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Dietary intake and anthropometry in elite Spanish athletes

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ABSTRACT

It is crucial to assess an athlete's dietary intake and control the evolution of his/her anthropometric variables throughout the training season. However, there are few modern studies in this area carried out on elite adult track and field athletes. In a project commissioned by the Spanish athletics federation and supported by the Spanish Sports Council, the authors made controlled diet and body composition assessments of members of the Spanish national athletic team training at the national high-performance training centre in Madrid. The sample included 19 female and 19 male elite athletes from the middle- and long-distances, sprints, jumps and combined events. Working closely with the coaches, the authors gathered extensive data, including anthropometric measurements, nutritional intake and energy expenditure. They compared their findings with references and suggested intakes published by a variety of sources. They were able to draw 18 conclusions, including the identification of a) deficits in the consumption of carbohydrates as well vitamins D and E for the athletes studied, b) a deficit in fluid intake for the middle- and long-distance runners and c) a deficit in folic acid for the female athletes. They end with a recommendation for further research projects in this area, with larger samples and specific protocols.

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Introduction

When attempting to maximise an athlete's performance, it is crucial to assess dietary intake and to control the evolution of anthropometric variables throughout the training season (O'CONNOR, OLDS, & MAUGHAN, 2007). Naturally concerned about this point, the Spanish Athletics Federation (RFEA), supported by the

Spanish Sports Council (CSD), signed a collaboration agreement with the Faculty of Physical Activity and Sport Sciences (INEF) of the Technical University of Madrid (UPM) in order to provide top Spanish athletes with nutritional counselling and monitoring.

Few modern studies dealing with these issues and carried out on elite adult track and field athletes have been published in scientific impact sources. Articles on nutrition for elite athletes disclose the characteristics of specialised nutrition for top athletes (HOUTKOOPER et al., 2007; PORTUGALOV, 1998; STELLINGWERFF et al., 2007; TIPTON et al., 2007) and the appropriate nutritional supplements for increasing athletic performance (GIAMPIETRO et al., 1998), but not many analyse the nutritional status of the elite athlete and its relationship with anthropometric characteristics (MULLINS et al., 2001).

The same can be said about specialised articles on anthropometry. Some are general surveys including athletes from different Olympic disciplines (FLECK, 1983), others are focused on female athletes (MALINA et al., 1971) or junior athletes (HOLLINGS & ROBSON, 1991; HOUSH et al., 1984; THORLAND et al., 1981), or they just compare the differences between athletes and non-athletes (ROUSANOGLOU et al., 2006).

Methods

This study consisted of a controlled diet and body composition assessment of members of the Spanish national athletic team training at the national high performance training centre in Madrid.

The sample (n=38) included 19 female and 19 male elite athletes from middle-distance ("1/2D" = 800 and 1500m; six females and six males), long-distance ("LD" = more than 3000m; seven females and seven males) and speed events ("S.E." = 400m and shorter, jumpers and combined events; six females and six males). A more detailed description of the sample is given in Table 1.

Before the diet assessment, we contacted the athletes and their coaches in order to explain the purpose of the assessment and the protocols that were to be applied. It was emphasised that they were to be asked to report a complete description of dietary intake on three different days of the week prior to the appointment.

The diet assessment made through a personal interview of each athlete, using standardised questionnaires for recording the food intake throughout the day (breakfast, lunch, dinner and snacks). Three different days were measured corresponding to a hard-training day (normally a double-session day), a normal-training day and a rest day.

Dietary data were transformed into energy and nutrients by DIAL software (Alce Ingeniería S.A., Madrid). This computer program is open and it can be updated introducing new recipes and/or commercial products. The software allowed us to analyse diet composition in macronutrients (proteins, carbohydrates and lipids) and in micronutrients (vitamins and minerals) and their distribution among the three main meals. Kilocalories and fibre intake were also reported and compared with the Dietary Reference Intakes (DRIs) by age and gender suggested by the FOOD AND NUTRITION BOARD & INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE (2006).

Physical activity and energy expenditure were estimated from a detailed report (15 minute fractions) of daily activity carried out during the three recorded days (hard-training, normal-training and rest days). Data were subsequently checked by the coach.

The physical activity level (PAL) was calculated dividing sum of daily MET by 24 hours ($PAL = \sum MET/24\ hr$).

The activity factor (PA) and the athletes' gender and age were considered for calculating the estimated energy requirements (EER) (FNB & IOM, 2002). Both in females and males, the PA was established according to the previously calculated PAL following the recommendations of the FOOD AND NUTRITION BOARD (2002) by activity group.

Equations for the estimation of the EER by gender and age of the athlete were:

Females (Over 18 years): EER (kcal/day) = 354 – (6.91 * age [years]) + PA * [(9.36 * weight [kg] + (726 * height [m])]

Males (Over 18 years): EER (kcal/day) = 662 – (9.53 * age [years]) + PA * [(15.91 * weight [kg] + (539.6 * height [m])]

(FOOD AND NUTRITION BOARD & INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE, 2002)

Previously calibrated and validated anthropometrical instruments (GPM, Switzerland) were used for collecting 28 anthropometrical variables following the ISAK (MARFELL-JONES et al., 2006) and Spanish Kinantropometry Group (GREC) (ESPARZA, 1993) standard protocols.

The Drinkwater-Ross method (DRINKWATER & ROSS, 1980) was established for analysing body composition (percentage of fat mass: %FM, percentage of skeletal mass: %SM, percentage of muscular mass: %MM, and percentage of residual mass: %RM). The percentage of body fat mass estimated by the Yuhasz equation (ESPARZA, 1993) was additionally calculated as a second reference for the %FM.

Phantom (ROSS et al., 1982) and Somatotype (CARTER, 2002) methodologies were applied in order to display and analyse the anthropometric data in a brief and comprehensive way.

ANOVA and Tukey post hoc tests were run into SPSS 12.0 to analyse differences by gender and discipline groups for each recorded variable. The Student T-test was used to test intra-individual comparisons of energy intake from the diet (EI) and estimated energy expenditure (EER). Additionally, Pearson product-moment correlation coefficients were calculated between nutrition and anthropometric variables in order to find a relationship between energy expenditure and food intake and body composition.

Results and Discussion

Anthropometric results

Averaged results by gender and discipline for age, body mass index (BMI) and all recorded anthropometric variables are shown in Table 1. After applying the Phantom methodology to the original variables, “Z” Phantom scores were obtained and these are presented in Table 2.

Somatotypes by disciplines are detailed in Table 3. They are displayed in Figure 1 for females and Figure 2 for males so that the results can be seen side by side.

