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VITAMIN D SUPPLEMENTATION: EFFECT ON THE 25(OH)D PROFILE AND OCCURRENCE OF MUSCLE INJURIES IN PROFESSIONAL SOCCER ATHLETES

SUPLEMENTAÇÃO DE VITAMINA D: EFEITO SOBRE O PERFIL DE 25(OH)D E OCORRÊNCIA DE LESÕES MUSCULARES EM ATLETAS DE FUTEBOL PROFISSIONAL

SUPLEMENTACIÓN DE VITAMINA D: EFECTO SOBRE EL PERFIL DE 25(OH)D Y LA OCURRENCIA DE LESIONES MUSCULARES EN ATLETAS DE FÚTBOL PROFESIONAL

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ABSTRACT

Context: Vitamin D insufficiency has been described among professional soccer athletes. Objective: To evaluate 25(OH)D profile and occurrence of muscle injuries (MI) in Series A athletes with (2015 season - S1) and without Vitamin D supplementation (2016 season - S2). Methods: An observational, analytical, prospective, cohort study of 22 athletes who received the same evaluation at the start of the seasons and 25(OH)D and total calcium measurements in January and August of S1 and S2. Data on MI were obtained from the physiotherapy department of the club. Results: Chronological age: 23.4 ± 3.0 years; height (cm) 182 ± 0.7; total body mass (kg) 78.5 ± 8.6; total lean mass (kg) 65.9 ± 6.7 and total fat mass (kg) 13.2 ± 3.3. Solar radiation (kj/m^2) at 10 a.m. did not differ between S1 and S2 (p = 0.19) while at 3 p.m., there was a significant difference (S2 > S1, p = 0.01). Total calcium was different between January and August of S2 (p <0.001); in August, the 25(OH)D of S2 was significantly lower than that of S1 in January (p = 0.01). On August of S2, 78.9% of the athletes had 25(OH)D values within the range of insufficiency/deficiency (p = 0.02). MI were twice as frequent in S2 (31 vs 16); the midfield and forward athletes were the ones most affected; grade I injuries were more prevalent; in S1, MI were more frequent in the dominant limb (75.0%) while in S2, there was no difference between the dominant (35.5%) and non-dominant (48.4%) limbs. Conclusion: Professional soccer athletes with adequate exposure to solar radiation do not appear to benefit from vitamin D supplementation to prevent muscle injuries. ***Level of evidence II, Therapeutic study.***

Keywords: Athletic performance; Soccer.

RESUMO

Contexto: A insuficiência de vitamina D tem sido descrita entre atletas de futebol profissional. Objetivo: Avaliar perfil de 25(OH)D e ocorrência de lesões musculares (LM) em atletas da série A com (temporada 2015 - T1) e sem suplementação de vitamina D (temporada 2016 - T2). Métodos: Estudo observacional, analítico, de coorte, prospectivo com 22 atletas que receberam a mesma avaliação no início das temporadas e dosagens de 25(OH)D e cálcio total nos meses de janeiro e agosto da T1 e T2. Dados das LM foram obtidos no setor de fisioterapia do clube. Resultados: Idade cronológica: 23,4 ± 3,0 anos; estatura (cm) 182 ± 0,7; massa corporal total (kg) 78,5 ± 8,6; massa magra total (kg) 65,9 ± 6,7 e massa gorda total (kg) 13,2 ± 3,3. A radiação solar (kj/m^2) às 10 horas não foi diferente entre T1 e T2 (p = 0,19), porém, às 15 horas houve diferença significativa (T2 > T1, p = 0,01). O cálcio total foi diferente entre janeiro e agosto da T2 (p < 0,001); em agosto, a 25(OH)D da T2 foi significativamente menor do que a da T1 em janeiro (p = 0,01). Em agosto da T2, 78,9% dos atletas tinham valor de 25(OH)D no nível de insuficiência/deficiência (p = 0,02). As LM foram o dobro na T2 (31 vs. 16); os jogadores de meio de campo e os atacantes foram os mais afetados; as LM de grau I foram mais prevalentes; na T1 predominaram as LM do membro inferior dominante (75,0%), enquanto na T2 não houve diferença entre membro dominante (35,5%) e não dominante (48,4%). Conclusão: Os atletas de futebol profissional com exposição adequada à radiação solar não parecem se beneficiar de suplementação de vitamina D visando a prevenção de lesões musculares. ***Nível de evidência II, Estudos terapêuticos.***

