Nutrición Hospitalaria

Nutr Hosp. 2013;28(3):1065-1076
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original / *Deporte y ejercicio*

Implementation of a nutrition education program in a handball team; consequences on nutritional status

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Abstract

Objective: **To evaluate nutritional status and dietary habits after implementation of a nutritional education program in professional handball players.**

Research methods and procedures: **Longitudinal study of 14 handball players evaluated with 72-h recall, a questionnaire on food consumption and anthropometric measures during 4 months. The intervention consisted of a nutrition education program.**

Results: **Energy intake was consistently below the recommended allowances. Macronutrient intakes as a percentage of total energy intake were below the recommended allowances for carbohydrates, and above recommended allowances for fats. Nutritional education was followed by a significant increase ($p < 0.01$) in total energy and macronutrient intakes, with no significant changes in macronutrient or micronutrient intakes after adjustment for energy intake.**

Discussion: **The imbalance in nutrient intake in handball players suggests that detailed re-analysis is needed to determine specific recommendations for this population. Nutritional education with continuous follow-up to monitor athletes' dietary habits may lead them to adopt appropriate nutritional habits to optimize dietary intakes. The lack of specific recommendations for micronutrient intakes in athletes leads to confusion regarding appropriate intakes; biochemical tests that yield normal values (albeit approaching cut-off values for deficiency) may disguise deficient status for some nutrients when strenuous exercise is involved.**

Conclusion: **In-depth studies with nutrition education programs that include long-term follow-up are advisable**

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Recibido: 28-III-2013.
Aceptado: 28-V-2013.

IMPLEMENTACIÓN DE UN PROGRAMA DE EDUCACIÓN NUTRICIONAL EN UN EQUIPO DE BALONMANO; CONSECUENCIAS EN ESTADO NUTRICIONAL

Resumen

Objetivos: **Evaluar el estado nutricional y los hábitos dietéticos en respuesta a la aplicación de un programa de educación nutricional en jugadores profesionales de balonmano.**

Sujetos y metodología: **Estudio longitudinal realizado a una muestra de 14 jugadores pertenecientes a un equipo de balonmano de alto rendimiento, a los que se les evaluó mediante recordatorio de 72 horas, un cuestionario de frecuencia de consumo, medidas antropométricas a lo largo de 4 meses, y a los que se les aplicó un programa de educación nutricional al inicio del estudio. Los valores de ingesta y de frecuencia de consumo fueron comparados con las recomendaciones de macronutrientes existentes para deportistas y micronutrientes para población sana, respectivamente, y con la pirámide de alimentos para población sana española.**

Resultados: **La ingesta de energía de los deportistas se situó por debajo de las recomendaciones a lo largo de todo el estudio. La ingesta de macronutrientes respecto a la energía ingerida, se situó por debajo de las recomendaciones para la ingesta de carbohidratos y por encima de las recomendaciones para la ingesta de grasa, mostrada en los resultados obtenidos de frecuencia de consumo de alimentos. La educación nutricional produjo un incremento significativo ($p < 0,01$) en la ingesta de energía y macronutrientes tras su aplicación. A pesar de ello, no se produjeron cambios significativos en la ingesta de macronutrientes y micronutrientes al ajustar por energía ingerida. Los niveles bioquímicos se encontraron dentro de los rangos de normalidad durante todo el estudio.**

Discusión: **El desequilibrio en la ingesta de nutrientes presente en los jugadores de balonmano hace necesario realizar un ajuste nutricional completo para poder establecer recomendaciones específicas para este tipo de población. La aplicación de un programa de educación nutricional monitorizada de manera continuada mediante seguimiento en los deportistas, puede tener como consecuencia la instauración de hábitos nutricionales adecuados que lleve a una optimización en la ingesta. La ausencia de recomendaciones específicas de micronutrientes en el deporte, provoca**

to avoid deficiencies that can lead to irreversible damage in competitive athletes.

(*Nutr Hosp.* 2013;28:1065-1076)

DOI:10.3305/nh.2013.28.4.6600

Key words: *Handball. Nutritional education. Nutritional assessment. Team sports. Supplementation.*

una cierta confusión a la hora de establecer una ingesta adecuada de micronutrientes, ya que en muchos casos demuestran normalidad en los niveles bioquímicos, aunque muy cercanos a la deficiencia, pudiendo comprometer el estatus de algún nutriente en situaciones de ejercicio extremo.

Conclusión: **Sería aconsejable realizar estudios exhaustivos de valoración del estatus nutricional que planteen la instauración de programas de educación nutricional a largo plazo, con el fin de evitar carencias que deriven en daños irreversibles en el deportista de competición.**

(*Nutr Hosp.* 2013;28:1065-1076)

DOI:10.3305/nh.2013.28.4.6600

Palabras clave: *Balonmano. Educación nutricional. Valoración nutricional. Deportes de equipo. Suplementación.*

Introduction

Changes are currently taking place in sports nutrition in favor of strategies intended to favor the adaptations that occur in response to training.[1] Acquiring knowledge about athletes' energy and nutrient needs is a priority to facilitate maximum performance.[2-6] Training and nutrition are closely interrelated, since optimum adaptation to meet the demands of repeated training sessions generally requires an appropriate diet in terms of the amounts and types of nutrients.[7,8]

