Original research

Vitamin D status in professional ballet dancers: Winter vs. summer

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Abstract

Objective: Serum 25-hydroxyvitamin D is produced by the exposure of the skin to sunlight. Therefore athletes who train indoors, such as dancers, are vulnerable to vitamin D deficiency. The purpose of the study was to evaluate the serum 25-hydroxyvitamin D status in UK professional dancers during periods of reduced and increased sunlight exposure (i.e., winter vs. summer), and to assess the impact on bone metabolism and risk of injury.

Design: Cohort study.

Methods: 19 elite classical ballet dancers (age 26 ± 8.86 yr; height 1.66 ± 8.84 m; mass 54.3 ± 10.47 kg) were monitored over a 6 month period for 25-hydroxyvitamin D, PTH and blood serum bone turnover markers (CTX and PINP) along with injury data. Repeated measure ANOVA and Wilcoxon and Chi-square analyses were used and significance was set at p < 0.05.

Results: Significant changes were noted between the winter and summer test dates for 25-hydroxyvitamin D (14.9 ng/ml vs. 23.9 ng/ml; p < 0.001), PTH (38.7 pg/ml vs. 26.3 pg/ml; p < 0.001) and PINP (89.9 ng/ml vs. 67.6 ng/ml; p < 0.01). The oral contraceptive had a significant effect on serum 25-hydroxyvitamin D, PTH and CTX. Soft tissue injuries were significantly lower in summer compared to winter period (winter = 24, summer = 13; p < 0.05).

Conclusions: Professional ballerinas characterized by a high incidence of low serum 25-hydroxyvitamin D levels which improve marginally in the summer. These dancers also demonstrate a higher injury incidence in the winter. Oral contraception seems to increase serum 25-hydroxyvitamin D levels and has a positive effect on bone metabolism.

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has been associated with inflammatory and long-latency diseases such as multiple sclerosis, rheumatoid arthritis, tuberculosis, diabetes, and various cancers, though there is no causal evidence for most of these associations.

Dance is a high intensity intermittent exercise with activity periods lasting between 1 and 6 min followed by rest periods of 2–9 min. Dance has been linked to overtraining and burnout, the deleterious effects of which are known for some time. Dancers also demonstrate high incidence of injury which has been partly explained by inadequate levels of physical fitness, particularly by low levels of muscular strength. Inadequate muscular strength has been associated with vitamin D deficiency in athletes and non-athletes alike. However, Wang and DeLuca suggested that the effect of vitamin D on muscle function might be indirect as they could not detect a known vitamin D receptor in skeletal muscle.

Vitamin D deficiency is an increasingly described phenomenon worldwide. Among athletic populations, however, such deficiencies are more common in those training indoors. A cross-sectional study conducted in Australia revealed vitamin D insufficiency in over 80% of the female gymnasts tested while a study from Israel found that the incidence of insufficiency was 48% in outdoor athletes compared to 80% in those training indoors. Given the dearth of relevant data on dancers, we investigated serum 25(OH)D levels together with other markers of bone metabolism at 2 time points in the year (winter vs. summer) in a group of professional ballet dancers based in the UK. We also documented their injury profile at these 2 time points to ascertain possible associations with the serum 25(OH)D and bone markers.

2. Methods

The participants were recruited from a single international touring ballet company. The volunteers were professional Caucasian dancers on full-time contracts involved in 6–8 h of dancing per day, 38 h per week. The study initially recruited 28 dancers but due to touring commitments, only 19 completed the study (males: n = 6, 23 ± 2.1 yrs, 175.8 ± 8.1 cm, 68.5 ± 3.9 kg; females: n = 13, 24 ± 4.5 yrs; 162.2 ± 1.7 cm, 48.1 ± 4.7 kg). Participant consent was obtained prior to data collection. The research protocol was approved by the University of Wolverhampton Ethics Review Committee.

Data collection occurred at a latitude of 52°29’N in February 2010 (i.e., winter period) and August 2010 (i.e., summer period) during which there was sunlight for 55.1 and 172.5 h, respectively. Each participant completed a lifestyle questionnaire prior to anthropometric measurements and blood collection. Standing height was measured to the nearest 0.5 cm using a Seca stadiometer (Hamburg, Germany), with the participants in bare feet and their heads positioned in the Frankfort horizontal plane. Total body mass was measured to the nearest 0.5 kg with a Seca beam balance 710 (Hamburg, Germany).

