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Vitamin D Awareness, Prevalence Of Supplementation And Estimated Total Vitamin D Intake In College Athletes

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VITAMIN D AWARENESS, PREVALENCE OF SUPPLEMENTATION AND ESTIMATED TOTAL VITAMIN D INTAKE IN COLLEGE ATHLETES

by

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This thesis, submitted by Bennett Alexander Leitch in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Bennett Alexander Leitch

April 3, 2016

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ABSTRACT

This study aimed to investigate the awareness of vitamin D among collegiate athletes and evaluate the association between vitamin D awareness and total dietary intake of vitamin D. Eighty-one athletes completed the vitamin D awareness and dietary intake questionnaire. The results showed that males and females had very little concern over their vitamin D levels. Men reported 20.7% while females 25% for “likely” or “very likely”. Furthermore, overall male and female belief for being at risk for vitamin D deficiency was low. Males reported 24.1% for either “likely” or “very likely” to be at risk for deficiency and females 30.7% respectively. Overall, median intake of vitamin D was 330 IU, which is below the recommended daily allowance (RDA) of 600 IU. Median intake of vitamin D was higher for males (693 IU) when compared to females (263 IU). Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Awareness is positively correlated with vitamin D intake ($r = .483$, $p < 0.01$). It appears that concern for poor vitamin D status and familiarity influences total vitamin D intake. In addition, 60.5% (49) of our athletes not meeting the RDA for vitamin D intake represents poor vitamin D levels need to be improved. Interventions aimed at increasing awareness of the risk of poor vitamin D status may reduce the prevalence of vitamin D deficiency in collegiate athletes.

Key Words: NCAA, Nutrition, 25-hydroxyvitamin D

CHAPTER I

INTRODUCTION

Researchers have found 61% of children and adolescents, as well as, 77% of adults are vitamin D insufficient in the United States (Constantini, Arieli, Chodick & Dubnov-Raz, 2010). Having vitamin D deficiency appears to have a negative impact on multiple health outcomes (Constantini et al., 2010; Farrell, Cleaver, & Willis, 2011; Halliday et al., 2011; Larson-Meyer, 2013). A causal link has been made between vitamin D and bone health (Constantini et al., 2010; Farrell et al., 2011; Halliday et al., 2011; Holick, 2007; Lanteri, Lombardi, Colombini, & Banfi, 2012; Larson-Meyer, 2013; Willis, Peterson, & Larson-Meyer, 2008). More recently, evidence indicating that immune (Constantini et al., 2010; Halliday et al., 2011; Larson-Meyer, 2013; Willis, Smith, Broughton, & Larson-Meyer, 2012), muscle (Cannell, Hollis, Sorenson, Taft, & Anderson, 2009; Fitzgerald, Peterson, Warpeha, Johnson, & Ingraham, 2015a; Fitzgerald, Peterson, Wilson, Rhodes, & Ingraham, 2015b; Larson-Meyer, 2013) and cardiovascular function (Fitzgerald et al., 2014; Hamilton, Grantham, Racinais, & Chalabi, 2010; Halliday et al., 2011; Larson-Meyer, 2013) may be affected by vitamin D status. All stated outcomes might negatively influence health and physical performance in athletes.

This evidence, along with the high prevalence of deficiency, underscores the importance of assessing vitamin D awareness. Lack of knowledge about the importance and sources of this vitamin may be contributing to the high prevalence of deficiency. Sources of vitamin D from food include: oily fish, cod liver oil, and fortified foods, like milk, fruit juices, breads and cereals (Halliday et al., 2011). However, vitamin D is most commonly acquired through sunlight when available (Cannell et al., 2009). Current recommended daily value (RDA) is labeled at 600 IU, according to Larson-Meyer, (2013) athletes across the globe average 100 IU to close to 250 IU per day. Researchers recently conducted a study with male hockey players in Minnesota where food, multivitamin and supplementation combined was moderately correlated ($r = 0.58$) with vitamin D status (Fitzgerald et al., 2015). This data indicates that total dietary intake of vitamin D is related to 25(OH)D status and factors that increase dietary and supplemental intake will likely have a positive effect on status. Vitamin D awareness may be one factor that may impact total dietary intake (Walker et al., 2014).

Researchers have assessed vitamin D awareness in the general population (Alemu & Varnam, 2012; Pirrone, Capetola, Riggs, & Renzaho, 2013; Uddin et al., 2013; Zipitis, Elazabi, & Samanta, 2011); however, only recently has a study addressed this question in athletes (Walker et al., 2014). In a relatively large sample of internationally competing New Zealand athletes with an average age of 25.53 (SD = 3.11), a majority (76%) could name the primary source of vitamin D, the sun, albeit, very few (17%) were able to name another source. Moreover, only 6% were concerned about their vitamin D levels. Neither, vitamin D status nor dietary intake was recorded in this study.

Population-specific assessments are needed to characterize vitamin D awareness in athletes, as awareness may be highly variable among populations. We are unaware of any investigation evaluating the association between vitamin D awareness and vitamin D status, or quantifying a source of vitamin D. An understanding of NCAA collegiate athletes' awareness of vitamin D in relationship to total dietary intake of vitamin D may provide the necessary information to develop behavioral-based interventions aimed at reducing vitamin D deficiency in collegiate athlete populations in the United States.

The primary purpose of this study was to assess vitamin D awareness in NCAA collegiate athletes. The secondary purpose was to evaluate the association between vitamin D awareness and total dietary vitamin D intake. It was hypothesized that select aspects of vitamin D awareness would be associated with total dietary vitamin D intake.

Literature Review

Importance of Vitamin D

Vitamin D deficiency has been called an epidemic for all age groups in the United States (Willis et al., 2008). Vitamin D is a steroid hormone when activated (Cannell et al., 2009) and, to date, vitamin D receptors are located in over 30 different cells, including: skeletal muscle, adipose tissue and cardiac muscle (Farrell et al., 2011). The importance of vitamin D is just coming to the fore front and its awareness in the world of college athletics might be as well. The awareness and prevalence of vitamin D consumption and supplementation has rarely been researched with college athletes and could potentially play a vital role to health and performance success.

Vitamin D Sources

Vitamin D is not a typical vitamin. Most vitamins can be obtained through a normal diet; however, vitamin D is most commonly acquired through sunlight (Cannell et al., 2009). Exposure of arms and legs to sunlight for about 5 to 30 minutes between 10 a.m. and 3 p.m. twice a week is sufficient (Holick, 2007). It can also be attained through diet and supplements (Farrell et al., 2011). Foods in diets that are rich with vitamin D include: oily fish, cod liver oil, and fortified foods like milk, fruit juices, breads and cereals (Halliday et al., 2011).

Dietary vitamin D can be consumed as either ergocalciferol, D_2 or cholecalciferol, D_3 (Larson-Meyer, 2013). D_2 is created from UVB exposure of yeast and fungi ergosterols (Larson-Meyer, 2013). However, it has been expressed that vitamin D_2 is only about 20-40% as effective as D_3 in increasing and maintaining 25(OH)D levels, also known as, Calcifediol (Willis et al., 2008). Calcifediol is the circulating vitamin D in your blood that is measured when vitamin D levels are being evaluated for optimal ranges. These ranges are expressed as blood serum levels. When referencing these, levels of 25(OH)D, under 20 ng/ml is labeled as deficient. Insufficient is classified as 20-30 ng/ml, sufficient > 30 ng/ml, and optimal levels are believed to be in the range of 40-100 ng/ml (Larson-Meyer, 2013).

Researchers at the Mayo Clinic state the RDA for vitamin D is 600 IU for those ranging from 1-70 years old and pregnant or breast feeding women while 800 IU for those over 71 years of age. For athletes across the globe, the average vitamin D intake ranges from 100 IU to close to 250 IU/day (Larson-Meyer, 2013). The Endocrine Society suggested individuals with limited sun exposure to attain 1,500 IU to 2,000 IU/day to maintain sufficient status (Larson-Meyer, 2013). However, there is no standard as of yet. Most experts stated that if adequate sun exposure is not met along with the previous guidelines then about 800-1000 IU per day is recommended (e.g., Holick, 2007).

Vitamin D toxicity is very rare and is described when serum 25(OH)D levels are >150 ng/ml with high serum calcium concentrations (Larson-Meyer, 2013). In most scenarios it is due to unintentional ingestion of extreme doses, well above 50,000 IU for several months (Larson-Meyer, 2013). Classic signs of vitamin D toxicity include: fatigue, constipation, forgetfulness, nausea, back pain, vomiting, hypertension, heart rhythm abnormalities and tissue calcification (Larson-Meyer, 2013). Holick (2007) added to vitamin D toxicity by stating overdosing on vitamin D by sunlight is not possible. The excess vitamin D_3 is destroyed by sunlight (Holick, 2007). The destroying of the excess vitamin D occurs because of a feedback loop regulating vitamin D_3 synthesis, therefore, again, preventing vitamin D toxicity (Larson-Meyer, 2013).

