Prevention of Athletic Injuries Through Vitamin D Supplementation

Tylan Rogers
Pacific University

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Prevention of Athletic Injuries Through Vitamin D Supplementation

Abstract

Background: Rates have been reported in some populations of up to 90% of individuals at sub-optimal levels of vitamin D (<32mg/ml). Athletes are not excluded from these populations. In fact due to indoor training, winter seasons, etc, some athletes are more prone to decreased levels of vitamin D. With recent studies showing the benefits of adequate levels of vitamin D improving an individual's musculoskeletal and general overall health, the question emerges: is there a cause and effect between decreased levels of vitamin D and increased frequency of injuries? Therefore, would supplementation of vitamin D aid in the prevention of athletic injuries?

Methods: An extensive research process was done using relevant databases including EBSCO-Host, CINAHL, Evidence Based Medicine-Research, MEDLine, Web of Science, Google Scholar, and Cochrane CENTRAL. Key words used during the search were “vitamin D” and “athletic injuries.” Inclusion criteria included articles that looked at competitive athletes, had at least two groups by comparing a placebo group to a vitamin D supplementation (without calcium supplementation) group, and looked at the rate of occurrence of injuries between the vitamin D and placebo supplementation groups. Articles were excluded if not in English. Relevant articles were assessed for quality using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE).

Results: Two randomized control trial (RCT) studies met inclusion criteria and were included in this systematic review. Lewis et al demonstrated that all athletes were at sufficient vitamin D levels at baseline testing and there appeared to be no decrease in injuries with additional vitamin D supplementation. However, the majority of the injuries reported occurred soon after an observed drop in vitamin D levels in most athletes. Wyon et al was a RCT that looked at 24 elite professional ballet dancers. All the dancers were below 32ng/ml of vitamin D at baseline testing. The study ended by showing only 29% of the athletes in the vitamin D supplementation group receiving injuries and the placebo group had numbers equivalent to 100% of the athletes suffering from injuries.

Conclusion: Vitamin D deficiency and insufficiency is just as prevalent in the athletic population as in the general population. All athletes should be screened by health care providers if they have not been recently to evaluate their serum vitamin D levels. Athletes who are already at optimal levels of vitamin D may not benefit from additional supplementation of vitamin D. However, those athletes who have vitamin D levels <32ng/ml may be able to prevent athletic injuries simply by adding a supplementation of vitamin D to their daily routine.

Key Words: Vitamin D, athletes, injuries

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Keywords
Vitamin D, Athletic Injuries
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Prevention of Athletic Injuries Through Vitamin D Supplementation

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A Clinical Graduate Project Submitted to the Faculty of the
School of Physician Assistant Studies
Pacific University
Hillsboro, OR

For the Masters of Science Degree, August 8, 2015

Clinical Graduate Project Coordinator: Annjanette Sommers, PA-C, MS
Abstract

**Background:** Rates have been reported in some populations of up to 90% of individuals at sub-optimal levels of vitamin D (<32mg/ml). Athletes are not excluded from these populations. In fact due to indoor training, winter seasons, etc, some athletes are more prone to decreased levels of vitamin D. With recent studies showing the benefits of adequate levels of vitamin D improving an individual’s musculoskeletal and general overall health, the question emerges: is there a cause and effect between decreased levels of vitamin D and increased frequency of injuries? Therefore, would supplementation of vitamin D aid in the prevention of athletic injuries?

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observed drop in vitamin D levels in most athletes. Wyon et al was a RCT that looked at 24 elite professional ballet dancers. All the dancers were below 32ng/ml of vitamin D at baseline testing. The study ended by showing only 29% of the athletes in the vitamin D supplementation group receiving injuries and the placebo group had numbers equivalent to 100% of the athletes suffering from injuries.

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**Key Words:** Vitamin D, athletes, injuries
Biography