The questionnaire covered menstrual history, oral contraception, medication, overseas travel and activity levels. A 5–7 ml sample of blood was collected between 08:00 and 10:00 after an overnight fast into tubes which did not contain anticoagulants. The sample of blood was collected between 08:00 and 10:00 after an overnight fast into tubes which did not contain anticoagulants. The thawed samples were later analyzed for bone turnover markers (carboxy-terminal collagen crosslinks CTX and procollagen 1 N-terminal peptide P1NP) parathyroid hormone (PTH), and serum 25(OH)D. P1NP, sCTX, PTH and 25(OH)D were measured by electrochemiluminescent immunoassays (Roche Cobas e411 Analyzer, Roche Diagnostics, Basel, Switzerland), with interassay CV of 2.9%, 3.4%, 5.8% and 3.5%, respectively.

Vitamin D insufficiency was determined by circulating serum 25(OH)D levels of 10–30 ng/ml (25–75 nmol/l) and deficiency as a level below 10 ng/ml (25 nmol/l). A time-loss definition of injury was used whereby “any injury that prevented a dancer from taking a full part in all dance related activities that would normally be required of them for a period equal to or greater than 24 h after the injury was sustained”.

Injuries were reported by one of the 3 full-time in-house physiotherapists on a standardized injury reporting form. The authors deemed a dancer to have returned from injury when they were able to resume all dance related activities. The numbers of injuries sustained by the participants over two 4 month periods were recorded. The winter monitoring period was between December and March covering approximately 2 months either side of the blood collection date. Prior to the August blood collection date, the participants had been on vacation for 5 weeks, so the summer injury monitoring period was set between August and November.

Repeated measure ANOVA on the blood data with the questionnaire data as between subject effects were carried out. Wilcoxon and Chi-square analyses were performed between vitamin 25-D levels and injury data. A priori alpha-level was established at p ≤ 0.05.

3. Results

None of the dancers were taking vitamin D supplements either at the start or during the study, 4 dancers took vitamin B complex and C supplements. Out of the 13 female dancers 5 were on the oral contraceptive. They all took the monophasic pill, Yasmin which contains Ethinylestradiol 30 μg. Those not on the oral contraceptive had normal menstrual patterns. Holiday travel was recorded by all participants but the destinations were too varied in exposure to sunlight hours to allow categorization.

During the winter all 19 dancers were either insufficient (14) or deficient (5) in serum 25(OH)D. There was some improvement by the summer with 3 dancers with normal serum 25(OH)D, 14 insufficient and 2 deficient (Fig. 1). The average increase in serum 25(OH)D of 9 ng/ml from winter to summer was significant (F(1,18) = 24.9; p < 0.001). In parallel with these changes PTH significantly decreased during this time (F(1,18) = 34.4; p < 0.001). P1NP levels significantly decreased during this time (F(1,18) = 13.9;
p < 0.01), CTX also decreased during this time period but the change was not significant (Table 1). However there was a significant positive correlation between P1NP and CTX in both winter ($r = 0.67; p < 0.01$) and summer ($r = 0.86; p < 0.001$) periods.

The injury data reported a significant decrease in the total number of injuries sustained by the dancers between the winter (24) and summer (13) periods ($z = -2.0766; p < 0.05$) though Chi-square analyses failed to find a significant association between injuries and serum 25(OH)D.

Within the female participants it was noted that oral contraception had a significant beneficial effect on serum 25(OH)D, CTX and PTH. Those who were on oral contraception had lower measurements for the bone turnover markers which was statistical significant for the summer P1NP and the winter CTX (Table 2). Those on the oral contraceptive also increased their serum 25(OH)D in the summer by a significantly greater amount than those who were not on the oral contraceptive ($F_{1,11} = 4.8763; p = 0.05$, Fig. 1). The effect on PTH was the opposite with a significant difference being seen in the winter and values converging in the summer ($F_{1,11} = 5.4; p = 0.05$). The effect of gender, medication, menstrual history and overseas travel did not have a significant influence on the serum 25(OH)D levels.

