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High prevalence of vitamin D insufficiency among elite Spanish athletes; the importance of outdoor training adaptation

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Abstract

***Introduction:* The discovery of vitamin D muscle receptors in the last few years suggested a significant role in muscle tissue, pointing out athletes as a special group. Specific data are scarce.**

***Aim:* The main aim of the current paper was to provide, for the first time, comparable data about vitamin D status in elite Spanish athletes by sport, age, season and training environment.**

***Methods:* Four hundred and eight elite athletes with a mean age of 22.8 ± 8.4 years were recruited from the High-performance sport centre in Barcelona for this cross-sectional study. Athletes from 34 different sports modalities were analysed. Data were available for vitamin D status, training environment, seasonality and number of medical visits. All data were analysed using SPSS version 18.0.**

***Results:* Mean 25(OH)D of all athletes was 56.7 ± 23.4 nmol/L. Approximately 82% of the athletes were below the optimal levels, (< 75nmol/l), 45% had moderate deficient levels (< 50 nmol/L) and 6% had severe deficiency (< 27.5 nmol/L). We have observed a steady increase in 25(OH)D concentrations with increasing age (p < 0.01) Highest levels were observed in those subjects training outdoors compared with those training indoor (p<0.01). Differences between sport modalities were observed. Even during summer, 87% of the athletes had insufficient 25(OH)D concentrations.**

***Conclusion:* There is a high prevalence of vitamin D insufficiency among elite Spanish athletes. Outdoor training could ensure vitamin D sufficiency and differences between sports modalities should be taken into account for future research. The results contribute to identify the need of optimizing vitamin D status across athletes.**

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Key words: *25(OH)D concentrations. Elite ahtletes. Sun exposure. Sports modalities. Training.*

ALTA PREVALENCIA DE INSUFICIENCIA DE VITAMINA D ENTRE DEPORTISTAS DE ÉLITE ESPAÑOLES; LA IMPORTANCIA DE LA ADAPTACIÓN DEL ENTRENAMIENTO AL AIRE LIBRE

Resumen

***Introducción:* En los últimos años, el descubrimiento de receptores musculares para la vitamina D sugiere un papel significativo de esta vitamina en el tejido muscular, adquiriendo una relevancia especial en deportistas. No existen apenas datos disponibles acerca de las concentraciones de vitamina D en deportistas de élite Españoles.**

***Objetivo:* El objetivo del presente trabajo ha sido analizar y proporcionar datos comparables sobre el estado de vitamina D de atletas de élite españoles y la influencia de factores como la edad, la estación del año o el lugar de entrenamiento.**

***Métodos:* Cuatrocientos ocho atletas de élite pertenecientes al centro de alto rendimiento de San Cugat del Vallés, en Barcelona, fueron seleccionados con toma de datos transversal. La edad media fue de 22,8 ± 8,4 años con un total de 34 modalidades deportivas diferentes. Entre las variables analizadas se obtuvieron las concentraciones plasmáticas de vitamina D, el número de visitas médicas anuales, la toma de suplementos, la estación del año y el lugar de entrenamiento. La estadística se realizó con el programa SPSS versión 19.0.**

***Resultados:* La concentración media de 25(OH)D de la muestra total fue de 56.7 ± 23.4 nmol/L. Aproximadamente el 82% de los atletas obtuvieron concentraciones sanguíneas por debajo de los niveles óptimos (< 75nmol/L). Dentro de estos, el 45% presentó deficiencia moderada (< 50 nmol/L) mientras que un 6% deficiencia severa (< 27,5 nmol/L). Se observó un aumento lineal de las concentraciones de 25(OH)D con la edad (p < 0,01) y concentraciones más altas en las modalidades deportivas con entrenamiento al aire libre (tenis, natación piscina descubierta…) en comparación con los que entrenan bajo techo (natación piscina cubierta, balonmano..) (p < 0,01). Incluso durante los meses de verano, el 87% de los atletas obtuvieron concentraciones insuficientes de vitamina D en su mayoría los que entrenan en interior. Señalaron no tomar suplementos vitamínicos.**

