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Artículo Original

Vitamins, minerals and macronutrients adequacy in a group of Spanish menopausal athletes

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Resumen: La menopausia genera desequilibrios hormonales con efectos importantes en la salud física y mental de las mujeres, incluyendo a las deportistas. A pesar de su impacto, la relación entre menopausia, composición corporal y estado nutricional aún está poco explorada. Este estudio pretende caracterizar la composición corporal, hidratación y hábitos nutricionales de cinco deportistas posmenopáusicas (velocistas y corredoras de media distancia), de entre 49 y 60 años, mediante un diseño observacional transversal y cuantitativo con seguimiento de tres meses. Para ello, se evaluaron la ingesta de macro y micronutrientes, la composición corporal y el grado de deshidratación. En cuanto a los macronutrientes, se identificó una reducción del 22% en el consumo de carbohidratos y un aumento del 35% en el de lípidos, sin variaciones relevantes en la ingesta proteica respecto a la ingesta dietética recomendada (IDR). Asimismo, se observaron fluctuaciones importantes en el consumo de micronutrientes. El análisis mineral mostró ingestas elevadas de sodio (Na) y fósforo (P), y deficiencias en calcio (Ca), potasio (K) y zinc (Zn). En el control de la hidratación, se detectó una disminución de peso corporal tras cada sesión de entrenamiento, aunque la pérdida no superó el 2%, manteniéndose dentro de los márgenes aceptables. En conclusión, se evidencian alteraciones significativas en el perfil nutricional de estas deportistas posmenopáusicas, lo que subraya la necesidad de promover una dieta equilibrada. No obstante, se requieren estudios con mayor tamaño muestral para confirmar estos hallazgos.

Palabras Clave: Menopausia, Antropometría, Deportista, Nutrición, Hidratación.

Abstract: Menopause causes hormonal imbalances with significant effects on women's physical and mental health, including that of female athletes. Despite its impact, the relationship between menopause, body composition, and nutritional status remains underexplored. This study aimed to characterize the body composition, hydration, and nutritional habits of five postmenopausal athletes (sprinters and middle-distance runners), aged between 49 and 60 years, through a cross-sectional, observational, and quantitative design with a three-month follow-up. To achieve this, intake of macro- and micronutrients, body composition, and degree of dehydration were evaluated. Regarding macronutrients, a 22% decrease in carbohydrate intake and a 35% increase in fat intake were identified, with no significant variations in protein intake compared to the recommended dietary intake (RDI). Notable fluctuations in micronutrient consumption were also observed. Mineral analysis showed high intakes of sodium (Na) and phosphorus (P), and deficiencies in calcium (Ca), potassium (K), and zinc (Zn). In terms of hydration monitoring, a reduction in body weight was detected after each training session; however, the weight loss did not exceed 2%, remaining within acceptable margins. In conclusion, significant alterations in the nutritional profile of these postmenopausal athletes were identified, highlighting the need to promote a balanced diet. Nevertheless, studies with larger sample sizes are required to confirm these findings.

Key words: Menopause, Anthropometry, Athlete, Nutrition, Hydration.

1. Introduction

Menopause is the cessation of a woman's menstrual periods, diagnosed retrospectively, after one year of amenorrhea [1]. It occurs around the age of 45-55 years due to the atresia of the ovarian follicles and their inability to produce estrogen [2]. Women's life span has been increasing in recent years in developed countries, which means that approximately one-third of women's lives occur during menopause [3], hence the importance.

Body composition changes with age and can be modified through sport [4]. With the onset of menopause and the effect of estrogen on metabolism, women are more prone to fat accumulation and sarcopenia [5]. The fat tissue that used to be in the thighs, hips, and chest is now distributed in the waist and abdomen [6].

Menopause is an influential aspect of a woman's life, especially if she is an athlete. It is important to consider the role that women play in athletics and have also reached menopause, since the loss of muscle mass and gain of fat tissue influences their sports performance [7]. In this line, nutrition is a fundamental component, so it is relevant to know how it influences the development of a particular body composition [8]. To improve the performance of menopausal women athletes, a specific body composition is required, which should be provided not only by adequate training, but also by optimal nutrition [9]. In addition, proper hydration patterns have a significant impact on athletic performance, injury prevention and recovery [10].

