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Article

Nutrition Status of Female Winter Sports Athletes

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Abstract: Eating disorders, especially restrictive eating, are common among female athletes. There are two main types of winter sports, those that are practised outdoors on snow (-25 to +5°C and 2500 m), such as alpine skiing or snowboarding, and those that are practiced indoors on ice (5-10° C at low altitude), such as figure skating and ice hockey. The aim of this research was to identify the nutritional status and potential risk of female athletes practising winter sports considering the altitude of training. The sample was composed of 58 women (aged 19.81 years (SD: 12.61) who were competitors in some winter sports. Anthropometrics and nutritional variables were taken. Statistically significant differences were found between groups for all the characteristics except thigh skinfold and neither group had an EI that matched their TEE. Both groups met at least 2/3rd of the RDI for all minerals and vitamins, except iodine, fluorine, vit D, E and retinol. This study suggest that female winter sports athletes have insufficient energy, vitamin and mineral intake that can be worsened by altitude.

Keywords: female athletes; winter sports; nutrition; altitude; body composition

1. Introduction

Eating disorders, especially restrictive eating, are common among female athletes [1]. Frequently, they report low energy intake due to high training demands and a sport culture that is often focused on aesthetics from which winter sports are not exempt [2].

There are two main types of winter sports. On the one hand, those that are practised outdoors on snow, are exposed to cold temperatures ranging from -25 to +5° C and high-altitude conditions above 2500 m, such as alpine skiing or snowboarding. On the other hand, those that are practiced indoors on ice, are also exposed to cold conditions, with average temperatures of 5-10° C, but at low altitude, such as figure skating and ice hockey [3,4]. Ice hockey is a contact team sport, with intermittent bouts of high intensity [5,6], in which players are characterized by both muscle strength and endurance muscle power [2,7,8]. Thus, this sport requires aerobic and anaerobic metabolism as energy sources [9]. Figure skating requires as well aerobic and anaerobic endurance [10]. Currently, female athletes incorporate higher and more frequent jumps, spins, spiral elements, and steps which require a relatively low body weight and a good athleticism [10,11]. Alpine skiing and snowboard,

for its part, it is considered an intervallic strength-endurance sport performed at medium-high intensity [12].

These cold and altitude conditions, as well as the specific requirements of each sport, result in a combination of environmental stress and metabolic challenges that accelerate the onset of fatigue and decrease performance and have several nutritional implications [3,13]. Moreover, most winter sports athletes undergo periods of highly intensive training, requiring increased energy and nutrient intakes, as well as adequate nutrition and hydration before, during and after training [9].

Altitude exposure induces diuresis, reduces thirst, and increases ventilation in an environment of low humidity, resulting in a reduction in total body water and, with it, a possible state of dehydration [3,14]. In the case of alpine skiing, muscle damage induced by muscular ischemia, hypoxia and increased utilization of glycogen could be minimized by maintaining hydration with carbohydrate-protein beverages [15]. Ice hockey, despite the cold and low-altitude environment, is a high-intensity sport that results in a high sweat rate and its subsequent loss of sodium and other electrolytes, particularly during match sessions [16]. Staying hydrated by ingesting a sports drink containing carbohydrates and electrolytes helps preserve performance while reducing thermal and perceptual strains [5,17,18]. Upon ascent to altitude, energy expenditure increases, and weight loss frequently occurs, averaging ~1.4 kg per week, which is explained by appetite suppression, the increase in energy requirements to maintain core temperature, and at the same time, the use of protein as a metabolic fuel [3]. Therefore, one of the goals for winter sports athletes is to ensure that energy and fluid intakes are appropriate [19].

The adverse conditions in which winter sports are practiced condition the intake of micronutrients, mainly increasing the needs of vitamin D, since it is a key regulator of calcium homeostasis, and iron for its importance in oxygen transport and energy metabolism [19,20].

Despite the popularity of winter sports, there are no defined nutrition guidelines and there are only a few reviews and research papers about this topic [19]. It is necessary to deepen both the requirements and the dietary habits of winter athletes to improve their health and optimize performance.

Nutritional deficiencies in female athletes cause numerous health problems, as well as a worsening of sports performance because of these nutritional deficiencies. Awareness of these deficiencies and their prevention should be a major aspect for any sports manager [21,22].

Accordingly, the aim of this research was to identify the nutritional status and potential risk of female athletes practising winter sports considering the altitude of training.

2. Materials and Methods

The study design was cross-sectional, descriptive, and comparative. The Andalusian Federation of Winter Sports (Spain) collaborated on the project with the Department of Nutrition and Food Science of the University of Granada (Spain). The study protocols and procedures were developed in accordance with the standards of the Declaration of Helsinki and approved by the Research Ethics Committee of the University of Granada, Spain (ref. 1162/CEIH/2020). Prior to participating in the study, all participants were informed of the objectives of the research and provided their written informed consent.

The sample was composed of 58 women (aged 19.81 years (SD: 12.61) who were competitors in some winter sports. The sports practised were alpine skiing (43.10%), freestyle skiing or snowboarding (6.90%), ice hockey (25.86%) and figure skating (24.14%). Subsequently, the sample was divided into two groups according to the sport practiced: high altitude (HA), including alpine skiing, freestyle skiing or snowboarding, and low altitude (LA), including figure skating and ice hockey. The skiers of this sample usually train in Sierra Nevada Ski Resort (Granada, Spain), where the average altitude is 2800 m with a maximum altitude of 3300 m, while the ice sports sample train in Granada city, at constant altitude of 738 m.

The inclusion criteria were being female, being a minimum of 10 years of age, and competing in the Andalusian Winter Sports Federation during the study. Players who were injured or ill during the study were excluded. Data were collected during the competition season.

Anthropometric variables were taken by trained regular personnel of the European Leagues, certified by ISAK, International Society for the Advancement of Kinanthropometry, with a technical measurement error of 0.04% for basic measurements and of 2.12% for skinfolds, following the international standards recommended by the ISAK. All measures were taken in the morning. Height was measured in centimetres using a wall-mounted stadiometer (Seca 214, SECA Deutschland, Hamburg, Germany) and weight was measured in kilograms with a high-precision scale (Tanita BC-418, Tanita, Tokyo, Japan). On the measurement days athletes should neither have performed high intensity exercise the previous day, nor have performed training or stretching sessions on the same day. All participants were weighed wearing light clothing and barefoot (0.6 kg was subtracted from the total for clothing)[23,24]. Body mass index (BMI) was calculated by dividing the weight in kilograms by the square of height in meters (kg/m²). The skinfolds were measured with a Holtain plicometer. The skin folds measured were bicipital, tricipital, subscapular, suprailiac, abdominal, mid-leg and thigh. Faulkner's fat estimation formula was used[25]. All anthropometric measurements were taken in triplicate, using the mean of both for subsequent analysis.