Tylan Rogers earned a double major in Health, Fitness, and Wellness and Athletic Training from Whitworth University in 2009. He went on to work as the head Athletic Trainer for a semi-professional baseball team in Maui, Hawaii as well as at a local high school for several years before transitioning in the role of Athletic Director. Realizing his passion for medicine, he chose to continue his education at the University of Hawaii studying biology and chemistry before accepting a position at Pacific University in the Physician Assistant Program. After graduation he hopes to continue to work with athletes and help integrate the role of PA’s into more non-traditional areas of sports medicine.
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<th>Abbreviation</th>
<th>Definition</th>
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</thead>
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<tr>
<td>1,25(OH)\textsubscript{2}D</td>
<td>1,25 Hydroxy vitamin D</td>
</tr>
<tr>
<td>25(OH)D</td>
<td>25-Hydroxy vitamin D\textsubscript{3}</td>
</tr>
<tr>
<td>AMP</td>
<td>Antimicrobial Peptides</td>
</tr>
<tr>
<td>ATC</td>
<td>Certified Athletic Trainer</td>
</tr>
<tr>
<td>ATP</td>
<td>Adenosine Triphosphate</td>
</tr>
<tr>
<td>BMC</td>
<td>Bone-Mineral Content</td>
</tr>
<tr>
<td>BMD</td>
<td>Bone-Mineral Density</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>Ca++</td>
<td>Calcium</td>
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<tr>
<td>FT</td>
<td>Fat Mass</td>
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<tr>
<td>GRADE</td>
<td>Grading of Recommendations, Assessment, Development, and Evaluation</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>--------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>IBS</td>
<td>Inflammatory Bowel Disease</td>
</tr>
<tr>
<td>IU</td>
<td>International Units</td>
</tr>
<tr>
<td>MET</td>
<td>Metabolic Equivalent of Task</td>
</tr>
<tr>
<td>MFL</td>
<td>Mineral-Free Lean Mass</td>
</tr>
<tr>
<td>MOA</td>
<td>Mechanism of Action</td>
</tr>
<tr>
<td>NFL</td>
<td>National Football League</td>
</tr>
<tr>
<td>NNT</td>
<td>Number Needed to Treat</td>
</tr>
<tr>
<td>PLA</td>
<td>Placebo Daily Group</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized Control Trail</td>
</tr>
<tr>
<td>RR</td>
<td>Relative Risk</td>
</tr>
<tr>
<td>TNF</td>
<td>Tumor Necrosis Factor</td>
</tr>
<tr>
<td>URI</td>
<td>Upper Respiratory Infections</td>
</tr>
<tr>
<td>UVB</td>
<td>Ultra-Violet B Radiation</td>
</tr>
<tr>
<td>VIT D</td>
<td>Vitamin D Daily Group</td>
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Metaanalysis; Prevention of Athletic Injuries Through Vitamin D Supplementation

Background

Athletes who practice indoors versus outdoors, levels of melanin in their dermis (according to race), time of season (eg, winter has less UVB exposure), where the athletes live (above or below 35-37 degrees North and South latitude), and athletes’ diet are all contributing factors in vitamin D levels. With as many factors as these playing a role in determining an athlete’s vitamin D status, it comes as no surprise that many athletes may be performing at sub-optimal levels. In order to fully assess and appreciate all these components of the vitamin D deficiency problem, one must have a basic understanding of the complexity of vitamin D synthesis and the process that it goes through to reach its active form of 1,25 hydroxy vitamin D (1,25(OH)2D) in the body.

Vitamin D is a secosteroid that is produced through cutaneous absorption of ultraviolet B radiation (UVB) that is then converted to 7-dehydrocholesterol and further converted to previtamin D. Previtamin D is converted to vitamin D3 (cholecalciferol) in the dermis. From here vitamin D3 is taken to the liver where it transforms to become 25-hydroxyvitamin D (25(OH)D). 25(OH)D is then transported to the kidney where it is converted one last time via hydroxylation to the active form 1,25 hydroxy vitamin D (1,25(OH)2D). Vitamin D functions as a modulator for over 1000 genes making it vital to everyday health and well being. It is involved in cellular growth, protein synthesis, intestinal calcium absorption, osteoclastic activity, muscle strength, size, reaction time, balance, coordination, endurance, inflammation, as well as numerous other musculoskeletal, cardiovascular and immune system functions. This leads to vitamin D
impacting multiple pathologies, such as chronic and autoimmune diseases, hypertension, diabetes, inflammatory bowel disease (IBS), depression, multiple sclerosis, rheumatoid arthritis, and certain types of cancer. 1,3-7 According to one recent study,3 50-70% of children and adolescents are vitamin D deficient and over 75% of Caucasians and 90% of African Americans and Latinos are vitamin D deficient. What is staggering is the fact that from 1994 to 2004 vitamin D deficiency rates have doubled.3

Several factors influence this including, but not limited to, the increase in sun avoidance, overuse of sun block, and generally rising rates of obesity which causes sequestration of this fat-soluble vitamin. While some vitamin D is obtained through diet, the body’s main source of vitamin D is through ultraviolet B radiation (UVB). Fatty fish such as mackerel, salmon, sardines, and tuna are the best food source for vitamin D. Other vitamin D rich foods include egg yolks, selected brands of cereal, yogurt, margarine, and fortified milk and orange juice. Consuming 100 IU of vitamin D3 per day only increases serum levels by 1 ng/ml.3 But with the current recommended vitamin D sufficiency levels being 25-hydroxyvitamin D3 (25(OH)D) above 30 ng/ml, it’s easy to see how individuals need more than just a proper diet to reach these goals. The recommended standard goal is to consume 200 IU of vitamin D per day through diet. The difference leaves an average of up to 2000 IU of supplementation needed daily to achieve optimal levels of vitamin D3 in individuals at sub-optimal levels.2 This is why the primary source of obtaining vitamin D is through UVB exposure to the sun. To make things even more complicated is the fact that just because one is outside doesn’t mean they are effectively absorbing vitamin D.

