, 4).

High-level female VB athletes must be supported with professional nutritional information and guidance, so that they manage to adopt a balanced diet–in both energy and nutrients-that will help them cope with the high demands of volleyball training and competition (21, 17, 37, 24, 38).

Conclusions

An adequate and balanced diet–with regard to both quantity and quality-fulfilling EI needs of top female VB athletes is of critical importance. Lack of appropriate energy availability has negative consequences on female athletes' both athletic performance and health, particularly in adolescent girl athletes. Dietary guidance and further education of elite female VB athletes is imperative, in order to optimize their athletic performance and protect their overall health status.

References

1. Tietjen-Smith T, Mercer J (2008). The female athlete triad: A statement of the problem. *J Sports Recr*, 2(1): 1-6.
2. Larson-Meyer E (2003). Optimal nutrition and hydration for the volleyball athlete. In: JC Reeser, R Bahr, (eds). *Volleyball - Handbook of Sports Medicine and Science*. Blackwell Publishing, Mass. U.S.A., pp. 45-57.
3. Swinburn B, Ravussin E (1993). Energy balance or fat balance? *Am J Clin Nutr*, 57(suppl), 766S-71S.
4. American College of Sports Medicine (ACSM), American Dietetic Association (ADA), Dietitians of Canada (DC) (2009). Nutrition and athletic performance. *Med Sci Sport Exer*, 41(3): 709-31.
5. American Dietetic Association (ADA) (2000). Position of the American dietetic association, dietitians of Canada, and the American College of sports medicine: nutrition and athletic performance. *J Am Diet Assoc*, 100(12): 1543-1556.
6. Kirkendall D (1993). Effects of nutrition on performance in soccer. *Med Sci Sports Exerc*, 25: 1370-4.
7. Murray R (1998). Nutrient requirements for competitive sports. In: I Wolinsky, ed. *Nutrition in Exercise and Sport.* 3rd ed. New York: CRC Press, pp. 521-58.
8. Thompson JL (1998). Energy balance in young athletes. *Int J Sport Nutr*, 8(2): 160-74.
9. Bangsbo J (2000). Team Sports. In: RN Maughan, ed. *Nutrition in Sport.* Oxford: Blackwell Science, pp. 574-87.
10. Juzwiak CR, Paschoal VCP, Lopez FA (2000). Nutrition and physical activity. *J Pediatr (Rio J)*, 76(Suppl 3): S349-S358.
11. Papadopoulou SK, Papadopoulou SD, Skoufas D, Yiannakos A, Natsis K (2008). Differences in Dietary Intake between Volleyball and Handball Women Athletes of the Greek Olympic National Teams. *Med Sport*, 16: 983-9
12. Hassapidou MN & Manstrantoni A (2001). Dietary intakes of elite female athletes in Greece. *J Hum Nutr Dietet*, 14(5): 391-96.
13. Papadopoulou SK, Papadopoulou SD, Gallos GK (2002). Macro and micro-nutrient intake of adolescent Greek female volleyball players. *Int J Sport Nutr Exe*, 12(1): 73-80.
14. Farajian P, Kavouras SA, Yannakoulia M, Sidossis LS (2004). Dietary intake and nutritional practices of elite Greek aquatic athletes. *Int J Sport Nutr Exerc Metab*, 14(5): 574-85.
15. Papandreou D, Eystathiadis P, Bouzouki V, Hassapidou M, Tsitskaris, G, Garefis A (2007). Dietary assessment, anthropometric measurements and nutritional status of Greek professional athletes. *Nutr Food Sci*, 37(5): 338-44.
16. Papadopoulou SD, Papadopoulou SK, Vamvakoudis E, Tsitskaris G. (2008). Comparison of Nutritional Intake between Volleyball and Basketball Women Athletes of the Olympic National Teams. *Gazz Med Ital - Arch Sci Med*, 167(4): 147-52.
17. Papadopoulou SD, Papadopoulou SK, Zaggelidis G, Konstantinidou X, Tsitskaris G, Maraki Z (2009). Dietary and Health Related Habits of Greek Elite Female Team Sport Athletes, *Ştiinta Sportului*; 1: 79-91.
18. Rico-Sanz J, Zehnder M, Buchli R, Dambach M, Boutellier U (1999). Muscle glycogen degradation during simulation of a fatiguing soccer match in elite soccer players examined noninvasively by 13C-MRS. *Med Sci Sports Exerc*; 31: 1587-93.
19. Montoye HJ, Kemper HCG, Saris WHM, Washburn RA (1996). *Measuring Physical Activity and Energy Expenditure.* Champaign, IL: Human Kinetics Publication, USA.
20. Manore MM, Thompson JL (2000). *Sport Nutrition for Health and Performance*. Champaign, Ill: Human Kinetics, USA.
21. Beals KA (2002). Eating behaviors, nutritional status and menstrual function in elite female adolescent volleyball players. *J Am Diet Assoc*, 102(9): 1293-6.
22. Taheri H, Harland BF (2004). An assessment of dietary intakes of the women's basketball, swimming, and volleyball teams at Howard university. *Ecol Food Nutr*; 43(5): 339-53.
23. Cortez D, Krebs-Holm L, Gish D, Wildman R (2011). Anthropometric measures and nutrition intake, habits and perceptions of Division I women's volleyball players. *J Int Soc Sports Nutr*, 8(Suppl 1): P8.
24. Wenzel RK, Valliant MW, Chang Y, Bomba AK, Lambert LG (2012). Dietary assessment and education improves body composition and diet in NCAA female volleyball players. *Top Clin Nutr*; 27(1): 67-73.
25. Mielgo-Ayuso J, Urdampilleta A, Martínez-Sanz JM, Seco J (2013). Nutritional analysis of