The 3-day 24-hour recall questionnaire (R24h) was completed through face-to-face individual interviews by specifically trained interviewers. It contains the diet followed by the subjects in the last days and allows estimating the intake of food, energy, and nutrients. Nutrient intakes were compared to the corresponding RDI (Recommended Dietary Intake) [26]. This questionnaire was previously validated by the research group [27].

Statistics

Statistical analysis was performed with the statistical computing software R (v 4.1.2., R Core Team, Vienna, Austria). The normality of the variables was analysed using the Kolmogorov–Smirnov test with the Lillieforts correction, and homoscedasticity was analysed with the Levene test. Means and standard deviations were used for basic descriptions. For the comparisons between groups of continuous variables, the nonparametric Mann-Whytney U test was used, and to calculate the effect size, the Cohen's d index was used. In the case of bivariate correlations, Spearman's rho correlation coefficient was used. All reported p values are based on the two-tailed test and the level of statistical significance for all tests was set at 95%.

3. Results

Table 1. shows a comparison of the anthropometric characteristics by altitude group. Statistically significant differences were found between groups for all the characteristics except thigh skinfold fold ($p = 0.473$; $\eta^2 = -0.15$; $CI = -0.68 - 0.38$) with the highest means corresponding to the high-altitude (HA) group.

Table 1. Anthropometric characteristics of the study sample by altitude group.

Variable (Mean, SD)	Sample (N=58)	Group		Sig. <i>p</i>	Effect size	
		High altitude (n=29)	Low altitude (n=29)		<i>d</i>	IC
Age (years)	19.81(12.61)	21.55(15.47)	18.07(8.84)	0.522	0.21	(-0.31, 0.72)
Height (cm)	153.16(17.51)	149.17(21.23)	157.14(11.85)	0.230	-0.46	(-0.98, 0.06)
Weight (kg)	51.70(17.82)	46.21(16.70)	57.19(17.46)	0.031	0.64	(0.11, -1.17)
BMI (kg/m ²)	21.28(4.50)	19.98(4.38)	22.59(4.31)	0.028	0.60	(0.07, 1.12)
Tricipital skinfold (mm)	16.46(6.37)	14.58(6.25)	18.15(6.08)	0.021	0.58	(0.04, 1.12)
Bicipital skinfold (mm)	9.23(5.01)	7.64(4.12)	10.65(5.36)	0.010	0.62	(0.08, 1.16)
Subscapular skinfold (mm)	12.77(7.47)	10.61(6.80)	14.71(7.63)	0.012	0.57	(0.02, 1.10)
Suprailiac skinfold (mm)	13.01(8.68)	10.42(8.42)	15.33(8.37)	0.008	0.59	(0.04, 1.12)
Abdominal skinfold (mm)	16.16(9.04)	13.84(8.66)	18.31(9.01)	0.033	-0.51	(-1.06, 0.05)
Thigh skinfold (mm)	24.24(10.01)	23.45(9.00)	24.94(10.95)	0.473	-0.15	(-0.68, 0.38)

Midleg skinfold (mm)	16.89(7.42)	14.15(5.31)	19.34(8.23)	0.009	0.74	(0.19, 1.29)
Faulkner Body Fat (%)	14.59(4.38)	13.27(4.05)	15.77(4.39)	0.013	0.59	(0.05, 1.13)

Bivariate correlations between these characteristics are shown in Figures 1 and 2. For the percentage of fat, in both groups the highest correlation values were found in the tricipital, suprascapular, suprailiac and abdominal folds ($r > 0.9$).

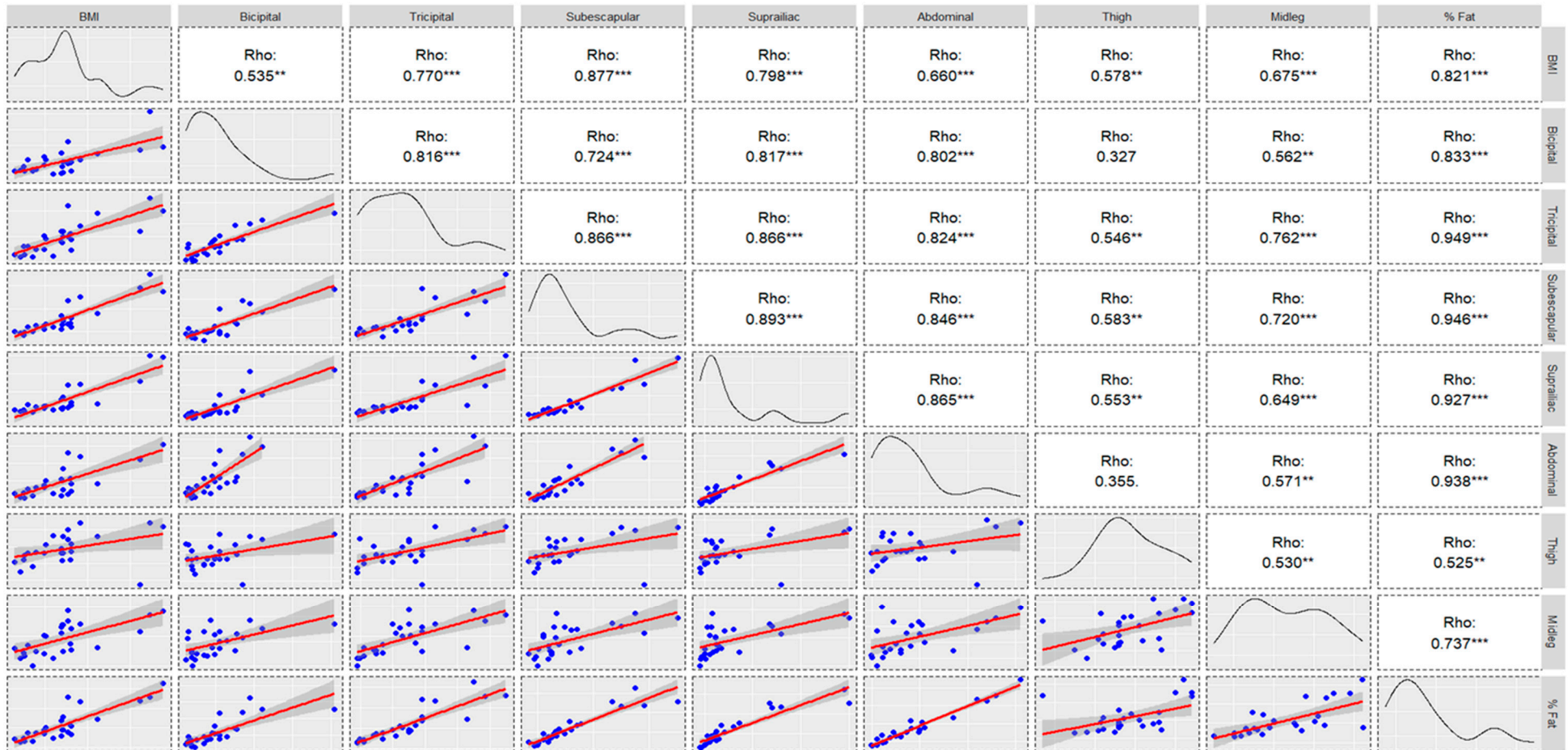


Figure 1. Chart of correlations, density curve, and regression models of anthropometric measures for high altitude group (* $p \leq 0.050$; ** $p \leq 0.010$; *** $p \leq 0.001$).