Our general results for females agree with a classic survey carried out during the 1972 Olympic Games (2.3 – 3.4 – 3.5) (CARTER et al., 1982). However, female somatotypes showed slight differences among athletic disciplines, which were confirmed by the short Somatotype Attitudinal Distances ($\text{SAD}_{(\text{FE-}{}^{1}/_{2}\text{D})}$ = 0.59, $\text{SAD}_{({}^{1}/_{2}\text{D-LD})}$ = 0.54, $\text{SAD}_{(\text{FE-LD})}$ = 0.19) and the small Somatotype Attitudinal Mean (SAM = 0.44). These lack of differences have been reported previously in junior Olympic ath-

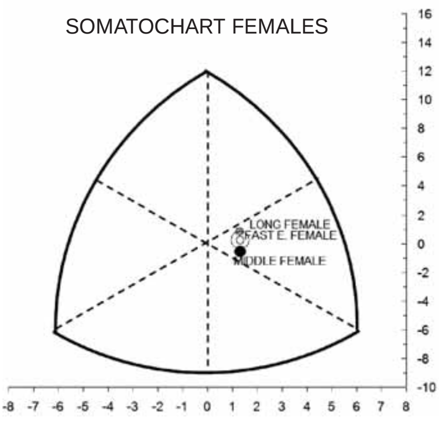

Figure 1: Somatotype of females by discipline

Table 1: Basic anthropometric data by gender and discipline (mean±sd) (Body mass (W), Stature (H), Body Mass Index (BMI), Upper limb length (ULL), Biacromial breath (BAB), Anteio-posterior chest depth (APC), Transverse chest breath (TCB), Biiliocristal breath (BIC), Biepicondylar humerus breath (HB), Wrist breath (WB), Biepicondylar femur breath (FB), Mesosternal chest girth (MG), Waist girth (WAG), Hip girth (HG), Flexed and tensed arm girth (FAG), Relaxed arm girth (RAG), Wirst girth (WIG), Thigh Girth (TG), Calf Girth (CG), Ankle girth (AG))

	Age (yrs)	**W (kg)**	**H (m)**	**BMI (kg/m²)**	**ULL (cm)**	**BAB (cm)**	**APC (cm)**	**TCB (cm)**	**BIC (cm)**	**HB (cm)**	**WB (cm)**	**FB (cm)**
FEMALE	22.4±3.9	54.7±6.2	167.9±0.1	19.4±1.0	73.2±3.8	36.5±2.1	17±1	25.8±1.4	26.7±1.6	6.1±0.5	5±0.3	8.7±0.5
MALE	25.0±5.1	70.6±9.6	181.8±0.1	21.3±1.9	79.6±3.5	40.7±2.2	19.4±1.3	28.9±1.9	27.7±1.6	6.9±0.3	5.7±0.3	9.9±0.5
S.E. FEMALE	20.8±3.4	58.8±7.8	170.5±0.1	20.2±1.0	74.2±5.9	38.3±2.1	16.3±1.4	26.3±1.3	27.4±2	6±0.7	5.1±0.4	9±0.6
$^{1}/_{2}$D FEMALE	23.2±4.5	54.3±3.4	167.9±0.0	19.3±0.7	73.7±2.8	36.5±1.6	17.3±0.4	26.2±1.4	26.8±1.2	6.1±0.3	5±0.4	8.6±0.5
LD FEMALE	23.2±3.7	51.1±5.4	165.3±0.1	18.7±1.0	71.8±3.1	35.1±1.8	17.3±1.1	24.8±0.9	25.9±1.4	6.3±0.6	5±0.2	8.7±0.2
S.E. MALE	23.4±4.1	80.0±6.1	186.3±0.0	23.0±1.4	81.2±1.5	42.8±1.5	19.2±1.7	30.4±1.1	28.1±1.7	7.1±0.2	6±0.2	10.4±0.2
$^{1}/_{2}$D MALE	25.8±4.2	69.5±8.7	183.7±0.0	20.5±1.8	81±3.2	40.1±1.5	19.6±1.3	28.5±1.6	28.4±1.3	7±0.3	5.7±0.2	9.9±0.4
LD MALE	25.5±7.2	62.5±4.1	175.0±0.0	20.4±1.0	76.2±3.2	39.2±2.1	19.4±1.2	27.9±2	26.6±1.2	6.7±0.3	5.4±0.2	9.5±0.4
(continued)	**MG (cm)**	**WAG (cm)**	**HG (cm)**	**FAG (cm)**	**RAG (cm)**	**WIG (cm)**	**TG (cm)**	**CG (cm)**	**AG (cm)**			
FEMALE	84.7±3.2	68.3±3.8	90±4.8	25.6±1.5	23.8±1.8	14.3±0.7	51.8±2.9	34.6±2.5	20.8±1			
MALE	95.6±6.2	77.1±3.9	93.9±5.2	30.2±2.7	27.7±2.4	16.1±0.7	54.9±3.7	37.5±2.8	22.4±1.4			
S.E. FEMALE	86±4.4	70.1±4.9	91.4±6.7	26.5±1.6	24.8±2	14.5±0.8	54±3.2	37.4±2.5	21.5±0.8			
$^{1}/_{2}$D FEMALE	85.4±2.3	68.4±3.6	90.8±3.5	25.7±0.9	24.1±1	14.4±0.7	51.6±2.2	34.1±1.2	20.6±0.8			
LD FEMALE	82.8±2.7	66.7±2.9	88±4.3	24.8±1.7	22.8±2	14.2±0.6	50.3±2.8	32.9±1.6	20.4±1.1			
S.E. MALE	100.4±3.7	80.1±2.2	98.3±4.6	32.9±2.5	30.3±1.6	16.9±0.5	58.6±2.2	40±3.1	23.6±1.3			
$^{1}/_{2}$D MALE	95.4±6	77.3±2.7	93.4±4.4	29.4±2	27.2±2	16±0.4	54.4±2.9	37±2.1	22±1.2			
LD MALE	91.2±5.7	74.1±4.4	90±3.1	28.4±1.6	25.9±1.2	15.6±0.4	51.8±2.6	35.7±1.1	21.7±1.1			
(continued)	**TS (mm)**	**BS (mm)**	**PS (mm)**	**SBS (mm)**	**SS (mm)**	**ICS (mm)**	**AS (mm)**	**TS (mm)**	**CS (mm)**			
FEMALE	9.9±1.8	4.4±1.4	5.4±2.4	7±1.6	6.5±1.3	8.1±3.8	11.1±3.7	15.5±5	7.3±2			
MALE	6.7±1.5	3.3±0.5	4.9±1	8.1±1	5.7±1.1	7.4±2	9±3.4	8.7±2.7	5.2±1.6			
S.E. FEMALE	9.6±0.8	3.8±0.6	5.3±1.8	7.3±1.7	5.9±0.7	7.9±2.2	10.4±2	14.6±3.7	7.7±1.7			
$^{1}/_{2}$D FEMALE	10.4±2.1	4.6±1.5	6.6±3.2	7.5±2	7±1.8	10±5.2	12.8±5.1	16.6±5.9	7.1±2.3			
LD FEMALE	9.7±2	4.8±1.6	4.3±0.9	6.3±0.8	6.5±1.1	6±1.4	9.9±2.1	15.1±5.3	7.2±2			
S.E. MALE	7±1.4	3.3±0.6	4.8±1.5	8.4±1.2	5.8±0.9	8.1±1.7	9.3±4.1	9.1±2.9	5.6±2.2			
$^{1}/_{2}$D MALE	6±0.8	3.3±0.3	4.8±0.8	8±1	5.7±1	6.6±1.1	8.5±2.8	7.5±2.3	4.9±1.1			
LD MALE	7.1±2.1	3.3±0.6	5.1±0.8	7.9±0.9	5.7±1.6	7.7±2.9	9.3±4	9.6±3	5.3±1.5			