The aim of the present study was to characterize the body composition, hydration and nutritional habits of a group of Spanish menopausal female athletes.

2. Material and methods

A cross-sectional and quantitative observational study was conducted.

2.1. Subjects

The population sample consists of 5 women between 49-60 years old who are members of an athletic club in the province of Valencia (Spain) federated in the Royal Spanish Athletic Federation. The following selection criteria were applied to the athletes interested in participating in the study: women with natural menopause and amenorrhea established for more than one year, absence of heart problems, and federated in the Athletics Federation of the Valencian Community or in the Spanish Athletics Federation. The exclusion criteria included: women with diabetes and/or diagnosed with arterial hypertension, women under hormone treatment, and previous mastectomy. All participants received detailed information about the study and signed an informed consent form after accepting to take part in the study. The study was developed in accordance with the Declaration of Helsinki, with the prior approval of the protocol by the Human Research Committee of the Universidad Católica de Valencia "San Vicente Mártir" (procedure number UCV/2018-2019/083).

2.2. Materials

Portable clinical scale, SECA model, with a 150-200 kg capacity and 100 g precision; height rod, SECA model, 220 Hamburg, Germany, with a 0.1 cm precision; metal, inextensible and narrow anthropometric tape, model Lufkin W606PM, with 0.2 mm precision; a mechanical skin fold caliper, model Holtain LTD, Crymych, UK, with a 0.2 mm precision and measurement range from 0 to 48 mm; a bicondylar pachymeter to measure the diameter of small bones, model Holtain, with 1 mm precision and measuring range from 0 to 140 mm; and a dermographic pencil to mark anatomical points.

2.3. Measurements

2.3.1. Diet and eating habits

The Food Frequency Questionnaire was used [11] to gather information about how often the different food groups were consumed by the athletes: dairy products, fruits, vegetables, meat, fish, rice, legumes, pasta, eggs, juices, nuts, seafood, snacks, sweets, alcohol, etc. The self-administered questionnaire asked about how often certain food groups were usually consumed in a week. In addition, each athlete registered their solid and liquid food intake for 7 days. This period allowed us to collect enough data on the athletes' normal diet, reducing the risk of bias associated with choosing one day a week [12]. Athletes also took note of the type of food they consumed, the different ingredients used to prepare each meal, and the amount that was consumed per intake (a glass, a portion, a cup, a plate, etc.) or the exact weight of the food or drink. In order to help the athletes to complete the task, they were provided with information regarding the weight for each portion and the most common household measurements [13].

With the information from the athletes' food diary over 7 days and the Food Frequency Questionnaire, the quality of the diet was calibrated by using the Easy Diet-Programa de gestión de la consulta® software. With this software, a nutrition profile containing the daily energy intake and percentage distribution of macronutrients and micronutrients was obtained from the meals introduced to the program. Vitamins B1, B2, B3, B6, B9, and B12 were determined, whereas the minerals assessed were Ca, Na, K, Mg, Fe, P, and Zn. The total energy expenditure (TEE) was calculated with the Harris-Benedict formula for each of the athletes considering the moderate activity factor, menopause, and their ages. Dietary Reference Intake (DRI) from "Ingestas de referencia para la población Española" [14] and "Consenso de la Sociedad Española de Nutrición Comunitaria (SENC)" [15] were taken as guidelines.

2.3.2. Anthropometric measures

Body weight, height, body diameters and perimeters, and skinfolds (tricipital, subscapular, abdominal, supra-iliac, thigh, and calf) were measured following the protocol established by The International Society for the Advancement of Kinanthropometry (ISAK) by an ISAK level 3 certified anthropometrist. Carter's formula was used to calculate fat deposits. To determine the volume of skeletal muscle, Lee's formula was used and to assess bone weight, Rocha's equation was applied.

2.3.3. Hydration control

In order to assess the percentage of dehydration, athletes were weighed before and after training with the minimum number of clothes and solid and liquid intake during training. Four training sessions were developed.

