BRIEF COMMUNICATION / COMMUNICATION BRÈVE

Seasonal variation in vitamin D status in professional soccer players of the English Premier League

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Abstract: The prevalence of seasonal variation in vitamin D status was examined in 20 FA Premier League soccer players residing at a latitude of 53°N. Serum 25-hydroxyvitamin D (25(OH)D) levels decreased (P < 0.001) between August (104.4 ± 21.1 nmol·L^{-1}, range 68–151) and December (51.0 ± 19.0 nmol·L^{-1}, range 22–86), such that levels for 65% of the sample were insufficient (<50 nmol·L^{-1}) in winter. Strategies to augment vitamin D_3 availability may therefore be advantageous for UK soccer players so as to maintain muscle function.

Key words: vitamin D receptor, muscle function, athletes, 25(OH)D.

Résumé : Dans cette étude, on analyse la prévalence des variations saisonnières du statut de la vitamine D chez 20 joueurs de soccer de la FA Premier League demeurant à la latitude 53°N. La concentration sérique de 25(OH)D diminue (P < 0,001) du mois d'août (104,4 ± 21,1 nmol·L^{-1}, 68–151) au mois de décembre (51,0 ± 19,0 nmol·L^{-1}, 22–86) de telle sorte que 65 % de l'échantillon présente une carence (<50 nmol·L^{-1}) durant l'hiver. Il serait donc indiqué de concevoir des stratégies pour augmenter la disponibilité de la vitamine D_3 à l'intention des joueurs de soccer au Royaume-Uni afin de maintenir leur fonction musculaire.

Mots-clés : récepteur de la vitamine D, fonction musculaire, athlètes, 25(OH)D.

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Introduction

Vitamin D is a hormonal precursor that plays a well documented role in supporting bone health and immune function (Larson-Meyer and Willis 2010). The discovery of the vitamin D receptor (VDR) in human skeletal muscle cells (Bischoff-Ferrari et al. 2004*a*) has also led to increased attention from muscle physiologists on the potential role of vitamin D in regulating protein synthesis and muscle function (Hamilton 2010). This research has application not only for clinical populations (Bischoff-Ferrari et al. 2004*b*, 2004*c*; Broe et al. 2007), but also for elite athletes, where there is the constant requirement to maximize protein synthesis in response to daily physical training (Larson-Meyer and Willis 2010; Willis et al. 2008). However, the role of vitamin D in supporting muscle function is likely to be compromised during the winter months when the exposure to ultraviolet-B (UV-B) radiation may be reduced. In this regard, the stimulus to support the main precursor (i.e., vitamin D_3 or cholecalciferol) to promote endogenous vitamin D synthesis is thereby negated (Chen et al. 2007).

With this in mind, the aim of the present study was to examine the prevalence of a seasonal variation in serum vitamin D status in professional soccer players of the English Premier League. Despite the fact that these athletes train outdoors for 1.5 h daily, we hypothesized that vitamin D status would be significantly lower in the winter months compared with the summer months due to seasonal changes in exposure to UV-B radiation. These athletes may be particularly sensitive to seasonal variations due to the significant change in daily duration of habitual sun exposure between the summer (it is common practice for these athletes to take vacation for 3–4 weeks in Mediterranean climates, take part in international tournaments in hot climates and southern destinations, e.g., the 2010 FIFA World Cup in South Africa, as well as attend preseason training camps in European destinations that are

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known for longer durations of sun exposure) and winter months where daily outdoor training predominantly occurs between 1030 and 1200 at a latitude of 53°N in the British Isles, which normally experiences extreme cloud cover (Gillie 2010).

Materials and methods

Participants

Twenty professional male soccer players of varying nationalities (six English, four Danish, three Spanish, and one player from each of the following countries: Scotland, Australia, Serbia, Holland, Greece, Brazil, and France; age, 26 ± 4 (mean ± SD) years; mass, 79.5 ± 7.5 kg; height, 1.82 ± 0.06 m) volunteered to participate in the study. Of the total sample, two players were dark-skinned. All participants gave informed consent to participate after procedures of the study were fully explained. The study was approved by the Human Ethics Committee of Liverpool John Moores University in accordance with the Helsinki Declaration of 1975.