Table 2: Phantom Z values by gender and discipline (mean±sd) (Body mass (ZW), Upper limb length (ZULL), Biacromial breath (ZBAB), Anterio-posterior chest depth (ZAPC), Transverse chest breath (ZTCB), Biiliocristal breath (ZBIC), Biepicondylar humerus breath (ZHB), Wrist breath (ZWB), Biepicondylar femur breath (ZFB), Mesosternal chest girth (ZMG), Waist girth (ZWAG), Hip girth (ZHG), Flexed and tensed arm girth (ZFAG), Relaxed arm girth (ZRAG), Wirst girth (ZWIG), Thigh Girth (ZTG), Calf Girth (ZCG), Ankle girth (ZAG), Triceps skinfold (ZTS), Biceps skinfold (ZBS), Pectoral skinfold (ZPS), Subscapular skinfold (ZSBS), Supraspinal skinfold (ZSS), Iliac crest skinfold (ZICS), Abdominal skinfold (ZAS), Thigh Skinfold (ZTS), Calf skinfold (ZCS))

	ZW	ZULL	ZBAB	ZAPC	ZTCB	ZBIC	ZHB	ZWB	ZFB
FEMALE	-0.4±0.6	-0.4±0.7	-0.1±0.8	-1.0±0.7	-1.0±0.7	-0.7±1.4	-0.2±0.8	-1.3±0.8	-0.4±0.6
MALE	-0.4±0.5	0.0±0.8	0.5±1.0	-0.5±0.7	-1.6±0.6	0.0±0.7	0.5±0.7	-0.5±0.6	-0.4±0.5
S.E. FEMALE	-0.7±0.5	0.0±0.5	-1.0±0.8	-1.0±0.7	-1.0±0.4	-1.4±1.0	-0.6±0.6	-1.3±0.7	-0.7±0.5
$^{1}/_{2}$D FEMALE	-0.4±0.5	-0.4±0.7	0.0±0.4	-0.8±0.9	-1.0±0.4	-1.0±0.6	-0.2±1.0	-1.6±0.9	-0.4±0.5
LD FEMALE	-0.3±0.7	-0.7±0.8	0.4±0.6	-1.1±0.4	-1.0±1.2	0.1±1.9	0.0±0.6	-1.0±0.9	-0.3±0.7
S.E. MALE	-0.5±0.3	0.5±0.6	0.0±1.1	-0.1±0.5	-1.8±0.8	-0.1±0.4	1.1±0.7	0.0±0.4	-0.5±0.3
$^{1}/_{2}$D MALE	-0.2±0.6	-0.4±0.6	0.5±0.9	-0.8±0.6	-1.4±0.6	0.0±0.6	0.4±0.3	-0.7±0.5	-0.2±0.6
LD MALE	-0.5±0.4	0.0±0.9	1.0±0.9	-0.4±0.9	-1.7±0.6	0.0±1.0	0.1±0.6	-0.6±0.6	-0.5±0.4
(continued)	**ZMG**	**ZWAG**	**ZHG**	**ZFAG**	**ZRAG**	**ZWIG**	**ZTG**	**ZCG**	**ZAG**
FEMALE	-0.3±0.6	-0.6±0.7	-0.5±0.8	-1.4±0.7	-1.1±0.8	-2.5±0.8	-0.8±0.6	0.0±0.7	1.3±0.2
MALE	0.3±0.8	0.1±0.5	-1.2±0.5	-0.5±0.9	-0.4±0.7	-1.7±0.6	-1.0±0.5	0.0±0.9	1.2±0.2
S.E. FEMALE	-0.5±0.7	-0.5±0.4	-0.7±0.6	-1.3±0.5	-1.0±0.8	-2.8±0.3 -	0.5±0.2	0.8±0.3	1.3±0.1
$^{1}/_{2}$D FEMALE	-0.1±0.6	-0.6±0.8	-0.5±0.4	-1.4±0.4	-1.1±0.4	-2.5±0.8 -	1.0±0.4	-0.3±0.4	1.2±0.1
LD FEMALE	-0.3±0.7	-0.5±0.8	-0.5±1.2	-1.5±1.0	-1.3±1.1	-2.2±0.9	-0.8±0.9	-0.4±0.6	1.3±0.2
S.E. MALE	0.7±0.5	0.3±0.4	-0.9±0.7	0.3±0.9	0.3±0.6	-1.3±0.5	-0.5±0.5	0.5±1.2	1.4±0.2
$^{1}/_{2}$D MALE	0.2±0.8	0.0±0.4	-1.4±0.5	-0.9±0.6	-0.7±0.7	-2.0±0.5	-1.2±0.4	-0.4±0.5	1.1±0.1
LD MALE	0.2±0.9	0.0±0.8	-1.3±0.3	-0.7±0.7	-0.7±0.5	-1.6±0.7	-1.3±0.5	-0.2±0.6	1.3±0.3
(continued)	**ZTS**	**ZBS**	**ZPS**	**ZSBS**	**ZSS**	**ZICS**	**ZAS**	**ZTS**	**ZCS**
FEMALE	-1.2±0.4	-1.7±0.7	-1.9±0.7	-2.0±0.3	-2.0±0.3	-2.1±0.6	-1.8±0.5	-1.3±0.6	-1.8±0.4
MALE	-2.0±0.3	-2.5±0.2	-2.2±0.3	-1.9±0.2	-2.2±0.2	-2.3±0.3	-2.2±0.4	-2.3±0.3	-2.4±0.3
S.E. FEMALE	-1.3±0.2	-2.1±0.3	-2.0±0.4	-2.0±0.3	-2.1±0.2	-2.1±0.3	-1.9±0.3	-1.5±0.3	-1.8±0.4
$^{1}/_{2}$D FEMALE	-1.1±0.5	-1.7±0.8	-1.6±1.0	-1.9±0.4	-1.9±0.4	-1.8±0.8	-1.6±0.7	-1.2±0.7	-1.9±0.5
LD FEMALE	-1.2±0.5	-1.5±0.8	-2.3±0.2	-2.1±0.2	-1.9±0.3	-2.4±0.2	-1.9±0.3	-1.3±0.7	-1.8±0.5
S.E. MALE	-2.0±0.3	-2.5±0.3	-2.3±0.4	-1.9±0.2	-2.3±0.2	-2.2±0.2	-2.2±0.5	-2.2±0.3	-2.3±0.4
$^{1}/_{2}$D MALE	-2.2±0.2	-2.5±0.2	-2.2±0.2	-1.9±0.2	-2.2±0.2	-2.4±0.2	-2.2±0.3	-2.4±0.3	-2.5±0.2
LD MALE	-1.9±0.4	-2.4±0.2	-2.1±0.2	-1.9±0.2	-2.2±0.3	-2.2±0.4	-2.1±0.5	-2.1±0.3	-2.3±0.3