Descritores: *Desempenho Atlético; Futebol.*

RESUMEN

Contexto: Se ha descrito una insuficiencia de vitamina D entre los atletas de fútbol profesional. Objetivo: Evaluar el perfil de 25(OH)D y la ocurrencia de lesiones musculares (LM) en atletas de la serie A con suplementación de vitamina D (temporada 2015 - T1) y sin suplementación (temporada 2016 - T2). Métodos: Estudio observacional, analítico, de cohorte, prospectivo con 22 atletas que recibieron la misma evaluación al inicio de las temporadas y medición de 25(OH)D y calcio total en enero y agosto de las T1 y T2. Los datos de las LM fueron obtenidos del sector *de fisioterapia del club. Resultados: Edad cronológica: 23,4 ± 3,0 años; estatura (cm) 182 ± 0,7; masa corporal total (kg) 78,5 ± 8,6; masa magra total (kg) 65,9 ± 6,7 y masa grasa total (kg) 13,2 ± 3,3. La radiación solar (kj/m²) a las 10h no fue diferente entre las T1 y T2 (p = 0,19), sin embargo, hubo una diferencia significativa a las 3 de la tarde (T2 > T1, p = 0,01). El calcio total fue diferente entre enero y agosto de la T2 (p < 0,001); el nivel de 25(OH)D, en agosto de la T2 fue significativamente menor que en enero de la T1 (p = 0,01). En agosto de la T2, el 78,9% de los atletas presentaba un valor de 25(OH)D en el nivel de insuficiencia/deficiencia (p = 0,02). Las lesiones musculares fueron el doble en la T2 (31 frente a 16); los atletas de medio campo y los delanteros fueron los más afectados; las LM de grado I fueron más frecuentes; en la T1 predominaron las lesiones del miembro inferior dominante (75,0%), mientras que en la T2 no hubo diferencia significativa (35,5% miembro dominante y 48,4% no dominante). Conclusión: Los atletas de fútbol profesional con una exposición adecuada a la radiación solar no parecen beneficiarse de la suplementación con vitamina D para prevenir lesiones musculares.* ***Nivel de evidencia II, Estudios terapéuticos.***

Descriptores: *Rendimiento atlético; Fútbol.*

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INTRODUCTION

Vitamin D has been the object of an increasing number of studies in recent years, demonstrating other functions besides its role in bone physiology. The main cause of vitamin D deficiency is decreased exposure to ultraviolet B (UVB) radiation. Environmental factors: time/duration of exposure to the sun, seasonality, latitude and individual: area of the body irradiated, skin pigmentation, aging, obesity, and use of sunscreen[1,2] all affect vitamin D synthesis.[3] In athletes, the type of clothing worn, and sport played (indoor/outdoor area) are intervening factors.

To determine the level of vitamin D, 25(OH)D[1] is measured and based on the plasma values obtained, to classify the status of vitamin D in deficiency, insufficiency or sufficiency. Currently, there is no consensus on the physiological level of vitamin D, although the following definitions have been proposed: deficiency, values less than 20 ng/mL; insufficiency, values between 20 and 30 and sufficiency, any value above 30.[4]

In 2017, the Brazilian Society of Clinical Pathology/Laboratory Medicine and the Brazilian Society of Endocrinology and Metabology proposed new reference intervals of 25(OH)D: above 20 ng/mL for healthy population up to 60 years and between 30 and 60 ng/mL for high-risk groups (elderly, pregnant women, infants, osteoporosis, falls and fractures, autoimmune diseases, chronic renal disease and malabsorption syndromes).[1]

For athletes, values above 30 ng/mL have been recommended, because from this level, vitamin D is stored in muscle tissue and fat and can improve athletic performance.[5,6] However, values in the disability/insufficiency range are common in a significant proportion of athletes.[7,8] Studies involving National Football League players showed that 80%[9] and 69%[10] presented decreased levels of 25(OH)D; and a metaanalysis of 23 studies involving 2313 athletes showed inadequate levels in 56%.[11]

Professional soccer players, before engaging in intense training and competitions, go through extensive clinical-laboratory evaluation. Therefore, it is reasonable to question whether a healthy, fit soccer player, with a 25(OH)D value of between 20 and 30 ng/mL, should be considered vitamin D insufficient.