dietary intake of professional female volleyball players during the competitive phase of the regular season. *Rev Esp Nutr Hum Diet*; 17(1): 10-6
26. Frideres JE, Palao Andres JM (2005). Eating disorder risk factors perceived by adolescent female volleyball players. *Int. J of Volleyball Res*; 8(1): 24-28.
27. Daneshvar P, Hariri M, Ghiasvand R, Askari G, Darvishi L, Iraj B, *et al.* (2013). Dietary behaviors and nutritional assessment of young male isfahani wrestlers. *Int J Prev Med*, Supplement 1: S48-52.
28. Giotopoulou A, Mankafa P (2009). Body composition and anthropometric features of high-level female volleyball players. *Dissertation*, Department of Nutrition & Dietetics, A.T.E.I., Crete, Greece.
29. Imbeault P, Saint-Pierre S, Alméras N, Tremblay A. (1997). Acute effects of exercise on energy intake and feeding behaviour. *Brit J Nutr*; 77: 511-21.
30. Papadopoulou SK, Papadopoulou SD (2010). Nutritional status of elite female team sport athletes according to body fat. *Nutr Food Sci*; 40(1): 64-73.
31. Meyer F, O'Connor H, Shirreffs SM (2007). Nutrition for the young athlete, *J Sports Sci*; 25(1): S73 - S82.
32. Williams NI, Young JC, Mcarthrur JW, Bullen B, Skrinar GS, Turnbull B. (1995). Strenuous exercise with caloric restriction: Effect of luteinizing hormone secretion. *Med Sci Sports Exerc*; 27: 1390-8.
33. Manore MM, Kam LC, Loucks A (2007). The female athlete triad: Components, nutrition issues, and health consequences. *J Sport Sci*; 25: S61–S71.
34. Arena B (1996). Hormonal problems in young female athletes. *Sports Exerc Inj*; 2: 122-125.
35. Papadopoulou SD (2006). Nutritional support of female and male during growth. *Nutr Diet*; 10(3-4): 78-85.
36. Collins AL, Hunking PJ, Stear SJ (2011). Nutrient Basics. In: SA Lanham-New, SJ Stear, SM Shirreffs, AL Collins (eds). *Sport and Exercise Nutrition*, 1st Edition. The Nutrition Society. Blackwell Publishing Ltd., pp. 1-15.
37. Valliant MW, Emplaincourt HP, Wenzel RK, Garner BH (2012). Nutrition education by a registered dietitian improves dietary intake and nutrition knowledge of a NCAA female volleyball team. *Nutrients*, 4: 506-16.
38. Mazzeo F, Tafuri D, Vasilescu M, Ionescu A M (2014). Pharmacologically active substances and dietary supplements used by athletes: the European and Italian regulation. *Medicina Sportiva;* X(2): 2309-14

