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Iron status in spanish junior soccer and basketball players.

Status en hierro de jugadores de fútbol y baloncesto de la categoría junior.

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Abstract

Aim: To assess the dietary iron intake and the iron status of Spanish junior athletes and its importance on performance, and to discuss abount the consequences of an iron deficiency.

Material and methods: Forty six soccer and eleven basketball players aged 17-21 years (mean age 18.2 +1.1) who played in the Spanish national junior soccer and basketball league, respectively, who had neither drugs, medicines intake nor illness during the study which altered the appetite or some studies parameters, took part in the study. Dietary intake was assessed by means of a 7-day weighed food intake record. Iron status was evaluated by means of a complete hemogram, serum iron, ferritin, transferrin and TIBC.

Results: Mean iron intake was 19.24±4.58 mg/day. Mean analytical data were all between reference ranges. Basketball players had higher intake levels compared with soccer ones (22.1+6.4 and 19.2+3.9 mg/day, respectively; $p< 0.05$). Nevertheless, basketball players had lower levels of mean red blood cells, haemoglobin, hematocrit and the mean corpuscular volumes comparing with soccer players.

Conclusions: During adolescence, iron requirements are very high which could place adolescent athletes in a high risk group for iron deficiency and iron deficiency anaemia. In the current research, the population studied shows an acceptable iron status although there are 3% of iron deficiency anaemia cases.

Key words: iron, spanish junior athletes, soccer players, basketball players, performance.

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Resumen

Objetivos: valorar la ingesta diaria y el estatus de hierro de los atletas junior españoles y su importancia sobre el rendimiento, así como lo que respecta a las consecuencias que tiene una deficiencia de hierro.

Material y métodos: cuarenta y seis jugadores de fútbol y once de baloncesto con edades comprendidas entre los 17 y 21 años (la media de edad 18.2 + 1.1) que jugaban en la liga junior nacional de fútbol y baloncesto, respectivamente, y que no tomaban drogas, medicinas ni presentaban ninguna enfermedad durante el desarrollo del estudio que pudiera alterar el apetito o algunos de los parámetros objeto de estudio, tomaron parte en este estudio. La ingesta dietética se cuantificó mediante la técnica de "registro de consumo de alimentos" durante 7 días consecutivos. El estatus de hierro se evaluó por un completo hemograma, hierro sérico, *ferritina, transferritina y TIBC.*

Resultados: La media de ingesta de hierro fue de 19.74±4.58 mg/día. Los datos analíticos significativos estaban todos entre los rangos de referencia. Los jugadores de baloncesto presentaron una ingesta significativamente superior que los de fútbol (22.1±6.4 y 19.2±3.9 mg/día). Sin embargo, los jugadores de baloncesto presentaron valores inferiores para los hematíes, hemoglobina, hematocrito y de los valores corpusculares medios al compararlos con los jugadores de fútbol.

Conclusiones: durante la adolescencia están aumentadas las necesidades de hierro, por lo que los adolescentes deportistas podrían ser un grupo de riesgo de padecer deficiencia de hierro y anemia del deportista. En la presente investigación, la población objeto de estudio presenta unos valores aceptables de status en hierro pero habiendo un 3% de casos con anemia por deficiencia de hierro.

Palabras clave: hierro, atletas junior españoles, jugadores de baloncesto, jugadores de fútbol, desarrollo.

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Introduction

Iron is the most studied mineral in athletes. Approximately, 25% of female and 10% of male athletes have iron deficiency (Constantini et al. 2000; Dubnov and Constantini, 2004), a higher prevalence than in the general population, where it is around 8% among females, although in both athletes and non-athletes there is a rising tendency in suffering from iron deficiency (Dubnov and Constantini, 2004). The prevalence of iron deficiency anaemia among athletes has been estimated to be similar to the sedentary population, that is, around 3% (Shaskey and Green, 2000).