The concept of normality of relation to 25(OH)D levels in professional soccer players in a tropical country such as Brazil does not seem to be fully established.

This study evaluated the profile of 25(OH)D in professional soccer athletes of a Series A club of the Brazilian Football Confederation (*Confederação Brasileira de Futebol* - CBF), with and without vitamin D supplementation, and the effects of supplementation on the history of muscle injury (MI).

MATERIALS AND METHODS

An observational, analytical, prospective cohort study to evaluate the 25(OH)D profile and history of MI of professional soccer athletes of a Series A CBF club during a full season with vitamin D supplementation (2015) and a full season without vitamin D supplementation (2016).

Inclusion criteria

Professional athletes resident at the training center (TC), released by the medical department (MD), in regular intensive training (five sessions of 2-3 hours a week), and able to participate in competitions.

Exclusion criteria

Traumatic injury (bone or ligament) or clinical problem lasting for more than four consecutive weeks that interrupted the athletes' participation in training/competitions, and termination of contract during the study.

Study population

Of 32 athletes regularly enrolled in the 2015 season, 10 were excluded; thus, the final study population consisted of 22 athletes.

METHODS

Clinical, orthopedic, cardiorespiratory evaluation, routine biochemical tests and field tests (physical, technical and tactical) at the start of the season.

Cholecalciferol, at a dose of 50,000 IU, was administered once a week, immediately after breakfast, from February to November 2015.

Muscle injuries

The MIs observed during the study were described in the regular way, and recorded in the physiotherapy reports, under the supervision of the orthopedist, noting: severity of the injury (grades I, II and III) according to Barroso & Thiele;[12] affected lower limb, and the player's position on the field.

Dietary control

At the training center, meals were made exclusively in the club cafeteria and in other cities, the menu followed the same dietary prescriptions, drawn up by the same nutritionist.

Laboratory Tests

Biochemical tests at the start of the seasons: complete blood count, urea, creatinine, sodium, potassium, insulin, glucose, HbA1c, lipid profile, TGO, TGP, GGT, total proteins and fractions, TSH, Free T4, testosterone, total calcium, phosphorus, alkaline phosphatase, CK, DHL. 25(OH)D was measured at the start of the seasons and in the month of August.

Measurement of 25(OH)D

Method A: Throughout the study, by the Laboratory of Hospital Nossa Senhora das Graças (HNSG), using a commercial kit (Architect 25-OH vitamin D 5P02®, Abbott Laboratories, Abbott Park, IL 60064, USA). Method B: At the end of the study, by the Clinical Analysis Laboratory of Hospital de Clínicas da UFPR (HC-UFPR), using serum samples collected during the two seasons and stored in a freezer at -20ºC and measured using a commercial kit (LIAISON® 25-OH vitamin D, DiaSorin Inc, MN 55082, USA).

Solar radiation

Measurements of solar radiation (kj/m^2), at 10 a.m. and 3 p.m., in the city of Curitiba, in 2015 and 2016, were obtained from the Hydrometeorological Information System of the National Meteorology Institute (thermometer QMT 102, Vaisala).

Body composition

Body composition was determined by dual-energy X-ray absorptiometry (RX QDR®, Hologic®, Hologic Inc., Bedford, MA 0173, USA).

Statistical analysis

The quantitative variables were described considering the statistical mean and standard deviation. The difference between repeated variables was estimated using the ANOVA test with the Duncan post-hoc test. For the categorical variables, Fisher's exact test and the test for difference between proportions were applied. In each of the semesters, the Poisson regression model was used to evaluate the association between 25(OH)D level and number of MIs.