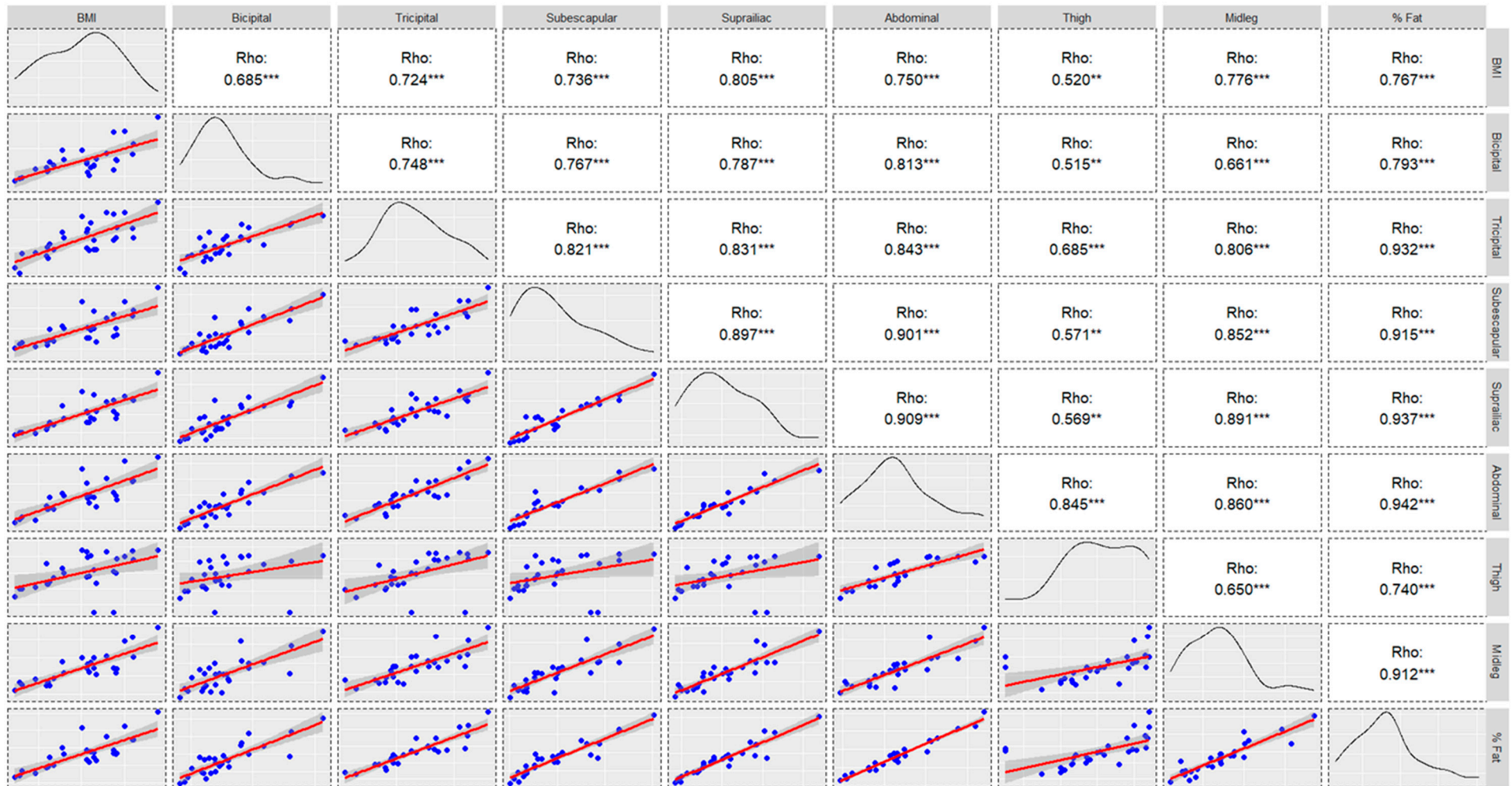


Figure 2. Chart of correlations, density curve, and regression models of anthropometric measures for low altitude group (* $p \leq 0.050$; ** $p \leq 0.010$; *** $p \leq 0.001$).

Regarding macronutrients intake, as shown in Table 2, neither group had an energy intake (EI) that matched their total energy expenditure (TEE). The HA group had the highest mean intakes of water ($p = 0.035$; $\eta^2 = -0.52$; $CI = -1.04 - 0.01$), carbohydrates ($p = 0.018$; $\eta^2 = 0.54$; $CI = 0.11 - 1.16$), soluble fibre ($p = 0.009$; $\eta^2 = 0.54$; $CI = 0.02 - 1.06$) and indissoluble fibre ($p = 0.008$; $\eta^2 = 0.63$; $CI = 0.10 - 1.16$). No statistically significant differences were found with respect to the caloric profile ($p \leq 0.005$), but with respect to the lipid profile, SFA was higher in LA group ($p = 0.001$; $\eta^2 = 1.22$; $CI = 0.65 - 1.78$).

Table 2. Macronutrients daily intake by altitude group.

Variable	Sample	Group		Sig. <i>p</i>	Effect size	
		High altitude	Low altitude		<i>d</i>	IC
BMR, kcal*	1272.63(238.86)	1197.33(261.85)	1347.93(189.30)	0.102	0.66	(0.13, 1.19)
TEE, kcal*	2068.52(613.89)	2115.16(825.86)	2021.89(283.94)	0.699	0.15	(-0.37, 0.67)
Energy intake, kcal*	1755.76(453.28)	1652.86(409.72)	1858.66(477.98)	0.125	-0.46	(-0.98, 0.60)
Water, g*	2471.48(910.90)	2242.00(861.03)	2700.97(915.78)	0.035	-0.52	(-1.04, 0.01)
Protein, g*	80.81(28.30)	76.11(19.88)	85.51(34.48)	0.262	-0.33	(-0.85, 0.19)
Carbohydrate, g*	165.06(47.59)	150.51(46.54)	179.62(44.78)	0.018	0.64	(0.11, 1.16)
Lipid, g*	80.21(30.33)	77.65(28.82)	82.76(32.07)	0.797	-0.17	(-0.68, 0.35)
<i>Simple carbohydrate</i>						
Glucose, g*	7.78(4.59)	6.25(3.93)	9.32(4.75)	0.004	0.70	(0.17, 1.23)
Fructose, g*	9.73(6.01)	8.11(5.90)	11.35(5.77)	0.013	0.56	(0.03, 1.08)
Lactose, g*	9.12(6.48)	7.69(5.12)	10.56(7.41)	0.135	-0.45	(-0.97, 0.07)
Soluble fibre, g*	3.61(2.89)	2.85(1.43)	4.37(3.70)	0.009	0.54	(0.02, 1.06)
Indissoluble fibre, g*	6.34(4.50)	4.97(2.65)	7.71(5.51)	0.008	0.63	(0.10, 1.16)
Cholesterol, mg*	352.57(21.99)	343.07(218.70)	363.20(208.17)	0.662	-0.09	(-0.63, 0.45)
<i>Caloric profile</i>						
Proteins, %	18.47(4.46)	18.80(4.32)	18.15(4.65)	0.888	0.15	(-0.37, 0.66)
Carbohydrates, %	38.07(7.91)	36.71(8.19)	39.43(7.52)	0.269	-0.35	(-0.86, 0.17)
Lipids, %	40.49(7.20)	41.62(7.28)	39.36(7.06)	0.297	0.31	(-0.21, 0.83)
<i>Lipids profile</i>						
SFA, %	11.41(4.23)	13.62(2.99)	9.20(4.17)	0.001	1.22	(0.65, 1.78)
MUFA, %	15.84(5.93)	16.63(6.35)	15.04(5.49)	0.291	0.27	(-0.25, 0.78)
PUFA, %	5.08(2.57)	4.99(2.49)	5.16(2.70)	0.779	-0.06	(-0.58, 0.45)