During the winter months if one is above or below the latitudes of 35-37 degrees north or south they are effectively converting zero percent of the UVB to which they are exposed to
vitamin D. In 2012, Sports Health goes as far as to write that the only demographic group who can achieve optimum levels of 25(OH)D naturally is lifeguards following a full summer of sun exposure. The journal of Dance Medicine & Science looked at 16 male ballet dancers from the Australian Ballet School and found only 44% of the dancers were within optimal levels of 25(OH)D. Another study looked at 89 National Football League (NFL) players and found that 27 players (30%) were 25(OH)D deficient (<20ng/ml), 45 players (50%) were insufficient (<32ng/ml), leaving only 17 players (20%) within normal ranges (>32ng/ml). This same study went on to find that the mean levels of vitamin D in Caucasian athletes was 30.3ng/ml, but for African American players mean levels were 20.4ng/ml.

Because of the vast amount of uses the body has for vitamin D, a deficiency may lead to any number of health issues among individuals. One article suggests that adults with low levels of vitamin D have a 26% higher chance of dying prematurely due to heart disease than those with adequate levels. Another focuses on how insufficiencies are associated with increased risk of stress fractures, decreased muscle performance, and increased sick days. Some look more specifically at how maximal oxygen consumption and top physical performance is positively associated with adequate levels of vitamin D. Recent studies demonstrate the direct link of increased amounts of pro-inflammatory cytokines including TNF-alpha and interleukin-6 with a decreased level of serum 25(OH)D. It is clear that by not having sufficient levels of 25(OH)D there is a vast array of complications that this could result in. Little research has been done looking specifically at the cause and effect relationship between sub-optimal levels of 25(OH)D and incidence of athletic injuries.
Methods

An extensive research process was done using relevant databases including EBSCO-Host, CINAHL, Evidence Based Medicine-Research, MEDLine, Web of Science, Google Scholar, and Cochrane CENTRAL. Key words used during the search were “vitamin D” and “athletic injuries.” Inclusion criteria were articles that looked at competitive athletes, had at least two groups comparing a placebo group to a vitamin D supplementation group, and had measured the rate of occurrence of injuries between the vitamin D and placebo supplementation groups. Articles were excluded if they didn’t have a group receiving vitamin D, if any calcium was included in any of the supplementation groups, or if the articles were not in English. Relevant articles were assessed for quality using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE).11

Results

Initial search results included 63 total articles. After applying all inclusion and exclusion criteria only two articles remained both being randomized control trials (RCT).12,13 See Table I.

Lewis et al

This study12 looked at the effects of season-long vitamin D supplementation in collegiate swimmers and divers. It took place over 6 months and had a double-blind, randomized, placebo controlled vitamin D supplementation intervention. The study was conducted in the United States at a southeastern NCAA Division 1 University at a location of latitude 38 degrees north. It included both male and female athletes over the age of 18 with medical screening performed on all participants. Exclusion criteria included pre-existing medical conditions that may cause potential harm to the individual or may affect the results of the study. This study was approved.
by the institutions review board and all eligible participating athletes signed a written consent before the initiation of the study at the start of the season. Collegiate swimming and diving season begins in August so this is when baseline measurements were taken. Baseline measurements included a blood draw, body composition measurements, anthropometric measurements, and a lifestyle questionnaire.\textsuperscript{12}

Blood draw consisted of 20ml of whole blood being collected from the antecubital vein for baseline measurements between the times of 2:00pm-5:00pm. Mid-point blood collection was taken between 10:00am-1:00pm. End point blood collection was taken between 8:00am-4:00pm. Measurements of importance included 25(OH)D, PTH, bone turnover markers, and inflammatory cytokines. All blood was analyzed by The University Biospecimens Core of the Center for Clinical and Translational Science.\textsuperscript{12}

Body composition and anthropometric measurements were obtained using a dual energy x-ray absorptiometry (DEXA) scan of the total body, vertebrae L1-L4, and proximal dual femurs. The athletes’ height and weight were also used to calculate their body mass index (BMI) at baseline and endpoint.\textsuperscript{12}