Vitamin D Synthesis

Vitamin D goes through many changes before it is used. The reaction for the synthesis of vitamin D needs sunlight; therefore, any type of factors that would limit sunlight exposure hinders and compromises vitamin D status. The skin is exposed to ultraviolet B radiation by the sun and the 7-dehydorcholesterol in the plasma membranes of the epidermis and dermis is converted to precholecalciferol, also known as previtamin D_3 (DeLuca, 2004; Larson-Meyer, 2013; Norman, 2008; Willis et al., 2008). Previtamin D_3 is then converted to cholecalciferol, or D_3, which enters the dermal capillary beds from the plasma membranes via vitamin D binding proteins (Willis et al., 2008). Cholecalciferol does not start to be stored in fat and muscle tissue for future use until 25(OH)D levels reach 40-50 $ngmL^{-1}$ (Cannell et al., 2009). Therefore, Cannell et al. (2009) stated that any level below this 40-50 threshold the body will divert the ingested, or sun created, vitamin D to satisfy metabolic needs. Now in synthesized form, vitamin

D is metabolized in the liver forming 25(OH)D and furthermore in the kidney tubules creating the biologically active form 1,25-dihydroxyvitamin D, or calcitiol (Farrell et al., 2011; Larson-Meyer, 2013; Willis et al., 2008). The newly formed active version of vitamin D is regulated by plasma parathyroid hormone levels, serum calcium, and phosphorus levels (Holick, 2007).

Factors Effecting Vitamin D Synthesis

The sun is the primary source for vitamin D; however, there are some factors that determine whether adequate status can be met. These factors include: wintertime longitude greater than 35 degrees north or south, skin pigmentation, sunscreen use, time of day, season of the year, age, extent of body clothing and excess adiposity (Cannell et al., 2009; Halliday et al., 2011; Larson-Meyer, 2013; Willis et al., 2008). The 35-degree north or south latitude line is labeled as a factor because the solar zenith angle during the winter months is large; therefore, UVB photons are absorbed by the atmosphere and cannot stimulate vitamin D synthesis in our bodies (Willis et al., 2008).

Vitamin D Deficiency in Athletes

Very few studies have been done on vitamin D deficiency in athletes. Vitamin D itself is sometimes forgotten in the sports nutrition world. Based on how important vitamin D has been found, not only in some performance aspects, but also for wellness, knowing deficiency levels in athletes appears important. In one study, researchers looked at vitamin D levels in young Finnish female athletes, runners, gymnasts, and non-athletes, ranging between 9 and 15 years old (Lehtonen-Veromaa et al., 1999). Results showed that 68% of the total sample were vitamin D insufficient in the winter months, and of those 13% were classified as deficient. In another study, 37% of the 85 athletes in East

Germany ranging between 8 and 27 years old were vitamin D deficient (Bannert, Starke, Mohnike, & Frohner, 1991). More interestingly, results from a study done in Baton Rouge, LA, where vitamin D synthesis can be possible year round, showed that 40% of distance runners tested ages 19-45 years were vitamin D insufficient (n = 20; Willis et al., 2008). Another set of researchers looked at middle eastern sportsmen, of which, 91% were vitamin D deficient (25(OH)D < 20ng/mL) (n = 93; Hamilton et al., 2010). French competitive cyclists were recorded having 25(OH)D serum levels of an adequate nature, however, the group mean of the seven participants was borderline sufficient despite having a rigorous outside training regimen (Maimoun et al., 2006). Taken together, the results of these studies show that not only is vitamin D deficiency prevalent in those that already have risk factors for synthesizing, but also for those that are available to synthesize vitamin D year-round.

Researchers have looked at prevalence of vitamin D levels during different seasons. For example, Halliday et al. (2011) found that there was a higher occurrence of athletes having an insufficient or deficient status of 25(OH)D in the winter, 63.6%, compared to the fall, 12.2%, and spring, 20%. Another recent study done using hockey players addressed vitamin D insufficiency (Fitzgerald et al., 2015b). The researchers found that 38% of the athletes had insufficient 25(OH)D concentrations ($<32 ngmL^{-1}$) during the testing period which occurred over the summer time. In a year-long study, Constantini et al. (2010) compared 25(OH)D levels of outdoor and indoor trained athletes. The findings revealed that 10 of the 21 outdoor athletes were vitamin D insufficient compared to 62 of the 77 indoor trained athletes. Vitamin D deficiency is starting to become, as Willis et al. (2008) put it so well, an epidemic for all ages and research is leading to heavily back that statement.

In order to fix this problem, athletes need to be aware of vitamin D. In a recent study researchers looked at knowledge and attitudes of New Zealand elite athletes (Walker et al., 2014). The authors asked 110 elite outdoor athletes to complete 57 multiple-choice or short answer questions about different aspects of vitamin D. A vast majority of the athletes, 107 out of 110 (97%), had heard about vitamin D, and 84 (76%) were able to identify the sun as a source of vitamin D. However, only 18 (17%) were able to name another source of vitamin D. Furthermore, the athletes of those who had heard of Vitamin D, only 27 (25%) of the 110 could name a health benefit of having sufficient vitamin D levels. Finally, only 7 (6%) of the athletes were worried about their vitamin D status (Walker et al., 2014). The numbers are surprising considering athletes will try just about anything to gain a competitive edge, whether it is a supplement or new training regimen, but little know the significance of their own body's steroid hormone. And it's not just athletes that are not aware of vitamin D. Kotta et al, (2015) had two groups of adults under the age of 65 and two groups of adults over the age of 65 from the United Kingdom complete an assessment about their general knowledge and awareness about vitamin D in an interview type style. Their responses followed the same general lack of awareness that was shown by group of elite New Zealand athletes. Some of these responses stated, "All I know about vitamin D is the sunshine thing" or, "Helps keep you fit" to falsities as, "[vitamin D] comes from vegetables." These researchers found a general limited knowledge base about vitamin D and confusion about benefits and risks.

However, when comparing over and under the age of 65 groups, the over group was more aware and better educated than the younger group (Kotta et al., 2015).

Importance of Vitamin D Status on Performance

In 1938, the Russians conducted a study with ultraviolet irradiation to improve the speed in the 100-m dash in four students, compared with controls; both groups participated in daily identical training sessions (Gorkin, Gorkin, & Teslenko, 1938). Irradiation was used because it has the same mechanisms as the sun and helped to synthesize vitamin D. Their results showed the control group improving 1.7%; however, the irradiated students increased 7.4% with identical training. Several years later in 1944, the Germans irradiated 32 medical students two times a week for 6 weeks and found a 13% increase in performance on bike ergometers, whereas, the control students did not change (Lehmann & Mueller, 1944).

Although these studies were stimulating, Larson-Meyer (2013) suggested that they are not up to today's standards, as they did not test vitamin D status, and that scientific design is much more rigorous compared to years past. These studies were brought to the attention as a mere factoid that researchers have looked at vitamin D as an important aspect for athletic performance for many years. More recent studies have looked at vitamin D levels in hockey players in relation to performance outcomes (Fitzgerald et al., 2014). These findings are geared more towards the likes of Larson-Meyer's idea on vitamin D and performance as it is up to "today's standards" as she called it by testing for vitamin D and going through the rigors of scientific design. The researchers found during the graded exercise test on a skating treadmill with male hockey players' vitamin D status was not associated with VO_2peak or the end stage completed

(Fitzgerald et al., 2014). In addition, researchers have found mixed results with vitamin D in relation to handgrip strength and a rate of force development measured during a squat jump (Fitzgerald et al., 2015a). Vitamin D has been looked at as a potential impact on athletic performance as far back as 1938 and is still seen as important today, however, the latest trend is now something possibly more relevant, well-being.

Importance of Vitamin D Status on Well-Being

Vitamin D has been well linked to bone health with up-regulation of calcium to increase absorption and bone deposition (Halliday et al., 2011; Holick, 2007; Lanteri et al., 2012; Larson-Meyer, 2013; Willis et al., 2008). Recent studies have established a link between vitamin D deficiency and diseases like cardiovascular disease, diabetes, hypertension, certain types of cancer as well as autoimmune disorders such as multiple sclerosis, rheumatoid arthritis and inflammatory bowel disease (Vacek et al., 2012; Willis et al., 2008).

The relationship between bone health and vitamin D intake has been well established (Holick, 2007; Lanteri et al., 2012; Larson-Meyer, 2013; Willis et al., 2008). Vitamin D helps with bone health by upregulation of genes that increase calcium absorption and osteoclast activity (Lanteri et al., 2012; Larson-Meyer, 2013). Researchers have shown that when serum 25(OH)D levels are at least 30ng/mL (sufficient level) 30-40% of calcium and 80% of phosphorus is absorbed (Holick, 2007; Larson-Meyer, 2013). However, when serum levels drop down past the sufficient level, only 10-15% of calcium and 60% of phosphorus is absorbed (Holick, 2007; Larson-Meyer, 2013). It has also been shown that those with sufficient vitamin D levels have less stress fractures (Larson-Meyer, 2013, Willis et al., 2008). Stress fractures are not the only worry with vitamin D deficiency. Parathyroid hormone can be positive and negative with bone health (Holick, 2007). The parathyroid hormone enhances calcium absorption and stimulates the kidneys to release 1,25(OH)D (Holick, 2007). In addition, the parathyroid hormone stimulates osteoblasts, which initiate preosteoclasts into osteoclasts which dissolve bone (Holick, 2007; Lanteri et al., 2013). During all of this osteoclast activity, bone weakens and the potential for osteoporosis, and again, stress fractures sets in (Holick, 2007; Lanteri et al., 2013).