* Data are presented as the mean (SD).

Micronutrients intake means were compared between groups and against European Union Recommendations Dietary Intake (RDI) values (Tables 3, and 4, Figure 3).

Table 3. Mineral intake and daily recommendation by altitude group.

Variable		Sample	Group		Sig. <i>p</i>	Effect size	
			High altitude	Low altitude		<i>d</i>	IC
Calcium	Intake, mg*	815(463.13)	855.88(349.29)	778.50(549.28)	0.123	0.17	(-0.38, 0.71)
	% RDI	75.70(40.81)	83.75(36.39)	68.52(43.77)	0.059	0.38	(-0.17, 0.92)
Iron	Intake, mg*	14.55(6.38)	15.09(7.77)	14.07(4.94)	0.694	0.16	(-0.38, 0.70)
	% RDI	110.48(59.42)	117.26(59.32)	104.43(59.94)	0.322	0.22	(-0.33, 0.75)
Iodine	Intake, μg^*	82.72(35.10)	81.58(34.19)	83.74(36.48)	0.992	-0.06	(-0.60, 0.48)
	% RDI	64.50(30.31)	62.82(29.09)	65.99(31.81)	0.823	-0.10	(-0.64, 0.44)
Zinc	Intake, mg*	9.73(2.99)	9.78(3.00)	9.69(3.04)	0.936	0.03	(-0.51, 0.57)
	% RDI	97.68(49.56)	111.37(56.34)	85.45(39.76)	0.085	0.54	(-0.01, 1.08)
Magnesium	Intake, mg*	285.32(109.85)	292.20(125.18)	279.18(96.06)	0.796	0.12	(-0.42, 0.66)
	% RDI	96.69(43.64)	104.39(49.37)	89.81(37.88)	0.314	0.34	(-0.21, 0.88)
Potassium	Intake, mg*	2944.21(987.14)	3004.68(1204.81)	2890.21(761.59)	0.852	0.12	(-0.43, 0.65)
	% RDI	95.39(37.59)	101.28(43.96)	90.13(30.69)	0.518	0.30	(-0.25, 0.84)

Sodium	Intake, mg*	2917.57)	2962.88(1524.79)	2877.11(1589.22)	0.839	0.06	(-0.48, 0.59)
	% RDI	200.03(109.41)	205.63(110.84)	195.03(109.90)	0.730	0.10	(-0.44, 0.64)
Selenium	Intake, µg*	96.18(46.75)	93.20(47.86)	98.83(46.45)	0.796	-0.12	(-0.66, 0.42)
	% RDI	219.15(128.30)	233.32(154.83)	206.49(100.21)	0.734	0.21	(-0.33, 0.75)
Manganese	Intake, mg*	2.88(1.47)	2.58(1.31)	3.15(1.57)	0.151	-0.39	(-0.93, 0.16)
	% RDI	127.22(58.34)	122.62(49.48)	131.33(65.89)	0.755	-0.15	(-0.69, 0.39)
Cooper	Intake, mg*	1.52(0.78)	1.63(1.05)	1.41(0.43)	0.844	0.28	(-0.26, 0.82)
	% RDI	140.18(79.08)	159.43(103.30)	122.99(43.70)	0.322	0.47	(-0.08, 1.01)
Chrome	Intake, µg*	48.58(47.68)	59.60(44.88)	38.75(20.58)	0.127	0.44	(-0.10, 0.99)
	% RDI	193.36(206.89)	247.56(274.49)	144.96(101.55)	0.128	0.47	(-0.08, 1.01)
Chlorine	Intake, mg*	1981.66(792.22)	2019.80(919.47)	1947.61(674.31)	0.907	0.09	(-0.45, 0.63)
	% RDI	87.94(36.21)	90.07(41.67)	86.03(31.20)	0.852	0.11	(-0.43, 0.65)
Fluorine	Intake, mg*	2.34(1.06)	2.22(1.12)	2.44(1.01)	0.446	-0.20	(-0.74, 0.33)
	% RDI	36.59(37.45)	25.64(29.58)	46.36(41.39)	0.123	0.57	(0.02, 1.12)
Phosphorus	Intake, mg*	1324.98(396.61)	1347.28(410.20)	1305.07(390.53)	0.957	0.11	(-0.43, 0.64)
	% RDI	150.92(65.08)	161.07(61.87)	141.85(67.63)	0.210	0.30	(-0.25, 0.84)

* Data are presented as the mean (SD).

Table 4. Vitamins daily intake by play altitude group.