***Conclusiones:* Existe una alta prevalencia de insuficiencia de vitamina D entre los deportistas de élite españoles. El entrenamiento al aire libre podría garantizar la suficiencia de vitamina D y las diferencias encontradas entre las distintas modalidades deportivas se deben tener en cuenta para futuras investigaciones. Los resultados contribuyen a identificar la necesidad de optimizar los niveles de vitamina D en deportistas de élite.**

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Palabras clave: *Concentraciones de 25(OH)D. Deportistas de élite. Exposición solar. Modalidades deportivas. Entrenamiento.*

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Introduction

Vitamin D is essential for a vast number of physiologic processes, such as an active role in immune function, protein synthesis, inflammatory response or cellular growth, and thus adequate concentrations are necessary for advantageous optimal health[1,2]. With over 80% of the general worldwide population considered vitamin D insufficient (< 75 nmol/L)[3-5], it is likely that many athletes fall into the same category. Although no evidence exists that athletes have a higher daily requirement than the general population[6], the discovery of vitamin D muscle receptors in the last few years suggested a significant role for vitamin D in muscle tissue. In fact, it has been identified as a regulator of skeletal muscle[1,7,8], pointing out athletes as a possible risk group. Vitamin D has been proposed to be, together with testosterone, the other steroid hormone that is important for muscle function and strength, and could play an important role on enhancing athletic performance[7,9-12]. A recent European study suggested that cardiorespiratory fitness and muscular strength is positively associated with 25(OH)D concentrations in male and female adolescents, respectively[13]. In addition, the first symptom of vitamin D deficiency is muscle weakness, hypotonia, prolonged time to peak muscle contraction, as well as prolonged time to muscle relaxation[14], which can severely affect the athlete population.

Vitamin D storage and concentrations in this population group could be compromised, and its deficiency may have an impact on decreased physical performance and health with higher predisposition to stress fractures[15].

In the last decade, researchers have examined 25(OH)D levels among various groups of athletes, ranging from gymnasts and runners to jockeys. And although some findings have suggested that vitamin D levels in athletes are comparable to those of the general population, results have found that vitamin D status is variable and is mainly dependent on type of sport, outdoor-indoor training time (during peak sunlight and season), skin color, and geographic location[15], which makes it necessary to study athletes independently by regions.

Even if Spain is a Mediterranean country, located at the south of Europe at 40º N, and caucasian skin color, some previous studies have already reported low vitamin D status among Spanish adolescents and elderly population[16,17], but little is known about vitamin D status among elite Spanish athletes.

Objectives

Therefore, the main aim of the current paper was to provide, for the first time, comparable data about vitamin D status in elite Spanish athletes of 35 different sport modalities. One of the main objectives was to describe vitamin D status in elite Spanish athletes and to analyze vitamin serum concentrations by sex, sport, season and training outdoor or indoor.

The results could contribute to identify the need of optimizing vitamin D status across athletes.

Methods

Four hundred and eight elite athletes with a mean age of 22.8 ± 8.4 years were recruited from the High-performance centre in Sant Cugat del Vallés, Barcelona, using elite athletes as primary sampling units and sports as secondary sampling units for this Cross-sectional study (CSS). Criteria for athletes' selection included active sport competition activity and no health problem declared. In total, 408 athletes from 34 different sports modalities were analysed. Data were available for aerobics, athletics, car racing, handball, basketball, boxing, combat, cycling, alpine ski, football, gymnastics, golf, weightlifting, pentathlon, skeleton, taekwondo, triathlon, volleyball, yachting, kayak, field hockey, shot, motorcycling, swimming, synchronized swimming, tennis, table tennis, rolling skate, waterpolo, fencing, diving board jump and also the referees of the National Basketball league (ACB). The data were obtained within the rutine medical assessment the elite athletes must pass periodically at the High Performance Center. They all sign an informed consent in order the data obtained can be used for research anonymously.

Subjects were classified according to outdoor or indoor training as shown in table II in the results part.

Specimen collection and biochemical analyses

Fasting blood samples were collected by venipuncture between eight and nine o'clock in the morning. For the measurement of vitamin D, blood was collected in EDTA tubes, immediately placed on ice, and centrifuged within 30 min (3,500 rpm for 15 min). The supernatant fluid was transported at a stable temperature of 4-7°C to the central laboratory in Barcelona, and stored there at -80°C until assayed.