The clinical signs of iron deficiency anaemia are well-known. A decrease in both physical and mental performance has been described. Very low or depleted iron stores reduce blood count and haemoglobin values and make it difficult to transport oxygen into the cells (Paige and Owen, 1988). Iron status has been related to cognitive performance in several studies. So, an inadequate iron status produces loss in strength and flexibitity, it´s easier to be tired and decreases the capability of attention being the visual perception lost, all necessary sport's components. This general problem gets worse in athletes because of the red cells hemolysis in high efforts, absorption decrease and the increase elimination of iron via sweat (Poleman and Peckenpaugh, 1991). Another iron depletion explanation in athletes, consisting in a plasma volume expansion because of the training has been proposed (Clarkson,1991; Biancotti et.al. 1992). Not always the hemolysis means an iron lost, due to that iron can be supplied (Biancotti et.al.1992). Pattini et al. (1990) found in skiers that endurance exercise increases the rate of iron metabolism.

The controversy about whether iron depletion doesn´t affect performance, but ferropenic anemia does still persists (Clarkson,1991; Resina et.al. 1991; Dubnov and Constantini, 2004), although there are several studies which indicate that even a low deficiency has negative effects on performance (Freidman et al, 2001; Brownlie et al. 2002).

Until now, less attention has been paid to team sport athletes than to individual ones. So we have assessed iron status in a group of soccer and basketball players, comparing them with other studies of athletes and sedentary population data.

Material and methods

Subjects

Fifty seven junior soccer and basketball players aged 17 – 21 years (mean = 18.2±1.1), who played in the youth teams of the Real Madrid, Club de Fútbol, in the Spanish national first and second leagues for their age and sport modality, were recruited for the study. After presentation of the study protocol, written informed consent was obtained from interested subjects. The players who took part in the study were 81% of all playing in the teams of these age groups. The study was approved by the Human Research Review Committee of the Universidad Complutense of Madrid, School of Pharmacy. None of the players was eating a supervised diet at the time of the record taking. Personal data of study subjects are shown in *Table 1*.

Before starting the study, the players had to answer some personal questions and some related with their socio-economic status and health. The exclusion criteria were drugs or medicines intake both suffering some illness which altered the appetite or some studies parameters. None of the volunteers had to be excluded from the study.

Dietary intake was assessed by means of a 7-day dietary record, during a whole week. Prior to obtaining food records, subjects were instructed on portion size control, and the importance of recording complete data. Afterwards, each record was evaluated by a dietician for completeness and accuracy with participants being asked to provide additional information about any unclear food item. Dietary record data were analyzed for energy and nutrient content using the Spanish Food Composition *Tables (2, 3)*, completed with those from Souci et al. The DRI were used to assess the adequacy of dietary intake (20).

After an overnight fast, blood samples were drawn between 8:00 and 10:00 h in the morning without stasis via venipuncture of the antecubital vein.

Red and white blood cell count, haemoglobin (Hb), haematocrit (Hct), mean corpuscular volume (MCV); mean corpuscular hemoglobin (HCM); mean corpuscular haemoglobin concentration (MCHC) were measured using a Coulter S plus analizer (Cox et.al. 1985; Mayer et.al.,1985).

Serum iron was measured by a colorimetric spectrolight meter assay (Peters et.al.,1965; Levy and Vitacce,1961; Goodwin et.al.1966;Webster,1960) (C.V.= 3.4%). The total iron binding capacity (TIBC) by the colorimetric assay of Nakamura et.al.(1965) (C.V.= 3.5%). Ferritin was measured using the inmuno enzyme assay "sandwich" type (Kalwasser and Werner, 1980) (C.V. = 5%). Transferrin was measured by an immunoturbidimetric assay (Haddow and Ritchie, 1980) on the array protein systems (Beckman) (C.V. =3.3%).

For statistical analysis we calculated mean values, standard deviation and correlation coefficients between dietetic, haematological and biochemical data with the statistics computer program SPSS 11.0. We have also calculated the significance of the differences between soccer and basketball players. We used Mann-Whitney test, when appropriate. Differences were considered statistically significant at a p level of 0.05.