Although there is no specific set of dietary recommendations or consensus regarding nutritional requirements during exercise,[9] it is generally agreed that athletes need to consume a diet consistent with recommendations for the general population for overall good health.[10,11] Current studies have emphasized that nutrition in athletes is often inadequate.[4,12] One of the most important strategies to help athletes consume an adequate diet is nutrition education.[11] The aims of this strategy for athletes are identify and take appropriate measures to meet nutritional needs, correct possible deficiencies in food intake and promote optimum health and performance.[11,13]

The nutritional requirements for different sports are determined by the game's rules, duration and frequency of competition, duration of the sports season, training phase, number of players and substitutions that are allowed during competition.[14] Like other team sports, handball is characterized by an intermittent pattern of activity, with periods that requires mainly aerobic metabolism as an energy source alternating with bursts of highly intense activity that require mainly anaerobic metabolism.[14,15] In this highly complex sport, successful performance depends on a series of basic skills such as strength, power, speed and endurance.[16] During periods of intensive training, the recommended intakes for energy and macronutrients must be met, especially for carbohydrates (CHO) and proteins, in order to maintain appropriate body mass, optimal recovery of muscle glycogen stores, and tissue construction and regeneration. Fat intake should be sufficient to cover the requirements for essential fatty acids,[7,17] and micronutrient intakes should not be overlooked since exercise increases micronutrient requirements.[18-21]

In the last 30 years there have been no studies designed to analyze nutritional status in men's handball teams or to investigate whether nutrition education in handball players affects their nutritional status. The present study aimed to evaluate professional handball players' responses to a nutrition education program in terms of their clinical and nutritional status.

Material and methods

The present study involved 14 handball players and was carried out between October 2009 and February 2010 during the first phase of training and competition in the Honor B Division of the Spanish professional handball league.

Subjects

Mean age of the participants was 22.9 ± 2.7 years, and all were members of the Puente Genil Handball Club in Granada, Spain. Training took place an average of 4 to 5 days per week and competition matches were held once per weekend. Participation in the study was voluntary, and after receiving information about the procedures and objectives of the study, each participant provided his informed consent in writing, and was allowed to withdraw from the study at any time. The study was approved by the University of Granada Ethics Committee.

Dietary intake

Dietary intakes in all participants were recorded by 72-h recall,[22] and each 3-day recall period included one Saturday or Sunday. Intakes were recorded during the 4-month study period at three times: baseline (control) in week 0 before the nutrition education program was implemented, week 8 after the nutrition education program, and week 16. Data on food intakes were obtained in the course of individual interviews to request information from each participant about the types of foods and serving sizes. Recall accuracy was facilitated with a set of photographs of prepared foods and dishes that are frequently consumed in Spain.

The Nutriber® software program was used to convert food intakes to absolute and percentage values of recommended intakes of each nutrient for individual athletes.[23] Estimated energy expenditure was calculated for each participant with the equation proposed by the Food and Agriculture Organization (FAO)/ World Health Organization (WHO)/ United Nations University (UNU).[24] Resting metabolic rate (RMR) was calculated from body weight and height. Total energy expenditure was calculated by multiplying RMR by the appropriate activity factor. Macronutrient intakes were compared with the recommended daily allowances (RDA) proposed by the American Dietetic Association (ADA) and American College of Sports Medicine (ACSM).[5,6] Vitamin and mineral intakes were compared with the dietary reference intakes (DRI) for the Spanish population and the European Union population according to Cuervo et al.[25] Adequate intake levels were determined by comparing actual intakes of each nutrient with the recommended intake for each participant, and were recorded as < 75% of the RDA, between 75% and 100% of the RDA, and > RDA.

A questionnaire was used to obtain information about consumption frequencies (CF) for a list of more than 200 types of food. For each participant we compared these frequencies with the recommendations proposed by the Spanish Community Nutrition Society (Sociedad Española de Nutrición Comunitaria, SENC),[26,27] and recorded the results as the percentage of participants whose CF was below or above the recommended number of servings. If the SENC had not issued a recommended number of servings for a given food because it is consumed only occasionally or in small portions, we reported the results as servings consumed per week.

Nutritional educational program

The educational intervention was designed ad hoc for this type of study population by a team of nutrition specialists. The intervention consisted of three phases. First, the nutrition team explained, by personalized way, aspects related with nutrition in general, with emphasis on the different types of nutrients and their importance for maintaining good health in basically healthy persons. This was followed by education focusing more specifically on nutrition and physical activity. In this second phase, the emphasis was on specific nutritional requirements in persons who perform continuous physical activity, and on frequent errors in nutrition in this population. In the third phase, researchers responded to the questions each participant individually raised at any time throughout the study period, to provide additional information and clarification.

Biochemical analysis

Blood samples for laboratory analyses were obtained after a 12-h fast after the last training session in each time period, and were collected in the morning after the participants had abstained from eating and drinking overnight.

Venous blood was drawn, centrifuged to separate plasma and red blood cells, and stored at -80° C. Laboratory values were determined for glucose, transferrin, albumin, prealbumin, creatinine, high-density lipoprotein, low-density lipoprotein, triglycerides, total cholesterol concentrations and iron with enzymatic colorimetric tests in a Hitachi Modular P autoanalyzer (Roche Diagnostics, Grenzach, Germany). These data were used to verify adequate nutritional status in all participants and rule out the possibility of nutritional alterations that might have affected the findings.