Vitamin D also plays a role in skeletal muscle function (Dirks-Naylor & Lennon-Edwards, 2011; Holick, 2007; Lanteri et al., 2013; Larson-Meyer, 2013). Researchers have shown that it influences muscle cell proliferation and differentiation, calcium transport across the sarcolemma and cell signaling (Dirks-Naylor et al., 2011; Lanteri et al., 2013; Larson-Meyer, 2013). Furthermore, vitamin D is not only connected with calcium transport across the sarcolemma, it is believed that it is related to both calcium and protein transcription and total body calcium levels (Lanteri et al., 2013). Therefore, vitamin D would then play a role in membrane calcium channels of muscle cells which impact contractile properties (Lanteri et al., 2013). Along with proliferation and differentiation of myoblasts, $1,25(OH)_2D_3$ may play a role in stimulating muscle contractile forces in differentiated muscle fibers (Dirks-Naylor et al., 2011). The vitamin D-vitamin D receptor complex has been hypothesized to modulate protein synthesis (Lanteri et al., 2013; Willis et al., 2008). It has been noted that skeletal muscle pain and weakness, especially in proximal limbs, is related to Vitamin D deficiency (Lanteri et al., 2013; Larson-Meyer, 2013).

Vitamin D has been linked to immunity and inflammation (Larson-Meyer, 2013; Willis et al., 2012). It has been shown that vitamin D up regulates gene expression of antimicrobial peptides (AMPs), which are important to immune defense, as well as, down regulates expression of inflammatory cytokines (Larson-Meyer, 2013; Willis et al., 2008). Vitamin D levels increase production of the anti-inflammatory signaling molecules or cytokines (Larson-Meyer, 2013; Willis et al., 2008). Several of these cytokines elevate after intense workloads, these elevated levels are thought to be involved in over training syndrome (Larson-Meyer, 2013; Willis et al., 2008).

AMPs are secreted by monocytes, macrophages, natural killer cells and epithelial cells in the respiratory tract and function by compromising the cell membrane integrity of invading bacteria, fungi, and viruses (Larson-Meyer, 2013; Willis et al., 2008). When serum levels of 25(OH)D fall below 20ng/mL, monocytes and macrophages are halted from stimulating an immune response (Holick, 2007). Cyclic adensosine monophosphate (cAMP) is a type of AMP that is released which helps convert $25(OH)D_3$ to the active form of $1,25(OH)_2D_3$, while also helping to trigger vitamin D receptors to release cAMP (Willis et al., 2008). cAMP has been studied in African Americans that have a reduced 25(OH)D concentration and a decreased ability to create cAMP (Willis et al., 2008). Researchers conducting a study done with athletes on vitamin D status in the winter and spring found that if 25(OH)D serum levels were at 38 ng/mL, then athletes had one or fewer episodes of illness, compared to lower levels which had between one and four episodes (Larson-Meyer, 2013). Therefore, those with low serum levels have a decreased ability to create cAMP causing a higher likelihood of illness. Vitamin D levels were measured in the winter, fall and spring in athletes and those that were low in the spring had a higher prevalence of illness, including URI, common cold and influenza (Halliday et al., 2011).

Purpose

Vitamin D is becoming more prominent in the sports nutrition world with the ever growing effects it has on the human body. Vitamin D has yet to be tapped with its many functions that can impact athletes by improving bone health, performance, immune and inflammatory actions (Constantini et al., 2010; Farrell et al., 2011; Halliday et al., 2011; Holick, 2007; Lanteri, Lombardi, Colombini, & Banfi, 2012; Larson-Meyer, 2013; Willis et al., 2012; Fitzgerald et al., 2015a; Fitzgerald et al., 2015b). However, the amount of vitamin D insufficiency and deficiency affecting the worldwide population does not reflect the new found importance of vitamin D (Bannert et al., 1991; Constantini et al., 2010; Hamilton et al., 2010; Lehtonen-Veromaa et al., 1999; Willis et al., 2008). This study is significant because it will draw attention to how little is known about the importance of vitamin D among college athletes at the University of North Dakota (UND) and then can be generalized to those athletes in the surrounding at risk latitude regions.

Through recent studies, researchers have found that athletes are not in tune with vitamin D and its important role in their potential athletic career (Kotta et al., 2015; Walker et al., 2014). The baseline for knowledge and awareness of vitamin D in athletes is non-existing. Athletes strive to gain competitive edges in whatever sport they participate in but few know the potential of a completely legal, naturally made vitamin. If athletes are not aware of the potential for deficiency and the importance of the vitamin, they may be less likely to obtain adequate amounts of vitamin D in their diet. If we can measure the awareness and general knowledge athletes have, we can better address this growing issue. There is a potential for a substantial regional impact on college athletes and those responsible for their health and performance.

A key part to this study is the location. According to the National Weather Service, the University of North Dakota resides on the 47.9-degree latitude line. This location falls under the at risk population for vitamin D deficiency, as it is above the 35-degree line of latitude, therefore, making vitamin D synthesis from the sun impossible in the Winter months (Cannell et al., 2009; Halliday et al., 2011; Willis et al., 2008). Hence, dietary supplementation of vitamin D may be necessary for those at risk (Fitzgerald et al., 2014). Awareness of the importance of vitamin D to health and performance likely influences the choice to consume vitamin D supplements.

We hypothesize that few of the athletes at the University of North Dakota know the benefits of vitamin D and either take supplements or monitor their intake of vitamin D. By evaluating the athletes' awareness to the risk of deficiency and importance of vitamin D status to health and performance we can determine if interventions are needed to increase awareness. Increased awareness of vitamin D may play a role in decreasing the prevalence of deficiency and insufficiency in this population, which may impact the health and performance of student athletes. Not only would this study impact athletes, but also sports medicine staff and sports dieticians. The results of this study would help these health professionals better suit their athletes for continued good health and staying on the field. The purpose of this study was to evaluate the awareness that athletes at the University of North Dakota have about vitamin D. In addition, the study looked at estimated vitamin D intake based on food, multivitamin, and supplement intake. Finally, another goal of the study was to see if awareness was correlated with intake in our college athletes.

CHAPTER II

METHOD

Participants

Division I collegiate athletes from several different sports at the University of North Dakota (UND) were recruited for this study, which was approved by the Institutional Review Board (IRB) and the athletic department. Athletes were recruited using a sample of convenience and selected based on geographic location being above 35 degrees north, which is a risk factor for vitamin D deficiency. Vitamin D, health and physical performance has become a popular area of research, but few investigators have examined vitamin D intake in athletes, therefore, this is our area of focus. We are not aware of any studies evaluating the association between dietary vitamin D intake and vitamin D awareness. The inspection of vitamin D intake as it relates to awareness is important in athletes to enable the design of interventions aimed at reducing the prevalence of vitamin D deficiency in this population. The prevalence of vitamin D insufficiency in athletes has been estimated from 100 to 250 IU (Larson-Meyer, 2013). Vitamin D deficiency in athletes may negatively impact their health and physical performance as it has been linked to reduced exercise performance (Willis et al., 2008; Cannell et al., 2009; Fitzgerald et al., 2014; Fitzgerald et al., 2015), increased stress fractures (Holick, 2007; Larson-Meyer, 2013), and increases incidence of respiratory infection (Constantini et al., 2010; Farrell et al., 2011; Halliday et al., 2011; Willis et al., 2012). Athletes were excluded if they no longer participated in a collegiate sport. The questionnaire was sent out to athletes competing at UND (n = ~500) with the exception of men's and women's basketball (n = 15, n = 18), men's hockey (n = 27), men's golf (n = 7), women's volleyball (n= 15), and women's tennis (n = 10) as permission was not granted by the head coach of these sports. That left a potential participant pool of 336 and 81 completed the questionnaire.

Measures

Vitamin D awareness was assessed using a questionnaire (see Appendix A) with five questions: 1) How much have you heard about vitamin D? 2) Are you concerned about your vitamin D levels? 3) Do you believe you are at risk for vitamin D deficiency? 4) Do you believe that vitamin D plays a role in your health? 5) Do you believe vitamin D plays a role in your athletic performance? These questions were rated on a 5-point Likert Scale. There were three sets of anchors for these questions: Never to A lot for question one, Very Unlikely to Very Likely for question two and three, and Definitely Will Not to Definitely Will for question four and five. After questions 3, 4 and 5, an open ended follow up question was included. These consisted of: 1) Do you know any factors that may affect your vitamin D levels? 2) If so, what benefits do you believe it to have? The last question was used twice, once for health benefits, once for performance benefits.

Dietary vitamin D intake was assessed using the the Diet and Lifestyle Questionnaire (see Appendix A), which was adopted from Halliday et al. (2011). This questionnaire was also used by Fitzgerald et al. (2015b) when evaluating dietary vitamin

D intake in hockey players. It contains questions asking about foods and supplements consumed. It also includes a few questions related to sun exposure habits, but these were not analyzed due to the geographical and temporal characteristics of the data collection period.

Procedure

A cross-sectional study design was used to assess awareness of vitamin D in collegiate athletes and evaluate the relationship between awareness and total dietary intake of vitamin D. In order to recruit college athletes, we received approval from the UND athletic department, as well as, permission from head coaches of the college athletes that participated. Emails were sent to all 16 head coaches at UND of all male and female sports. A copy of the email can be seen in the Appendix B. All athletes completed an informed consent document. Self-reports of age, race, sex, sport, height, and weight were recorded for all athletes. Athletes completed the questionnaire via an online survey using 'Qualtrics'. The online survey instrument was designed to facilitate accurate data collection. To facilitate participation and accuracy the survey only took approximately 5 minutes to complete. The survey was opened for completion November 1st of 2015 and kept open until January 30th of 2016.