Results

Mean iron intake was 19.74 $\pm$4.58 mg/day (Table 2) and is higher than the RDA of 15 mg/day set by the US Institute of Medicine (2000). It is higher than the average intake found in a sedentary male population (Jiménez, 1992; González-Fernández, 1989; Van Dokkum et al., 1991) of the European community and it is similar to other studies with athletes (Burke and Read, 1988; Resina et al. 1991). Basketball players have higher intake levels compared with soccer ones (22.1$\pm$6.4 and 19.2$\pm$3.9 mg/day, respectively; $p< 0.05$).

Comparing the haematological and biochemical parameters there are no differences between them and the normal stabilized ranks (table). Between sports, basketball players had lower levels of mean red blood cells (4.85±0.54 against 5.09±0.33), Haemoglobin (14.47±1.54 against 15.48±1.18), hematocrit (43.56±4.36 against 45.53._±24) comparing with soccer players, being the difference, p<0.05, p<0.01, p<0.05, respectively.

The mean corpuscular volumes are higher in football players too, with a significant difference in CHCM (34.04±1.21 against 33.22±1.31, p<0.01, for football and basketball respectively).

With a percentiles classification, there are several athletes with lower values of 25 percentile in hemoglobin, red cells and hematocrit. 13.3% of the athletes have less than 4.6 mill/mm^3 red cells, 7.8% less than 13 of hemoglobin (Galan et al,19885;Hallberg,1982)and 7.8% less than 40% of hematocrit level (Liebman et al,1983), all these data considered the limit normal values.

In reference with corpuscular, there is found 2.2% of deficiency to the VCM(<80)(Powers et al,1985), 6.7% to HCM (<27)(Bailey et al,1980) and 7.8% to CHCM (<32) (Formon,1976).

Regarding iron status, it is observed that serum iron, ferritin and transferritin medium values are normal (table). Taking 80 mg/ml, like the inferior limit of serum iron, there are 27.8% of the deficiency cases. Related with ferritin, 3.3% of the study people have low levels to 12ng/ml and 4.4% have low transferritin saturation level.

Discussion

The iron intake ranged from 12 to 18 mg/day which was exactly in line with the recommended level (12-18 mg/day), but lower than the level seen in 15- to 18- year-old soccer players by Hickson et al. (20 mg/d) and higher than in the French soccer layers studied by Leblanc et al. (2002). Mean iron intake was 19.74 ±4.58 mg/day (*Table 2*) and is higher than the RDA of 15 mg/day set by the US Institute of Medicine (2000). It is higher than the average intake found in several sedentary male population groups (Jiménez, 1992; González-Fernández,1989; Van Dokkum et al.,1991) of the European community and it is similar to other studies with athletes (Burke and Read, 1988; Resina et al. 1991). It´s important to emphasize that a correct iron intake assures good physiological processes, which are the base of attention, memory, intelligence and psychic behaviour (Lovenberg, 1986). But also there is needed for the neurotransmitters synthesis (Lovenberg, 1986; Wurtman et al. 1981) and to other formation and transform nervous system process, related with the nerve impulse transmission not only with the control of attention, memory, intellectual performance but also with the personal behaviour and social attitude (Barrett and Radke-Yarrow,1985; Buzina et al, 1989; Pollitt et al, 1986). Iron repletion has been shown to have a positive effect on physical performance as discussed, in addition to improving overall vitality and mental health and decrease of fatigue, all factors crucial to competitive players (Dubnov et al, 2004). Moreover, iron deficiency can be shown in a decrease of doing exercise, low capacity to capture oxygen, blood lactate increase and less tolerance to exercise (O´Neil et al.1986). The prevalence of iron depletion among athletes is still remarkably high, considering the fact that this is an easily modifiable obstacle to improving performance (Dubnov et al, 2004).