Vitamin D status

Plasma 25(OH)D was analysed by Immunoassay quimioluminiscent in a Roche Elecsys Analizer 170[18] in Barcelona. The sensitivity of this method is 4.01 ng/mL 25(OH)D. The CV for the method was 8.5%.

Seasonality

The variable "blood extraction date" was used to compute seasonality defined as following and similar to previous studies[13,19,20]: Winter (1; January through March), Spring (2; April through June), summer (3; July through September) and Autumn (4; October through December).

Statistical analysis

Descriptive statistics were performed and values are shown as mean and standard deviation. Frequency statistics for categorical variables are shown as valid percentage. For this study, vitamin D status was classified into four groups (vitamin D sufficiency/optimal levels >75 nmol/l; insufficiency 50-75 nmol/l; deficiency 27.5-49.99 nmol/l and severe deficiency <27·5 nmol/l) following international guidelines[21]. The differences between sex, vitamin D status groups, sports, training environment groups and seasonality were analysed using one-way ANOVA. All data were analysed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Table I shows descriptive characteristics of the study sample stratified by 25(OH)D concentration. Prevalence rates of vitamin D status according to the aforementioned sufficient–insufficient classification are shown. Mean 25(OH)D of all athletes at baseline was 56.7 ± 23.5 nmol/L. Considering the cut-off set for adults at 75nmol/l, approximately 82% of the athletes were below the optimal levels, for both males and females. Approximately, 45% had moderate deficient levels (< 50 nmol/L) and 6% had severe deficiency (< 27.5 nmol/L). As no significant differences have been observed between sexes, the sample has been analyzed as a whole. None of the subjects reported any vitamin D supplement intake. The number of annual medical visits did not show any significant influence on vitamin D groups.

Analyzing vitamin D status by age, we have observed a steady increase in 25(OH)D concentrations with increasing age, with significant differences between the younger group (Q1) and the third quartile group (Q3) (48.5 ± 18.7 nmol/L and 61.8 ± 27.0 nmol/L), respectively; ($p < 0.01$) (fig. 1).

Differences in 25(OH)D concentrations were observed by training environment. Our results show that the highest levels were observed in those subjects training outdoor compared with those training indoor for the whole sample ($p < 0.01$). Those differences have been also observed within the vitamin D groups. Although not significant, within the vitamin D sufficient group, those subjects training outside got higher 25(OH)D concentrations compared with those training inside. Same results were obtained for the insufficient group with higher vitamin D levels for those training outdoor (table I).

Table II shows vitamin D concentrations splitted by sport modality according to training environment (indoor-outdoor). Differences between sports were observed. Highest mean 25(OH)D concentrations were obtained in synchronized swimmers, tennis players, swimmers, rolling skaters, field hockey players, athletics and waterpolo players, most of them with outdoor training. While lower 25(OH)D concentrations were obtained in handball players, boxers, fencers, alpine skiers, gymnast, table tennis players and diving board jump, all training indoor.

Figure 2 presents differences in 25(OH)D concentrations by season according to blood extraction date and environment. Surprisingly, the mean highest levels of the global sample were observed in winter. Further analysis indicates that most of the athletes measured in wintertime were outdoors trainers. Even during summer, 87% of the

Table I
Descriptive characteristics of Spanish elite athletes splitted by vitamin D sufficiency or insufficiency (nnom/l)

	(75 nmol/l) Total = 408 Mean ± SD	*Vitamin D Insufficiency (≥ 75 nmol/l n = 334 Mean ± SD*	*Vitamin D Sufficiency n = 73 Mean ± SD*
25(OH)D concentrations (nmol/L)	56.7 ± 23.5	48.5 ± 13.6	93.7 ± 22.9
Males n = 238	56.7 ± 22.7		
Females n = 170	56.7 ± 24.5		
Severe deficiency/deficiency/ insufficiency/sufficiency	5.6/38.7/37.7/17.9	72.1%	17.9%
Age (years)	22.8 ± 8.4	23.1 ± 8.9	21.8 ± 6.0
Blood extraction season			
% (winter/spring/summer/autumn)	8.4/19.8/42.8/29.0	6.9/19.5/45.5/28.1	15.1/21.9/30.1/32.9
Training session environment			
% (indoor/outdoor)	39.9/60.1	44.4/55.6	20.8/79.2
Training session indoor	49.3 ± 18.6	45.1 ± 13.4	87.5 ± 15.1
Training session outdoor	62.4 ± 25.9	51.2 ± 13.9	95.8 ± 24.7
Number of medical visits per year	4.1 ± 5.2	4.1 ± 5.7	3.9 ± 2.6