A lifestyle questionnaire was obtained before every blood draw and used to asses external factors that may affect the athletes’ levels of vitamin D and thus affect the study. Diet, other supplementation, sun light exposure, and indoor versus outdoor activities were of main concern. All training sessions were recorded including date, duration, and intensity in hopes of finding a correlation with inflammatory cytokines. Female athletes also kept track of menstrual periods and oral contraceptive use.\textsuperscript{12}
A side analysis was done throughout this study which looked at the incidence of illness and injury. Certified athletic trainers (ATC) reported cases of bone, muscle and connective tissue injury not caused by an acute traumatic incident. They also recorded incidences of common cold, influenza, upper respiratory infections (URI), and gastroenteritis on a monthly basis.\(^{12}\)

Athletes were randomly assigned to either a group supplementing 4000 IU of vitamin D daily (VIT D) or to the placebo group (PLA). The athletes as well as the personnel distributing the intervention were blinded for this process. All athletes began supplementation interventions the middle of September. In December a midpoint analysis was done that included blood measures and a lifestyle questionnaire. A final endpoint analysis was done in March which repeated all baseline measurements. This study began with a pool of 60 male and female swimmers and divers. From this group only 45 met eligibility requirements and they underwent baseline measurements. Only 32 athletes completed the full 6 months of intervention (VIT D \(n=19\), PLA \(n=13\)).\(^{12}\)

Vitamin D status of all athletes at baseline showed no one to be deficient or \(25(OH)D < 20 \text{ ng/ml}\). In fact \(25(OH)D\) concentrations were greater than or equal to 32ng/ml in all athletes. Mean measurements of \(25(OH)D\) at baseline was \(57\pm/-\ 16 \text{ ng/ml}\), \(57\pm/-\ 19 \text{ ng/ml}\) at mid point, and \(50\pm/-\ 16 \text{ ng/ml}\) at end point. In the fall, \(88\%\) \((n=23)\) of athletes were able to keep concentrations of \(25(OH)D\) above \(40\text{ng/ml}\). In the winter that dropped to \(81\%\) \((n=26)\) and only \(69\%\) \((n=22)\) in the spring.\(^{12}\) At the end of the 6 month intervention changes in \(25(OH)D\) were examined. The top 25\% of athletes that showed the greatest improvement in \(25(OH)D\) levels were all from the VIT D group. Inversely, the athletes that showed the least improvement or greatest decrease in \(25(OH)D\) concentrations were all from the PLA group minus one athlete from the VIT D group whose compliance had dropped to zero. When looking at blood marker
changes it was found that all athletes had normal (4.6mg/dL to 5.6mg/dL) ionized calcium levels at midpoint. At no point during the 6 month intervention was there a difference in inflammatory cytokines between VIT D and PLA supplementation groups that was appreciated. Furthermore, there appeared to be no correlation between inflammatory cytokines and 25(OH)D levels nor did a change in one seem to affect the levels of the other.12

When looking at the athletes’ body compositions there were no significant differences between VIT D and PLA groups. Mineral-free lean mass (MFL) was \( p=0.8 \), fat mass (FM) was \( p=0.6 \), bone mineral density (BMD) was \( p=0.3 \), and bone mineral content (BMC) was \( p=0.4 \). When comparing swimmers to divers also no significant difference was appreciated (MFL \( p=1.0 \); FM \( p=0.9 \); BMD \( p=0.4 \); BMC \( p=0.9 \)).12 An interesting discovery was how 25(OH)D affected men and women differently over the course of this study. At the end of the 6 months changes to total body, proximal dual femur, and lumbar spine BMD and BMC were unaffected by the intervention of 25(OH)D in both men and women. In men however there was a direct connection to increases in total MFL and MFL of the trunk in the 25(OH)D intervention group (\( p=0.03 \) and \( p=0.04 \) respectively). The android region (\( p=0.02 \)) and left femoral neck (\( p=0.03 \)) also showed improvement in men in the VIT D supplementation group. The female athletes on the other hand had completely different results. In the 25(OH)D intervention group right femoral neck BMD and BMC as well as right femoral Ward’s region BMD, increases were found to be related to similar increases in 25(OH)D (\( p<=0.05 \) and \( p=0.02 \)). Right femoral neck bone density increased (0.003 +/- 0.04g/cm\(^2\)) while the left side femoral neck bone density decreased (-0.006+/-0.03g/cm\(^2\)).3 An interesting fact to take note of was 92% of females in this study reported being right leg dominate. This might help account for the apparent changes in the right side when compared to the left.12
When examining the incidence of injury, 13 athletes were found to have sustained at least one injury (VIT D $n=9$; PLA $n=4$) while three athletes developed multiple injuries. This results in a relative risk of 1.25 where there were more injuries in the vitamin D supplementation group. While the injuries were confined to muscle ($n=7$) and connective tissue ($n=9$) most of these injuries occurred during the winter and spring months when 25(OH)D concentrations were the lowest. Also it was found that in 77% ($n=10$) of athletes that sustained an injury there had recently been a clear decrease in 25(OH)D levels (-11ng/ml to -47ng/ml loss).\textsuperscript{12}