Table 3: Somatotype coordinates (X and Y) and components: Endomorphy (ENDO), Mesomorphy (MESO) and Ectomorphy (ECTO) (mean±sd)

	X	Y	ENDO	MESO	ECTO
FEMALE	-0.8±0.6	0.2±2.1	2.4±0.4	3.2±0.7	3.7±0.8
MALE	-0.7±0.4	2.9±2.4	1.8±0.3	4.1±0.9	3.6±0.7
S.E. FEMALE	-0.7±0.3	0.8±1.4	2.2±0.3	3.3±0.6	3.5±0.4
$^{1}/_{2}$D FEMALE	-0.9±0.3	-0.6±1.5	2.5±0.6	2.9±0.5	3.9±0.4
LD FEMALE	-0.7±1	0.7±3.0	2.3±0.2	3.4±1.0	3.6±1.4
S.E: MALE	-0.4±0.3	4.7±2.0	1.8±0.3	4.8±0.8	3.1±0.5
$^{1}/_{2}$D MALE	-0.9±0.4	1.9±1.9	1.7±0.2	3.7±0.6	3.9±0.6
LD MALE	-0.8±0.4	2.2±2.6	1.9±0.5	3.9±0.9	3.7±0.7

letes after throwers had been excluded from the sample (THORLAND et al., 1981) but we considered it quite surprising, especially in the case of the mesomorphic components, which are similar between speed event athletes and distance runners. However, our results match up with others from the Spanish national womens' team, in which the sample was much larger ($^{1}/_{2}$D: 2.6 – 3.1 – 3.5; LD: 2.1 – 3.2 – 3.5; Sprinters: 2.4 – 3.3 – 3.3; Combined Events: 2.5 – 3.5 – 3.5) (CANDA, 2001), and can be explained by the low level of the female sprinters in Spain and the lack of 100m and 200m athletes, who generally have greater muscular development, in our sample.

The mean somatotype for males agrees with the classic model (1.7 – 5.0 – 2.9) (CARTER et al., 1982) and other older values from the Spanish national team ($^{1}/_{2}$D: 1.5 – 4.3 – 3.6; LD: 1.4 – 4.2 – 3.7; Sprinters: 1.7 – 5.2 – 2.8; Combined Events: 1.8 – 5.6 – 2.4) except for the mesomorphic component in middle- and long-distances. In this aspect, it must be stated that the data collection was conducted in a phase of high volume and low intensity workload for these athletes, which could have an influence on the low mesomorphic component registered.

The Somatotype Attitudinal Distances among the speed events and the other disciplines for males were slightly longer than for females (SAD$_{(FE-^{1}/_{2}D)}$ = 1.32, SAD$_{(FE-LD)}$ = 1.09). This data indicate a specific typology in the sprinters and jumpers. However, middle- and long-distance runners had quite similar somatotypes (SAD$_{(^{1}/_{2}D-LD)}$ = 0.31), which indicates a similar typology between those athletes. Finally, the Somatotype Attitudinal Mean for the male athletes was greater than for females (SAM = 0.44), which points again to a more heterogeneous Somatotype by disciplines.

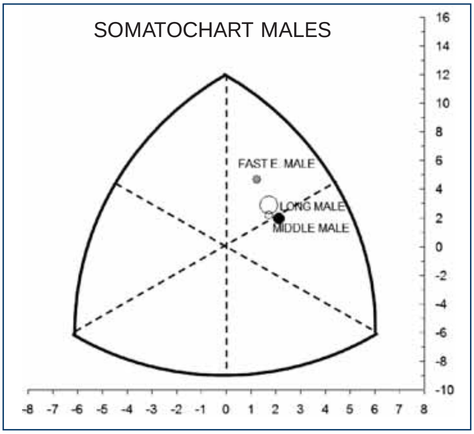

Figure 2: Somatotype of males by discipline

Table 4 shows a summary of the estimates of the percentage of body fat mass (%FMDR), muscle mass (%MMDR), skeletal mass (%SMDR) and residual mass (%RMDR), along with the sum of the four components obtained by the Drinkwater approach (SUMDR) by gender and athletic discipline. Additionally, the estimate of the percentage of

Table 4: Body composition variables (Sum of six skinfolds (S6 = TS + SBS + ICS + AS + TS + CS), Yuhasz estimation of body fat percentage (%FMY), and Drinkwater method estimation for the percentage of body fat mass (%FMDR), muscular mass (%MMDR), skeletal mass (%SMDR) and residual mass (%RMDR) (mean±sd); Sum of the four components obtained by the Drinkwater approach (SUMDR))