Data analysis

The data are reported with descriptive statistics. For numerical variables we used the arithmetic mean, standard deviation, confidence interval and standard error of the mean. The results for categorical variables are reported as percentage frequencies. To determine whether the data fitted a parametric model, the Kolmogorov-Smirnov test was used to verify normal distribution. For comparisons we used single-factor analysis of variance. Linear regression analysis was used to identify correlations by calculating Pearson's bivariate correlation coefficient. All statistical analyses were done with SPSS v. 17.0 for Windows.

Results

The general characteristics of the participants (age, height, weight, body mass index, VO_2 max, body fat and estimated energy expenditure and estimated energy intake) are shown in table I. Mean estimated intake was significantly greater ($p < 0.01$) in week 8 and week 16 compared to week 0. No significant differences were seen for any of the other nutritional parameters compared across the three time points.

Food intake

The results for energy, macronutrient and fatty acid intakes as a percentage of the allowances for athletes recommended by the ACSM and ADA[5,6] are shown in

Table I
Characteristics of the participants

Sample characteristics						
Measurement	*Mean*		*SD*			
Age (years)	22.9		2.7			
Height (m)	1.87		0.06			
VO_2 max ($mL·min·kg^{-1}$)	60.44		5.19			
Estimated energy expenditure ($kcal·day^{-1}$)	3,534.64		169.63			
	Week 0		*Week 8*		*Week 16*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Weight (kg)	86.72	5.36	86.47	5.59	86.38	4.81
Body mass index (kg/m^2)	24.72	1.12	24.61	1.30	24.62	1.14
Body fat (%)	11.58	2.53	11.60	2.45	11.57	2.34
Estimated energy intake ($kcal·day^{-1}$)	2,974.50	211.12	3,355.10[a]	325.30	3,328.64[a]	306.13

All data are expressed as the mean and standard deviation (SD).
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.01$) according to Student's t-test.

Table II
Macronutrient intake in handball players

		Measurement points					
		Week 0		*Week 8*		*Week 16*	
	*Recommendation**	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Energy							
Per day ($kcal·day^{-1}$)		2,974.50	211.11	3,355.08[a]	325.31	3,328.64[a]	306.13
Per unit body mass ($kcal·kg^{-1}$)	44	34.45	3.56	38.91[a]	4.15	38.54[a]	2.94
Protein							
Per day ($g·day^{-1}$)	104-147	133.43	14.32	146.64	35.64	147.04[b]	25.51
Per unit body mass ($kcal·kg^{-1}$)	1.2-1.7	1.54	0.22	1.70	0.44	1.70[a]	0.33
Per energy ($mg·kcal·day^{-1}$)	–	44.93	4.58	43.68	9.32	39.67	5.42
Carbohydrate							
Per day ($g·day^{-1}$)	519-865	360.91	27.64	421.50[a]	49.24	416.80[a]	38.82
Per unit body mass ($kcal·kg^{-1}$)	6-10	4.17	0.41	4.88[a]	0.60	4.82[a]	0.36
Per energy ($mg·kcal·day^{-1}$)	–	121.67	10.26	125.54	6.35	125.51	9.07
Fat							
Per day ($g·day^{-1}$)	78-95	118.57	22.52	132.22[a]	17.75	129.57	21.79
Per unit body mass ($kcal·kg^{-1}$)	0.9-1.1	1.37	0.28	1.53[a]	0.19	1.49	0.21
Per energy ($mg·kcal·day^{-1}$)	–	39.67	5.42	39.45	4.23	38.80	4.45

All data are expressed as the mean and standard deviation (SD).
Macronutrient intakes are expressed as $g·day^{-1}$. $kcal·kg^{-1}$ and $mg·kcal·day^{-1}$.
*Recommended intakes for athletes according to the ADA[6].
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.01$).
[b]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.05$).

table II. Energy intake was below the recommended amount at all three time points. Compared to week 0 (baseline), energy intake was significantly higher ($p < 0.01$) at week 8 and week 16 after the nutrition education program was implemented.

Protein intake met the recommended amount at week 0 and week 8 but not at week 16, when intake was slightly above the recommended amount of 147 $g·day^{-1}$. At week 16, protein intake was significantly higher than at week 0 ($p < 0.05$). Carbohydrate intake was significantly higher after the nutrition education program at week 8 and week 16 than at week 0 ($p < 0.01$). Despite the significant change in this macronutrient with time, the reference value was not met at any of the three time points. In contrast, fat intake was above the recommended amount at all three time points, and the difference between week 0 and week 8 was significant ($p < 0.01$). When the data were adjusted