Statistical Analysis

IBM SPSS Statistics for Macintosh, Version 23.0 was used to analyze data. The data were analyzed for normality. Descriptive statistics were presented as means and standard deviation for normally distributed data. Median and interquartile range (IQR) were used to describe variables that were not normally distributed. Proportions were used to describe the distribution of Likert scores, as they are not a continuous variable.

Spearman rank correlation coefficient (rho) was used to assess the correlations between Likert values from vitamin D awareness questions and estimated vitamin D intake from food, supplements and total dietary vitamin D intake. Alpha was set at $p = 0.05$ and two-sided p-values were used for calculations.

CHAPTER III

RESULTS

Out of the roughly 500 college athletes at UND, we were allowed to send our questionnaire to 336 athletes. Male sports that were approved are as follows: baseball, cross country, track and field, football, swim and dive, and tennis. Out of the possible 175 male athletes, 29 completed the questionnaire (mean (SD): age = 19.9 (1.6) yrs, height = 185.2 (7.2) cm, weight = 88.1 (22.2) kg, body mass index [BMI] = 25.6 (5.1) $kg \cdot m^{-2}$, 26 white, 1 black, 1 Hispanic, 1 Asian). Female sports that were approved include: cross country, golf, hockey, soccer, softball, swim and dive, and track and field. Out of the possible 161 female athletes, 52 completed the questionnaire (mean (SD): age = 20.0 (1.5) yrs, height = 168.2 (6.2) cm, weight = 64.8 (7.9) kg, BMI = 23.0 (2.2) $kg \cdot m^{-2}$, 50 white, 1 black, 1 Hispanic).

Estimated dietary intake of vitamin D from foods and supplementation is shown in Table 1. Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Median and interquartile ranges were used as our data was skewed. Our median male intake reached 693 IU, females recorded 263 IU.

Table 1. Vitamin D Intake from Food and Supplement per Day (n=81).

	Overall	Male	Female
Dietary vitamin D from food	231 (125-408)	407 (162-656)	213 (122-297)
Dietary vitamin D supplement	0 (0)	0 (0)	0 (0)
Dietary vitamin D from multivitamin	0 (0-267)	0 (0-367)	0 (0-200)
Dietary vitamin D from supplement and multivitamin	0 (0-507)	40 (0-600)	0 (0-200)
Total dietary vitamin D intake	330 (182-835)	693 (309-1564)	263 (162-705)

Values in IU, Median and IQR used, Median supplement values include those participants that did not take a supplement and therefore had a 0 value.

Multivitamin and vitamin D supplementation was reported by 41.9% of athletes (16 males, 18 females). Mean intake of vitamin D from supplements was 1,207 IU per day, and did not differ substantially between males and females (males: 1,126 IU, females: 1,279 IU). Multivitamin intake was the most common, with 38.3% (13 males, 18 females) of athletes reporting intake with a mean dose per day of 487 IU. When analyzed separately, males' average intake was 355 IU per day, while females consumed 583 IU per day. Fewer athletes reported taking Vitamin D supplements. Only 19.8% (10 males, 6 females) reported consumption. Of these, 8 athletes documented supplementation values and their mean dose per day was 3,241 IU.

Correlations between dietary and supplemented vitamin D intake and Likert awareness scores are presented for males and females in Table 2 and Table 3, respectively. In males, higher intake of supplementation, as well as, supplement and multivitamin intake was positively correlated to belief in performance enhancement ($p < 0.05$). In females, a higher intake of multivitamin consumption, along with combined supplementation and multivitamin together was correlated with concern about their vitamin D levels.

Table 2. Correlations between Dietary Vitamin D Intake and Vitamin D Awareness Scale for Males.

	Food	Multivitamin	Supplement	Multivitamin and Supplement	Total
Familiarity	.098	.118	.198	.185	.286
Concern	.228	.109	.345	.322	.448*
Risk	-.030	.073	.094	.111	.147
Health	.010	.172	.254	.222	.186
Performance	.040	.225	.495*	.442*	.385*
Likert Total	.229	.222	.365	.375*	.483**

Spearman rho correlation test, n=29 *significance at the 0.05 level (2-tailed).
**significance at the 0.01 level (2-tailed)

Table 3. Correlations between Dietary Vitamin D Intake and Vitamin D Awareness Scale for Females.

	Food	Multivitamin	Supplement	Multivitamin and Supplement	Total
Familiarity	.227	.199	.061	.212	.334*
Concern	.061	.336*	-.205	.315*	.224
Risk	.-027	.153	.221	.139	-.008
Health	.278*	.068	-.138	.055	.187
Performance	.088	-.139	.036	.-134	-.091
Likert Total	.163	.196	-.204	.186	.191

Spearman rho correlation test, n=52 *significance at the 0.05 level (2-tailed).
**significance at the 0.01 level (2-tailed)

Likert scores for awareness in our male athletes are shown in Table 4, females' awareness is recorded in Table 5. Likert scales used to assess vitamin D awareness were presented using the proportion of athletes indicating a given value for each question, as these scores are not continuous in nature. Responses for the qualitative data were coded by finding overall themes in the data. For question one, all answers dealing with sun were put into the "sun" category. Any response that mentioned food, diet or nutrition were labeled "diet." The "supplements" category contains any answer stating vitamins or supplements. Those responses that did not make up the top three responses were placed in the "other" section. These included: stress, exercise, age, weight, skin color, health and sunscreen. Finally, the "no response" category contains those that did not respond to the question or answered no.

Question two and three were also split into this same format and had the same categories, however, they were in different order of prevalence. The first category was "mood." This was comprised of statements about mood, happiness, and seasonal affective disorder (SAD). "Bone" was themed for responses that mentioned bone health, strength and osteoporosis. Those responses that were placed in the "energy" category consisted of those stating energy and fatigue. The other category again was comprised of those that did not make the top three responses and included responses related to health, metabolism, vitamin, immune, calcium absorption, performance and stress. The "other" category for the third question consisted of responses of: vitamin/mineral, muscle, performance, recovery, health, stress, immune and vision. It is important to note that responses that were placed into the "health" section were generic answers that restated the question. Again, those that did not respond to question two and three or responded "not sure" or "don't know" were placed in the "no response" section.

Interestingly, 55% of males reported "very unlikely" or "unlikely" when asked about their concern of vitamin D levels. Approximately 59% of males reported either "very unlikely" and "unlikely" when asked if they believed they were at risk for poor vitamin D status. In contrast, when asked if vitamin D plays a role in health males reported a combined, "likely" and "very likely" score of 86.3%. When asked the same question about performance males answered "likely" and "very likely" a combined 69%. Females reported very similar numbers. After combining their responses, 61.5% stated they were "unlikely" or "very unlikely" to concerned over their vitamin D levels. When asked if they believed they were at risk for vitamin D deficiency 61.6% responded "unlikely" or "very unlikely". However, when asked if vitamin D impacts health 90.4% responded "likely" or "very likely." For its impact on performance 73.2% reported "likely" or "very likely."

Table 4. Proportions of Male Athletes (%) within each Category on Various 5-Point Likert Scales in Response to Vitamin D Awareness Questions.

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*A Lot*
How much have you heard about vitamin D?	0.0	24.1	48.3	20.7	6.9
	Very Unlikely	*Unlikely*	*Undecided*	*Likely*	*Very Likely*
Are you concerned about your vitamin D levels?	20.7	34.5	24.1	6.9	13.8
Do you believe you are at risk for vitamin D deficiency?	24.1	34.6	17.2	17.2	6.9
	Definitely Will not	*Probably Will Not*	*Don't Know*	*Probably Will*	*Definitely Will*
Do you believe that Vitamin D plays a role in your health?	0.0	0.0	13.7	41.3	45.0
Do you believe that vitamin D plays a role in your performance	0.0	6.9	24.1	44.9	24.1

Table 5. Proportions of Female Athletes (%) within each Category on Various 5-Point Likert Scales in Response to Vitamin D Awareness Questions.

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*A Lot*
How much have you heard about vitamin D?	0.0	19.2	48.1	28.9	3.8
	Very Unlikely	*Unlikely*	*Undecided*	*Likely*	*Very Likely*
Are you concerned about your vitamin D levels?	13.4	48.1	13.5	19.2	5.8
Do you believe you are at risk for vitamin D deficiency?	11.6	50.0	7.7	28.8	1.9
	Definitely Will not	*Probably Will Not*	*Don't Know*	*Probably Will*	*Definitely Will*
Do you believe that Vitamin D plays a role in your health?	0.0	1.9	7.7	52.0	38.4
Do you believe that vitamin D plays a role in your performance	0.0	3.7	23.1	54.0	19.2

Proportions were also used for our qualitative data on awareness shown in Table 6. Sun, diet and supplements are known factors in vitamin D intake, which consisted of 56.3% of our responses. Athletes generally thought mood, bone and energy were the most impacted from vitamin D intake.

Table 6. Qualitative Reponses to Vitamin D Awareness Questions.