A minimum significance level of 5% and a minimum test power of 90% were considered.

The study was approved by the Ethics Committee for Research on Humans of HC-UFPR (CAAE Registration: 45068215.9.0000.0096). The athletes signed an Informed Consent Form; Resolution 196/96 of the Brazilian National Research Ethics Committee.

RESULTS

Table 1 shows the general characteristics of the 22 athletes. At admission, the mean age was 23.4 ± 3.0 years; height 182 ± 0.7cm; total body mass 78.5 ± 8.6kg; total lean mass 65.9 ± 6.7 kg and total fat mass 13.2 ± 3.3 kg. Most of the athletes (72.7%) had dark skin. As regards playing position, 22.7% were defenders, 22.7% forwards, 18.2% goalkeepers, 18.2% midfielders, 9.1% wingbacks and 9.1% central midfielders.

There was no difference in biochemical profiles between 2015 and 2016, except for a significant difference in calcium levels between January and August 2016 ($p < 0,001$) and in 25(OH)D between January 2015 and August 2016 ($p = 0.01$) (Table 2, Figures 1 and 2).

The distribution ranges of the individual 25(OH)D values for January and August 2015 and January 2016 are similar, while for August 2016 we see a different pattern, with a higher concentration of values in the range between 20 and 30 ng/m (Figure 3).

As shown in Figure 4, most of the 25(OH)D values obtained by method A are higher than those obtained by method B in all the semesters analyzed.

In August 2016, as shown in Table 3, a significant number of athletes presented 25(OH)D values in the range of insufficiency/disability (78.9%; $p = 0.02$).

Fourteen athletes (63.6%) presented a total of 47 injuries: 16 in 2015 and 31 in 2016, one injury in 7; two in 3, three in 1 and four or more in 3 athletes (Table 4). Despite the occurrence of higher number of MI in the 2016 season there was no significant difference between the two seasons.

Table 1. General sample characteristics – athletes of the category

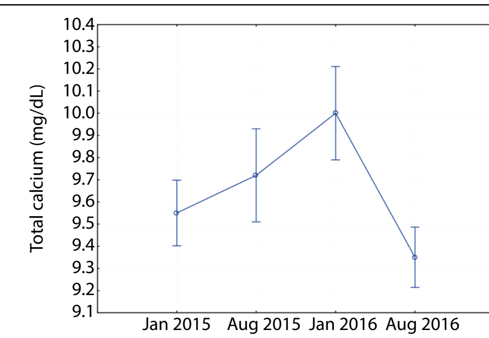
athletes	CA Years	TBM Kg	Height Cm	TLM Kg	TFM Kg	Skin color	Playing Position
1	26.8	81.6	1.89	68.6	12.9	Dark	Goalkeeper
2	21.6	78.4	1.91	66.7	11.7	Light	Midfielder
3	30.1	70.7	1.72	61.6	9.1	Dark	Wingback
4	24.4	79.0	1.88	66.2	12.8	Dark	Defender
5	20.5	88.2	1.87	72.0	16.1	Dark	Forward
6	20.8	63.0	1.76	54.2	8.8	Dark	Forward
7	24.7	86.0	1.81	67.0	19.0	Light	Forward
8	22.8	78.2	1.89	66.9	11.2	Dark	Central midfielder
9	19.9	65.7	1.71	54.5	11.2	Light	Midfielder
10	19.8	78.0	1.87	64.4	13.6	Dark	Defender
11	22.5	85.4	1.87	69.7	15.7	Light	Goalkeeper
12	20.6	78.4	1.85	65.6	12.8	Dark	Defender
13	21.4	66.2	1.74	55.6	10.6	Dark	Midfielder
14	20.6	73.8	1.79	60.2	13.6	Light	Midfielder
15	24.4	88.1	1.74	70.0	18.0	Dark	Forward
16	20.1	75.0	1.79	64.5	10.4	Dark	Forward
17	22.6	69.0	1.72	58.1	10.9	Dark	Central midfielder
18	24.9	83.1	1.90	71.7	11.4	Dark	Defender
19	25.8	87.6	1.89	74.9	12.7	Dark	Goalkeeper
20	23.6	70.9	1.76	59.6	11.3	Dark	Wingback
21	27.3	85.5	1.83	63.7	21.8	Dark	Defender
22	29.0	95.7	1.89	80.6	15.1	Light	Goalkeeper

Note: CA= chronological age; TBM= total body mass; TLM= total lean mass; TFM= total fat mass

Table 2. Biochemical parameters measured every six months in 2015-2016.