Procedures

After an overnight fast, players provided a venous blood sample from the antecubital crease of the forearm while resting in the supine position. Samples were collected in serum separation tubes, allowed to clot at room temperature for 1 h, and subsequently analysed for serum vitamin D concentration (assayed as 25-hydroxyvitamin D, 25(OH)D) in an independent laboratory (The Doctors Laboratory, London, UK, www.tdlpathology.com) according to the DiaSorin assay kit (LIASON 25 OH Vitamin D TOTAL Assay (code 310600), Diasorin Inc., Stillwater, Minnesota, USA). All players provided a sample in the summer (24 August 2010) and the winter (24 December 2010). All players also maintained their normal dietary patterns during this time period. Although each batch of samples was analysed in different runs, each run was analysed with two internal controls (provided by the kit manufacturer) and two external controls (Liquichek Specialty Immunoassay Control, BioRad, Hempstead, UK) across both low and high concentrations.

To investigate any potential relationship between adiposity and serum 25(OH)D, all players were also assessed for sum of seven skinfolds (biceps, triceps, subscapula, iliac crest, abdominal, front thigh, and medial calf) according to the protocol of the International Society for the Advancement of Kinathropometry.

Study location and activity of participants

For 3–4 weeks prior to collection of the first sample and throughout the remainder of the study period, all players resided in the United Kingdom (Liverpool) at a latitude of 53°N. During this time, the players typically trained (Monday to Friday) outdoors between 1030 and 1200 followed by a further 30 min in an indoor gymnasium. Actual competitive match play usually took place on a Saturday or Sunday between 1500 and 1700 (3 and 5 pm). Throughout the duration of the study period, no player travelled to any southern destinations.

Competitive matches in the English Premier league usually commence mid-August and end in May, and periods of intense game schedules are typically during the opening weeks of the season and the Christmas period in December. Preseason training commences in July and typically lasts for 4–5 weeks during which the rebuilding and development of sport-specific fitness is the main goal. It is also customary for 1–2 weeks of preseason training to take place in a foreign destination that is associated with warmer temperatures and longer hours of sunlight than that occurring within the British Isles during the summer months.

In relation to the season studied in this investigation, 10 of the players studied also took part in the 2010 FIFA World Cup in South Africa, which took place between 11 June and 11 July 2010. Following this period, these players were then on vacation for 2–3 weeks in a variety of Mediterranean destinations before subsequently returning to the UK for preseason training in late July or at the beginning of August. The remaining players who were not involved in this competition were on vacation for 3–4 weeks in June (also at a variety of Mediterranean destinations) and returned to preseason training in the UK on 1 July 2010. After 2 weeks of training in the UK, these players then travelled to a preseason training camp in Switzerland between 13 and 25 July 2010 and then remained in the UK thereafter. Given the competitive playing and training schedule and also the duration and timing of vacations described above, it is noteworthy that the soccer players studied here are therefore not representative of the majority of the population of the UK in terms of the typical daily duration of habitual sun exposure during the summer months.

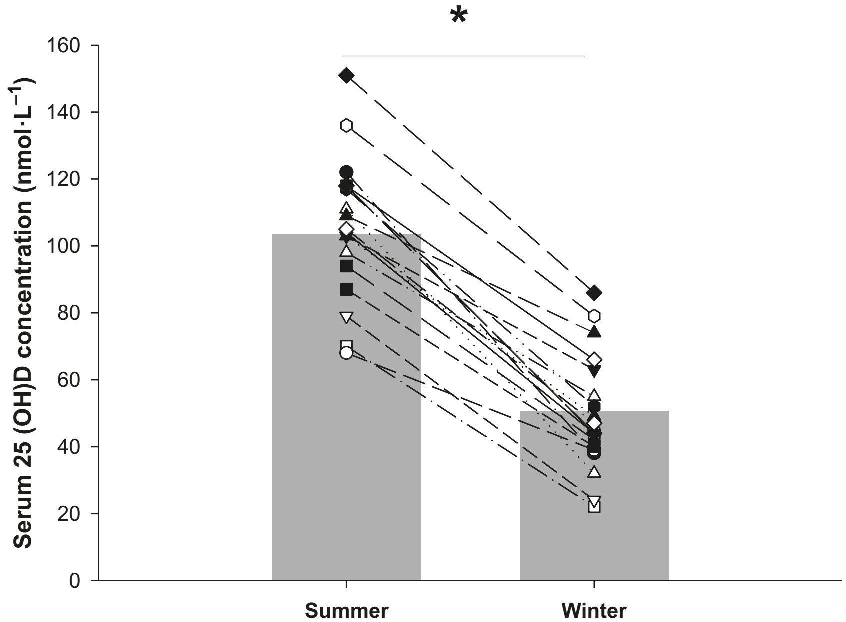
Statistical analyses

Changes in 25(OH)D concentration between summer and winter were analysed using Student's *t* test for paired samples, after verifying for normal distribution (SPSS version 15 for Windows). Data are presented as means ± SD, with $P < 0.05$ indicative of statistical significance. In accordance with recommendations for making inferences of meaningful differences (Batterham and Hopkins 2006), 95% confidence intervals (CI) for the differences between summer and winter are also presented so as to provide an estimate as to the true population mean magnitude of change. Potential relationships between adiposity (sum of seven skinfolds) and serum 25(OH) D were also analysed using Pearson's correlation.