2.4. Statistical analysis

Statistical analysis was performed with SPSS software v.20 (IBM Corporation, Armonk, NY, USA). The group studied fitted into the normality that was analyzed by the Kolmogorov–Smirnov test. A p-value below 0.05 was considered significant.

3. Results

3.1. Energy and macronutrient intakes

Table I shows the daily energy intake of each athlete and its comparison with the DRI.

Table I Daily energy intake of each athlete compared to the Dietary Reference Intakes (DRI)

	Energy/day (Kcal)	DRI (Kcal)	Difference (Kcal)
Athlete 1	1815.2	2090	-274.8
Athlete 2	1815.0	2273	-458.0
Athlete 3	3061.7	2444	+617.7
Athlete 4	1686.3	1958	-271.7
Athlete 5	1987.4	2018	-30.6
Mean ± SD	**2073.1 ± 562.9**		

Values are expressed as mean ± standard deviation (SD).

The mean daily intake of the study sample was 2073.1 kcal. This caloric intake presented a minimum value of 1686.3 kcal and a maximum value of 3061.7 kcal. It should be noted that athletes number 1, 2, 4 and 5 presented a deficient caloric intake compared to the DRI. Athlete number 3 was the only case to present a mean caloric intake higher than the DRI. However, no statistically significant differences were identified in any of the cases.

The mean carbohydrate intake was 43%, which was 22% significantly ($p<0.01$) lower than the DRI (55%). Conversely, the lipid intake was 41%. This was 35% significantly ($p<0.01$) higher than the DRI (30%). In the case of protein, a mean intake of 17% was obtained, which was slightly higher than the recommended intake (15%). No significant differences were observed in the consumption of proteins compared to the DRI (Figure 1).

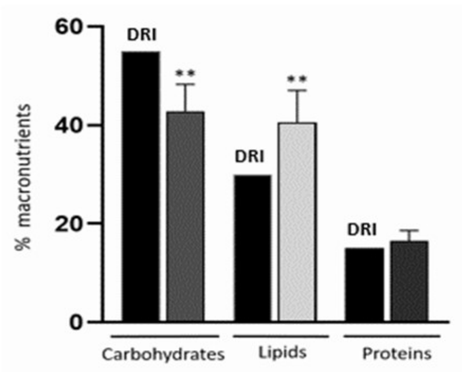

Figure 1 Average intake of carbohydrates, lipids and proteins in relation to Dietary Reference Intakes (DRI).

3.2. Vitamin intakes

Table II shows the nutritional intake of vitamins

Table II. Vitamins intake compared to Dietary Reference Intakes (DRI).

	Vitamin A (μg)	Vitamin C (mg)	Vitamin D (μg)	Vitamin E (mg)
Athlete 1	1200	52.4	2.1	11.7
Athlete 2	998.4	53.7	2.0	14
Athlete 3	1500	90	4.3	15
Athlete 4	1434	86.3	3.6	12.6
Athlete 5	976	116.4	2.5	10.3
Mean ± SD	1221 ± 241.5	79.8 ± 27.0	2.9 ± 1.0	12.7 ± 1.8
DRI	800	60	10	12
Difference (%)	+53%*	+33%	-71%**	+6%

Vitamin B group

	Vit B1 (mg)	Vit B2 (mg)	Vit B3 (mg)	Vit B6 (mg)	Vit B9 (mg)	Vit B12 (μg)
Athlete 1	0.9	1.2	18	1.4	216.7	3.8
Athlete 2	1.2	1.9	21	1.8	296.0	4.5
Athlete 3	1.9	2.4	21	2.9	385.0	4.2
Athlete 4	1.2	1.2	21	2.0	274.0	3.1
Athlete 5	1.1	1.2	19	1.8	245.0	2.8
Mean ± SD	1.3 ± 0.4	1.6 ± 0.5	20.0 ± 1.4	2.0 ± 0.6	283.3 ± 64.2	3.7 ± 0.7
DRI	0.8	1.2	14	1.6	400	2
Difference (%)	+63%*	+33%	+43%**	+25%	-30%**	+85%**

Values are expressed as mean ± standard deviation (SD). *$p<0.05$, **$p<0.01$ versus Dietary References Intakes (DRI).