\textbf{Wyon et al}

This study\textsuperscript{13} looked at elite ballet dancers and how specific physical fitness abilities as well as musculoskeletal injuries may be related to vitamin D deficiencies. Ballet dancers are very unique athletes in many ways. First they must be able to perform at a high level of physical fitness in order to best articulate their power, precision, grace, and attention to detail in their highly artistic form of dance. Second, they train almost exclusively indoors, predisposing them to potential 25(OH)D deficiency. For this study a single touring professional ballet company was used. The same ballet company had their serum 25(OH)D monitored the previous year and it was found that all dancers had either insufficient levels of 25(OH)D (10-30ng/ml) or deficient levels (<10ng/ml). Of this entire dance company, only 15% of dancers were able to achieve normal levels of 25(OH)D following the summer months and maximal sun exposure. Currently the nationally accepted definition of vitamin D sufficiency is 25(OH)D above 30ng/ml. Due to the severity of 25(OH)D deficiency across the board in all dancers it was clinically prudent to start supplementation in everyone in order to bring levels back within normal ranges. Because of this, volunteers were needed for the placebo group in order to perform this study with the knowledge that they would begin 25(OH)D supplementation at the end of the observational period. Seven
dancers volunteered to be a part of the placebo group (male $n=2$; female $n=5$) and 17 dancers agreed to be a part of the intervention group (male $n=9$; female $n=8$). The VIT D supplementation group received 2000 IU of vitamin D daily in tablet form for the four month period. Since all dancers were from the same company, all activity, practice and performances were considered similar between the two groups. The Ethics Review Committee from the lead author’s University approved all research protocol before the start of the study. The study was conducted from the months of January to May with baseline measurements gathered at latitude 52 degrees 29’N. Muscle strength, power, injuries and overall statistical analyses were the primary areas of focus. On top of this a lifestyle questionnaire was given to all participants covering activity levels, medications, overseas travel, menstrual history and oral contraception.

Muscular strength was observed through an isometric quadriceps contraction for five seconds on the dominant leg. Dancers were given five trial runs to understand the test and then three separate sets were preformed for five seconds each of maximal quadriceps contraction. The highest score of the three sets was recorded. Visual feedback and verbal encouragement was given throughout the test.

Muscular power was assessed using a vertical jump. All dancers began in a dance first position (heels together, hips externally rotated), performed a demi-plié (half squat) and then jumped as high as they could. The test was conducted on a jump meter and the highest of three scores was recorded.

Statistical analyses was obtained using a 3-way ANOVA with repeated measures. The two between-subjects being “group” (VIT D or PLA) and “gender”, while the within-subject being “time” (pre vs. post intervention).
Injuries were classified by a time-loss criteria. That being, if a dancer was unable to perform or take part in all dance related activities for longer than 24 hours, they were considered to be injured. There were 3 full time physiotherapists who reported all injuries on a standardized report form. Injuries were then further classified as transient (return within 7 days), mild (return within 7-28 days), and severe (return after 84 days).

Isometric strength results through the ANOVA showed the main effect was due to “gender” and “time.” The pre isometric strength versus post isometric strength for the PLA group was -1.79N (95% CI was -143.98 to 140.39). For the VIT D group it was -190.32N (95% CI was -276.61 to -104.02). For vertical jump again the main difference that ANOVA identified was due to “gender” and “time.” Pre vertical versus post vertical in the PLA group was 0.714cm (95%CI was -0.93 to 2.36) and -3.05cm (95%CI was -4.05 to -2.06) for the VIT D group. See Figure I.