Table III
Fatty acid intakes in handball players

	Recommendation*	Week 0 Mean	Week 0 SD	Week 8 Mean	Week 8 SD	Week 16 Mean	Week 16 SD
Saturated fatty acids							
Per day ($g \cdot day^{-1}$)	–	39.42	8.94	40.09	7.20	40.54	12.02
Per energy ($mg \cdot kcal \cdot day^{-1}$)	–	13.21	2.54	11.95	1.90	12.02	2.63
Per energy (%)	10 %	11.89	2.89	10.76	1.72	10.82	2.37
Per percentage of RDA (%)	100 %	151.92	34.33	155.07	30.47	155.16	41.04
Monounsatured fatty acids							
Per day ($g \cdot day^{-1}$)	–	40.13	5.53	48.82[a]	13.07	50.43[b]	11.81
Per energy ($mg \cdot kcal \cdot day^{-1}$)	–	13.49	2.34	14.60	3.86	15.09	2.97
Per energy (%)	10 %	12.14	2.11	13.14	3.47	13.59	2.68
Per percentage of RDA (%)	100 %	155.75	33.83	188.42[a]	50.46	194.25[b]	43.49
Polyunsatured fatty acids							
Per day ($g \cdot day^{-1}$)	–	12.52	3.34	14.20	4.63	15.45	5.55
Per energy ($mg \cdot kcal \cdot day^{-1}$)	–	4.18	0.90	4.27	1.48	4.64	1.64
Per energy (%)	10 %	3.76	0.81	3.84	1.33	4.18	1.48
Per percentage of RDA (%)	100 %	48.78	14.71	55.17	19.04	59.86	22.05

All data are expressed as the mean and standard deviation (SD).
Fatty acid intakes are expressed as $g \cdot day^{-1}$, $mg \cdot kcal \cdot day^{-1}$, percentage energy or percentage of the RDA covered.
*Recommended intakes for athletes according to the ADA[6].
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.01$).
[b]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.05$).

for each macronutrient separately as a percentage of energy intake, there were no significant differences for comparisons between any pair of time points.

The results for fatty acid intake showed significant differences ($p < 0.01$ and $p < 0.05$) for monounsaturated fatty acids (MUFA) between week 0 and week 8 ($p < 0.01$), and between week 0 and week 16 ($p < 0.05$). There were no significant differences between time points when MUFA intake was recorded as an absolute value or calculated as a percentage of total energy intake. When fatty acid intakes as a percentage of total energy intake were compared, we found that saturated fatty acids (SFA) and MUFA intakes were above the amounts recommended by the ADA and ACSM,[5,6] according to which saturated, polyunsaturated (PUFA) and monounsaturated fatty acids should each account for 10% of the total energy intake.

The results for vitamin intake showed no significant changes for any vitamin at any time point, with the exception of vitamin B_{12} at week 8 and vitamins D and E at week 16 compared to week 0 (both $p < 0.05$). The intake of B group vitamins (thiamin, riboflavin, niacin and vitamin B_6) as a percentage of total energy decreased significantly ($p < 0.05$) at week 8 after the nutrition education program compared to week 0. Mineral intake showed no significant changes for any of the minerals. When intakes were expressed as a percentage of energy intake, significant differences were found at week 16 compared to week 0 ($p < 0.05$) for calcium, potassium and copper. In addition, potassium intake showed a significant decrease at week 8 ($p < 0.05$) compared to week 0.

Consumption frequency

Comparisons of the CF for different foods in our sample of athletes (table VI) showed no significant changes in any of the values except for beer and wine intake, which was significantly higher at week 8 compared to week 0 ($p < 0.05$) (table VI). When we compared the results with the recommendations of the SENC for the healthy population,[26,27] a large percentage of participants consumed fewer than the recommended number of servings of potatoes, rice, bread, wholemeal bread and pasta, vegetables, fruits, olive oil, milk and dairy products. In addition, a large percentage of participants did not meet the recommended number of servings per day at any of the three time points (table VI). None of the participants consumed more than the recommended number of servings of any type of food except for milk and dairy products: at each time point, 14.3% of the participants consumed more than the recommended allowance.

The numbers for fish, lean meat, poultry and egg consumption (servings/week) showed that most participants consumed more than the recommended number of servings of each of these types of food. The frequency of consumption was as high as 100% above the recommended allowance for lean meats, poultry and eggs. For fish, although approximately half of the participants (42.9% at weeks 0 and 16, 50% at week 8) exceeded the recommended number of servings, other participants (between 14.3% and 35.7% depending on the time point) consumed less than the recommended amount.