The mean intake of vitamin A was equal to 1221.7 μg. Compared to their DRI (800 μg), vitamin A levels were 53% significantly higher ($p<0.05$). The intake of vitamins C and E was also higher than the recommendations, by 33% and 6%, respectively. However, this excess was not statistically significant. The mean intake of ascorbic acid was equal to 79.8 mg and that of vitamin E was equal to 12.7 mg. In contrast, mean vitamin D intake was equal to 2.9 μg and was significantly reduced by 71% ($p<0.01$), compared to DRI.

Regarding group B vitamins, the intake of all B vitamins was higher compared to their corresponding DRI except for vitamin B9, whose intake was significantly below the recommendations ($p<0.01$). Furthermore, these increases were significant for vitamins B1, B3 and B12 ($p<0.01$).

3.3. Mineral intakes

The following nutritional variables were assessed: calcium, sodium, potassium, magnesium, iron, phosphorus, and zinc. The intake of the minerals Na, Mg, Fe, and P was higher compared to their corresponding DRI. These excesses were significant for Na ($p<0.05$) and P ($p<0.01$). In contrast, Ca, K, and Zn were significantly ($p<0.01$) deficient (Table III).

Table III. Mineral intakes compared to Dietary Reference Intakes (DRI).

	Ca (mg)	Na (mg)	K (mg)	Mg (mg)	Fe (mg)	P (mg)	Zn (mg)
Athlete 1	640.2	1589	2573	329	11.2	1052	8.2
Athlete 2	673.3	2134	2451	322	10.6	1073	7.0
Athlete 3	657.9	2278	2303	317	8.0	1015	5.9
Athlete 4	840.3	1635	2644	296	10.6	1310	8.0
Athlete 5	942.6	2071	3585	409	16.3	1666	11.5
Mean ± SD	750.9 ± 133.8	1941.4 ± 310.4	2711.2 ± 505.3	334.6 ± 43.4	11.4 ± 3.0	1223.2 ± 273.3	8.1 ± 2.1
DRI	1200	1600	3500	300	10	700	15
Difference (%)	-37%**	+21%*	-23%**	+12%	+14%	+75%**	-46%**

Values are expressed as mean ± standard deviation (SD). *$p<0.05$, **$p<0.01$ versus Dietary Reference Intakes (DRI).

3.4. Anthropometric variables

In the present study, the body composition of the athletes was analysed through the following compartments: muscle mass, fat mass, bone mass and residual mass in order to determine the anthropometric profile of the athletes. These results are shown in Figure 2.

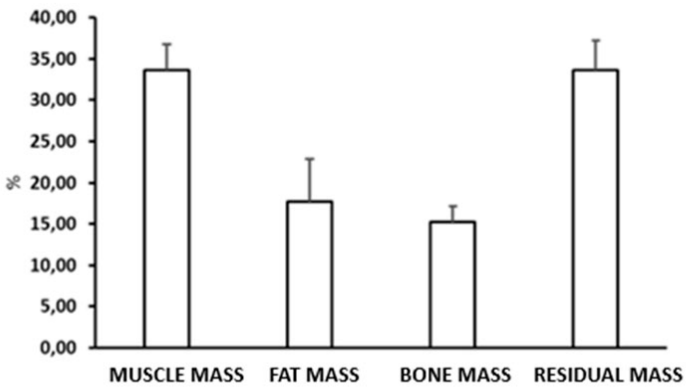

Figure 2 Analysis of muscle mass, fat mass, bone mass and residual mass of the athletes.

The athletes presented an average of 33.6% of muscle mass. The percentage of fat mass was equal to 17.7%. As for the percentage of bone mass, this was equal to 15.3%, while the percentage of residual mass was equal to 33.6%.

3.5. Hydration control

After comparing body weight before and after training, a decrease in this variable was determined in all sessions. The body weight before training ranged between 64.4 - 64.5 kg, while this same variable after the end of training ranged between 64 - 64.2 kg. The percentage of weight loss varied slightly and ranged from 0.36 % to 0.87 %, never reaching 2% of dehydration that would be considered significant.