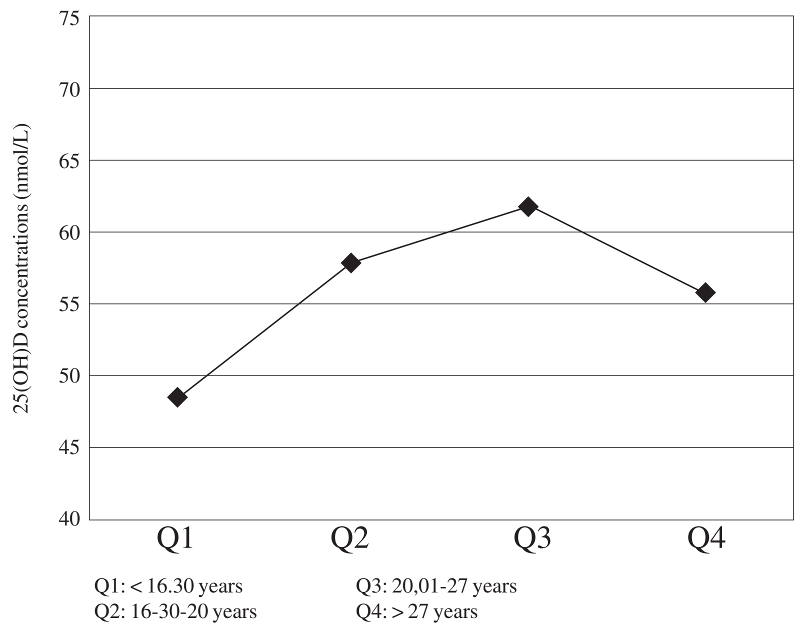

Fig. 1.—Differences in 25(OH)D concentrations (nnom/L) by age quartiles.

athletes were vitamin D insufficient. Lower values of 25(OH)D concentrations were observed for those training indoor compared with those training outdoor during all seasons (all $p < 0.05$ except winter time).

Discussion

Although extensive data exist in documenting vitamin D concentrations of the general population[22,23], limited comparable information is available, specifically for the athletic population. Those existing studies have mainly focused on one sport modality with a reduce number of subjects[24]. Vitamin D status is variable and dependent on several determinants like type of sport, outdoor-indoor training time (during peak sunlight and season), skin color, and geographic location[15]. It makes necessary to study results by regions and sports modalities.

To the best of our knowledge, the data obtained in this study are the first aiming at establishing descriptive 25(OH)D status in occidental elite athletes of different sport disciplines, taking also into account seasonal and training variations.

Results of our study indicated that approximately 82% of the athletes were below the optimal levels (< 75 nmol/L). Approximately 45% were below < 50 nmol/l which is the optimal level for maintaining bone health in adults according to the report of the Institute of Medicine launched in 2011[23]. A general hypovitaminosis problem ranging from 13 to 72% has already been postulated in studies performed in young people in several European countries[3,25-27], USA and Canada[28,29]. Studies in athletes are also in line with our deficiency prevalence[30-33]. Morton et al (2012) concluded that vitamin D concentrations for 65% of their athletes were insufficient (< 50 nmol·L(-1)) in winter[31]. Similar results were obtained by Constantini et al (2010), that reported vitamin D insufficiency in 73% of the measured athletes.

Complications from vitamin D insufficiency are often late-onset rather than immediate, given that the majority of subjects with vitamin D insufficiency are completely asymptomatic, and this fact complicates diagnosis[12]. But in athletes, the impact on decreasing physical performance due to muscle weakness could be more evident. An adequate vitamin D level together with the stimulus of weight-bearing exercise should be required in athletes, especially during adolescence for bone formation and cell growth[16,34]. Despite of optimal 25(OH)D levels are no exception to the controversy, superior benefits are observed at even greater levels, due to only at 25(OH)D levels >100 nmol/L, does vitamin D begin to be stored in the muscle and fat for future use[35]. As fat is required for vitamin D storage, the low subcutaneous fat levels that some athletes have could also compromise their vitamin D status. Although research has found that athletes generally do not meet the dietary reference intake for vitamin D, inadequate endogenous synthesis is the most probable reason for insufficient status[15]. Some sports could be at higher risk. Our results showed that rhythmic gymnasts, long distance runners, skeleton or cyclers got the lowest vitamin D concentrations (lower than 52 nmol/L).