Injury reports from the physiotherapists were collected and analyzed at the end of the study. Of the seven dancers that volunteered for the PLA group five reported one injury, one reported two injuries, and one reported no injuries. The VIT D intervention group had five dancers report one injury and 12 dancers report no injuries. Specifically, 26% of the vitamin D group experienced an injury while 100% in the control group had injuries (a risk reduction of 74%). All injuries were classified as “mild” leaving the dancer out for 7-14 days and involved only muscle spasms, strains, or tears. “The Mann-Whitney U analysis of injuries also identified a significantly higher number of injuries in the control (1.87/1000h) compared to the intervention group (0.55/1000h)(p=0.005).”
Discussion

Though the studies illustrate that vitamin D intervention on athletes can cover issues from body and bone composition to muscle strength and performance, the original question remains; can vitamin D supplementation aid in the prevention of athletic injuries? The research on this particular question is minimal but provides promising data. The studies do at first seem to be contradictory with the vitamin D group in the Lewis et al study\textsuperscript{12} demonstrating more injuries than the control group; however, it was noted that the majority of these injuries (77\%) occurred after a recent and significant decline in the participants’ vitamin D level. In the Wyon et al study\textsuperscript{13}, it was clearly demonstrated that the low and unsupplemented vitamin D levels carried a greater incidence of injury (a relative risk reduction of 74\%).

Recent studies have shown that having increased 25(OH)D levels leads to improved health, body composition and performance.\textsuperscript{14,15} However when looking at the data from Lewis et al\textsuperscript{12} we see 13 different athletes who sustained injury (VIT D $n=9$; PLA $n=4$). Coming from the two different supplementation groups (VIT D $n=19$; PLA $n=13$) this leaves us with an EER of 0.474 and a CER of 0.308 giving us a final relative risk (RR) of 1.25. This is shocking data after hearing multiple studies pushing the use of vitamin D supplementation in athletes. The Lewis et al study\textsuperscript{12} was unique in the fact that at baseline measurements there were no athletes deficient in vitamin D levels (<32ng/ml). Most other studies primarily look at individuals who have deficient or insufficient levels of vitamin D at the initiation of vitamin D intervention. The Wyon et al study\textsuperscript{13} for example looked at an entire professional company of ballet athletes and found that every single athlete was operating at below optimal levels (<32ng/ml). Their data was significantly different showing only 29\% of the vitamin D intervention group receiving injuries (Total VIT D $n=17$; injuries $n=5$) while the control group had a 100\% occurrence rate (Total
PLA $n=7$; injuries $n=7$). This gave a final number needed to treat (NNT) of 1.4. This is a powerful statistic because it shows that for every two athletes that are treated with a 25(OH)D intervention due to sub-optimal levels, an injury will be prevented in one of them. To summarize the data of both studies we can conclude that vitamin D supplementation in athletes who are below optimum levels of concentration ($<32\text{ng/}ml$) may indeed lead to a decreased number of athletic injuries. Keeping in mind the numerous limitations to the Lewis et al study, their data suggests that supplementing vitamin D in athletes who already have sufficient levels may prove to have negative effects when looking at athletic injuries. It is because of this that all athletes should be screened by a health care professional before the initiation of vitamin D supplementation.

Moreover, in regards to the other outcomes measured in the Lewis et al study\textsuperscript{12}, the most important thing to note was that swimmers and divers were injured more in the winter months particularly after they had a drop in vitamin D levels just prior to becoming injured. This leaves one to believe that an inadequate level of vitamin D could in fact predispose someone to athletic injuries. Athletes who practice indoors are already at risk of not being able to maintain adequate levels of 25(OH)D but this observed drop of vitamin D concentrations during winter months significantly compounds the issue.\textsuperscript{16} Both these factors make it easy to see how vitamin D supplementation among this athletic population, specifically during the winter months, becomes clinically prudent in those athletes known to be deficient. Taking it a step further, it has been found that low levels of vitamin D during the spring months is directly correlated with an increase in frequency of the common cold, influenza, URI, and gastroenteritis.\textsuperscript{17} This is most likely due to the fact that vitamin D has been shown to up-regulate the occurrence of antimicrobial peptides (AMP) which are a powerful part of the body’s immune response that
compromises the integrity of invading pathogen’s cell membranes. This leads us to think that continual vitamin D supplementation throughout the spring months may be also advised in all deficient athletes.