Comparing with sedentary adolescents (Jimenez,1992; Gonzalez-Fernandez,1989) of the Comunidad of Madrid, our haematological values are a bit low. Athletes tend to have less hemoglobin concentrations than sedentary people (Biancotti et al, 1992; Resina et al, 1991). The results of one recent study done in basketball players revealed that athletes' iron deficiency is much higher than in the general population, showing that eighteen percent of them had anaemia (Dubnov et al, 2004). This is the wrong called "athlete anaemia". The athlete anaemia is a false anaemia and a profitable adaptation for the aerobic exercise, a cause of a major plasma volume which dilutes red cells (Eichner, 1992). Dilutional pseudoanemia, caused by exercise-induced plasma volume expansion, might be the case in those players with Hb levels just below the lower range and with normal iron parameters (Dubnov et al, 2004). Athletes can develop a real anemia, because of an iron deficiency in most of the cases. This kind of anemia decreases physical performance (Clement and Sawchuk, 1984; Newhouse and Clement, 1988).

However the results of a soccer study carried out by Leblanc et al (2002) showed that total energy intake was insufficient for athletes but the iron intake was satisfactory in all the groups, increasing it according with the periods, being in 1996, 12 $\pm$ 2 mg/ d; in 1997, 16 $\pm$ 2 mg/d and in 1998, 17 $\pm$ 2 mg/d. the study showed that all players had iron intakes that were higher than or within the range of recommended levels. Iron intake rose significantly (at least $p<0.05$) during the 3-year period.

According to Nickerson et al (1990) iron deficiency in athletes is considered when the levels of ferritin are less or same to 12 ng/ml and transferritin saturation is less or same to 16% with a normal haemoglobin. Iron deficiency anaemia goes joint with hemoglobin values <13 g/dl in males (Nickerson et al, 1990). These data are important to be checked before starting the sport term, because deficiency can be developed in these athletes who are in the limit values (Nickerson et al, 1990; Resina et al, 1991; Biacotti et al,1992). Athletes have several risk factors for anaemia and iron depletion due to poor nutritional intake of iron, haemolysis caused by repeated foot strikes, blood and iron loss through menstruation, gastrointestinal and urinary tracts and iron through sweating (Dubnov et al, 2004). To be more concret, intermittent sports based in aerobic-anaerobic exercise, like football or field hockey, are seemed to have more iron lost (Resina et al, 1991). Exercise, above all jogging, causes a significant iron expense. Running has an essential role in football training (Ekblom, 1986). Hence, a mechanism of anaemia usually related to running can also be expected in ball players (Dubnov et al, 2004).

Serum ferritin decreases because of protein-energy malnutrition, liver diseases, nefrotic syndrome, neoplasia, while his hepatical synthesis increases thanks to iron deficiency. On the other hand, serum ferritin concentration is reduced in case of an iron deficiency (Linder, 1988). Unless after three days of intense exercise, athletes can have a false ferritin increased levels (Resina et al, 1991).

The low levels of ferritin found was 43.4 ± and of transferrin 275 ± 37. the lowest values found in boys of 17 years old of haemoglobin, MCV and ferritin encountered were 10.7 g/dl, 69.1 Fl and 2.7 ng/l, respectively and no subject had macrocytosis (Dubnov et al, 2004).

50.4% of the players complained for fatigue. The ferritin blood levels must be measured in anemia risk athletes to assess their iron status. Athletes should change their food habits to assure the appropiate iron intake (Faber and Spinnler Benadé, 1991).