Variable		Group			p*	Effect size	
		Sample	High altitude	Sample		d	IC
Thiamine	Intake, mg*	1.59(0.69)	1.54(0.72)	1.78(0.73)	0.865	0.07	(-0.47, 0.61)
	% RDI	162.31(73.20)	164.98(73.44)	159.92(74.26)	0.809	0.07	(-0.47, 0.61)
Riboflavin	Intake, mg*	1.69(0.60)	1.84(0.66)	1.55(0.51)	0.107	0.50	(-0.05, 1.05)
	% RDI	126.37(49.54)	141.88(58.52)	112.52(35.52)	0.054	0.62	(0.06, 1.05)
Niacine	Intake, mg*	35.03(10.85)	34.92(11.56)	35.15(10.24)	0.809	-0.02	(-0.56, 0.52)
	% RDI	238.53(77.73)	242.30(86.95)	234.31(67.44)	0.914	0.10	(-0.44, 0.64)
B6	Intake, mg*	2.19(0.80)	2.12(0.68)	2.25(0.90)	0.661	-0.15	(-0.69, 0.39)
	% RDI	157.34(62.08)	164.35(58.52)	151.07(65.52)	0.309	0.21	(-0.33, 0.75)
Folic acid	Intake, µg*	275.75(132.40)	278.60(146.28)	273.21(121.35)	0.950	0.04	(-0.50, 0.58)
	% RDI	88.74(46.67)	96.19(50.27)	82.10(43.03)	0.170	0.30	(-0.24, 0.84)
B12	Intake, µg*	4.77(4.109)	4.42(2.17)	5.08(5.28)	0.590	-0.16	(-0.70, 0.38)
	% RDI	174.39(199.31)	141.07(77.88)	204.15(263.00)	0.475	-0.32	(-0.86, 0.23)
Vitamin C	Intake, mg*	118.32(94.48)	121.60(116.33)	115.39(71.73)	0.816	0.07	(-0.47, 0.60)
	% RDI	210.00(185.74)	252.30(245.17)	170.84(94.22)	0.489	0.45	(-0.11, 0.99)
Vitamin A	Intake, µg*	901.00(503.10)	988.84(608.11)	822.57(381.11)	0.636	0.33	(-0.21, 0.87)
	% RDI	135.62(93.56)	155.48(105.29)	117.23(78.78)	0.785	-0.04	(-0.58, 0.51)
Vitamin D	Intake, µg*	2.57(2.40)	1.98(1.55)	3.09(2.89)	0.172	-0.47	(-1.02, 0.08)
	% RDI	48.72(40.61)	39.59(30.92)	57.18(46.89)	0.226	-0.44	(-0.99, 0.11)
Vitamin E	Intake, mg*	8.15(3.75)	8.19(4.59)	8.10(2.89)	0.655	0.02	(-0.52, 0.56)
	% RDI	54.30(25.00)	54.61(30.58)	54.02(19.29)	0.655	0.02	(-0.52, 0.56)
Vitamin K	Intake, µg*	168.43(144.84)	179.08(172.28)	158.92(117.56)	0.907	0.14	(-0.40, 0.68)
	% RDI	179.01(169.36)	210.36(197.86)	151.02(136.81)	0.462	0.35	(-0.19, 0.89)
Retinol	Intake, µg*	384.58(343.87)	469.68(388.07)	308.63(284.94)	0.025	0.48	(-0.07, 1.02)
	% RDI	59.17(52.90)	72.25(59.70)	47.48(43.84)	0.462	0.35	(-0.19, 0.89)
Betacaroten ^e	Intake, µg*	2452.37(896.53)	2239.59(1658.70)	2690.70(2141.49)	0.538	-0.24	(-0.78, 0.31)
	% RDI	350.34(270.93)	319.94(236.96)	384.39(305.93)	0.538	-0.24	(-0.78, 0.31)

* Data are presented as the mean (SD).

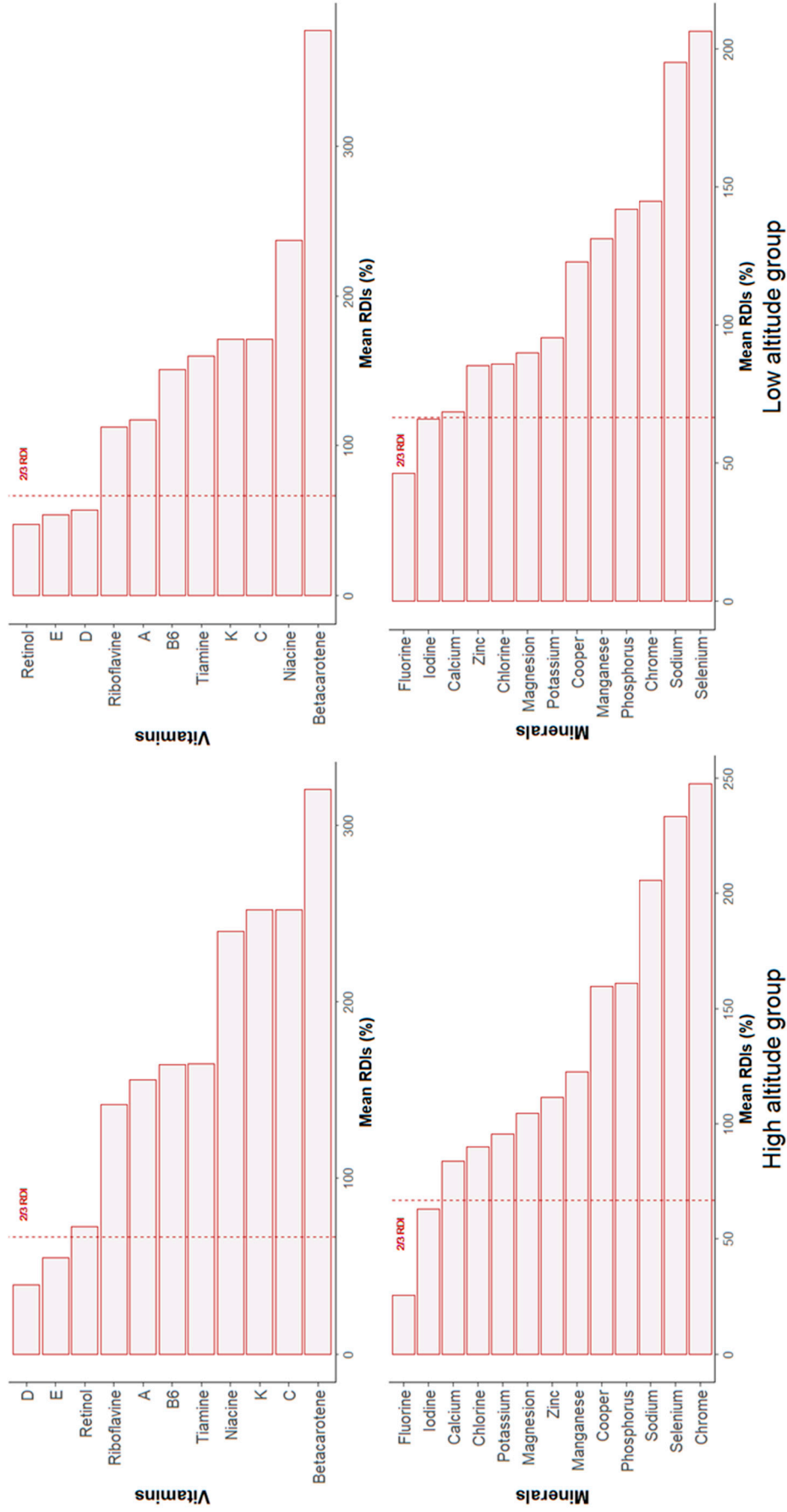


Figure 3. Percentage of adjustment to the RDIs of minerals and vitamins intakes by altitude group.

Micronutrients intake means were compared between groups and against European Union Recommendations Dietary Intake (RDI) values (Tables 3, and 4, Figure 3).