Table IV
Vitamin intakes in handball players

	Spain RDAs*	European RDAs*	Measurement points: Week 0 Mean	Week 0 SD	Week 8 Mean	Week 8 SD	Week 16 Mean	Week 16 SD
Thiamin								
Per day (mg·day^{-1})	1.2	1.1	2.49	0.49	2.32	0.57	2.38	0.75
Per energy (mg·kcal·day^{-1})†			0.84	0.17	0.69[a]	0.15	0.73	0.27
Riboflavin	1.8	1.6						
Per day (mg·day^{-1})			2.67	0.62	2.57	0.60	2.43	0.93
Per energy (mg·kcal·day^{-1})†			0.90	0.21	0.76[a]	0.15	0.75	0.33
Niacin	20	18						
Per day (mg·day^{-1})			39.10	8.04	34.99	8.17	40.34	9.58
Per energy (mg·kcal·day^{-1})†			13.15	2.63	10.55[a]	2.88	12.16	2.94
Vitamin B6	2.1	2.5						
Per day (mg·day^{-1})			2.88	0.68	2.69	0.53	3.02	0.53
Per energy (mg·kcal·day^{-1})†			0.97	0.23	0.81[a]	0.18	0.91	0.19
Folic acid (mg)	400	200						
Per day (mg·day^{-1})			301.97	89.06	316.11	54.49	290.35	98.57
Per energy (mg·kcal·day^{-1})†			101.53	29.59	94.61	15.99	88.11	30.61
Vitamin B12	2	1.4						
Per day (µg·day^{-1})			7.44	1.75	10.98[a]	4.30	7.92	1.74
Per energy (µg·kcal·day^{-1})†			2.49	0.58	3.27	1.27	2.39	0.56
Vitamin C	60	45						
Per day (mg·day^{-1})			118.53	52.52	128.10	52.62	109.93	67.57
Per energy (mg·kcal·day^{-1})†			39.95	17.68	39.29	17.83	33.68	21.32
Vitamin A	1,000	700						
Per day (µg·day^{-1})			898.16	305.88	893.79	397.46	991.28	499.82
Per energy (µg·kcal·day^{-1})†			300.95	96.82	268.01	124.86	294.79	131.66
Vitamin D	5	10						
Per day (µg·day-1)			5.31	2.63	6.47	3.75	8.75[a]	3.69
Per energy (µg·kcal·day-1)†			1.78	0.88	1.97	1.26	2.65	1.07
Vitamin E	12	–						
Per day (mg·day^{-1})			10.56	4.37	12.49	2.96	14.70[a]	5.12
Per energy (mg·kcal·day^{-1})†			3.50	1.30	3.77	1.05	4.43	1.53

All data are expressed as the mean and standard deviation (SD).
Vitamin intakes are expressed as mg·day^{-1} or µg·day^{-1}.
*Recommendations for the healthy population according to Cuervo et al.[25]
†All data are expressed as a factor of 103.
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.05$).

For legumes (servings/week), between 35.7% and 57.1% of the participants consumed fewer then the recommended number of servings, and for nuts, CF was below the recommended amount in 92.9% of the participants at all three time points.

The CF of foods from the sausages and meat fats, sweets, snacks, soft drinks, butter, margarine and pastries, and beer and wine groups, which should be consumed only occasionally and in moderation according to current recommendations, is reported as servings/day because these foods were consumed relatively frequently by the participants in this study. Mean CF for sausages and meat fats ranged from 0.85 to 1.03 servings/day depending on the time point. For the group that included sweets, snacks and soft drinks, CF ranged from 2.90 to 3.03 servings/day depending on the time point.

Biochemical analysis

Table VII summarizes the biochemical profiles of athletes at each of the three time points. The results indicate that the values for all parameters were normal. The values for lipid profile parameters showed significant differences ($p < 0.05$) in high- and low-density lipoprotein (mg/dL) at week 16 compared to week 0 and week 8.

Table V
Mineral intakes in handball players

	Spain RDAs*	European RDAs*	Measurement points Week 0 Mean	Week 0 SD	Week 8 Mean	Week 8 SD	Week 16 Mean	Week 16 SD
Calcium	800	700						
Per day (mg·day^{-1})			1,251.36	338.19	1,383.33	365.24	1,235.28	392.57
Per energy (mg·kcal·day^{-1})†			421.37	112.75	413.91	114.60	367.19[a]	94.23
Phosphorus	700	550						
Per day (mg·day^{-1})			1,682.58	318.01	1,809.93	437.88	1,814.46	228.40
Per energy (mg·kcal·day^{-1})†			566.01	104.17	538.75	116.18	546.23	64.31
Potassium	3,500	3,100						
Per day (g·day^{-1})			4,191.29	923.16	4096.86	653.42	3,983.64	854.64
Per energy (g ·kcal·day^{-1})†			1,415.15	328.13	1,222.20[a]	170.17	1,203.42[a]	269.13
Magnesium	350	–						
Per day (mg·day^{-1})			374.30	122.62	388.74	79.62	385.89	92.11
Per energy (mg·kcal·day^{-1})†			126.12	41.79	115.47	18.40	116.28	27.40
Iron	10	9						
Per day (mg·day^{-1})			24.15	8.50	24.87	4.96	24.42	6.10
Per energy (mg·kcal·day^{-1})†			8.19	3.09	7.45	1.52	7.39	1.88
Zinc	15	9.5						
Per day (mg·day^{-1})			18.06	9.91	26.13	12.50	23.70	10.16
Per energy (mg·kcal·day^{-1})†			5.98	3.29	7.59	4.17	7.06	2.97
Copper	–	1.1						
Per day (mg·day^{-1})			1.56	0.89	1.45	0.83	1.17	0.32
Per energy (mg·kcal·day^{-1})†			0.52	0.27	0.43	0.24	0.36[a]	0.10
Iodine	140	130						
Per day (µg·day^{-1})			105.37	68.22	96.24	44.81	110.51	50.25
Per energy (µg·kcal·day^{-1})†			35.60	24.16	28.85	13.69	33.29	15.76
Selenium	70	55						
Per day (µg ·day^{-1})			95.68	20.73	105.71	30.52	106.14	23.53
Per energy (µg ·kcal·day^{-1})†			32.23	7.10	31.40	8.08	32.03	8.92

All data are expressed as the mean and standard deviation (SD).
Mineral intakes are expressed as mg·day^{-1} or µg·day^{-1}.
*Recommendations for the healthy population according to Cuervo et al.[25]
†All data are expressed as a factor of 103.
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.05$).