Corresponding author
Sophia D. Papadopoulou
Faculty of Physical Education & Sports Science,
Aristotle University of Thessaloniki, 54006
Thessaloniki, Greece.
Phone: +302310991837
Email: *sophpapa@phed.auth.gr*

Received: December 10, 2014
Accepted: February 21, 2014

Medicina Sportiva (2015), vol. XI, no 1, 2482-2494
Journal of the Romanian Sports Medicine Society

Magnesium supplementation in top athletes - effects and recommendations

Adriana Sarah Nica[1], Adela Caramoci[2], Mirela Vasilescu[3], Anca Mirela Ionescu[2], Denis Paduraru[4], Virgil Mazilu[4]
[1]Departament of Rehabilitation, University of Medicine and Pharmacy Carol Davila, Bucharest, Romania
[2]Departament of Sports Medicine, University of Medicine and Pharmacy Carol Davila, Bucharest,
[3]Department of Kinetotherapy and Sports Medicine, University of Craiova,
[3]National Institute of Sports Medicine, Bucharest, Romania

Abstract. Magnesium is a cofactor involved in many enzymatic systems, being necessary for protein synthesis, functioning of nervous and muscular systems, regulation of blood pressure and glycaemia, bone metabolism. A low dietary intake of magnesium is very common in general population. Additionally, there are categories of population that are even more predisposed to hypomagnesaemia. Top athletes represent a population category predisposed to magnesium deficiency due to increased urinary and sudorific losses, and in case of heavyweight disciplines, due to a decreased dietary intake. Many studies supported the role of magnesium in athletic performance and showed that magnesium increased the physical endurance and improved the force indices and muscle metabolism in athletes that had a rich diet in magnesium or received magnesium supplements. It is still uncertain whether the positive effects of magnesium supplementation in athletic performance are due to pharmacological actions of magnesium itself or to the reversal of a pre-existing magnesium deficiency. Therefore, the purpose of this article is briefly review of Magnesium importance in human health and athletics performance, various hypotheses that may explain magnesium's physiologic action mechanisms but also possible pathways for magnesium deficiency's correction.
Key words: *magnesium, athlete, deficiency, supplementation.*

Some basics of Magnesium

Magnesium is the second most abundant mineral in cells after potassium, but the two ounces or so found in the typical human body is present not as metal but as magnesium ions (positively-charged magnesium atoms found either in solution or complexed with other tissues, such as bone). Roughly one quarter of this magnesium is found in muscle tissue and three-fifths in bone; but less than 1% of it is found in blood serum, although that is used as the commonest indicator of magnesium status.

This blood serum magnesium can be further subdivided into free ionic, complex-bound and protein-bound portions, but it's the ionic portion that's considered most important in measuring magnesium status, because it is physiologically active.

The importance of magnesium as an essential nutrient has been emphasised as early as 1932 by Kruse et al., who induced an acute magnesium deficiency in rats by limiting the dietary intake of this element to 0.09mEq/kilogram. Hypo-magnesaemia produced hyperemia, neuromuscular progressive irritability that eventually precipitated fatal convulsions in these animals (1).

The role of Magnesium in the body

Mg is a cofactor involved in many enzymatic systems (more than 300 biochemical reactions), being necessary for protein synthesis, functioning of nervous and muscular systems, regulation of blood pressure and glycaemia, bone metabolism (2-4). Most studies regarding magnesium metabolism and homeostasis have shown that magnesium interferes with transmembrane sodium and potassium ion flow in smooth muscle, which explains its involvement in many physiological processes and why magnesium deficiency is linked to many pathological conditions of the cardiovascular, skeletal and nervous systems (5-7).