No statistically significant differences were found between groups in mineral intake ($p \geq 0.05$). The percentage of calcium intake respecting RDI was higher in the HA group ($p = 0.059$; $\eta^2 = 0.38$; IC = -0.17 - 0.92). Both groups met at least 2/3rd of the RDI for all minerals, except iodine and fluorine intake.

With respect to vitamins intake, only retinol showed statistically significant differences between groups ($p = 0.025$; $\eta^2 = 0.48$; IC = -0.07 - 1.02), with higher values in the HA group. The percentage of riboflavin intake respecting RDI was higher in HA group ($p = 0.054$; $\eta^2 = 0.62$; IC = 0.06 - 0.92).

Both groups met at least 2/3rd of the RDI for all vitamins except vitamins D, E and retinol in the LA group and vitamins D and E in the HA group.

4. Discussion

The main findings from this study were that both the HA group and LA group had similar and adequate dietary patterns with respect to macronutrients and micronutrients but insufficient energy intake, which corroborates what was published by Vazquez Franco et al. in 2020 on the female athlete triad due to energy intake deficiencies [21]. Differences were found to be statistically significant between groups in the total amount of water, carbohydrate, fibre, and retinol intake. The micronutrient intake is in line with RDI, being lower to 2/3rd only the intake of iodine, fluorine, vitamin D, vitamin E and just in LA group, as well retinol intakes. These results may be due to the high prevalence of the Mediterranean diet pattern in all southern regions of Spain [29]. Nevertheless, considering the sample sex, type of sport practised and altitude, some of these differences could be important.

Anthropometry

The percentage of body fat (BF) in the LA group was like that in previous studies focusing on women, reporting values of 17.2-17.6% in figure skating [10,11], and 13-18.9% in ice hockey [30]. However, in the HA group, BF was lower than those reported for alpine skiers in several reviews of the literature (18.4-22.1%) [31,32]. This may be because most of the studies focusing on skiers used samples from North/Central European regions or North America, places where skiing is popular [33] but where eating habits were more Westernized and unhealthier [34]. Differences between groups could be explained first by the metabolic response to the altitude of women, relying on fat as fuel to a greater extent during submaximal exercise and at rest [3], and second, by the improved body composition associated with improvements in insulin sensitivity found in alpine skiers [35,36].

Macronutrients

In the current study, in both groups, EI was not enough to cover the TEE, and the athletes were probably at risk of low energy availability (LEA), a dangerous state that should be monitored by both parents and coaches. LEA occurs when there is insufficient energy to maintain basic physiological and endocrine functions, causing female athlete's triad, reduced performance, chronic fatigue sensation, low mood, poor concentration, impaired immune system, absence of menarche and poor bone health [19,37-39] and is associated with eating disorders [1]. Recent studies placed the LEA threshold for healthy female athletes at an intake lower than or equal to 30 kcal/kg FFM/day [40].

Fluid balance plays a crucial role in exercise performance, and as well in winter sports [14]. Ice hockey players became mildly dehydrated by 1.3-4.3% body mass [17]. In athletes training at altitude, it is suggested to have a fluid intake of 4.5 L per day and rehydration at 1.5 L of fluid per kg body mass lost after training [3,19]. The fluid intake in the HA group was far from that suggested by these authors. One of the reasons is the lack of on-snow availability, and because of that, skiers should make a conscientious effort to stop skiing to go into the lodge and get their drinks [14]. Another reason is the necessity of holistic sports nutrition education [19].

In the LA group, the caloric profile differed from that reported in other studies with professional ice hockey players, with a significantly lower proportion of energy from carbohydrates (18-32%) and a higher proportion of energy from protein (38%) [8], which could affect physical performance [5,8] since during an ice hockey match, muscle glycogen has been reported to decline between 38-88% [8], it could even affect the growth of those athletes who have not yet completed their own growth due to the energy/protein imbalance. Nevertheless, in the HA group, the results differ in percentages of energy from total fat and SFA, being both considerably higher compared with WHO dietary guidelines for the European Region [41] and recommendations established previously by Butterfield [4] for high-altitude sports (30% and 10%, respectively). This higher energy intake from total fat and SFA is not reflected in a higher body fat and may be due to the different behaviours of fat metabolism at different altitudes, as discussed in the previous section.

If we also consider the higher intake of fibre and fructose, mainly present in fruits and vegetables, everything seems to indicate that the dietary habits of LAG are healthier than those of the HA group.

Micronutrients: vitamins

Iron, calcium, and vitamin D are micronutrients that female athletes commonly consume in low quantities [2]. The high prevalence of vitamin D deficiency is a worldwide problem, affecting athletes in a wide range of sports, especially in the winter months [42,43]. Given the impact of vitamin D on health, particularly bone health [44], and the high risk of bone injury from falls or impacts in all sports studied, athletes, particularly those playing indoor sports, should consider ways to increase vitamin D status through diet, supplements, and sun exposure [20]. In our study, no group met the 2/3rd of RDI for vitamin D intake, although the HA group might be compensating for the low vitamin D intake with higher exposure to ultraviolet B (UVB) sunlight [43]. These results are consistent with other studies conducted in alpine skiers [44], hockey players [2,45] and other team sports with Spanish elite athletes [43].

Free radical production during exercise is increased by environmental factors, such as altitude, low temperatures, and increased UV light exposure [46,47]. Therefore, for all athletes, but especially the HA group, it is important to at least meet the 2/3rd of antioxidant RDI (vitamins A, C, E, retinol, and beta-carotene). However, both groups were deficient in vitamin E, probably due to the poor consumption of vegetables characteristic of the Westernized diet recently adopted by Mediterranean young people [34].

Micronutrients: minerals

In the case of female athletes who practise winter sports, calcium and iron are minerals of special interest due to their roles in bone health and erythrocyte production, respectively [3,44]. Nevertheless, unlike other similar studies that showed a low intake of potassium, calcium, or iron [2,19], only the intake of fluorine and iodine showed deficiencies, with possible consequences for bone structure and thyroid disease, which are common in female athletes, conditions that may be exacerbated by strenuous exercise, but easily corrected by increasing the intake of tea, seafood, dairy products and/or iodized salt [48-50].

Strengths and Limitations

Main strengths of the current study were that the subjects were female in that both the HA and LA group had similar dietary patterns in terms of macronutrients and micronutrients but insufficient energy intake (EI). The current study has also limitations. The main limitation is its descriptive cross-sectional design, which does not allow for the establishment of any causal inferences. These results need to be interpreted with caution because dietary habits were reported by the participants. It should also be noted, that to date, studies of nutrition in winter sports specific to women or that incorporate women in their sample are scarce, and therefore necessary.

5. Conclusions

This study suggests that female winter sports athletes have insufficient energy, vitamin and mineral intake that can be worsened by altitude. Moreover, by being a woman there would be a loss of sporting performance, health problems, overtraining, and poor preparation for early specialised sports, where optimal work is not being well done. All these could not lead the female athlete to her best performance in her future professional career as an athlete.