Questions	Responses (n)	Number and Proportion of Athletes Reporting Theme				
Do you know any factors that may affect your vitamin D levels? (list all)	119	Sun Related	Diet Related	Supplements	Other	No Response
		37 (45.7%)	24 (29.6%)	6 (7.4%)	15 (18.5%)	37 (45.7%)
If so, what benefits do you believe it (vitamin D) to have (on health)?	99	Mood	Bone	Energy	Other	No Response
		13 (16.1%)	12 (14.8%)	9 (11.1%)	33 (40.7%)	32 (39.5%)
If so, what benefits do you believe it (vitamin D to have (on performance)?	90	Energy	Mood	Bone	Other	No Response
		12 (14.8%)	6 (7.4%)	5 (6.2%)	21 (25.9%)	46 (56.8%)

*Proportions of athletes reporting each theme were out of n=81.

CHAPTER IV

DISCUSSION

The primary aims of this study were to assess the awareness of vitamin D among collegiate athletes, evaluate the association between vitamin D awareness and total dietary intake of vitamin D and establish how many of our college athletes were meeting the RDA for vitamin D intake. We found, based on our awareness scales, that although all our athletes reported hearing about vitamin D few, 23.4%, are "likely" or "very likely" to be concerned about their levels. In addition, 28.4% believe they are "likely" or "very likely" to be at risk for vitamin D deficiency. Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Our median male intake reached 693 IU, females recorded 263 IU. To our knowledge, this is the first study to report bivariate associations between awareness and vitamin D intake (.483, $p < 0.01$).

Characterizing vitamin D awareness in our population was the primary purpose of this study. We characterized awareness with our college athletes' by their familiarity to vitamin D, levels of concern and attitudes toward being at risk for poor vitamin D status, health and performance benefits. All of our college athletes reported hearing something about vitamin D. About half (43.2%) of our athletes reported "unlikely" and 16.1% stated they were "very unlikely" when asked about their concern about vitamin D levels. In addition, 44.4% of athletes believe they have an "unlikely" and 16.1% "very unlikely" chance of being vitamin D deficient. This is inline with the results reported by Walker et al. 2014 surveying New Zealand athletes. Ninety-seven percent of these athletes (n = 107) stated that they had heard about vitamin D. In addition, only 6% (n = 7) were concerned about their vitamin D status. Risk of being deficient was not evaluated in these athletes. Other studies were conducted with non-athletes, including pregnant mothers, elderly, pharmacy students, general population and African migrants to Australia. Of these studies, people were generally aware of vitamin D, but their personal concern for poor vitamin D status was never asked (Alemu & Varnam, 2012; Pirrone, Capetola, Riggs, & Renzaho, 2012; Uddin et al., 2013; Zipitis, Elazabi, & Samanta, 2011). However, these populations are not comparable to our sample population of college athletes.

Overall, our athletes had restricted awareness about vitamin D factors contributing to vitamin D status, as well as, the benefits it provides. All athletes reported hearing about vitamin D. However, when asked about risk or concern over vitamin D levels, very few indicated concern. Interestingly, when asked if vitamin D may play a role in performance (males: 69%, females: 73.2%) and overall health (males: 86.3%, females: 90.4%) the majority of athletes reported a positive benefit. Although 45.7% of our athletes could name the biggest source of vitamin D, the sun, 45.7% also couldn't name a factor that affects vitamin D levels. When asked what benefits they believe vitamin D to have on health, 14.8% answered bone, which has been casually linked with vitamin D intake (Holick, 2007; Lanteri et al., 2012; Larson-Meyer, 2013; Willis et al., 2008). Mood and energy were also represented with 16.1% and 11.1% respectively, however, these have not been causally linked with vitamin D intake (Anglin, Samaan, Walter, & McDonald, 2013; Scott et al., 2015). Even though every athlete reported being aware of vitamin D at some level, the actual awareness of the sources and importance of vitamin D appears to be lacking in our population. A novel finding of our study was the positive correlation between Likert total, or their total awareness score, and multivitamin and supplement intake, as well as, total dietary vitamin D intake. This appears to indicate those athletes that know the benefits of vitamin D will choose to take multivitamins or supplement vitamin D, therefore, also consuming more vitamin D.

Vitamin D supplementation in our study was minimal at 19.8% of athletes (n = 16). Multivitamin supplementation was reported by 38.3% (31) of our athletes, with again, lower than RDA values at 488 IU mean dose per day. This compares to Lehtonen-Veromaa et al., (1999) study where 65% of their sample did not use vitamin D supplementation. Broken down by sex, both males and females are below RDA value. When combining vitamin D supplementation and multivitamin intake the total reaches 41.9% (34) athletes. Therefore, a little less than half are supplementing vitamin D directly or through a multivitamin. However, total dietary intake of vitamin D for most still does not reach the RDA standard. Split by sex, 62.1% (18) of the males reached the RDA, however, women dropped down with only 26.9% (14) meeting the standard. We speculate that males' higher vitamin D intake is likely due to greater caloric intake. These numbers appear problematic and are inline with a recent systematic review in which 56% had poor vitamin D status which is troublesome for our college athletes (Farrokhyar et al., 2015).

When comparing our study's results with others we see a common trend of inadequate vitamin D intake. Lehtonen et al., (1999) showed that out of the 186 girls 13.4% had blood serum of <20nmol/L, which is equivalent to <8ng/ml, or the severely deficient range. Overall, 68% were vitamin D insufficient. Other studies conducted with distance runners in Baton Rouge, LA, sportsmen in Qatar, and indoor and outdoor athletes in Israel had poor vitamin D status, reporting varying levels of insufficiency or deficiency, ranging from 40% to 90% (Willis et al. 2007; Hamilton et al., 2009; Constantini et al., 2009).

In contrast, Halliday et al., (2011) measured 41 athletes throughout an academic year revealing low percentages of insufficient status in college athletes during the fall and spring. Finally, Fitzgerald et al., (2015b) reported in their sample of 53 competitive ice hockey players that 62.3% (33) had sufficient vitamin D levels, 37.7% (20) possessed insufficient status and none of the participants were labeled vitamin D deficient.

Diet and supplement intake of vitamin D contributes roughly 30% of the variance in vitamin D status (Fitzgerald et al. 2015a). That is a large percentage of overall status. Low vitamin D status may influence bone health, immune health as well as muscle health (Halliday et al., 2011; Holick, 2007; Larson-Meyer, 2013; Willis et al., 2008). Although evidence is lacking, poor vitamin D status might affect physical performance in tasks related to strength, power and aerobic fitness (Cannell et al., 2009; Farrell et al., 2011; Fitzgerald et al., 2015a; Fitzgerald et al., 2014). The results of this study can have multiple implications not only for the athletes themselves who are deficient but also those that work with these athletes. Medical doctors, athletic trainers and physical therapists are all in association with these athletes, all responsible for their athlete's health. With the impacts we are finding about vitamin D on health and possibly performance, but more importantly, the lack of awareness and concern over vitamin D status, monitoring vitamin D can be an advantage. Awareness about poor vitamin D levels has to incorporate the entire medical field. By increasing awareness about vitamin D overall dietary intake should increase, therefore, we may positively affect the health and physical performance of athletes (Odukya, Odeyemi, Oyeyemi, & Upadhyay, 2014). This stresses the need for programs and campaigns about vitamin D awareness for not only athletes, but for those that work with athletes and those at risk for poor vitamin D status.

This investigation has some limitations. Our population was relatively homogenous in race, 93.8% white (n = 76). This cross-sectional study design used a sample of convenience, which could introduce bias. Athletes that completed the survey may not be representative of the population. We did not have approval to send the questionnaire to all sports teams at UND. Our results are only generalizable to college athletes competing in the sports with sufficient representation in the sample. In addition, the questionnaire used to assess dietary vitamin D intake has not been validated; however, it has been used in other investigations in college athletes (Fitzgerald et al., 2015a, Fitzgerald et al., 2015b; Halliday et al., 2011). Strengths of the study include the relatively large sample size of an at risk population (latitude greater than 35 degrees N). In addition, we included both males and females competing in numerous NCAA DI sports.

The results of this study show that the majority of athletes report low concern related to their vitamin D status and risk of deficiency. The overall majority believe vitamin D will play a role in health and performance, however, most express little concern for their vitamin D status, 60.5% (49) of our athletes did not meet RDA for vitamin D intake. Our study shows "concern" and "familiarity" are positively correlated with vitamin D intake. In conclusion, increased vitamin D familiarity in women and concern of vitamin D levels in men are associated with increase total intake of vitamin D. It appears that interventions aimed to increase vitamin D-related familiarity in women and concern in vitamin D status in men may reduce the prevalence of vitamin D deficiency in athletes.

APPENDICES

APPENDIX A
DIET AND LIFESTYLE QUESTIONNAIRE

Diet and Lifestyle Questionnaire
Adopted from Halliday et al., 2011

Foods Section

For each food listed, check the box indicating how often on average you have used the amount specified during the last three months.