Discussion

The main finding from our analysis of food and nutrient intakes in professional handball players is a tendency toward imbalances in nutritional status, as previously found in other team sports.[28,29] To date there have been no studies that were designed to evaluate overall nutritional status in male handball players.

Although the anthropometric parameters we studied showed some similarities with the measures reported by Chaouachi et al.[30] such as height and body weight, the values for percentage fat were slightly higher in their study compared to our participants. Sibila et al.[31] found percentage values almost identical to those in our study, and noted that in general, a greater mean height and lower percentage of fat was often associated with better team performance. In sports such as volleyball, handball and basketball, team members are usually characterized by their tall stature and high proportion of muscle mass,[14] and the predominant body type is mesomorphic tending toward ectomorphic.[31] In our participants, VO_2 max (mL·min·kg^{-1}) was slightly higher than in the sample of Croatian national handball team players studied by Sporis et al.,[16] and was similar to the 58 mL·min·kg^{-1} value reported by Rannou et al.[32] as indicative of good aerobic capacity in the handball players they studied.

Macronutrient intakes, whether considered in quantitative or qualitative terms, play a fundamental role in performance during training and competition.[8,17] When we compared macronutrient intakes as a percentage of total energy intake, we found that our results were

Table VI
Frequencies of consumption of different types of foods in handball players

		Measurement points								
		Week 0			Week 8			Week 16		
Food groups	*Recommendations*	*Mean (CI)*	*< R*	*> R*	*Mean (CI)*	*< R*	*> R*	*Mean (CI)*	*< R*	*> R*
Potatoes, rice, bread, wholemeal bread and pasta	4-6 servings/day	3.55 (2.77-4.38)	64.3%	–	3.50 (2.86-4.15)	57.1%	–	3.40 (2.90-3.91)	71.4%	–
Vegetables	≥ 2 servings/day	2.21 (1.65-2.77)	42.9%	–	2.30 (1.89-2.72)	28.6%	–	2.06 (1.56-2.55)	57.1%	–
Fruits	≥ 3 servings/day	1.70 (0.68-2.72)	85.7%	–	1.29 (0.61-1-98)	85.7%	–	1.14 (0.66-1.63)	92.9%	–
Olive oil	3-6 servings/day	1.62 (1.17-2.07)	100%	–	1.50 (1.13-1.88)	100%	–	1.43 (1.05-1.80)	100%	–
Milk and dairy	2-4 servings/day	2.72 (1.84-3.60)	42.9%	14.3%	2.71 (2.02-3.40)	42.9%	14.3%	2.71 (2.16-3.27)	14.3%	14.3%
Fish	3-4 servings/week	4.46 (2.97-5.95)	14.3%	42.9%	3.88 (2.93-4.84)	21.4%	50.0%	3.71 (2.70-4.73)	35.7%	42.9%
Lean meats, poultry and eggs	3-4 servings/week	7.45 (6.30-8.60)	–	100%	7.20 (5.93-8.46)	–	100%	6.80 (5.76-7.83)	–	100%
Legumes	2-4 servings/week	2.12 (1.42-2.81)	57.1%	7.1%	2.17 (1.59-2.75)	35.7%	–	1.95 (1.37-2.53)	50.0%	–
Nuts	3-7 servings/week	0.97 (0.24-1.70)	92.9%	–	1.06 (0.35-1.78)	92.9%	–	1.05 (0.44-1.65)	92.9%	–
Sausages and meat fats*	Occasional and moderate	1.03 (0.66-1.41)	–	100%	0.85 (0.61-1.09)	–	100%	0.87 (0.54-1.19)	–	–
Sweets, snacks and soft drinks*	Occasional and moderate	2.90 (2.18-3.62)	–	–	3.03 (2.35-3.72)	–	–	2.98 (2.15-3.80)	–	–
Butter, margarine and pastries*	Occasional and moderate	0.85 (0.50-1.21)	–	–	0.85 (0.52-1.18)	–	–	0.87 (0.48-1.25)	–	–
Beer or wine*	Optional consumption and moderate in adults	0.17 (0.10-0.23)	–	–	0.20 (0.13-0.28)[a]	–	–	0.16 (0.08-0.23)	–	–

All data are expressed as the mean followed by the confidence interval in parentheses.
Consumption of different foods is reported as the number of servings for each food group. Recommendations for athletes according to SENC[26,27].
*If occasional servings are recommended or if there is no specific recommendation for a food group, intake is reported as servings/day.
[a]Statistically significant differences between Week 0 *vs* Week 8, and Week 16 ($p < 0.05$).
R = Percentage of participants in whom intake covered (> R) or failed to cover (< R) the recommended amounts.