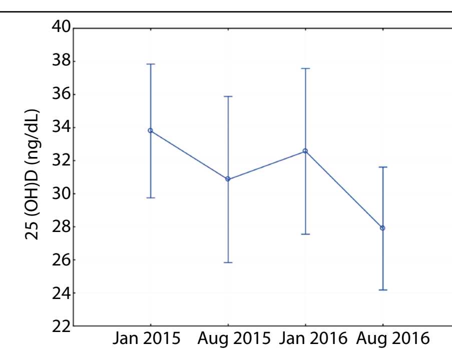
Variable	January 2015	August 2015	January 2016	August 2016	P
Phosphorus (mg/dL)	3.9 ± 0.3	4.3 ± 0.4	4.2 ± 0.4	4.2 ± 0.4	0.15
CK (U/L)	333.7 ± 206.5	364.3 ± 263.2	440.6 ± 276.6	438.0 ± 242.7	0.68
LDH (U/L)	574.8 ± 100.1	559.4 ± 67.3	538.5 ± 70.0	544.8 ± 62.2	0.72
Alkaline phosphatase (U/L)	80.2 ± 20.1	79.4 ± 16.8	76.7 ± 17.6	84.6 ± 21.5	0.19
25(OH)D (ng/mL)	33.8 ± 7.5	31.7 ± 8.6	32.4 ± 8.8	27.0 ± 6.8	0.01
Calcium (mg/dL)	9.6 ± 0.2	9.7 ± 0.2	9.8 ± 0.5	9.2 ± 0.3	< 0.001

Anova - Duncan Post-hoc Test.



Note: Averages and CI 95% Anova - Duncan Post-hoc Test.

Figure 1. Distribution of the difference between total calcium measurements.



Note: Averages and CI 95% Anova - Duncan Post-hoc Test.

Figure 2. Six-monthly distribution of the mean 25(OH)D measurements.

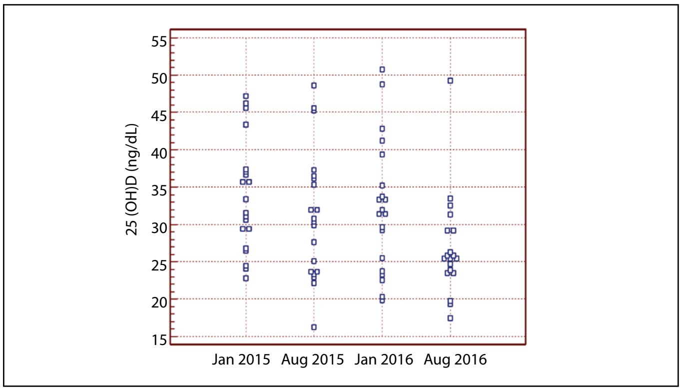


Figure 3. Distribution of individual 25(OH)D values.

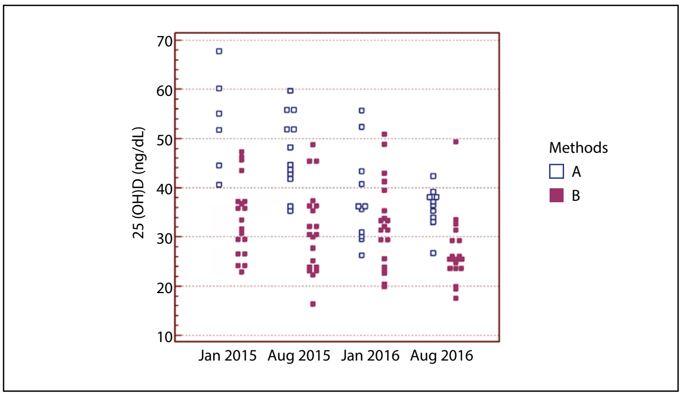


Figure 4. Distribution of individual 25(OH)D values by methods A and B.