4. Discussion

Having a balanced nutrient diet is essential for maintaining optimal physical performance for athletes, especially for women athletes. Menopause leads to pronounced hormonal imbalances that can impact various, including physical and mental well-being in significant ways. Menopause also significantly affects the risk of having cardiovascular disease and poorer bone health [16].

4.1. Energy, macronutrients and micronutrients

Macronutrients play a pivotal role in energy production, tissue growth/repair, hormone production, satiety, and appetite regulation. Despite the energy intake was adequate and this is something positive for endurance sports, our study revealed a significant difference in macronutrient intake in menopausal athletes. The average carbohydrate intake was significantly lower than the DRI. This observation correlates with previously published research that highlights the importance of macronutrient imbalance in postmenopausal women [17]. Low-carbohydrate diets can impede the replenishment of glycogen stores and have detrimental effects on physical performance, particularly in athletes [18]. Conversely, the lipid intake was significantly higher than the DRI. High fat intake may lead to gastrointestinal problems in runners and reduces gastric emptying, as observed in the athletes' training sessions, where much experienced heaviness after meals before going to training. These observations have high ramifications in the physiological and psychological aspects of menopausal athletes. However, to generalise our results much larger cohort is needed.

In addition, micronutrients such as vitamins play a vital role in athletes' overall health and performance. Vitamin C, D, and the B-complex vitamins play a crucial role in energy metabolism, muscle function, and recovery. They aid in the conversion of macronutrients into usable energy, support the production of red blood cells, maintain bone strength, and contribute to a healthy immune system [19]. We particularly observed a reduced intake of vitamin B9 in study participants. Vitamin B9 is essential for various body functions, including building blocks for DNA and RNA synthesis and cellular regeneration and growth. A deficiency of vitamin B9 can result in megaloblastic anemia. This in turn results in the altered oxygen-carrying capacity of RBC. In the context of our study, menopausal women, have intakes of vitamin B9 below the recommended DRI levels. This could be attributed to their low consumption of leafy green vegetables and legumes, which are rich sources of vitamin B9, which can be attributed to observed in the dietary records. Similar to B-complex, vitamin C is vital for the regeneration of muscle collagen and osteoarticular health, as well as reducing athletic performance [20]. Although we did not observe significant differences in vitamin C and E, a larger cohort is needed to solidify our observations.

Strikingly, participants of our study showed a lower intake of vitamin D. Vitamin D is important for the regulation of phosphate and intestinal calcium absorption, optimal bone health, and immune system function [21]. Menopausal women often have low levels due to limited sun exposure and inadequate dietary intake. Insufficient vitamin D levels increase the risk of coronary disease, osteoporosis, and hip fracture. Literature suggests that supplementation of vitamin D reduces triglyceride levels and total cholesterol in postmenopausal women [22]. Further, a recent report demonstrated randomized calcium and vitamin D supplementation significantly enhanced total bone mineral density [23]. Thus, a diet rich in vitamin D has the potential to significantly enhance intestinal calcium absorption, lower concentrations of parathyroid hormone, mitigate bone loss, and increase bone mineral density [24]. Also, vitamin D supplementation could potentially have a significant impact on reducing skeletal muscle injuries in athletes who engage in exercise involving eccentric muscle contractions [25].

In our mineral analysis, we observed reduced uptake of Ca, K, and Zn. Vitamin D has many cofactors, including Zn to efficiently carry out its functions in promoting bone health and supporting the immune system. Zinc is essential for numerous biological processes, including immunity, programmed cell death, brain maturation and development, taste and smell regulation, skin and mucosal integrity, and metabolic function [26]. Moreover, Zn is an abundant trace mineral in the body and plays a vital role in the functioning of over 600 enzymes, more than 2500 transcription factors, and several proteins [27]. It is used as a signalling ion to regulate gene expression, protein synthesis, DNA synthesis, cell division, and genomic stability [28]. Daily intake of zinc is needed as our bodies do not have a true zinc storage system [29]. Notably, a study conducted in Spain involving individuals ranging from 9 to 75 years old revealed that more than 80% of participants did not meet the recommended Zn intake requirements [30]. Moreover, older adults are particularly susceptible to zinc deficiency. Data from the Third National Health and Nutrition Examination Survey indicated that 35–45% of adults aged 60 or above failed to meet the estimated average requirement for zinc [31]. In addition to the Zn, we noticed a significant reduction in Ca, K which can also have a prominent role in maintaining strong bones and teeth, muscle contraction, and nerve transmission. Especially, K is an electrolyte that helps maintain fluid balance, lower blood pressure, nerve conduction, and muscle contraction, including heart muscle, contributing to a decrease in the risk of cardiovascular and renal disease [32]. A reduced intake of these two minerals will significantly affect these physiological processes.