Author Contributions: The study was designed by FOS, JAT and MM-A; data were collected and analyzed by MJJ-C, IV-B, RR-C, CB and JC-P; data interpretation and manuscript preparation were undertaken by MJJ-C, JC-P, IV-B, CB, FOS, JAT and MM-A. All authors reviewed and approved the final manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the University of Granada, Spain (code 1162/CEIH/2020). All participants were informed of the purpose and the implications of the study, and all provided their written informed consent to participate. The results and writing of this manuscript followed the Committee on Publication Ethics (COPE) guidelines on how to deal with potential acts of misconduct, maintaining the integrity of the research and its presentation following the rules of good scientific practice, the trust in the journal, the professionalism of scientific authorship, and the entire scientific endeavor.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent was obtained from the patient(s) to publish this paper.

Data Availability Statement: There are restrictions on the availability of data for this trial, due to the signed consent agreements around data sharing, which only allow access to external researchers for studies following the project's purposes. Requestors wishing to access the trial data used in this study can make a request to mariscal@ugr.es.

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References

1. Ravi S, Ihalainen JK, Taipale-Mikkonen RS, Kujala UM, Waller B, Mierlahti L, et al. Self-reported restrictive eating, eating disorders, menstrual dysfunction, and injuries in athletes competing at different levels and sports. *Nutrients*. 2021 Sep 1;13(9).
2. Vermeulen TF, Boyd LA, Spriet LL. Dietary macronutrient and micronutrient intake over a 7-day period in female varsity ice hockey players. *Nutrients*. 2021 Jul 1;13(7).
3. Meyer NL, Manore MM, Helle C. Nutrition for winter sports. *J Sports Sci*. 2011 Jan;29(SUPPL. 1).
4. Butterfield GE. NUTRIENT REQUIREMENTS AT HIGH ALTITUDE. *Clin Sports Med*. 1999 Jul;18(3):607–21.
5. Vigh-Larsen JF, Ermidis G, Rago V, Randers MB, Fransson DAN, Nielsen JL, et al. Muscle Metabolism and Fatigue during Simulated Ice Hockey Match-Play in Elite Players. *Med Sci Sports Exerc*. 2020 Oct 1;52(10):2162–71.
6. Vigh-Larsen JF, Beck JH, Daasbjerg A, Knudsen CB, Kvorning T, Overgaard K, et al. Fitness Characteristics of Elite and Subelite Male Ice Hockey Players: A Cross-Sectional Study. *J Strength Cond Res*. 2019;33(9):2352–60.

7. Petré H, Psilander N, Rosdahl H. Between-Session Reliability of Strength- and Power-Related Variables Obtained during Isometric Leg Press and Countermovement Jump in Elite Female Ice Hockey Players. *Sports*. 2023 May 1;11(5).
8. Akermark C, Jacobs I, Rasmusson M, Karlsson J. Diet and muscle glycogen concentration in relation to physical performance in swedish elite ice hockey players. *Int J Sport Nutr*. 1996;6:272–84.
9. Zaborova V, Kurshev V, Kryuchkova K, Anokhina V, Malakhovskiy V, Morozova V, et al. Metabolic and Body Composition Changes in Ice Hockey Players Using an Ergogenic Drug (Cytoflavin). *Biology (Basel)*. 2023 Feb 1;12(2).
10. Mostaert M, Deconinck F, Pion J, Lenoir M. Anthropometry, Physical Fitness and Coordination of Young Figure Skaters of Different Levels. *Int J Sports Med*. 2016 Jun 1;37(7):531–8.
11. Ziegler PJ, Jonnalagadda SS, Lawrence C. Dietary intake of elite figure skating dancers. *Nutrition Research*. 2001;21:983–92.
12. Conde-Pipó J, Valenzuela-Barranco I, López-Moro A, Román-Alconchel B, Mariscal-Arcas M, Zurita-Ortega F. Influence of Alpine Skiing on Health-Related Quality of Life and Physical Self-Concept in Physically Active Adults over 55 Years of Age. *Sports*. 2022;10(10).
13. Pellicer-Caller R, Vaquero-Cristóbal R, González-Gálvez N, Abenza-Cano L, Horcajo J, de la Vega-Marcos R. Influence of Exogenous Factors Related to Nutritional and Hydration Strategies and Environmental Conditions on Fatigue in Endurance Sports: A Systematic Review with Meta-Analysis. *Nutrients*. 2023 Jun 9;15(12):2700.
14. Seifert JG, Burke ER, White A, Luetkemeier MJ. The effects of ad libitum fluid ingestion on fluid balance during alpine skiing in recreational skiers. *J Sports Sci*. 2006 Feb;24(2):137–42.
15. Seifert JG, Kipp RW, Amann M, Gazal O. Muscle Damage, Fluid Ingestion, and Energy Supplementation During Recreational Alpine Skiing. *Int J Sport Nutr Exerc Metab*. 2005;15:528–36.
16. Bigg JL, Gamble ASD, Vermeulen TF, Bigg LM, Spriet LL. Sweat Loss and Fluid Intake of Female Varsity Ice Hockey Players During On-Ice Practices and Games. *J Strength and Cond Res*. 2019;34(2):389–95.
17. Palmer MS, Heigenhauser G, Duong M, Spriet LL. Ingesting A Sports Drink Enhances Simulated Ice Hockey Performance while Reducing Perceived Effort. *Int J Sports Med*. 2017 Dec 1;38(14):1061–9.
18. McCarthy DG, Wickham KA, Vermeulen TF, Nyman DL, Ferth S, Pereira JM, et al. Impairment of Thermoregulation and Performance via Mild Dehydration in Ice Hockey Goaltenders. *Int J Sports Physiol Perform*. 2020 Jul 1;15(6):833–40.
19. Hannon MP, Flueck JL, Gremeaux V, Place N, Kayser B, Donnelly C. Key Nutritional Considerations for Youth Winter Sports Athletes to Optimize Growth, Maturation and Sporting Development. *Front Sports Act Living*. 2021 Jan 27;3.
20. Orysiak J, Mazur-Rozycka J, Fitzgerald J, Starczewski M, Malczewska-Lenczowska J, Busko K. Vitamin D status and its relation to exercise performance and iron status in young ice hockey players. *PLoS One*. 2018 Apr 1;13(4).
21. Vázquez M, Giménez-Blasi N, Latorre-Rodríguez J, Martínez-Bebia M, Bach-Faig A, Olea F, et al. Actualización sobre deficiencias nutricionales en la mujer deportista a partir de la literatura científica. *Arch Latinoam Nutr*. 2020 Sep 1;70(3):191–204.
22. Giménez-Blasi N, Latorre JA, Martínez-Bebia M, Sáenz M, Cantero L, López-Moro A, et al. Menstrual Cycle and Sport: effects on the performance and metabolism of the athlete woman. *Retos*. 2022 Jul 28;46:565–72.
23. Wang ZM, Heshka S, Pierson RN, Heymsfield SB. Systematic organization of body-composition methodology: an overview with emphasis on component-based methods. *Am J Clin Nutr*. 1995 Mar;61(3):457–65.
24. Conde-Pipó J, Bouzas C, Mariscal-Arcas M, Tur JA. Association between Functional Fitness and Health-Related Quality of Life in the Balearic Islands' Old Adults with Metabolic Syndrome. *Nutrients [Internet]*. 2022 Apr 25;14(9):1798. Available from: <https://www.mdpi.com/2072-6643/14/9/1798>
25. Martínez-Rodríguez A, Sánchez-Sánchez J, Vicente-Martínez M, Martínez-Olcina M, Miralles-Amorós L, Sánchez-Sáez JA. Anthropometric dimensions and bone quality in international male beach handball players: Junior vs. senior comparison. *Nutrients*. 2021 Jun 1;13(6).
26. Hamdan M, Monteagudo C, Lorenzo-Tovar ML, Tur JA, Olea-Serrano F, Mariscal-Arcas M. Development and validation of a nutritional questionnaire for the Palestine population. *Public Health Nutr*. 2014 Nov 16;17(11):2512–8.