The Lewis et al study produced unexpected results because baseline measurements showed that there were only a few athletes who were vitamin D insufficient (25(OH)D <32ng/ml) and found no athletes to be deficient (25(OH)D <20ng/ml). This is surprising because in recent studies, including two done in 2011, up to 61% of athletes had 25(OH)D concentrations at levels below 32ng/ml at baseline. There are many potential factors that may have led to this finding. It is important to note that this test was conducted primarily on Caucasian individuals, as that is who comprised the team. There was a total of one Asian in the PLA group, two Latino’s in the VIT D group, and 29 Caucasians VIT D \( n= 17 \) and PLA \( n=12 \). Again, this was a randomized placebo controlled trial so the allocation of race to PLA or VIT D groups was not predetermined. The team also participated in outdoor team training in the fall at the beginning of the season. Since the University was located at latitude 38 degrees, this means that anytime the sun was out from the months of March to October the body could readily convert UVB exposure to vitamin D. After October, however, anytime spent outside did not result in UVB conversion due to the latitude of the University. Although the total team time spent with potential UVB exposure was only 2-3 hours a week, the team was made up of primarily Caucasians with minimal melanin in their dermis that allowed for maximal absorption and conversion of UVB. The potential results being elevated 25(OH)D concentrations at baseline measurements. Had the team been more ethnically diverse and consisted of athletes with a much higher melanin concentration to their skin then this minimal UVB exposure would have converted only trace amounts, if any, UVB to vitamin D leaving more athletes in the deficient or
insufficient range. This could be a reason as to why baseline measurements of 25(OH)D concentrations were much higher than expected. This being said, even with the elevated 25(OH)D concentration levels in the athletes at baseline 16% of all athletes who participated in this 6 month study ended with a 25(OH)D concentration level of <32ng/ml.

When looking at the body composition of the athletes at the conclusion of this study\textsuperscript{12}, it was interesting to see how different 25(OH)D intervention affected men as opposed to women. Men showed a direct correlation between increases in 25(OH)D levels and increases in MFL, while there was no similar affect to MFL in woman. This correlation, as well as the fact that vitamin D is a vital component to type 2 muscle fiber synthesis has been shown in the past.\textsuperscript{14,22,23} While it is known that men have the ability to gain muscle mass at a quicker rate than woman, this doesn’t mean that women still wouldn’t receive a benefit from supplementation of vitamin D. In 2005 Sato et al\textsuperscript{23} did a randomized control trial which looked specifically at women and found that both the size and number of type 2 muscle fibers increased with the intervention of 25(OH)D. This suggests that women can in fact see increases in protein synthesis via vitamin D supplementation just at a slower rate than men.

BMD and BMC resulted in no changes at the end of the 6 months. At first this was surprising because numerous other studies have shown the extensive benefits of vitamin D supplementation to improve BMD and BMC.\textsuperscript{24,25} However, when considering the population of athletes is comprised of swimmers and divers, this shines a new light on the matter. Season long loss of bone mass is not uncommon to see in these athletes due to the non-weight bearing nature of this sport.\textsuperscript{26,27} Taking that into consideration, while there was no increase in bone mass, the fact that there was no decrease in bone mass may lead to the conclusion that 25(OH)D intervention led to a preservation of existing bone mass instead of a likely decrease.
The Wyon et al\textsuperscript{13} study’s significance lies in the concluding numbers of the study that show only 29\% of the VIT D group became injured while 100\% of the PLA group was injured. Also, through the use of ANOVA, the researchers were able to qualitatively demonstrate the extent of increased performance difference between PLA and VIT D intervention groups. There was a total of a 19\% increase in isometric quadriceps strength between the VIT D intervention group and the PLA group.\textsuperscript{13} This falls within a suspected range when compared to other studies looking at only isometric quadriceps strength of a 25(OH)D intervention group, as one reported an increase of 24\% while the other reported a 8.5\% increase.\textsuperscript{28,29} Both of these other studies showed increase in quadriceps isometric muscle strength after supplementation of 800 IU daily of vitamin D for 6 month and 90 000 IU per month for 4 months. The main difference between these three studies, however, is that Wyon et al\textsuperscript{13} looked at athletes who were exerting an average of 2.2 \( \pm 1.54 \) METs of activity per day over 6-8 hours of dancing with the mean age being 26 \( \pm 4.57 \) years old. Both of the other studies\textsuperscript{28,29} were looking at an elderly population, which makes this article more much more relevant in terms of answering our clinical question.

It is impossible to talk about muscle strength without also talking about the different types of muscle fibers involved. Muscle strength involves the recruitment of fast twitch or type 2 muscle fibers. It is these same fast twitch fibers that are involved in muscle power. While we saw a dramatic 19\% increase in muscle strength in the VIT D intervention group we also saw a 7.2\% increase in muscle power in that same group.\textsuperscript{13} This could suggest that vitamin D plays a separate role in muscle strength and muscle power and just affects muscle strength more effectively. It also could suggest that fast twitch type 2 muscle fibers, regardless of how they are delineated in the body, all respond in a positive way with increased performance when supplemented with vitamin D. One older study suggests that ATP content in muscle cells is
directly increased with increased vitamin D supplementation. A more recent study breaks down 25(OH)D in more detail and looks at three different possible effects that could play out on select muscle receptors which could therefore lead to increased muscle performance. These three mechanisms of actions (MOA) are “control of serum calcium concentration, which has a direct effect on muscle contraction; the possible direct action on muscles to induce expression of specific genes (Ca++ ATPase enzyme) thereby altering calcium handling by the muscle cell; and dividing myoblast and inducing differentiation to multinucleated non-dividing myotubes.”