Foods Consumed	Never or < 1 per mo.	1-3 per month	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
1. Milk, Vitamin D fortified, 1 cup	0	2	4	12	22	30	75	135	180
2. Soy Milk or Rice Milk, Vitamin D fortified, 1 cup									
3. Cereal, Vitamin D fortified (Total Corn Flakes, Kelloggs Raisin Bran, Oat Bran, Cheerios),3/4 cup Specify Cereal:									
4. Subway Sandwich, 6 inch									
5. Margarine, Vitamin D fortified (Promise, etc.), 1 teaspoon									
6. Orange Juice, Vitamin D fortified (Tropicana, Florida's Natural), 1 cup									
7. Liver, cooked, 3 ½ oz.									
8. Egg, 1 whole									
9. Cod liver oil, 1 teaspoon									
10. Salmon, cooked, 3 ½ oz.									
11. Mackerel, cooked, 3 ½ oz.									
12. Sardines, canned in oil, 3 ½ oz.									
13. Walleye, cooked, 3 1/2 oz.									
14. Tuna, canned, 3 oz.									
15. Eel, cooked, 3 ½ oz.									
16. Other Fatty Fish, 3 1/2 oz.									
17. Other Vitamin D fortified food, if applicable.									

Supplements Section

For each supplement, check the box indicating how often on average you have used the amount specified during the last three months (since you last completed this questionnaire).

Supplements Consumed	Never or < 1 per mo.	1-3 per month	1 per week	2-4 per week	5-6 per week	1 per day	2-3 per day	4-5 per day	6+ per day
1. Multiple Vitamin, 1 Tablet									
2. Calcium Vitamin, 1 Tablet									
3. Vitamin D , 1 Tablet (list amount __________)									
4. Calcium + Vitamin D (Viactiv), 1 Tablet									
If you take any of the above three, please list which you use, brand name, etc.									

Are you concerned about your vitamin D levels?

1	2	3	4	5

Do you believe you are at risk for vitamin D deficiency?

1	2	3	4	5

Do you know any factors that may affect your vitamin D levels? (List all)

Do you believe vitamin D plays a role in your health?

1	2	3	4	5

If so, what benefits do you believe it to have? (List all)

Do you believe vitamin D plays a role in your athletic performance?

1	2	3	4	5

If, so what benefits do you believe it to have? (List all)

APPENDIX B

EMAIL TO COACHES

Dear Coach _____,
My name is Bennett Leitch and I am a certified Athletic Trainer pursuing my Master's degree in Kinesiology at UND. I am conducting a survey about vitamin D awareness and using a series of food-related questions to estimate vitamin D levels. The survey will be completed online and takes no longer than 15 minutes to complete. Vitamin D is becoming an important topic in health and sports. I am looking to collect this data between December and February.

I have approval from the IRB and the UND athletics department, however, I still need your approval to send the link to the survey to your athletes. If you approve, Daniella Irle, Deputy Director of Athletics, will send the link to the survey to your athletes via email. Participation in the study is voluntary. Please respond back to my email if you approve of Daniella Irle sending the link to the survey to your athletes.

And Coach, thank you for your time. I know how busy you must be. I sincerely hope that I hear from you in the near future.

Bennett Leitch, ATC, 320-905-3543, bennett.leitch@und.edu

APPENDIX C

EMAIL TO COLLEGE ATHLETES

Hi. My name is Bennett Leitch and I am a certified Athletic Trainer pursuing my Master's degree in Kinesiology at UND. I am conducting a survey about vitamin D awareness and using a series of food-related questions to estimate vitamin D levels. Vitamin D is becoming an important topic in health and sports. I would very much appreciate it if you would complete an online version of my survey by using the link below. It takes only about 3-5 minutes and it is very important to me, as it will help me complete my degree! Thank you.
https://und.qualtrics.com/SE/?SID=SV_7WIMgitRw8HN5nn

APPENDIX D

IRB APPROVAL FORM

UNIVERSITY OF NORTH DAKOTA

UND.edu

Institutional Review Board
Twamley Hall, Room 106
264 Centennial Drive Stop 7134
Grand Forks, ND 58202-7134
Phone: 701.777.4279
Fax: 701.777.6708

November 19, 2015

Principal Investigator:	Bennett Leitch
Project Title:	Vitamin D Awareness, Prevalence of Supplementation and Estimated Total Vitamin D Levels in College Athletes
IRB Project Number:	IRB-201511-143
Project Review Level:	Exempt 2
Date of IRB Approval:	11/18/2015
Expiration Date of This Approval:	11/09/2018

The Protocol Change Form and all included documentation for the above-referenced project have been reviewed and approved via the procedures of the University of North Dakota Institutional Review Board.

You have approval for this project through the above-listed expiration date. When this research is completed, please submit a termination form to the IRB.

The forms to assist you in filing your project termination, adverse event/unanticipated problem, protocol change, etc. may be accessed on the IRB website: http://und.edu/research/resources/human-subjects/

Sincerely,

Michelle L. Bowles

Michelle L. Bowles, M.P.A., CIP
IRB Coordinator

MLB/sb

Cc: Dr. John Fitzgerald, Ph. D.

The University of North Dakota is an equal opportunity / affirmative action institution

APPENDIX E

MANUSCRIPT

Vitamin D Awareness, Prevalence of Supplementation and Estimated Total Vitamin D Intake in College Athletes

Submitting to the International Journal of Sports Nutrition and Energy Metabolism

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Abbreviated Title: Vitamin D Awareness and Estimated Intake in College Athletes

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ABSTRACT

This study aimed to investigate the awareness of vitamin D among collegiate athletes and evaluate the association between vitamin D awareness and total dietary intake of vitamin D. Eighty-one athletes completed the vitamin D awareness and dietary intake questionnaire. The results showed that males and females had very little concern over their vitamin D levels. Men reported 20.7% while females 25% for “likely” or “very likely”. Furthermore, overall male and female belief for being at risk for vitamin D deficiency was low. Males reported 24.1% for either “likely” or “very likely” to be at risk for deficiency and females 30.7% respectively. Overall, median intake of vitamin D was 330 IU, which is below the recommended daily allowance (RDA) of 600 IU. Median intake of vitamin D was higher for males (693 IU) when compared to females (263 IU). Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Awareness is positively correlated with vitamin D intake ($r = .483$, $p < 0.01$). It appears that concern for poor vitamin D status and familiarity influences total vitamin D intake. In addition, 60.5% (49) of our athletes not meeting the RDA for vitamin D intake represents poor vitamin D levels need to be improved. Interventions aimed at increasing awareness of the risk of poor vitamin D status may reduce the prevalence of vitamin D deficiency in collegiate athletes.

Key Words: NCAA, Nutrition, 25-hydroxyvitamin D

INTRODUCTION

Researchers have found 61% of children and adolescents, as well as, 77% of adults are vitamin D insufficient in the United States (Constantini, Arieli, Chodick & Dubnov-Raz, 2010). Having vitamin D deficiency appears to have a negative impact on multiple health outcomes (Constantini et al., 2010; Farrell, Cleaver, & Willis, 2011; Halliday et al., 2011; Larson-Meyer, 2013). A causal link has been made between vitamin D and bone health (Constantini et al., 2010; Farrell et al., 2011; Halliday et al., 2011; Holick, 2007; Lanteri, Lombardi, Colombini, & Banfi, 2012; Larson-Meyer, 2013; Willis, Peterson, & Larson-Meyer, 2008). More recently, evidence indicating that immune (Constantini et al., 2010; Halliday et al., 2011; Larson-Meyer, 2013; Willis, Smith, Broughton, & Larson-Meyer, 2012), muscle (Cannell, Hollis, Sorenson, Taft, & Anderson, 2009; Fitzgerald, Peterson, Warpeha, Johnson, & Ingraham, 2015a; Fitzgerald, Peterson, Wilson, Rhodes, & Ingraham, 2015b; Larson-Meyer, 2013) and cardiovascular function (Fitzgerald et al., 2014; Hamilton, Grantham, Racinais, & Chalabi, 2010; Halliday et al., 2011; Larson-Meyer, 2013) may be affected by vitamin D status. All stated outcomes might negatively influence health and physical performance in athletes.

This evidence, along with the high prevalence of deficiency, underscores the importance of assessing vitamin D awareness. Lack of knowledge about the importance and sources of this vitamin may be contributing to the high prevalence of deficiency. Sources of vitamin D from food include: oily fish, cod liver oil, and fortified foods, like milk, fruit juices, breads and cereals (Halliday et al., 2011). However, vitamin D is most commonly acquired through sunlight when available (Cannell et al., 2009). Current recommended daily value (RDA) is labeled at 600 IU, according to Larson-Meyer, (2013) athletes across the globe average 100 IU to close to 250 IU per day. Researchers recently conducted a study with male hockey players in Minnesota where food, multivitamin and supplementation combined was moderately correlated (r = 0.58) with vitamin D status (Fitzgerald et al., 2015). This data indicates that total dietary intake of vitamin D is related to 25(OH)D status and factors that increase dietary and supplemental intake will likely have a positive effect on status. Vitamin D awareness may be one factor that may impact total dietary intake (Walker et al., 2014).

Researchers have assessed vitamin D awareness in the general population (Alemu & Varnam, 2012; Pirrone, Capetola, Riggs, & Renzaho, 2013; Uddin et al., 2013; Zipitis, Elazabi, & Samanta, 2011); however, only recently has a study addressed this question in athletes (Walker et al., 2014). In a relatively large sample of internationally competing New Zealand athletes with an average age of 25.53 (SD = 3.11), a majority (76%) could name the primary source of vitamin D, the sun, albeit, very few (17%) were able to name another source. Moreover, only 6% were concerned about their vitamin D levels. Neither, vitamin D status nor dietary intake was recorded in this study.