	S6	%FMY	%FMDR	%MMDR	%SMDR	%RMDR	SUMDR
FEMALE	59.0±14.6	13.0±2.1	11.8±1.9	45.9±2.0	16.0±1.5	26.4±1.6	100.2
MALE	45.1±10.2	8.0±1.0	8.8±1.4	46.9±1.3	17.4±0.7	26.9±1.0	100.0
S.E. FEMALE	57.5±7.5	12.8±1.1	11.3±1.0	46.4±1.7	15.1±1.2	25.6±1.1	98.4
$^{1}/_{2}$D FEMALE	64.4±20.0	13.8±2.9	12.6±2.7	46.3±1.0	15.9±1.6	27.2±1.2	102.0
LD FEMALE	54.1±11.2	12.3±1.6	11.4±1.3	45.1±2.9	16.9±1.5	26.2±2.1	99.6
S.E. MALE	47.6±11.0	8.3±1.1	8.5±1.2	47.3±1.7	17.2±0.6	25.9±0.3	98.9
$^{1}/_{2}$D MALE	41.5±5.7	7.7±0.6	8.6±1.2	47.3±1.2	17.4±0.7	27.2±0.7	100.5
LD MALE	46.9±13.7	8.2±1.3	9.4±2.0	46.2±0.8	17.5±1.0	27.4±1.1	100.5

body fat mass was calculated by the Yuhasz equation (%FMY) for the same groups. Our results of body composition are quite consistent with those obtained in other studies by Spanish authors (CANDA, 2001; ESPARZA, 1993; PACHECO, 1996), but differ from the percentage values due to differences in the method used to estimate each component.

The results show significant differences by gender for the %FM estimated both by the Yuhasz equation ($F_{\%FMY(1.35)} = 88.1$; $p < 0.05$) and by the Drinkwater method ($F_{\%FMDR(1.35)} = 29.1$; $p < 0.05$) and also for the %SM ($F_{\%SMDR(1.35)} = 11.7$; $p < 0.05$), but not for the %MM ($F_{\%MMDR(1.35)} = 3.5$; $p = 0.07$) or the % RM ($F_{\%FMDR(1.35)} = 1.0$; $p = 0.31$).

No significant differences were found in any body composition component in female athletes, and only differences for the %RM were found in males ($F_{\%FMDR(2,16)} = 7.4$; $p < 0.05$), with lower percentages of residual mass in speed event athletes (25.9%) than in middle- (27.2%) and long-distance runners (27.4%).

Nutritional results

The energy balance of the athletes was determined based on the estimated energy input (EI) by diet and energy expenditure. We registered the EI from all the daily meals and snacks and estimated energy expenditure (EER) of each athlete during the assessment period (see Figure 3).

In general, the correlation between individual EI and EER data was significant ($r = 0.551$; $p < 0.05$) and their differences were non-significant ($t_{(37)} = -1.02$; $p = 0.32$). All these data reflect a trend towards an adequate energy balance in elite Spanish athletes. However, the energy intake (EI) was lower in the female middle-distance athletes, surpassing the variability between IE and EER by more than 10%.

Energy distribution (Kcal) was analysed in its three macronutrients (Figure 4) and the results were compared with the recommended acceptable macronutrient distribution range (AMDR) for carbohydrate, protein and fat which are 45-65%, 10-30% and 25-35% of total calories respectively established by the FOOD AND NURTRITION BOARD (2006). The percentages of energy coming from proteins fulfilled the recommendations, however although the provision of calories from carbohydrate fell within the AMDR it was at the lower end of the range (50% of total calories), which is not desirable for such an athletic population (ACSM; ADA & CD, 2000). Mean percentage of energy coming from lipids was located in the upper limit both in male and female athletes, and the middle-distance runners of both genders exceeded the recommended range (20-35%).

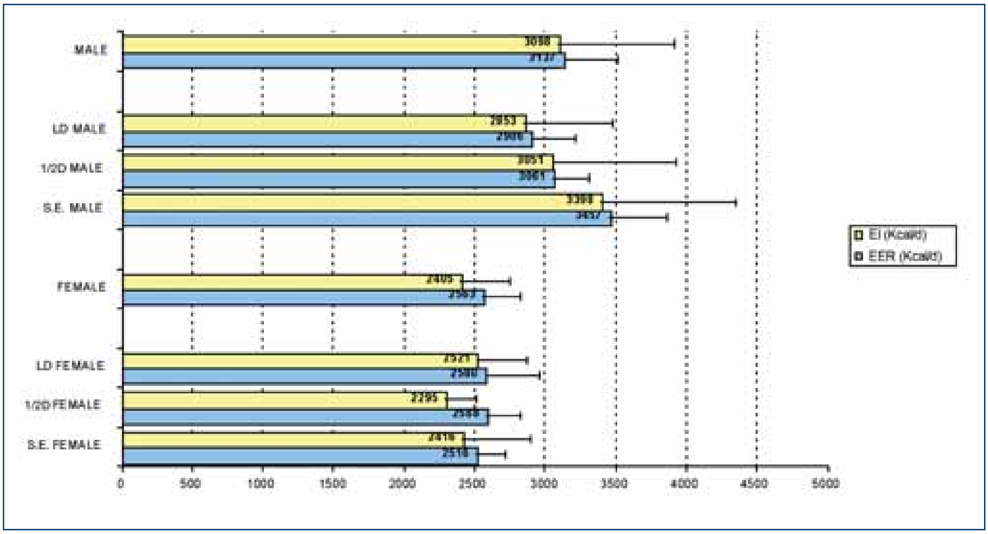

Figure 3: Energy intake (EI) and Estimated Energy Requirements (EER) by gender and discipline (mean±sd)

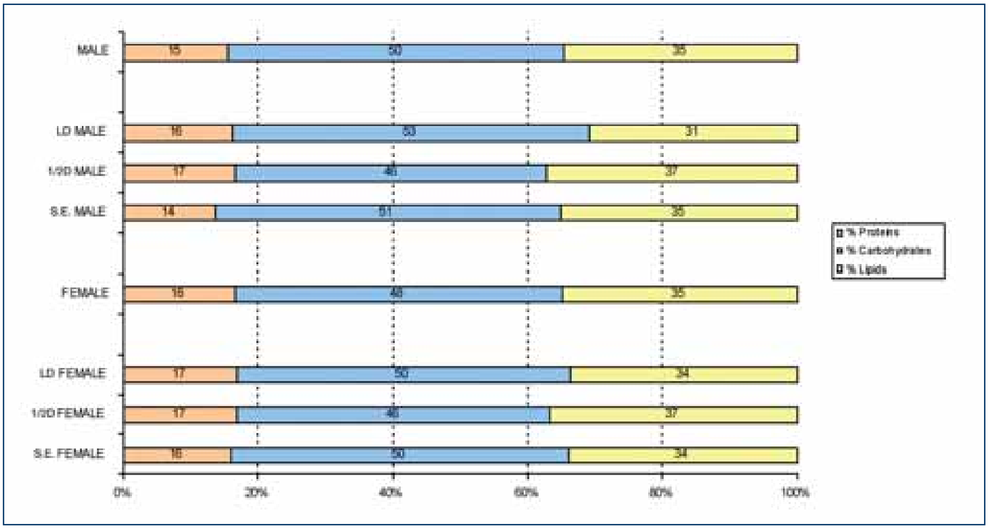

Figure 4: Energy distribution from different macronutrients by gender and discipline

This general pattern of relative under-consumption of carbohydrates and over-consumption of fat has been found in other athletic populations (HAWLEY et al., 1995; HINTON et al., 2004).