As expected, differences in vitamin D concentrations were found in athletes participating in indoor activities compared with those involved in outdoor

Table II
25(OH)D concentrations (nmol/L) according to sport modality and indoor/outdoor training

	Total			*Indoor*			*Outdoor*		
Sport modality	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
ACB REFEREES	32	51.1	12.4	32	51.1	12.4	–	–	–
AEROBIC	2	44.7	12.2	2	44.7	12.2	–	–	–
ALPINE SKI	3	33.0	8.0	3	33.0	8.0	–	–	–
ARTISTIC GYMNASTICS	17	44.2	15.6	17	44.2	15.6	–	–	–
ATHLETICS	48	60.1	27.7	1	41.4	–	47	60.5	27.8
BASKETBALL	2	74.0	0.5	2	74.0	0.5	–	–	–
BOXING	8	45.5	15.3	8	45.5	15.3	–	–	–
CAR RACING	2	40.2	7.0	–	–	–	2	40.2	7.0
CYCLING	20	52.2	18.3	–	–	–	20	52.2	18.3
DIVING BOARD JUMP	13	41.3	12.5	13	41.3	12.5	–	–	–
FENCING	6	43.9	8.2	6	43.9	8.2	–	–	–
FIELD HOCKEY	12	61.3	11.7	–	–	–	12	61.3	11.7
FIGHTING	16	50.0	14.7	16	50.0	14.7	–	–	–
FOOTBALL	5	61.1	27.5	–	–	–	5	61.1	27.5
GOLF	9	61.7	15.5	–	–	–	9	61.7	15.5
HANDBALL	12	42.0	15.8	12	42.0	15.8	–	–	–
KAYAK	8	40.1	6.3	–	–	–	8	40.1	6.3
MOTORCYCLING	6	60.6	31.0	–	–	–	6	60.6	31.0
PENTATHLON	6	60.4	16.9	–	–	–	6	60.4	16.9
RHYTHMIC GYMNASTICS	7	45.3	8.3	7	45.3	8.3	–	–	–
ROLLER HOCKEY	1	55.2	.	1	55.2	.	–	–	–
ROLLING SKATE	4	62.9	17.9	–	–	–	4	62.9	17.9
SHOOTING	2	61.3	13.2	2	61.3	13.2			
SKELETON	1	34.7	.	–	–	–	1	34.7	–
SWIMMING	58	69.2	21.9	2	64.5	13.4	56	69.4	22.2
SYNCHRONIZED SWIMMING	11	88.5	35.2	–	–	–	11	88.5	35.2
TABLE TENNIS	11	33.6	11.4	11	33.6	11.4	–	–	–
TAEKWONDO	21	55.3	21.9	21	55.3	21.9	–	–	–
TENNIS	5	98.4	61.2	–	–	–	5	98.4	61.2
TRIATHLON	3	50.4	8.2	–	–	–	3	50.4	8.2
VOLLEYBALL	14	57.4	19.3	13	56.1	19.3	1	75.0	–
WATERPOLO	37	60.7	23.0	11	73.9	23.4	26	55.1	20.9
WEIGHTLIFTING	2	53.1	1.4	2	53.1	1.4	–	–	–
YACHTING	4	49.2	27.1	–	–	–	4	49.2	27.1
TOTAL	408	56.7	23.5	150	49.3	18.6	226	62.4	25.9

activities. Our results indicated that the highest mean of 25(OH)D concentrations were obtained for those training outdoors. Interestingly, synchronized swimmers who trained outdoor during the whole day, obtained higher 25(OH)D concentrations than swimmers training outdoor but early in the morning or late in the evening. Data are in line with other studies[36,37]. Lovell et al. reported that the majority (83%) of female Australian indoor athletes were at vitamin D insufficiency[38]. In the study of Constantini et al (2010), a higher prevalence of vitamin D insufficiency was observed among dancers (94%), basketball players (94%), and Taekwondo fighters (67%), but they also obtained higher vitamin D deficiency prevalence among indoor training athletes comparing with those training outdoor (80% vs 48%; $P < 0.01$)[32].