### 4. Discussion

The purpose of the current study was to investigate serum 25(OH)D levels together with other markers of bone metabolism at 2 time points in the year (winter and summer) in a group of professional dancers based in the UK. We found a significant increase in serum 25(OH)D between the winter and summer test dates and significant decreases for PTH and PINP over the same time period. The oral contraceptive had a significant positive effect on serum 25(OH)D levels seen in this group of dancers would be vitamin D supplementation.

We were also able to show an inverse correlation between serum 25(OH)D and PTH, a well-recognized association. In its extreme form, a low serum 25(OH)D can lead to secondary hyperparathyroidism. None of the dancers in our study reached this level of disordered metabolism. However, the low serum 25(OH)D seen in the winter was associated with a significantly higher PTH than in the summer. The bone turnover markers were also higher in the winter (which reached the level of statistical significance for P1NP but not for CTX). However P1NP and CTX were significantly correlated with each other, both in the winter and summer. P1NP is a sensitive marker of bone formation while CTX is a marker of bone resorption, if bone turnover is in balance there should be a correlation between these formation and resorption markers. These findings indicate that the observed changes in the blood markers, when serum 25(OH)D is low in the winter months PTH rises and bone turnover increases compared to summer, is a genuine effect.

Persistently low serum 25(OH)D in a population doing regular intensive exercise is likely to increase the risk of injury. It has been suggested, for instance, that insufficient serum 25(OH)D status may increase risk for frequent injury and illness in college athletes. Also, large cohort studies on the Israeli and Finnish military have both shown that the incidence of stress fractures was correlated with low serum 25(OH)D and high PTH. Although no bone stress injuries were found in the present study, there was a higher incidence of soft tissue injuries during the winter months. There are several possible explanations for this observation including the lower serum 25(OH)D which is also known to have an adverse effect on muscle function. However we detected no significant associations between the rise in 25(OH)D from winter to summer and the fall in injury incidence. Although this may have been due to the relatively low power of the current study, there are other possible explanations. For instance, although the hours of dancing were controlled between winter and summer, the type of activities within these training hours could not be controlled. Furthermore in the summer, our dancers had just returned from a 5-week holiday trip.
and were probably less fatigued during this data collection period compared to the winter one, as previously suggested. Further studies on a larger cohort of dancers and other indoor athletes looking at injury incidence and measurement of muscle performance may help to shed further light on this aspect of serum 25(OH)D function.

Our study was also able to identify potential effects of the oestrogen-containing oral contraceptive. Those on this medication had lower bone turnover markers than those menstruating naturally, as previously suggested. They also demonstrated higher levels of 25(OH)D compared to those who received no oral contraceptives. This may be due to the fact that oral contraceptive can alter the relative proportions of free and protein bound 25(OH)D by influencing levels of vitamin D binding protein thereby causing the observed increase in serum 25(OH)D levels. Of greater surprise was the fact that the increase in serum 25(OH)D levels from winter to summer and the associated fall in PTH during the same period was greater in those taking the oral contraceptive. There is no clear explanation for this observation.

It is reasonable to assume that the present results may have been influenced by the relatively low number of participants. The low number of participants resulted from the need to control the dancers’ workloads, including performance and travel schedules and this was most easily achieved using just one dance company which immediately limits the number of potential volunteers. The need for participants to have fasted overnight also affected the total numbers. Dancers with morning rehearsals needed to eat prior to coming into the company, so fasting would have been detrimental to their work schedule (6–8 h of physical work per day).

5. Conclusion

We have shown a high incidence of serum 25(OH)D insufficiency/deficiency in a group of professional dancers which only improved marginally during the summer months. The effect of low serum 25(OH)D levels on bone markers has been shown. The increased incidence of injuries in the winter compared to summer was not linked to serum 25(OH)D levels. Further studies on the impact of vitamin D3 supplementation on markers of bone metabolism, muscle function and injury profile would help to enhance our understanding of this important area of metabolism in athletes/dancers.

Practical implications

The study has also highlighted the possible need to monitor serum 25(OH)D levels during summer periods as well for these populations.

For female athletes there is a potential benefit of oral contraception having a metabolic effect on bone metabolism in conjunction with increased sunlight exposure.

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