While further studies that continue to break down and decipher these effects more specifically are needed, it is apparent that regardless of the MOA, vitamin D supplementation has a positive effect on muscle performance when compared to a PLA group.

So it appears that VIT D intervention affects muscle performance, but does this prove a cause and effect of VIT D intervention and number of injuries seen in athletes? In 2012, the Journal of Orthopedics Sports Physical Therapy looked at the injury incidence and severity to ballet dancers over the course of one year. What they found was that among the professional dancers they were observing, almost 50% reported having to miss anywhere from 1-6 days due to an injury, most commonly to the low back, pelvis, legs, knees, or feet. The Wyon et al study showed us objectively that while there were injuries to both VIT D and PLA groups, there were drastically less injuries to the VIT D intervention group. While it is unclear why exactly this was the case, it is still medically significant to take note of. Was it because of the simple fact that there was an increase in fast twitch muscle fiber performance leading to increased proprioception and thus decreasing injuries? Or did 25(OH)D have other benefits outside of its interaction on muscle receptors that needs more research done to uncover and expose? What the Wyon et al study did show us was that in the young, indoor trained athlete,
where there is a known risk of vitamin D insufficiencies, there appeared to be a direct correlation with increased levels of vitamin D and subsequent decrease in frequency of injuries.

Despite these remarkable findings, both studies had limitations. See Table I. Both studies\textsuperscript{12,13} had a small sample size and included fairly nondiverse populations. The Lewis et al study\textsuperscript{12} had the swimming and diving team from only one University being observed, this resulted in an extremely limited starting pool of athletes to pull from. This becomes important when looking at the precision of this study and how to apply it clinically. The use of tanning beds, while included in the lifestyle questionnaire, was recorded only if reported by the athlete. Human error in forgetting to report, or over reporting, becomes an issue as UVB due to tanning directly correlates to increased levels of vitamin D concentrations. This swim team was comprised of primarily Caucasians leading to another limitation. Had the team been more ethnically diverse we might have seen a greater number of sub optimal 25(OH)D levels at baseline due to less effective conversion of UVB during outdoor fall training. In regards to the Wyon et al study\textsuperscript{13}, the issues start with the way the study was set up. From the start it was a challenge because at baseline all participants were below optimum minimal levels of vitamin D (<32ng/ml).\textsuperscript{1} Because of this, it was decided ethically pertinent to recruit for volunteers to consent to be a part of the PLA group because this would potentially leave them at deficient or insufficient levels throughout the study. Due to this needed ethical step blinding was impossible. In order to standardize the level of activity and METs used on a regular basis, only one professional dance company was observed for this study. While this was an effective method, it subsequently left a small pool of athletes who participated in the study.
Conclusion

With vitamin D deficiency being as high as 75-90% in the general population, athletes should start considering vitamin D supplementation. However, there are many known factors that inhibit an athlete’s body from reaching adequate levels of vitamin D: whether they practice and perform indoors versus outdoors, the level of melanin in their dermis, season the year, latitude they live at, and their diet are of primary concern. The results of these studies, though small and limited in scope, show that there are many health factors to be considered with vitamin D insufficiency or deficiency. Athletes who are found to be at sub-optimal levels of 25(OH)D (<32ng/ml) appear to benefit from supplementation according to preliminary research as there may be a link between adequate levels of 25(OH)D and a decrease in athletic injuries. Athletes at or above 32ng/ml of 25(OH)D didn’t see any benefit from additional supplementation. However, the majority of injuries to this group occurred after a significant drop in 25(OH)D. This supports the idea that maintaining adequate levels of 25(OH)D may indeed help in the prevention of athletic injuries.

A definite clinical recommendation for athletes to avoid injury by supplementing with vitamin D cannot be made at this time based on the limited amount of research and the lack of primary research on the subject. However, the preliminary research and secondary data from available studies is promising. Because vitamin D is inexpensive, low risk, and could provide great health benefits and injury prevention, clinicians can safely recommend supplementation of vitamin D to athletes at sub-optimal levels until further research has been completed.
References


10. Michos, E, 'Health benefits of Vitamin D confirmed by new study', *18 (1): Active Living* 2010;


Table I. The GRADE Table

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<sup>a</sup> Small sample size  
<sup>b</sup> Lack of blinding
Figure I. Figures from the Wyon et al\textsuperscript{13} study

Fig. 1. Mean changes in isometric strength for the intervention and control groups.

Fig. 2. Mean changes in vertical jump for the intervention and control groups.