Seasonal differences were also found regarding 25(OH)D concentrations, confirming the results of other studies across Europe[27,39-41]. Casual exposure to sunlight is thought to provide most of the vitamin D requirements of the human population[39]. Many outdoor athletes avoid peak sunlight hours during summer time, opting to practice early in the morning or late at night, which greatly reduces UVB exposure[42], putting them at considerable risk of vitamin D insufficiency even in the sunny months. Galán et al (2012) proposed 25(OH)D concentrations of > 122.7 nmol/L in autumn in order to have adequate levels in spring. In our study, none of the analysed athletes achieved these concentrations, independently of the season. Our results reveal lower vitamin D values during summer time than in wintertime. But most of the athletes measured in winter time were outdoors trainers and probably do not avoid this peak sunlight for training as in summer time. These higher concentrations could be also due to a low number of subjects measured at wintertime and to seasonal influences in winter blood extraction that was performed from January to March.

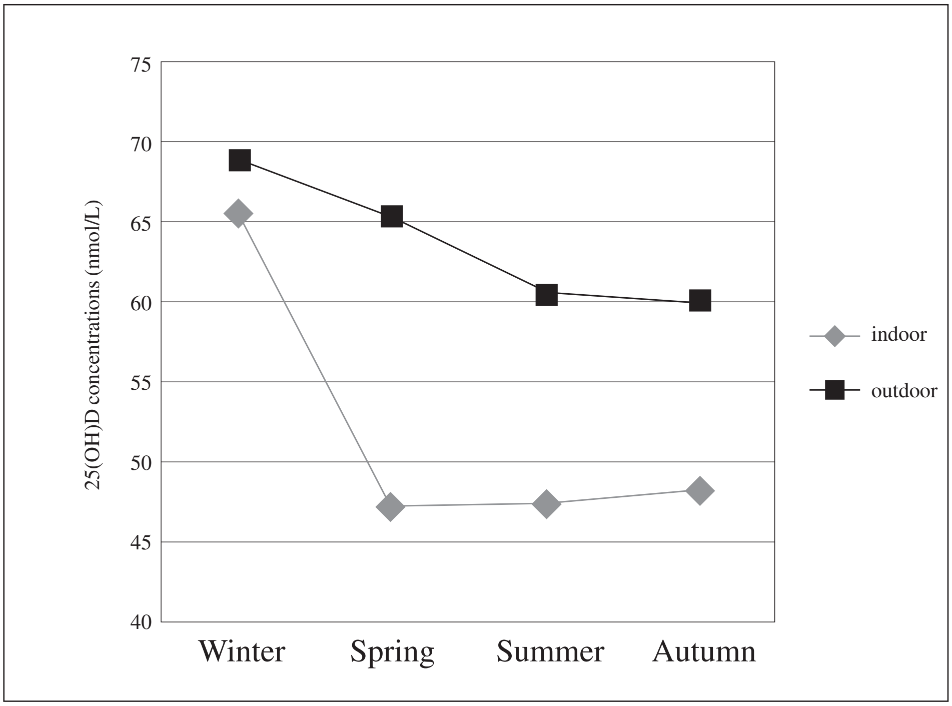

Fig. 2.—Differences in 25(OH)D concentrations (nnom/L) by season and training enrivonment.

Although we have to keep in mind that the results of vitamin D concentrations are variable according to different parameters, geographical location (latitude) or gender do, it does not appear to be the case in our results nor to be the major risk factors for vitamin D insufficiency in athletes. As stated above, lack of sun exposure appears to be the main risk factor, putting, indoor athletes and those who avoid peak daylight hours, regardless of latitudinal location, at the greatest risk for vitamin D insufficiency[37,42].

Ultraviolet light irradiation has been proposed for improving athletic performance and decreasing chronic sports related pain[35]. German Olympic officials considered these effects significant enough for UVB radiation to be considered an ergogenic aid[35], not forbidden and not blamed as doping.