Results

Serum 25(OH)D significantly decreased ($P < 0.001$) between summer (mean ± SD, 104.4 ± 21.1 nmol·L^{-1}; range, 68–151) and winter (51.0 ± 19.0 nmol·L^{-1}, 22–86) months. All 20 players exhibited a decrease in vitamin D concentration within this time period (see Fig. 1), where the mean decrement was 52.7 ± 15.1 nmol·L^{-1} (range, 29–84). These decrements corresponded to a percentage decrease of 54% ± 15% (range, 27%–71% decrease). The 95% CI for magnitude of decrease between summer and winter values was 46 to 61 nmol·L^{-1}, magnitudes of change that can be interpreted qualitatively as very likely harmful. The two players who were dark-skinned exhibited the lowest serum 25(OH)D values in both summer (70 and 68 nmol·L^{-1}, respectively) and winter (22 and 39 nmol·L^{-1}, respectively). Sum of seven skinfolds was 50.5 ± 10.2 mm in summer and 48.7 ± 9.6 mm in winter,

Fig. 1. Changes in serum 25(OH)D concentration between summer (August) and winter (December). Bars are presented as group mean data and individual lines represent changes in individual player's vitamin D status during this time period. The asterisk (*) denotes significant difference between summer and winter ($P< 0.001$) as assessed by Student's t test for paired samples.



and there was no significant correlation with serum 25(OH)D levels at either time point (P = 0.48 and 0.1, respectively).

Discussion

We provide novel data by reporting that a seasonal variation exists in serum vitamin D status between summer and winter months in professional soccer players playing in the English Premier League. Importantly, all 20 athletes studied here displayed this seasonal variation. Our chosen time point of sampling for winter was also associated with the most intense game schedule of the playing season (five competitive games in 16 days), a time when efficient recovery between competition and daily training is particularly important. Deficient vitamin D status during this time period may therefore negatively impact upon various aspects of health and athletic performance.

Interpretation of the present data is initially difficult due to the lack of available data from healthy age-matched control individuals (i.e., nonathletes) studied during a similar time scale and at a similar latitude. To the authors' knowledge, the most suitable comparable reference data set is provided by Cashman et al. (2008), who observed serum 25(OH)D values of 70.3 nmol·L^{-1} (range, 53.4–90.3) in the month of October in a large cohort (n = 221) of white men and women (aged 20–40 years) residing within the British Isles (51–55°N). These values are substantially lower than the basal values reported here (mean ± SD, 104.4 ± 21.1 nmol·L^{-1}; range, 68–151), which is likely due to the location of the soccer players in the weeks and months prior to collection of the baseline sample (i.e., a combination of time spent at the 2010 FIFA World Cup in South Africa, on vacation at Mediterranean destinations, and also at preseason training camps). A precise comparison of data between studies is difficult, however, due to the different biochemical methods utilized by us (Diasorin Liason) and the aforementioned researchers (an ELISA method from Immuno Diagnostic Systems Ltd., UK), though it is noteworthy that these methods produce highly comparable data according to the Vitamin D External Quality Assessment Scheme (www.deqas.org). When taken together, therefore, our data suggest that the vitamin D status of the athletes studied here was not of major concern at the beginning of the competitive season.