Studying the values and comparing them with what was said before, we can observe that in 2.2% of the cases deficiency by haematological data agree with deficient iron status data, which can be interpreted as an iron deficiency anemia. These athletes had talked about their tiredness, confirmed by their coach and shown in their worse performance. These anemic athletes were subdued to an iron treatment, after it the blood analysis was repeated showing a clear improve, confirmed by the subjective impression of the athletes. So, the periodic iron status control with a blood analysis is easy to get and really important, because if it isn´t detected on time, the athlete is subdued to a big effort, due to the coach demands him the same performance but the athlete is not capable of doing it. Iron intake of athletes with low or deficient levels is similar to the athletes intake with an adecuated iron status (18.9± 2.7 and 19.8± 5.1 mg/day respectively, NS), deducing that the first have lower absorbtion and more iron lost (by sweat, urine and feces) than the seconds. The total iron lost during an intense training programme has been estimated in 1.75 mg/day (Haymes and Lamanca, 1989). Thus, the decrease of iron stores is due to a negative iron balance during a long period of time.

TIBC is an interesting biochemical parameter that lets us see the difference between an anaemia and an infection, because an iron deficiency increases the TIBC, and an inflammation process decreases it. An infectious cause for iron deficiency in athletes has recently been identified as Helicobacter Pylori. Eradication of the bacteria without iron supplements resulted in improvement of iron store status (Dubnov et al, 2004). The average in our population is 443.7 ±55.07 mg/dl near to the superior limit of the normal ranges of 240-450 mg/dl. This means that there are 40% of the players with values higher than the cut-off.

Conclusions

The population who has been studied shows an aceptable iron status, being similar to other published data, although there are 3% of deficiency cases. Team players usually have a better situation than those who practise individual sports, although most of the times they are in the limit values, as it is the case in the population studied. At least at the begining of the season it is necessary to do a routine blood analysis, in order to be sure that we are not demanding heavy efforts from those players who have clinical or subclinical iron deficiency. Unfortunately, this is not a common practice in the inferior categories of adolescents team sports. During adolescence, iron requirements are very high. This fact places adolescent athletes in a high risk group for iron deficiency and iron deficiency anaemia.

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Table 1. Personal data of study subjects

	Total (n = 57)		Soccer (n = 46)		Basketball (n = 11)	
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Age (years)	18.2±1.1	17 - 21	18.7±1.1	17 - 21	18.3±1.2	17 - 21
Weight (kg)	76.8±9.1	60.8 - 102	74.2±6.6[a]*	60.8 - 94	87.9±10.2	70 - 102
Height (cm)	183.2±9.3	166 - 209	180.1±6[a]*	166 191.5	196.7±9.2	180 - 209
BMI (kg/m^2)	22.82±1.35	19.5 -25.72	22.86±1.31	19.5 -25.72	22.68±1.63	20.1724.87
Body fat (%)[1]	10.03±0.85	9.12 -10.33	10.12±0.77	9.92 -10.33	9.71±1.05	9.12 -10.29
Waist to hip ratio	0.83±0.03	0.75 - 0.92	0.83±0.03	0.75 - 0.92	0.84±0.04	0.81 - 0.87

a difference statistically significant, * $p < 0.001$
[1] estimated from fatfolds using the formula proposed by Faulkner: (biceps + subscapular + suprailiac + abdomen) x 0.153 + 5.783)

Table 2. Energy, protein and iron intake data (mg/day) found in the studied population

Subjects Parameter	All (n =56)	Basketball players (a*) (n= 11)	Soccer players (n =46)	Defenders	Forwards	Midfield players	Goalkeepers
Energy (kcal/day)	3499±778.2 (2275-5866)	3638.1±825.13 (2447.4-4859.3)	3465.4±772.26 (2275-5866)	2881.5±351.9 (2275-3401.6)	3840±873 (2408.5-5161)	3539.84±803.7 (2391.3-5866)	3245.7±377.3 (2777.3-3912.6)
Protein (g/day)	151.46±34.19 (97.58-252.2)	162.48±41.35 (111.1-236.6)	148.8±32.2 (97.6-252.18)	122.7±13.14 (107-146.9)	158.4±35.76 (97.6-229.28)	154.5±35.7 (108.1-252.18)	146.4±14.06 (127.17-162.1)
Iron (mg/day)	19.74±4.58 (13.4-38.3)	22.13±6.41 (14.5-38.3)	19.16±3.9 (13.4-30.8)	16.25±2.2 (13.5-20.23)	20.7±4.56 (13.4-28.4)	19.5±4 (14.33-30.77)	18.74±2.3 (16.35-22.9)