Synthesis of vitamin D from the sun is also dictated by age[42]. And when analyzing vitamin D status by age, a steady increase in 25(OH)D concentrations with increasing age is observed, but those at younger ages have also higher rates of indoor training (data not shown). Our data agree with other published data[3]. It is important to emphasize these lower vitamin D concentrations found in younger athletes. Optimal vitamin D levels are essential at early ages for an adequate growth and development. Normally, active children and adolescents practice their sports activities after school, when sunset is coming or in an indoor environment, with negative consequences for their vitamin D status.

Although dietary intake of our subjects has not been included in this study, there is consistency in the literature regarding inadequate vitamin D intake among athletes. Moreover, due to low levels of vitamin D found and that none of the athletes reported vitamin D supplementation, supplementation could be considered, especially in those training indoor and at older ages. This is in accordance with emerging evidence emphasizing the need of vitamin D supplementation in high-risk groups especially during lack of sun exposure months[43]. Unfortunately, there are limited experimental studies available and even fewer that demonstrate a performance enhancement from vitamin D supplementation. In favour, Magee et al (2013) reported that all doses of supplementation significantly increased 25(OH)D concentrations in Irish athletes, and corrected any insufficiencies/deficiencies in their subset of athletes[44]. It has been also suggested that vitamin D supplementation in individuals with low vitamin D status may improve muscle strength and have beneficial effects on muscular performance and injury occurrence in athletes[45-47]. This is believed to be due to an increase in the size and amount of type II (fast twitch) muscle fibers associated with vitamin D supplementation[33]. It should be noted that type II fibers are predominant in power and anaerobic activities, and are recruited first to prevent falls, associated with muscle strength[48,49]. Close et al. suggested that skeletal muscle may require higher serum concentrations for a response, compared to other tissues[33].

Investigators have recently become interested in examining this possible link between vitamin D and the prevention of stress fractures in athletic individuals. Our data about the annual medical visits indicated that there were no differences according to vitamin D concentrations. We have not found well-controlled studies examining an association between medical visits regarding to stress fractures and serum 25(OH)D levels in a strictly athletic population, but some data in the military environment have been found. Following these studies and in agreement with our findings, Valimäki et al.[50] observed no difference in 25(OH)D levels among male recruits who developed a stress fracture during training compared with those who did not.

There is, however, an ongoing debate on the influence of vitamin D supplementation or fortified foods in young-healthy people[43]. But most experts agree that the combination between high intake of vitamin D, through dietary sources and ultraviolet B (UVB) exposure is necessary to obtain optimal serum vitamin D levels[51].

There are some limitations in our study. Unfortunately, due to the difficulties on assessing elite athletes and test them, few variables are available regarding vitamin D, and we cannot be certain that other unmeasured confounders have not influenced our observations.

Despite the aforementioned limitation, the study use of a large number of elite athletes from 32 different sports modalities, which provide a deeper understanding of the vitamin D status in athletes, which is an additional strength of our work. The majority of the studies only assess one sport modality and with small sample.

Conclusion

Considering the cut-off set adults at 75nmol/l, approximately 82% of the athletes were below the optimal levels, for both males and females. This study highlights a high prevalence of vitamin D insufficiency among elite Spanish athletes and demonstrats that outdoor training is an appropriate way to increase vitamin D concentrations in athletes, mostly during winter and early spring.

The current data supports previous findings that athletes living even at Mediterranean countries exhibit inadequate vitamin D concentrations, but differences among sports modalities have been observed, and should be taken into account for future research. Those athletes practicing sports modalities which favour lower body fat storages that could have an impact on vitamin D concentrations should be deeper analyzed.

Given the recent findings, it is recommended that sports dietitians and physicians routinely assess vitamin D status and make clear recommendations in order to help athletes achieve an optimal serum 25(OH)D concentration.

The results of the study could contribute to identify the need of optimizing vitamin D status across athletes. But further research is needed to determine the effect of vitamin D status on training, injury, and performance in elite athletes and their future health.

Competing interest

None of the authors had any conflict of interests.

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Contributorship statement

FD, LT,DD planned the study, recruited athletes and data collection; JV, MGG performed the statistical analysis; JV and MGG participated in the data interpretation. JV, MGG, FD participated in the literature search. JV wrote the paper. All authors read and approved the final manuscript.

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