Interpretation of the present data is also complicated by variations in definitions of what constitutes sufficient, insufficient, and deficient vitamin D status. For example, the Endocrine Society (Holick et al. 2011) defines insufficiency and deficiency as serum 25(OH)D values of 52.5–72.5 nmol·L^{-1} and <50 nmol·L^{-1}, respectively, and recommend a target level of 75 nmol·L^{-1}. The Institutes of Medicine (IOM) also recently identified sufficient status as 50 nmol·L^{-1}, a level that could be achieved by a daily dietary intake of 600 IU (IOM 2011). In contrast, the Scientific Advisory Committee on Nutrition (SACN) and the Food Standards Agency (FSA) of the UK define vitamin D deficiency as <25 nmol·L^{-1} (SACN 2007; Ashwell et al. 2010), although these policies have been the subject of recent critique (Gillie 2010). Despite these inconsistencies, it is important to note that by the month of December, 65% of the players studied here (n = 13) displayed serum 25(OH)D values that were lower than what would be considered acceptable for the recommended dietary allowance in North America (600 IU) to prevent values of <50 nmol·L^{-1}. Furthermore, unless these athletes were to travel south, take supplements, or utilize UV-B light devices, their values may decline further until at least April, as observed previously in healthy age-matched control individuals residing at a similar latitude (Cashman et al. 2008). Indeed, at the latitude studied in the present paper, there is no UV radiation of appropriate wavelength between mid-October and the beginning of April for cutaneous production of previtamin D_3 to occur (Webb and Holick 1988). In this regard, both bone and muscle function may therefore not be considered optimal during the second half of the competitive season, despite the sustained daily training and competitive match demands. On the basis of the above classifications, the prevalence of vitamin D insufficiency observed here agrees well with that observed in male junior athletes from Qatar (Hamilton et al. 2010), Australian female gymnasts (Lovell 2008), German male and female gymnasts (Halliday et al. 2011), and junior female runners from Finland (Lehtonen-Veromaa et al. 1999). To the authors' knowledge, however, this is the first report of vitamin D insufficiency in elite male soccer players and is also the first report of athletes residing in the UK.

An interesting finding in the present study is not only the presence of a seasonal variation in vitamin D status, but specifically the extent and prevalence of this variation (all 20 soccer players displayed this seasonal variation), an effect that compares well with the onset of UV light deprivation observed in submariners (for review, see Vieth 1999). It has been suggested that reported seasonal variations in vitamin D status should be interpreted in relation to any changes in fat mass given that greater fat mass is associated with lower peaks and smaller seasonal variations in 25(OH)D concentration (Bolland et al. 2007). However, the role of fat mass in modulating the present data is likely negligible given that our measure of body composition (sum of seven skinfolds) did not change over time and also displayed no correlation with 25(OH)D concentrations in either summer or winter. Indeed, when data from our skinfold measurements are used in conjunction with common prediction equations to estimate percentage of body fat (Reilly et al. 2009), all our players were <10% body fat (data not shown). Rather, we suggest that the stark contrast in serum 25(OH)D levels between summer and winter is likely due to the extreme variation in habitual daily sun exposure across this time scale, a variation largely reflective of the competitive playing and training schedule of professional soccer players. Indeed, during the summer months, most of the players studied here undertook long vacations in the Mediterranean, competed in international tournaments such as the 2010 FIFA World Cup in South Africa, as well as attended preseason training camps in which long durations of outdoor training and hence daily sun exposure were evident. In contrast, when the players subsequently returned to the British Isles (53°N), daily outdoor training was restricted to 1.5 h daily between 1030 and 1200, a time when there is usually extreme cloud cover.

Direct evidence for ergogenic effects of vitamin D on physical performance is currently lacking, though causative reports exist for improved musculoskeletal function in adolescent girls (Foo et al. 2009; Ward et al. 2009) and elderly populations (Bischoff-Ferrari et al. 2004*b*, 2004*c*; Broe et al. 2007). These data may relate to the purported role of vitamin D in regulating protein synthesis and muscle growth through interaction with the VDR expressed in skeletal muscle cells (Bischoff-Ferrari et al. 2004*a*) and, potentially, an insulin-like growth factor 1 mediated pathway (Soliman et al. 2008). However, further research evaluating the effects of correcting vitamin D insufficiency in athletic populations on physical performance is now required, as well as ascertaining potential mechanisms of action.

On the basis of the present data and those cited above, it may be pertinent for athletic populations to consider strategies to augment serum 25(OH)D levels during times when natural UV-B exposure precludes vitamin D_3 synthesis (e.g., through environmental changes or training indoors). This appears particularly the case for professional soccer players of the British Isles given the stark contrast in habitual daily duration of sun exposure between summer months (when players usually return from vacation, international tournaments, and preseason training camps) and winter months (when daily outdoor training is restricted to 1.5 h between 1030 and 1200, a time when the British Isles usually experiences extreme cloud cover). Supplementation with exogenous vitamin D_3 and (or) exposure to UV-B light devices may represent effective approaches, though the optimal dosage for both countermeasures and their relationship upon physical performance is not currently known.

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