Table VII
Biochemical profile

		Measurement points					
		Week 0		Week 8		Week 16	
Nutritional status parameters	*Reference value*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Glucose (mg/dL)	70-110	85.15	5.67	84.15	7.23	87.85	6.22
Creatinine (mg/dL)	0.7-1.2	0.92	0.11	0.93	0.12	0.92	0.11
Iron (μg/dL)	59-158	84.21	30.73	81.57	17.77	98.28	54.62
Transferrin (mg/dL)	200-360	261.21	27.81	261.71	33.00	265.50	28.67
Prealbumin (mg/dL)	20-40	26.76	3.53	27.18	3.12	26.76	2.77
Albumin (mg/dL)	3.5-5.2	4.68	0.15	4.68	0.21	4.76	0.19
HDL (mg/dL)	40-60	58.28[a]	13.58	57.28[a]	12.28	61.00	13.30
LDL (mg/dL)	70-150	74.00[a]	22.89	71.36[a]	20.84	83.07	22.59
Triglycerides (mg/dL)	50-200	64.50	26.59	69.86	27.00	57.00	14.83
Total cholesterol (mg/dL)	110-200	147.86	26.74	149.71	27.68	154.57[a]	26.80

All data are expressed as the mean and standard deviation (SD).
[a]Statistically significant differences between Week 0 *vs* Week 8, and *vs* Week 16 ($p < 0.05$) according to Student's t-test.

similar to those of Holway & Spriet,[14] who analyzed team sports similar to handball and found that percentage CHO intake was below the allowances recommended by the ADA and ACSM,[5,6] whereas fat and protein intakes were higher than the optimum values. This finding is consistent with our results: we found that CHO intake approached 50% of total energy intake, compared to 18% for protein and 35% for fat (fig. 1). Obtaining accurate information regarding athletes' energy and nutritional needs is a priority and can facilitate strategies to achieve maximal performance; moreover, a healthy and well-balanced diet forms the basis of maximum performance capacity in all athletes.[11]

Baseline values for energy intake in our participants was 2,974.50 ± 211.11 kcal·day^{-1}, a value similar to that reported recently by Aguiar et al.[33] in elite athletes in different team sports including handball. After the nutrition education program was implemented in the present study, energy intake increased significantly to a maximum of 3,355.08 ± 325.31 kcal·day^{-1}. This value is consistent with the results of the metanalysis of team sports in several countries by Holway & Spriet,[14] who found a similar result for energy intake measured with the same method as we used here. However, despite the increase in energy intake after the nutrition education intervention, energy intake remained below the mean energy expenditure. Aerenhouts et al.[10] evaluated

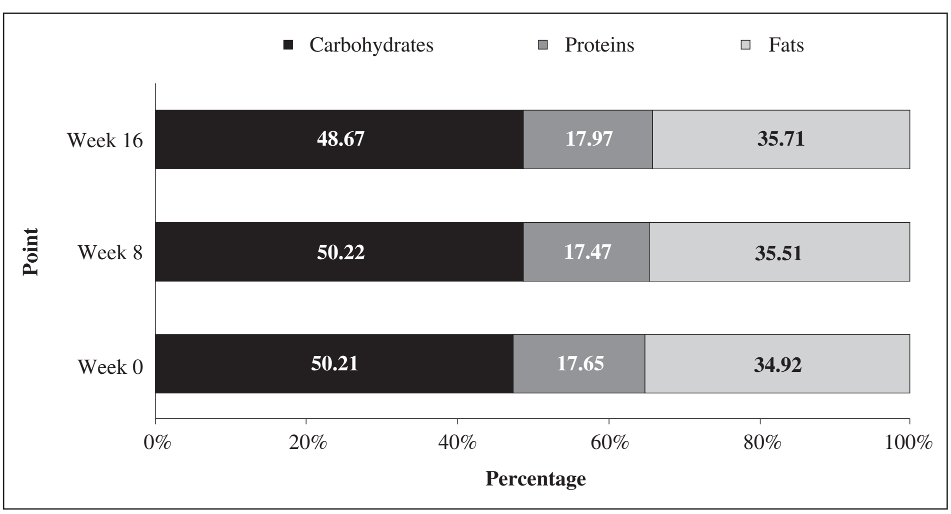

Fig. 1.—Percentage macronutrient intake referred to total energy intake at each time point.

energy intake in sprint runners, and found, like others, that energy intake was below energy expenditure. Although energy balance is not a priority for training and performance, athletes should aim to maintain energy balance within healthy limits.[34] We note, however, that although energy intake was below the recommended values and increased after the nutrition education program, plasma concentrations of nutritional status indicators (i.e. albumin and prealbumin) remained within normal limits throughout the study period.

The main characteristic of team sports such as handball is the intermittent activity pattern in which high-intensity and lower-intensity activities alternate. This pattern thus combines the use of aerobic and anaerobic systems, and CHO intake is the main source of fuel in both energy systems.[2,14] In our participants, CHO intake was clearly below the recommended allowance for athletes of 6-10 $g{\cdot}kg{\cdot}day^{-1}$ suggested by the ADA and ACSM.[5,6] Low CHO stores may result in increased levels of stress in athletes, which can in turn affect the functional capacity of their immune system[1]. In the present study we found a low CF for CHO-rich foods: in a large percentage of participants, intake was less than the amount recommended by the SENC[26,27] for the healthy population. This finding confirms an earlier report by Úbeda et al.,[29] who found that the CF of CHO-rich foods by Spanish combat sports athletes was very low. Similarly, Farajian et al.[35] noted that the CF of foods such as potatoes, rice, bread, wholemeal bread and pasta, vegetables and fruits, which are the main sources of CHO, was low in a large percentage of participants in their study.