Table 3. Distribution of the 25(OH)D value classification.

25(OH)D Classification	2015		2016	
	Months		Months	
	January	August	January	August
Sufficient	13 (65.0%)	11 (55.0%)	12 (57.2%)	4 (21.1%)
Insuf / def	7 (35.0%)	9 (45.0%)	9 (42.8%)	15 (78.9%)

Test for difference between proportions: P = 0.02. Sufficient: ≥30 ng/mL; insuf: Insufficient ≤30 ng/mL; def: deficient ≤20 ng/mL

Table 4. Number and percentage of athletes with injuries per semester.

year Variable	2015				2016			
	1St semester		2Nd semester		1St semester		2Nd semester	
No injury	17	77.3%	15	68.2%	12	54.5%	17	77.3%
Injury	5	27.7%	7	31.8%	10	45.5%	5	22.7%

Note: fisher's exact test p<0.07.

Table 5 shows the p values of the statistical tests for each semester. As we can see, there was no association between 25(OH)D level and number of MIs.

The percentage distribution of the MI according to the athlete's playing position was similar in both seasons. There was no significant difference in the distribution of injuries according to severity, with a predominance of grade I injuries in both seasons (Table 6).

There was no significant difference in the degree of solar radiation measured at 10 a.m., in both seasons (1516.7 and 1728.3; p = 0.19). However, there was a difference (p = 0.01) when solar radiation was measured at 3 p.m. (1339.7 and 1526.9). No association was observed between 25(OH)D and skin color.

While in 2015 there was a significant predominance (p = 0.02) of injuries in the dominant limb (75.0 *vs* 25.0%), in 2016 the injuries occurred more homogeneously (35.5% in the dominant limb, 48.8% in the non-dominant limb and 16.1% without dominance). There was no association (p = 0.30) between the occurrence of injuries and 25(OH) levels (sufficiency or insufficiency/deficiency).

Table 5. 25(OH)D *vs* muscle injuries.

Period	p value
1st semester of 2015	0.152
2nd semester of 2015	0.856
1st semester of 2016	0.383
2nd semester of 2016	0.721

(*) Poisson regression test: P < 0.05.

Table 6. Distribution of muscle injuries according to severity.

Severity	2015	2016
Grade I	9 (56.2%)	23 (74.2%)
Grade II	2 (12.5%)	4 (12.9%)
Grade III	5 (31.2%)	4 (12.9%)

DISCUSSION

The use of vitamin D occurs in parallel with physiological demands and it is reasonable to admit that the athlete may need a greater amount of vitamin D to ensure storage and availability.[13] In athletes in the northern hemisphere, better athletic performance has been reported in the summer, followed by a sharp decline in early autumn, mimicking the seasonal variation in vitamin D.[14] The well-documented cause of vitamin D deficiency is decreased exposure to UVB radiation, as observed during most of the winter, in latitudes above 35° - 37°.[15] The solar radiation observed in the city of Curitiba (subtropical climate, latitude 25˚S) in the two years of this study showed a marked range of variation, both in the morning and in the mid-afternoon. Most workouts occurred in the mornings, during which there was no difference in the amount of solar radiation between 2015 and 2016.

Although it was not the purpose of this study to compare 25(OH)D values obtained in different laboratories, using a similar methodology, differences were observed between the values obtained, confirming the data described in the literature.[16,17] in this study, the statistical treatment considered the 25(OH)D values using method B to decrease the inter-assay coefficient of variation.