Population-specific assessments are needed to characterize vitamin D awareness in athletes, as awareness may be highly variable among populations. We are unaware of any investigation evaluating the association between vitamin D awareness and vitamin D status, or quantifying a source of vitamin D. An understanding of NCAA collegiate athletes' awareness of vitamin D in relationship to total dietary intake of vitamin D may provide the necessary information to develop behavioral-based interventions aimed at reducing vitamin D deficiency in collegiate athlete populations in the United States.

The primary purpose of this study was to assess vitamin D awareness in NCAA collegiate athletes. The secondary purpose was to evaluate the association between vitamin D awareness and total dietary vitamin D intake. It was hypothesized that select aspects of vitamin D awareness would be associated with total dietary vitamin D intake.

METHOD

Participants

Division I collegiate athletes from several different sports at the University of North Dakota (UND) were recruited for this study, which was approved by the Institutional Review Board (IRB) and the athletic department. Athletes were recruited using a sample of convenience and selected based on geographic location being above 35 degrees north, which is a risk factor for vitamin D deficiency. Vitamin D, health and physical performance has become a popular area of research, but few investigators have examined vitamin D intake in athletes, therefore, this is our area of focus. We are not aware of any studies evaluating the association between dietary vitamin D intake and vitamin D awareness. The inspection of vitamin D intake as it relates to awareness is important in athletes to enable the design of interventions aimed at reducing the prevalence of vitamin D deficiency in this population. The prevalence of vitamin D insufficiency in athletes has been estimated from 100 to 250 IU (Larson-Meyer, 2013). Vitamin D deficiency in athletes may negatively impact their health and physical performance as it has been linked to reduced exercise performance (Willis et al., 2008; Cannell et al., 2009; Fitzgerald et al., 2014; Fitzgerald et al., 2015), increased stress fractures (Holick, 2007; Larson-Meyer, 2013), and increases incidence of respiratoryinfection (Constantini et al., 2010; Farrell et al., 2011; Halliday et al., 2011; Willis et al., 2012). Athletes were excluded if they no longer participated in a collegiate sport. The questionnaire was sent out to athletes competing at UND (n = ~500) with the exception of men's and women's basketball (n = 15, n = 18), men's hockey (n = 27), men's golf (n = 7), women's volleyball (n= 15), and women's tennis (n = 10) as permission was not granted by the head coach of these sports. That left a potential participant pool of 336 and 81 completed the questionnaire.

Measures

Vitamin D awareness was assessed using a questionnaire (see Appendix A) with five questions: 1) How much have you heard about vitamin D? 2) Are you concerned about your vitamin D levels? 3) Do you believe you are at risk for vitamin D deficiency? 4) Do you believe that vitamin D plays a role in your health? 5) Do you believe vitamin D plays a role in your athletic performance? These questions were rated on a 5-point

Likert Scale. There were three sets of anchors for these questions: Never to A lot for question one, Very Unlikely to Very Likely for question two and three, and Definitely Will Not to Definitely Will for question four and five. After questions 3, 4 and 5, an open ended follow up question was included. These consisted of: 1) Do you know any factors that may affect your vitamin D levels? 2) If so, what benefits do you believe it to have? The last question was used twice, once for health benefits, once for performance benefits.

Dietary vitamin D intake was assessed using the the Diet and Lifestyle Questionnaire (see Appendix A), which was adopted from Halliday et al. (2011). This questionnaire was also used by Fitzgerald et al. (2015b) when evaluating dietary vitamin D intake in hockey players. It contains questions asking about foods and supplements consumed. It also includes a few questions related to sun exposure habits, but these were not analyzed due to the geographical and temporal characteristics of the data collection period.

Procedure

A cross-sectional study design was used to assess awareness of vitamin D in collegiate athletes and evaluate the relationship between awareness and total dietary intake of vitamin D. In order to recruit college athletes, we received approval from the UND athletic department, as well as, permission from head coaches of the college athletes that participated. Emails were sent to all 16 head coaches at UND of all male and female sports. A copy of the email can be seen in the Appendix B. All athletes completed an informed consent document. Self-reports of age, race, sex, sport, height, and weight were recorded for all athletes. Athletes completed the questionnaire via an online survey using ‘Qualtrics’. The online survey instrument was designed to facilitate accurate data collection. To facilitate participation and accuracy the survey only took approximately 5 minutes to complete. The survey was opened for completion November 1st of 2015 and kept open until January 30th of 2016.

Statistical Analysis

IBM SPSS Statistics for Macintosh, Version 23.0 was used to analyze data. The data were analyzed for normality. Descriptive statistics were presented as means and standard deviation for normally distributed data. Median and interquartile range (IQR) were used to describe variables that were not normally distributed. Proportions were used to describe the distribution of Likert scores, as they are not a continuous variable. Spearman rank correlation coefficient (rho) was used to assess the correlations between Likert values from vitamin D awareness questions and estimated vitamin D intake from food, supplements and total dietary vitamin D intake. Alpha was set at $p = 0.05$ and two-sided p-values were used for calculations.

RESULTS

Out of the roughly 500 college athletes at UND, we were allowed to send our questionnaire to 336 athletes. Male sports that were approved are as follows: baseball, cross country, track and field, football, swim and dive, and tennis. Out of the possible 175 male athletes, 29 completed the questionnaire (mean (SD): age = 19.9 (1.6) yrs, height = 185.2 (7.2) cm, weight = 88.1 (22.2) kg, body mass index [BMI] = 25.6 (5.1) kg·m^{-2}, 26 white, 1 black, 1 Hispanic, 1 Asian). Female sports that were approved include: cross country, golf, hockey, soccer, softball, swim and dive, and track and field. Out of the possible 161 female athletes, 52 completed the questionnaire (mean (SD): age = 20.0 (1.5) yrs, height = 168.2 (6.2) cm, weight = 64.8 (7.9) kg, BMI = 23.0 (2.2) kg·m^{-2}, 50 white, 1 black, 1 Hispanic).

Estimated dietary intake of vitamin D from foods and supplementation is shown in Table 1. Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Median and interquartile ranges were used as our data was skewed. Our median male intake reached 693 IU, females recorded 263 IU. Multivitamin and vitamin D supplementation was reported by 41.9% of athletes (16 males, 18 females). Mean intake of vitamin D from supplements was 1,207 IU per day, and did not differ substantially between males and females (males: 1,126 IU, females: 1,279 IU). Multivitamin intake was the most common, with 38.3% (13 males, 18 females) of athletes reporting intake with a mean dose per day of 487 IU. When analyzed separately, males' average intake was 355 IU per day, while females consumed 583 IU per day. Fewer athletes reported taking Vitamin D supplements. Only 19.8% (10 males, 6 females) reported consumption. Of these, 8 athletes documented supplementation values and their mean dose per day was 3,241 IU.

Correlations between dietary and supplemented vitamin D intake and Likert awareness scores are presented for males and females in Table 2 and Table 3, respectively. In males, higher intake of supplementation, as well as, supplement and multivitamin intake was positively correlated to belief in performance enhancement ($p < 0.05$). In females, a higher intake of multivitamin consumption, along with combined supplementation and multivitamin together was correlated with concern about their vitamin D levels.

Likert scores for awareness in our male athletes are shown in Table 4, females' awareness is recorded in Table 5. Likert scales used to assess vitamin D awareness were presented using the proportion of athletes indicating a given value for each question, as these scores are not continuous in nature. Responses for the qualitative data were coded by finding overall themes in the data. For question one, all answers dealing with sun were put into the "sun" category. Any response that mentioned food, diet or nutrition were labeled "diet." The "supplements" category contains any answer stating vitamins or supplements. Those responses that did not make up the top three responses were placed in the "other" section. These included: stress, exercise, age, weight, skin color, health and sunscreen. Finally, the "no response" category contains those that did not respond to the question or answered no.

Question two and three were also split into this same format and had the same categories, however, they were in different order of prevalence. The first category was "mood." This was comprised of statements about mood, happiness, and seasonal affective disorder (SAD). "Bone" was themed for responses that mentioned bone health, strength and osteoporosis. Those responses that were placed in the "energy" category consisted of those stating energy and fatigue. The other category again was comprised of those that did not make the top three responses and included responses related to health, metabolism, vitamin, immune, calcium absorption, performance and stress. The "other" category for the third question consisted of responses of: vitamin/mineral, muscle, performance, recovery, health, stress, immune and vision. It is important to note that responses that were placed into the "health" section were generic answers that restated the question. Again, those that did not respond to question two and three or responded "not sure" or "don't know" were placed in the "no response" section.

Interestingly, 55% of males reported "very unlikely" or "unlikely" when asked about their concern of vitamin D levels. Approximately 59% of males reported either "very unlikely" and "unlikely" when asked if they believed they were at risk for poor vitamin D status. In contrast, when asked if vitamin D plays a role in health males reported a combined, "likely" and "very likely" score of 86.3%. When asked the same question about performance males answered "likely" and "very likely" a combined 69%. Females reported very similar numbers. After combining their responses, 61.5% stated they were “unlikely” or “very unlikely” to concerned over their vitamin D levels. When asked if they believed they were at risk for vitamin D deficiency 61.6% responded “unlikely” or “very unlikely”. However, when asked if vitamin D impacts health 90.4% responded “likely” or “very likely.” For its impact on performance 73.2% reported “likely” or “very likely.”