Protein intake in the handball players we studied was within the range of recommended values (1.2 to 1.7 $g{\cdot}kg{\cdot}day^{-1}$) proposed by the ADA and ACSM.[5,6] In contrast, fat intake was higher than the recommended range (20% to 35% of total energy intake) proposed by these organizations,[5,6] and was similar to the values for fat intake found by Holway & Spriet.[14] According to the CF in our participants, a high percentage consumed more servings of fatty foods than the SENC recommends.[26,27] Excess fat consumption has been reported to diminish glycogen stores in the muscle and liver, and may compromise training intensity because of premature fatigue.[17] However, research in rats found that the prolonged consumption of a high-fat, low-CHO diet increased muscle capacity for fat oxygenation by stimulating mitochondrial biogenesis, and could increase endurance.[1] Fatty acid intakes in the present study exceeded current ADA and ACSM recommendations (not more than 10% of total intake)[5,6] for SFA and MUFA, but PUFA intake was clearly below the recommended value. This result is consistent with the findings of Ruiz et al.[36] in a sample of participants similar in age to those in the present study. However, plasma concentrations of all components of the lipid and protein profiles in our participants remained normal throughout the study period.

Some authors have suggested that nutritional intervention programs for athletes are the best option for optimizing intakes since they can improve the quality of the diet by favoring appropriate food choices.[11,29] In the present study the increased macronutrient intakes after the nutrition education program led to increases in energy intake; however, when the intake of individual nutrients was determined as a percentage of total energy intake, we observed no improvements in the quality of the diet consumed by the athletes. This may have been related with the fact that our program consisted of a single session of nutrition education; continuous education throughout the sports season may be needed to achieve noticeable changes in athletes' dietary habits.

The role of micronutrients is fundamental during exercise, since they maintain immune system functioning, protect tissues against oxidative damage, support good bone health and help repair muscle tissue.[21] Physical activity is said to foment excess loss of micronutrients due to catabolism and excretion.[18,20] Micronutrient intakes in the present study were compared with the DRIs for the Spanish and European Union population (based on data provided by Cuervo et al.).[25] Our findings for vitamin intakes showed that all B group vitamins as well as vitamin C exceeded current recommendations. In fact, mean vitamin B_{12} intake in our participants was 784.39 ± 307.41% of the recommended allowance, a value similar to the el 854.7 ± 93.8% figure found by Lun et al. in Canadian athletes [4]. Like us, other authors[4,21,28,37] found that B group vitamin intakes (especially vitamin B_{12}) as well as vitamin C intake were in excess of current recommendations. In contrast, vitamin A, D and E intakes at all three time points were below the DRIs for the Spanish and European Union populations, a finding also reported by Iglesias-Gutiérrez et al.[28] in their study of adolescent Spanish soccer players. Low vitamin intakes can alter performance, while adequate intakes play a protective role. The aim of dietary nutritional supplementation is to achieve an appropriate nutritional status and restore biochemical and physiological functions as determined with specifically chosen biomarkers.[38]

In our sample of athletes, all mineral intakes were close to the DRIs for the healthy Spanish and European Union population (as reported by Cuervo et al.).[25] This result is consistent with earlier findings by Lun et al.[4] in Canadian athletes. Although mineral intakes in our participants were above the DRIs provided by Cuervo et al. for the healthy population,[25] it should be recalled that in overall terms, the total energy expenditure estimated for these athletes was not covered.[39,40] A further consideration is that specific recommendations for micronutrient intakes in athletes are lacking, so reliance on recommendations developed for the general population may underestimate the needs of high-performance athletes. Moreover, the generally inadequate quality of the diet in the handball players we studied may mean that even after the nutrition education intervention, the significant increase in energy intake may have been offset by a decrease in some micronutrient densities.

Conclusions

The main findings of the present study show a tendency toward imbalances in nutrient intakes in a sample of professional Spanish handball players. Nutritional status should be monitored to establish specific recommendations for the population of athletes. According to our results, the program of nutrition education we used to improve the diet consumed by athletes during three times into the professional competition season, was insufficient to achieve an appropriate balance between the participants' nutritional requirements and the quality and quantities of different foods and nutrients they consumed, despite disciplinary habits of this population. An intervention program prior and during competition based on nutrition education for athletes may result in appropriate eating habits that can lead to a balanced diet able to meet their nutritional requirements over the long term.

The intermittent nature of handball play makes it difficult to establish recommendations that will meet the athletes' actual requirements, because this sport involves aerobic metabolism as the main energy source, alternating with periods of highly intense activity that require mainly anaerobic metabolism. To add to this challenge, optimum performance in handball requires a combination of physical attributes such as strength, power, speed and endurance.

An additional factor that needs to be considered is the lack of specific recommendations for micronutrient intakes in athletes. These allowances, once determined, are likely to be higher than those recommended for the non-athlete population. For most of the micronutrients we analyzed, intakes were clearly inadequate to meet the recommended allowances even for the general population.

Acknowledgments

This work was supported by the Spanish Ministry of Education (grant number AP2009-3701) and by FIS Project PI07/1228, of Carlos III Health Institute. The authors thank K. Shashok for translating the manuscript into English and for advice on technical editing.

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