Figure 5 shows the average energy provided by the different meals from the daily diet (breakfast, lunch, dinner and snacks), both in absolute terms and in percentage of total daily energy intake. Additionally, the graph provides us with the distribution of macronutrients in each meal.

This data allowed us to be more precise with the nutritional requirements of athletes in order to establish guidelines for improved individual diet, which were reported and explained later to the athlete in a counselling session.

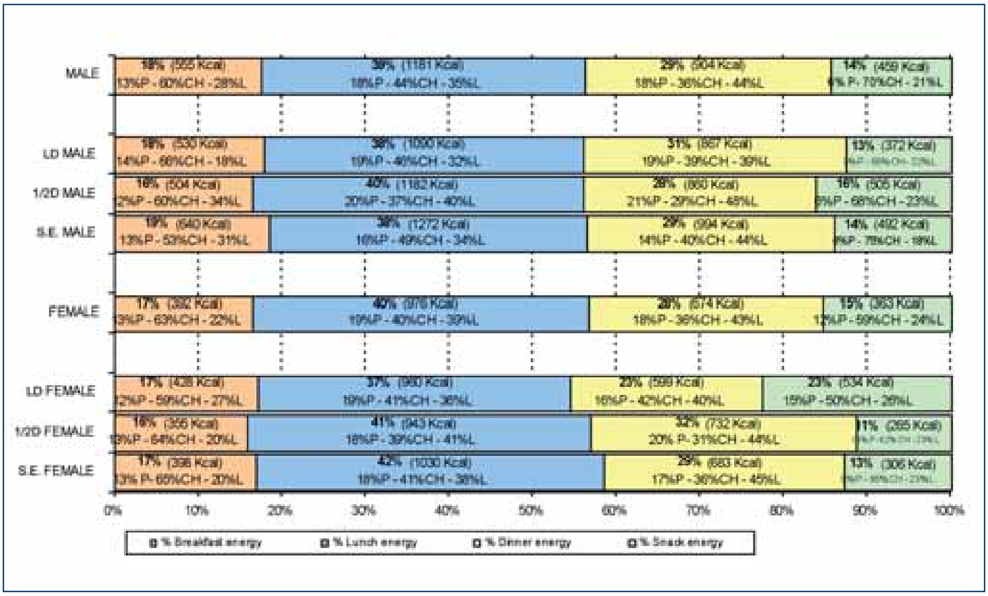

Figure 5: Energy intake and percentage of macronutrients(%proteins, %carbohydrates and %lipids) in different meals by gender and discipline

Table 5: Energy and macronutrient intakes expressed in absolute terms and relative to body weight by gender and discipline (mean±sd)

	EI (kcal/Kg)	P (g)	P (g/Kg)	CH (g)	CH (g/Kg)	L (g)	L (g/Kg)
FEMALE	45±9	100±19	1.9±0.4	272±60	5.0±1.2	94±17	1.7±0.4
MALE	44±12	118±31	1.7±0.5	371±125	5.3±1.9	119±41	1.7±0.5
S.E. FEMALE	41±9	97±18	1.7±0.4	289±81	4.9±1.2	92±22	1.6±0.5
$^1/_2$D FEMALE	43±6	97±15	1.8±0.3	248±44	4.6±1.0	94±12	1.7±0.2
LD FEMALE	50±9	106±26	2.1±0.6	284±55	5.6±1.4	95±18	1.9±0.4
S.E. MALE	43±12	115±43	1.4±0.5	419±136	5.2±1.5	134±53	1.7±0.7
$^1/_2$D MALE	44±13	124±29	1.8±0.4	337±128	4.9±2.0	125±39	1.8±0.5
LD MALE	46±12	113±21	1.8±0.3	364±116	5.9±2.1	97±24	1.6±0.4

P = Proteins, CH = Carbohydrates, L = Lipids

We found that the most balanced meal was breakfast. The higher energy intakes occurred during lunch and dinner. However, these meals turned out to be the most unbalanced in all groups, as there was low consumption of carbohydrates and high consumption of fats, especially at dinner, when compared with the recommended ranges (AMRD) established by the FOOD AND NUTRITION BOARD (2006).

Intake of energy, protein, carbohydrates and lipids were determined in absolute terms and relative to body weight of the sample (Table 2). Although the significantly largest consumers of energy ($F_{(1.36)} = 11.5$; $p < 0.05$), protein ($F_{(1.36)} = 4.6$; $p < 0.05$), carbohydrates ($F_{(1.36)} = 9,6$; $p < 0.05$) and lipids ($F_{(1.36)} = 6.2$; $p < 0.05$) in absolute values were male, we noted that those differences disappear when the intake values were related to the weight of

Table 6: Distribution of the lipids and cholesterol intakes by gender and discipline (mean±sd)

	Saturated Lipids (g)	Monosaturated Lipids (g)	Polyunsaturated Lipids (g)	Cholesterol (mg)
FEMALE	31±8	43±9	11±2	294±83
MALE	38±17	55±19	16±5	373±163
S.E. FEMALE	31±10	41±9	12±3	298±84
$^1/_2$D FEMALE	30±6	44±8	11±2	288±71
LD FEMALE	31±8	44±11	12±3	298±107
S.E. MALE	43±18	62±27	17±5	461±163
$^1/_2$D MALE	42±19	58±15	15±4	373±156
LD MALE	27±11	45±11	17±5	286±145

the athlete. In that case, the distribution of the diet was similar in females and males.

In Table 6, lipid consumption is shown in its different forms (saturated, monosaturated and polyunsatured fats), as well as the cholesterol intake. A greater prevalence can be observed in saturated fats consumption, and lower polyunsaturated fat intake in all groups, with the male group being the largest consumer of the three types of fats. The cholesterol intake in the female group approached the limit recommended (300 mg/day) by the American Heart Association (KRAUSS et al., 2000). However, the male group, particularly speed and middle-distance athletes, showed consumptions well above the established level.