Analysis of the 25(OH)D values for 2015 did not show any significant difference between the averages for January and August, i.e., there was no seasonal variation, indicating the effect of vitamin D supplementation, although the 25(OH)D levels reached were lower than expected. Holick *et al.*,[15] report that a dose of 50,000 IU/week of vitamin D, over eight weeks, is sufficient to increase serum levels in most individuals. A possible explanation for the finding that levels did not increase during supplementation could be related to vitamin D inactivation in an individual exposed to adequate solar radiation. However, in 2016, the values for January were significantly higher than those in August, showing the seasonal variation in vitamin D. On the other hand, the values of January 2016 and January 2015 were not different, probably due to the total vitamin D supplementation received up to the end of 2015 and exposure to solar radiation during December of the same year.

Throughout the study, the percentage of athletes with levels of 25(OH)D in the range considered to be insufficient (<30 ng/mL) by some researchers[2,4] ranged from 35% in January 2015 to 78.9% in August 2016 (including five athletes with values <20 ng/mL). Similar data were reported by Kopec *et al.*,[18] who evaluated 24 Polish professional soccer athletes and identified that 50% had insufficient vitamin D levels in summer and 83.3% in winter. A study of 521 male athletes of different sports in the Qatar national championships, including 269 elite-division soccer players, found levels of sufficiency (25(OH)D ≥ 30 ng/mL) in just 23%.[19] Other studies along similar lines reinforce the findings of levels of insufficiency or deficiency in professional athletes.[9,10,11]

Athletes with high levels of melanin in the skin need longer exposure to UVB radiation to achieve and/or maintain normal levels of vitamin

D.[1] Hamilton *et al.*,[20] in a study of 342 players from the first division of Qatar found lower levels among players of African and Middle Eastern descent than among Caucasians, demonstrating the relationship between skin pigmentation and vitamin D levels. According to Owens *et al.*,[21] Black athletes often present low serum levels of 25(OH)D without physiological changes.

In general, publications addressing the theme of adequate levels of 25(OH)D and soccer athletes[8,13] follow the same trend of "adjusting" the athlete to the value of 25(OH)D, even if he is healthy and in full professional activity. It is worth noting that the professional soccer athlete, before engaging in intense training and competitions, undergoes a series of assessments. Thus, if an athlete in full heath, with high physical demand, and has a value of 25(OH)D (20 - 30 ng/mL) levels in their biochemical profile which is considered insufficient, it is valid to question the recommended reference values. In our view, this equation should be reversed, especially for soccer players matching the profile of those in this study: young, good diet, minimum exposure to sunlight of two hours a day, and high athletic yield. These variables should dictate a sufficiency value of 25(OH)D.

According to this line of reasoning, in a country with a tropical and subtropical climate like Brazil, the 25(OH)D measurement should not be included in the biochemical profile of an athlete with characteristics similar to those evaluated in this study. This would reduce the financial costs of clubs as there would be no need to repeat the test to confirm a possible low value; there would be no vitamin D supplementation, hence, the 25(OH)D levels would not need to be repeatedly measured to ensure the efficacy of the supplementation.

As regards muscle injuries, the statistical analysis did not show significant difference between the two seasons, despite the higher number of injuries observed in 2016 (year without supplementation). The recurrence of injuries in some athletes could justify the finding of a non-association between 25(OH)D levels and muscle injury. Injuries in some athletes can be attributed to several factors, such as muscle overload, repetitive micro muscle injuries, early discharge from the medical department, and stress related to competitions.

Contrary to the findings of this study, several authors report that athletes with vitamin D deficiency can be considered a population with increased risk for MI, decreased muscle strength and lower athletic performance.[22] Rebolledo *et al.*,[23] report an association between low levels of vitamin D and increased risk of MI, suggesting that vitamin D supplementation should be considered, to prevent/decrease the risk of injuries.

It was observed, in both seasons, that midfielders and attackers were the players who received most injuries, and that grade I injuries were the most prevalent.[24,25] There was a higher incidence of injuries in the dominant limb in 2015, while in 2016 the frequency of injuries between the dominant and non-dominant limb did not differ.

A limitation of the present study is the number of athletes analyzed, as a result of the recurrent process of admission and contractual termination during the research.

CONCLUSION

Professional soccer athletes of the CBF A series, based in tropical or subtropical areas do not seem to benefit from vitamin D supplementation to prevent muscle injuries.

All authors declare no potential conflict of interest related to this article

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