* $p < 0,05$

Table 3. Haematological and iron status data of the studied population (mean ±SD; minimum-maximum)

Subjects Parameter	All (n =57)	Basketball players (n = 11)	Soccer players (n = 46)	Defenders	Forwards	Midfield players	Goalkeepers
RBC (mill/mm3)	5.01±0.4 (3.38 - 5.93)	4.85±0.54 (3.38 – 5.75)	5.09±0.33 (4.28 -5.93)	5.14±0.37 (4.57 – 5.93)	5.12±0.33 (4.55 – 5.76)	4.97±0.34 (4.28-5.6)	5.21±0.22 (4.95-5.6)
Haemoglobin (g/dl)	15.1±1.4 (9.6 - 17.8)	14.47±1.54 (9.6 – 16.9)	15.48±1.18 (10.3 – 17.8)	15.66±0.83 (14.5 – 16.7)	15.3±1.58 (10.3 – 17.8)	15.5±1 (12.8-17.5)	15.64±0.85 (14.4-17.1)
Haematocrit (%)	44.8±3.8 (29.7 - 53.0)	43.56±4.36 (29.7 – 50.7)	45.5±3.24 (34.1 -53)	46.48±2.62 (42.2 – 50.7)	45.24±4.10 (34.1 – 53.0)	45±2.98 (36.6-51.2)	46.16±2.02 (43.4-49.6)
MCV (fl)	89.6±4.3 (73.1 - 98.8)	89.97± 2414.6 (81.2 – 98.8)	89.47±4.23 (73.1 – 97.7)	90.49±4.49 (84.3 – 97.5)	88.28±5.24 (73.1 – 97.7)	90.5±3 (85.5-95.7)	88.52±3.31 (84.8-94.4)
MCH (pg)	30.2±1.99 (22.1 - 34.1)	29.9±2.18 (24.1 – 33.9)	30.45±1.87 (22.1 – 34.1)	30.44±1.11 (28.1 – 31.7)	29.89±2.36 (22.1 – 32.6)	31.21±1.45 (27.9-34.1)	29.97±1.77 (26.7-32.6)
MCHC (g/dl)	33.7±1.3 (29.7 - 37.1)	33.22±1.31 (29.7 – 36.9)	34.04±1.21 (30.3 – 37.1)	33.68±1.14 (31.1 – 35.3)	33.83±1.26 (30.3 – 35.5)	34.5±1.11 (32.4-37.1)	33.86±1.31 (30.7-34.8)
Iron (mg/ml)	96.5±34.1 (15 - 191)	96.28±36.9 (20 – 174)	96.68±32.82 (15 – 191)	90.9±29.81 (54 – 157)	89.1±34.76 (15 – 154)	104.9±36.84 (54-191)	103.37±16.12 (82-126)
Ferritin (ng/ml)	77.2±46.6 (4 - 240)	80.28±58.64 (14 – 240)	75.5±38.96 (4 – 220)	82.3±43.93 (19 – 138)	65.15±32.81 (4 – 121)	80.35±44.85 (12-220)	80.75±32.01 (21-124)
Transferrin (mg/dl)	311.9±44.06 (211.0412.0)	315.8±35.75 (254 – 412)	309.8±48.27 (211 – 412)	321.8±40.5 (262 – 400)	309.6±50.99 (211 – 412)	309.64±46.87 (263-404)	296.12±58.33 (225-401)
TIBC (mg/dl)	443.7±55.07 (317.5-568.75)	448.5±44.69 (371.25–568.75)	441.03±60.33 (317.5–568.75)	456±50.62 (381.2–553.75)	440.7±63.74 (317.5–568.75)	440.79±58.6 (382.5-558.75)	423.91±72.91 (335-555)