Water intake was determined by gender and athletic discipline (see Figure 6). Taking into account the recommendations for males (3.7 l/day) and females (2.7 l/day), (GRANDJEAN & CAMPBELL, 2004) requirements are not fulfilled in any male group and or female long-distance runners. Having a deficit level of hydration could lead to problems such as declining performance and increased muscle injury (ACSM, ADA, & CD, 2000; FOOD AND NUTRITION BOARD & INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE, 2006).

Fibre intake of our athletes was compared with the official recommendations of the FOOD AND NUTRITION BOARD (2006), and we found that the female speed events group did not reach the described values for women (25 g/day) and only the male middle-distance group reached the recommended values for men (35 g/day) (see Figure 7). Low dietary fibre intake has been linked with numerous health problems, including coronary heart disease, gastrointestinal pathologies and increased risk of constipation (INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE, 2005). The fibre intakes in our study were similar to those reported for other collegiate athletes (HINTON et al., 2004). A greater intake of unprocessed whole grain products, vegetables and fruits should be emphasised in this population. A recent review has revealed that environmental interventions in schools show potential for positively affecting consumption of fruits and vegetables among youth (FRENCH & STABLES, 2003).

Absolute intake values were estimated for the twelve vitamins, and the percentage of those on the Dietary Reference Intakes (DRI) described by the FOOD AND NUTRITION BOARD (2006) was calculated. In Figure 8, these data, along with the number of athletes that were below the recommended values (↓ #), are displayed. Generalised deficits in the intake of vitamins E and D were found in both males and females, as well as deficits in folic acid in the women.

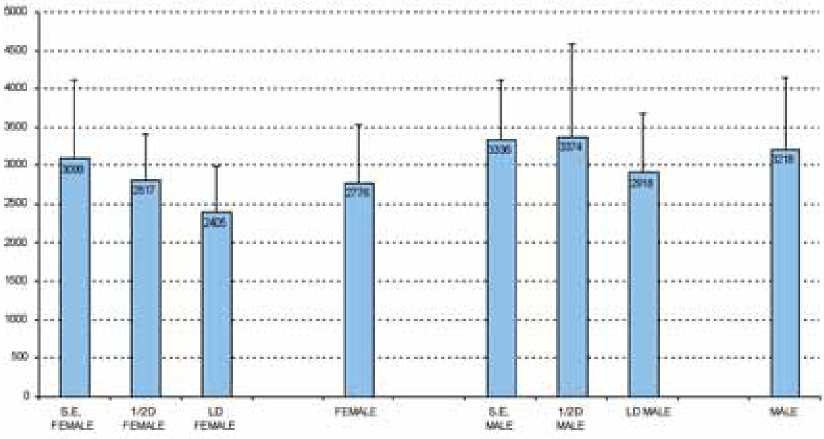

Figure 6: Water intake (ml/day) by gender and discipline (mean±sd)

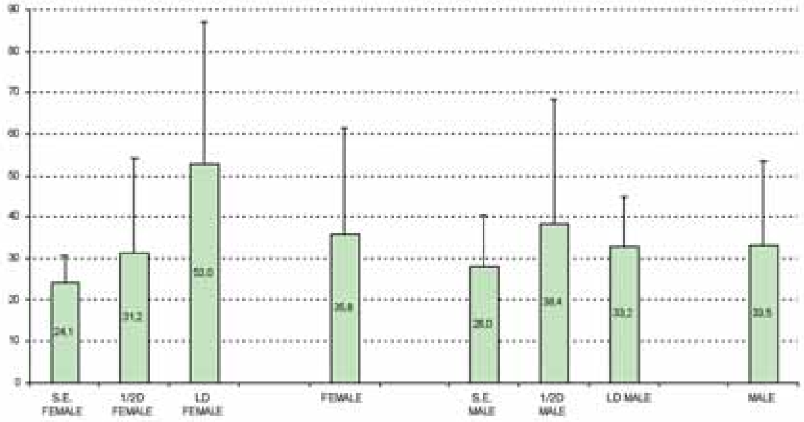

Figure 7: Fibre intake (g/day) by gender and discipline (mean±sd)

The low intake of vitamin E in athletes was most likely due to a low consumption of unsaturated fats in relation to saturated fats. The RDA for vitamin E increased the requirements from 10 to 15mg of a-tocopherol per day (INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE, 2000). However, the necessity of this increase has been subject to debate (HORWITT, 2001). Therefore, the “deficient” intakes of vitamin E in this and other studies with adolescent athletes (BOIOISSEAU et al., 2002; HINTON et al., 2004; IGLESIAS-GUTIERREZ et al., 2005) must be viewed with some caution.

It is well known that vitamin D, in addition to calcium and magnesium, is an important micronutrient for optimal bone health (INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES OF SCIENCE, 1997). The lower

Table 7: Vitamin intakes expressed in absolute values, percentage of Recommended Dietary Allowances (%RDA) (mean±sd)

	Vit. A (µg/d) %RDA	Vit. E (mg/d) %RDA	Vit. D (µg/d) %RDA	Vit. K (µg/d) %RDA	Vit. B_1 (mg/d) %RDA	Vit. B_2 (mg/d) %RDA	Vit. B_3 (mg/d) %RDA	Vit. B_6 (mg/d) %RDA	Folate (µg/d) %RDA	Pantothenic (mg/d) %RDA	Vit. C (mg/d) %RDA	Vit. B_{12} (µg/d) %RDA
FEMALE (n = 19)	1017±337 145% (↓3)	9±3 63% (↓18)	4±2 88% (↓12)	261±180 291% (↓2)	1.6±0.4 150%	2.4±0.7 222%	41±7 296%	2.7±0.5 211%	340±85 85% (↓14)	6±1 122% (↓3)	181±71 242%	6.8±2.4 283%
MALE (n = 19)	1190±394 132% (↓6)	12±6 82% (↓17)	5±2 93% (↓11)	241±177 204% (↓2)	2.4±0.9 200% (↓1)	2.8±0.9 219%	52±15 325%	3.7±2.0 285%	419±172 105% (↓10)	7±2 144% (↓2)	208±93 233%	7.4±2.8 306%
S.E. FEMALE (n = 6)	1096±386 157% (↓1)	11±5 73% (↓5)	5±3 98% (↓3)	144±59 165% (↓2)	1.7±0.6 155%	2.1±0.4 197%	43±5 306%	2.8±0.7 218%	348±101 87% (↓4)	6±1 116% (↓1)	200±91 271%	6.7±2.2 280%
$^1/_2$D FEMALE (n = 6)	1095±381 156% (↓1)	9±1 58% (↓7)	5±2 96% (↓4)	260±109 289%	1.6±0.3 142%	2.4±0.7 214%	40±4 284%	2.7±0.5 211%	358±94 89% (↓4)	6±1 124% (↓1)	165±60 220%	7.0±2.0 292%
LD FEMALE (n = 7)	848±186 121% (↓1)	9±3 60% (↓6)	3±2 67% (↓5)	379±256 421%	1.7±0.4 155%	2.8±0.8 155%	42±10 301%	2.7±0.3 205%	313±59 78% (↓6)	6±1 127% (↓1)	179±68 239%	6.6±3.3 275%
S.E. MALE (n = 6)	1243±368 138% (↓2)	15±10 101% (↓5)	4±1 76% (↓4)	171±50 142% (↓1)	2.0±1.0 170% (↓1)	2.7±1.1 206%	48±19 301%	3.9±3.3 300%	380±135 95% (↓4)	7±2 144%	232±95 258%	6.8±3.0 282%
$^1/_2$D MALE (n = 6)	1175±487 131% (↓2)	12±4 79% (↓6)	4±2 80% (↓5)	249±120 208%	2.4±0.7 198%	2.7±0.7 208%	52±11 324%	3.2±0.9 249%	397±117 99% (↓3)	8±2 151% (↓1)	196±85 218%	8.5±3.0 355%
LD MALE (n = 7)	1155±366 128% (↓2)	10±2 67% (↓6)	6±3 124% (↓2)	301±287 261% (↓1)	1155±366 128%	10±2 67%	6±3 124%	301±287 261%	485±252 121% (↓3)	7±2 136% (↓1)	199±111 225%	6.6±2.1 274%