4.2. Anthropometry and hydration

It is worth noting that during menopause, there is a 6% increase in body weight, primarily due to an approximate 17% increase in adipose tissue [33]. However, in this study, the percentage of body fat was equal to 17.7%. Despite the specific physiological changes during menopause, this value was appropriate, which could be related to physical activity, increasing basal and total energy expenditure, reducing the risk of weight gain. Nevertheless, it would be advisable to adjust calorie intake to the nutritional needs of each athlete and improve adherence to a balanced diet, as the average lipid intake was higher than recommended. This is relevant because lipids are the macronutrient that provides the most calories. In future studies, it would be interesting to analyze visceral fat because during menopause, there is an increase that is associated with a higher cardiovascular risk [34].

On the other hand, menopause is associated with a decrease in muscle mass due to the cessation of estrogen secretion35. In our study, the muscle mass was equal to 33.6%, an appropriate value that could be related to physical exercise, which helps maintain muscle mass, and adequate protein consumption [35]. The cessation of estrogen leads to a decrease in bone mineral density. Considering that calcium and vitamin D intake was deficient, it would be advisable to increase the consumption of calcium-rich foods such as milk, yogurt, kefir, and nuts and promote sun exposure for vitamin D synthesis. It is also necessary to reduce phosphorus intake (sodas, ultra-processed products, additives like phosphoric acid) [36], which was higher than the recommendations and could contribute to an imbalance between both minerals that could increase the risk of bone decalcification [37].

As for hydration, a very slight variation in the percentage of weight loss was determined when comparing this variable between the pre and post-training moments. This result can be considered positive because, in all cases, the percentage of weight loss did not exceed 1%. This indicates that the hydration status of the athletes and their hydration habits were appropriate because a 2% loss of body weight can disrupt thermoregulation, increase fatigue, decrease muscle strength, and result in reduced athletic performance [38].

4.3. Limitations of the study

The limited sample size of the study is insufficient to reach robust conclusions and further research is warranted. Furthermore, it is important to note that there are currently no specific DRIs for menopausal female athletes, who may have specific nutritional needs. Comparing the results obtained with previous studies is difficult due to the lack of similar studies conducted in Spain.

The dietary-nutritional software used in this study did not provide data on the consumption of simple carbohydrates. Furthermore, exposure to sun as a source of vitamin D was not considered. Biochemical analyses of serological values for vitamins and minerals would provide valuable insights into the impact of nutritional intake on menopausal female athletes.

In relation to all mentioned previously, more studies on this area of sports nutrition are needed in order to provide more solid knowledge regarding the adaptation of the diet in the case of female patients in menopausal period. Thus, future studies may bring light on the adaptation and monitoring of the diet to meet specific nutritional needs in this population.

5. Conclusions

Proper nutrition and sport modify body composition and can lead to better performance. However, these athletes in menopause do not reach the DRI for some macronutrients and micronutrients, minerals and vitamins, leading to a worsening of their health and physical performance. These deficiencies in the macro and micronutrients will have consequences on the athlete's performance in sports and also on the physiological and psychological condition of menopausal women. Moreover, reduced intake combined with the hormonal fluctuations during menopause can further affect nutrient absorption, which further culminates and impact the athletes' performance, leading to decreased endurance, impaired recovery, muscle weakness, and increase risk of injuries.

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Conflict of interest: The authors declare that there are no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

DRI: Dietary Reference Intakes
ISAK: International Society for the Advancement of Kinanthropometry
SENC: Consenso de la Sociedad Española de Nutrición Comunitaria
TEE: Total Energy Expenditure

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