27. Rivas A, Romero A, Mariscal M, Monteagudo C, Hernández J, Olea-Serrano F. Validation of questionnaires for the study of food habits and bone mass. *Nutr Hosp*. 2009;24(5):521–8.
28. Franco MV, Giménez-Blasi N, Latorre JA, Martínez-Bebia M, Bach A, Olea-Serrano F, et al. Actualización sobre deficiencias nutricionales en la mujer deportista a partir de la literatura científica.
29. Conde-Pipó J, Bouzas C, Mariscal-Arcas M, Tur JA. Association between Functional Fitness and Health-Related Quality of Life in the Balearic Islands' Old Adults with Metabolic Syndrome. *Nutrients*. 2022 Apr 25;14(9):1798.
30. Ransdell LB, Murray T. A PHYSICAL PROFILE OF ELITE FEMALE ICE HOCKEY PLAYERS FROM THE USA. *J Strength and Cond Res* . 2011;25(9):2358–63.
31. Ferland PM, Comtois AS. Athletic Profile of Alpine Ski Racers: A Systematic Review. *J Strength and Cond Res* . 2018;32(12):3574–83.
32. Andersen RE, Montgomery DL. Physiology of Alpine Skiing. *Sports Medicine*. 1988;6:210–21.
33. Seifert J, Kroll J, Muller E. The relationship of heart rate and lactate to cumulative muscle fatigue during recreational alpine skiing. *J Strength and Cond Res* . 2009;23(3):698–704.
34. Conde-Pipó J, Bouzas C, Zurita-Ortega F, Olea-Serrano F, Tur JA, Mariscal-Arcas M. Adherence to a Mediterranean Diet Pattern, Physical Activity, and Physical Self-Concept in Spanish Older Adults. *Nutrients*. 2022;14(12).
35. Dela F, Niederseer D, Patsch W, Pirich C, Müller E, Niebauer J. Glucose homeostasis and cardiovascular disease biomarkers in older alpine skiers. *Scand J Med Sci Sports*. 2011 Aug;21(SUPPL. 1):56–61.
36. Niederseer D, Ledl-Kurkowski E, Kvita K, Patsch W, Dela F, Mueller E, et al. Salzburg Skiing for the Elderly Study: Changes in cardiovascular risk factors through skiing in the elderly. *Scand J Med Sci Sports*. 2011;21(SUPPL. 1):47–55.
37. Dervish RA, Wilson LJ, Curtis C. Investigating the prevalence of low energy availability, disordered eating and eating disorders in competitive and recreational female endurance runners. *Eur J Sport Sci*. 2022;
38. Franco MV, Giménez-Blasi N, Latorre JA, Martínez-Bebia M, Bach A, Olea-Serrano F, et al. Actualización sobre deficiencias nutricionales en la mujer deportista a partir de la literatura científica. *Arch Latinoam Nutr*. 2020;70(3):191–204.
39. Kuikman MA, Mountjoy M, Burr JF. Examining the relationship between exercise dependence, disordered eating, and low energy availability. *Nutrients*. 2021 Aug 1;13(8).
40. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP. Direct and indirect impact of low energy availability on sports performance. *Scand J Med Sci Sports*. 2023 Mar 9;
41. World Health Organization. Regional Office for Europe. Food-based dietary guidelines in the WHO European Region. Copenhagen: WHO Regional Office for Europe; 2003.
42. Yagüe M de la P, Yurrita LC, Cabañas MJC, Cenual MAC. Role of vitamin d in athletes and their performance: current concepts and new trends. *Nutrients*. 2020 Feb 1;12(2).
43. Valtueña J, Aparicio-ugarriza R, Medina D, Lizarraga A, Rodas G, González-gross M, et al. Vitamin d status in spanish elite team sport players. *Nutrients*. 2021 Apr 1;13(4).
44. Vitale JA, Lombardi G, Cavaleri L, Graziani R, Schoenhuber H, Torre A La, et al. Rates of insufficiency and deficiency of vitamin D levels in elite professional male and female skiers: A chronobiologic approach. *Chronobiol Int*. 2018 Apr 3;35(4):441–9.
45. Most A, Dörr O, Nef H, Hamm C, Bauer T, Bauer P. Influence of 25-Hydroxy-Vitamin D Insufficiency on Maximal Aerobic Power in Elite Indoor Athletes: A Cross-Sectional Study. *Sports Med Open*. 2021 Dec 1;7(1).
46. Subudhi AW, Davis SL, Kipp RW, Askew EW. Antioxidant Status and Oxidative Stress in Elite Alpine Ski Racers. *Int J Sport Nutr Exerc Metab*. 2001 Mar;11(1):32–41.
47. Schippinger G, Fankhauser F, Abuja PM, Winklhofer-Roob BM, Nadlinger K, Halwachs-Baumann G, et al. Competitive and seasonal oxidative stress in elite alpine ski racers. *Scand J Med Sci Sports*. 2009 Apr;19(2):206–12.
48. Larson-Meyer DE, Gostas DE. Thyroid Function and Nutrient Status in the Athlete. *American College of Sports Medicine*. 2020;19(2).
49. Álvarez-San Emeterio C, Palacios-Gi Antuñano N, López-Sobaler AM, González-Badillo JJ. Effect of strength training and the practice of alpine skiing on bone mass density, growth, body composition, and the strength and power of the legs of adolescent skiers. *J Strength Cond Res*. 2011;25(1):2879–90.

50. Ratajczak AE, Rychter AM, Zawada A, Dobrowolska A, Kreła-Kaźmierczak I. Do only calcium and vitamin d matter? Micronutrients in the diet of inflammatory bowel diseases patients and the risk of osteoporosis. Vol. 13, *Nutrients*. MDPI AG; 2021. p. 1–14.

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