Note: (↓#) indicates the number of athletes of the group that were below the recommendations

Table 8: Mineral intakes expressed in absolute values, percentage of Recommended Dietary Allowances (%RDA) (mean±sd)

	Iron (mg/d) %RDA	Calcium (mg/d) %RDA	Magnesium (mg/d) %RDA	Phosphorus (mg/d) %RDA	Zinc (mg/d) %RDA
FEMALE (n = 19)	21±8 117% (↓7)	1104±239 109% (↓6)	372±84 119% (↓5)	1640±316 229%	11±2 127% (↓1)
MALE (n = 19)	23±9 283%	1220±450 121% (↓6)	437±142 109% (↓8)	1927±511 271%	14±4 128% (↓4)
S.E. FEMALE (n = 6)	17±3 96% (↓3)	966±200 93% (↓4)	323±76 102% (↓3)	1449±316 190%	11±1 120%
$^{1}/_{2}$D FEMALE (n = 6)	20±7 114% (↓3)	1112±249 111% (↓1)	362±64 117% (↓2)	1686±249 241%	11±2 119% (↓1)
LD FEMALE (n = 7)	26±10 142% (↓1)	1233±219 123% (↓1)	433±85 140%	1778±342 25%	13±2 142%
S.E. MALE (n = 6)	17±7 212%	1360±625 136% (↓2)	431±153 108% (↓3)	2010±628 287%	14±5 123% (↓1)
$^{1}/_{2}$D MALE (n = 6)	25±8 306%	1134±374 113% (↓2)	427±135 107% (↓3)	1960±520 280%	14±4 127% (↓1)
LD MALE (n = 7)	27±10 328%	1181±366 144% (↓2)	455±163 113% (↓2)	1807±440 243%	15±4 132% (↓2)

Note: (↓#) indicates the number of athletes who were below the recommendations

intake of vitamin D was probably due to the lower intake of dairy products especially in snacks and breakfast. Standardisation of dietary requirements of vitamin D is complicated by the fact that it can be obtained both exogenously (diet) and endogenously (from exposure of the skin to sunlight). In practice, this athlete population is not at significant risk of vitamin D deficiency as they spend a large amount of time training outside, and the resulting cutaneous production of vitamin D more than likely meets their requirements.

Finally, Table 8 shows the intakes for five minerals (Iron, Calcium, Magnesium, Phosphorus and Zinc) in absolute values and in percentages of the DRI. Furthermore, the number of cases below the recommended values (↓#) are noted. It can be observed that, in general, both males and females fulfilled the recommendations and only the female speed event athletes had a slight deficit in Iron and Calcium.

Conclusions

From our results we can conclude the following:

1. Elite Spanish female athlete somatotypes indicate a lack of specialisation in the speed events, since the athletes have reduced mesomorphic components.
2. Elite Spanish male athlete somatotypes show a higher level of specialisation with low levels of mesomorphy.
3. The percentage of fat mass of elite Spanish athletes is higher in females than in males for all the athletic disciplines.
4. The percentage of skeletal mass of elite Spanish athletes is higher in male athletes but the percentage of muscle mass and residual mass show non-significant differences.
5. The high correlation between EI and EER and the lack of significant differences between individual results confirm, with some exceptions, an adequate energy balance in elite Spanish athletes.

6. Elite Spanish female middle-distance runners reported energy intakes below 90% of their estimated energy expenditures.
7. Carbohydrate intake fell well short of the minimum recommended level for athletes.
8. Lipids consumption is located in the upper limit both in male and female elite Spanish athletes, and the middle-distance runners of both genders exceeded the recommended range of 35%.
9. The most balanced meal for elite Spanish athletes is breakfast. Lunch and dinner provided higher energy intakes, but with high consumption of fats and low consumption of carbohydrates.
10. The distribution of dietary macronutrients is more homogeneous in female than in male elite Spanish athletes.
11. There is a great prevalence of saturated fats consumption, and lower polyunsaturated fat intake in most of elite Spanish athletes.
12. Elite Spanish speed event athletes surpass the recommended intake levels of cholesterol.
13. Most elite Spanish male athletes and female long-distance runners do not meet water intake requirements.
14. Most elite Spanish speed event athletes and male long-distance runners do not meet fibre intake requirements.
15. There are quite generalised deficits in vitamin E and D intakes among elite Spanish athletes and poor Folic Acid intakes among elite Spanish female athletes.
16. There are specific/rare cases of deficits in mineral intakes in elite Spanish athletes.
17. Energy intake does not correlate with fat accumulation in elite Spanish athletes.
18. The amount of exercise correlates with reduction of body fat and increment of muscle and skeletal mass in elite Spanish athletes.

Recommendations

The lack of studies on nutrition, the poor nutritional culture among elite athletes, and the relevance of this issue to sport performance should encourage further research projects focused on this matter with larger samples and specific protocols of athletes.

We have experienced that nutritional counselling for elite athletes is crucial for detecting possible deficits and for providing them with guidelines for a more complete and correct diet that rewards the athletes for their hard training sessions.

Finally, only as a suggestion, the food of the official hotels at international competitions could be better controlled, and the athletes could be provided with information on available counselling.

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