Proportions were also used for our qualitative data on awareness shown in Table 6. Sun, diet and supplements are known factors in vitamin D intake, which consisted of 56.3% of our responses. Athletes generally thought mood, bone and energy were the most impacted from vitamin D intake.

DISCUSSION

The primary aims of this study were to assess the awareness of vitamin D among collegiate athletes, evaluate the association between vitamin D awareness and total dietary intake of vitamin D and establish how many of our college athletes were meeting the RDA for vitamin D intake. We found, based on our awareness scales, that although all our athletes reported hearing about vitamin D few, 23.4%, are “likely” or “very likely” to be concerned about their levels. In addition, 28.4% believe they are “likely” or “very likely” to be at risk for vitamin D deficiency. Over half of the males met the RDA for vitamin D (62.1%), while only 26.9% of females reached the RDA. Our median male intake reached 693 IU, females recorded 263 IU. To our knowledge, this is the first study to report bivariate associations between awareness and vitamin D intake (.483, $p < 0.01$).

Characterizing vitamin D awareness in our population was the primary purpose of this study. We characterized awareness with our college athletes' by their familiarity to vitamin D, levels of concern and attitudes toward being at risk for poor vitamin D status, health and performance benefits. All of our college athletes reported hearing something about vitamin D. About half (43.2%) of our athletes reported "unlikely" and 16.1% stated they were "very unlikely" when asked about their concern about vitamin D levels. In addition, 44.4% of athletes believe they have an "unlikely" and 16.1% "very unlikely" chance of being vitamin D deficient. This is inline with theresults reported by Walker et al. 2014 surveying New Zealand athletes. Ninety-seven percent of these athletes (n = 107) stated that they had heard about vitamin D. In addition, only 6% (n = 7) were concerned about their vitamin D status. Risk of being deficient was not evaluated in these athletes. Other studies were conducted with non-athletes, including pregnant mothers, elderly, pharmacy students, general population and African migrants to Australia. Of these studies, people were generally aware of vitamin D, but their personal concern for poor vitamin D status was never asked (Alemu & Varnam, 2012; Pirrone, Capetola, Riggs, & Renzaho, 2012; Uddin et al., 2013; Zipitis, Elazabi, & Samanta, 2011). However, these populations are not comparable to our sample population of college athletes.

Overall, our athletes had restricted awareness about vitamin D factors contributing to vitamin D status, as well as, the benefits it provides. All athletes reported hearing about vitamin D. However, when asked about risk or concern over vitamin D levels, very few indicated concern. Interestingly, when asked if vitamin D may play a role in performance (males: 69%, females: 73.2%) and overall health (males: 86.3%, females: 90.4%) the majority of athletes reported a positive benefit. Although 45.7% of our athletes could name the biggest source of vitamin D, the sun, 45.7% also couldn't name a factor that affects vitamin D levels. When asked what benefits they believe vitamin D to have on health, 14.8% answered bone, which has been casually linked with vitamin D intake (Holick, 2007; Lanteri et al., 2012; Larson-Meyer, 2013; Willis et al., 2008). Mood and energy were also represented with 16.1% and 11.1% respectively, however, these have not been causally linked with vitamin D intake (Anglin, Samaan, Walter, & McDonald, 2013; Scott et al., 2015). Even though every athlete reported being aware of vitamin D at some level, the actual awareness of the sources and importance of vitamin D appears to be lacking in our population. A novel finding of our study was the positive correlation between Likert total, or their total awareness score, and multivitamin and supplement intake, as well as, total dietary vitamin D intake. This appears to indicate those athletes that know the benefits of vitamin D will choose to take multivitamins or supplement vitamin D, therefore, also consuming more vitamin D.

Vitamin D supplementation in our study was minimal at 19.8% of athletes (n = 16). Multivitamin supplementation was reported by 38.3% (31) of our athletes, with again, lower than RDA values at 488 IU mean dose per day. This compares to Lehtonen-

Veromaa et al., (1999) study where 65% of their sample did not use vitamin D supplementation. Broken down by sex, both males and females are below RDA value. When combining vitamin D supplementation and multivitamin intake the total reaches 41.9% (34) athletes. Therefore, a little less than half are supplementing vitamin D directly or through a multivitamin. However, total dietary intake of vitamin D for most still does not reach the RDA standard. Split by sex, 62.1% (18) of the males reached the RDA, however, women dropped down with only 26.9% (14) meeting the standard. We speculate that males' higher vitamin D intake is likely due to greater caloric intake. These numbers appear problematic and are inline with a recent systematic review in which 56% had poor vitamin D status which is troublesome for our college athletes (Farrokhyar et al., 2015).

When comparing our study's results with others we see a common trend of inadequate vitamin D intake. Lehtonen et al., (1999) showed that out of the 186 girls 13.4% had blood serum of <20nmol/L, which is equivalent to <8ng/ml, or the severely deficient range. Overall, 68% were vitamin D insufficient. Other studies conducted with distance runners in Baton Rouge, LA, sportsmen in Qatar, and indoor and outdoor athletes in Israel had poor vitamin D status, reporting varying levels of insufficiency or deficiency, ranging from 40% to 90% (Willis et al. 2007; Hamilton et al., 2009; Constantini et al., 2009).

In contrast, Halliday et al., (2011) measured 41 athletes throughout an academic year revealing low percentages of insufficient status in college athletes during the fall and spring. Finally, Fitzgerald et al., (2015b) reported in their sample of 53 competitive ice hockey players that 62.3% (33) had sufficient vitamin D levels, 37.7% (20) possessed insufficient status and none of the participants were labeled vitamin D deficient.

Diet and supplement intake of vitamin D contributes roughly 30% of the variance in vitamin D status (Fitzgerald et al. 2015a). That is a large percentage of overall status. Low vitamin D status may influence bone health, immune health as well as muscle health (Halliday et al., 2011; Holick, 2007; Larson-Meyer, 2013; Willis et al., 2008). Although evidence is lacking, poor vitamin D status might affect physical performance in tasks related to strength, power and aerobic fitness (Cannell et al., 2009; Farrell et al., 2011; Fitzgerald et al., 2015a; Fitzgerald et al., 2014). The results of this study can have multiple implications not only for the athletes themselves who are deficient but also those that work with these athletes. Medical doctors, athletic trainers and physical therapists are all in association with these athletes, all responsible for their athlete's health. With the impacts we are finding about vitamin D on health and possibly performance, but more importantly, the lack of awareness and concern over vitamin D status, monitoring vitamin D can be an advantage. Awareness about poor vitamin D levels has to incorporate the entire medical field. By increasing awareness about vitamin D overall dietary intake should increase, therefore, we may positively affect the health and physical performance of athletes (Odukya, Odeyemi, Oyeyemi, & Upadhyay, 2014). This stresses the need for programs and campaigns about vitamin D awareness for not only athletes, but for those that work with athletes and those at risk for poor vitamin D status.

This investigation has several limitations. Our population was relatively homogenous in race, 93.8% white (n = 76). This cross-sectional study design used a sample of convenience, which likely introduced bias. Athletes that completed the survey may not be representative of the population. We did not have approval to send the questionnaire to all sports teams at UND. Our results are only generalizable to college athletes competing in the sports with sufficient representation in the sample. In addition, the questionnaire used to assess dietary vitamin D intake has not been validated; however, it has been used in other investigations in college athletes (Fitzgerald et al., 2015a, Fitzgerald et al., 2015b; Halliday et al., 2011). Strengths of the study include the relatively large sample size of an at risk population (latitude greater than 35 degrees N) including males and females competing in numerous NCAA DI sports.

The results of this study show that the majority of athletes report low concern related to their vitamin D status and risk of deficiency. The overall majority believe vitamin D will play a role in health and performance, however, most express little concern for their vitamin D status, 60.5% (49) of our athletes did not meet RDA for vitamin D intake. Our study shows “concern” and “familiarity” are positively correlated with vitamin D intake. In conclusion, increased vitamin D familiarity in women and concern of vitamin D levels in men are associated with increase total intake of vitamin D. It appears that interventions aimed to increase vitamin D-related familiarity in women and concern in vitamin D status in men may reduce the prevalence of vitamin D deficiency in athletes.

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Tables

Table 1. Vitamin D Intake from Food and Supplement per Day (n=81).

	Overall	Male	Female
Dietary vitamin D from food	231 (125-408)	407 (162-656)	213 (122-297)
Dietary vitamin D supplement	0 (0)	0 (0)	0 (0)
Dietary vitamin D from multivitamin	0 (0-267)	0 (0-367)	0 (0-200)
Dietary vitamin D from supplement and multivitamin	0 (0-507)	40 (0-600)	0 (0-200)
Total dietary vitamin D intake	330 (182-835)	693 (309-1564)	263 (162-705)

Values in IU, Median and IQR used, Median supplement values include those participants that did not take a supplement and therefore had a 0 value.

Table 2. Correlations between Dietary Vitamin D Intake and Vitamin D Awareness Scale for Males.

	Food	Multivitamin	Supplement	Multivitamin and Supplement	Total
Familiarity	.098	.118	.198	.185	.286
Concern	.228	.109	.345	.322	.448*
Risk	-.030	.073	.094	.111	.147
Health	.010	.172	.254	.222	.186
Performance	.040	.225	.495*	.442*	.385*
Likert Total	.229	.222	.365	.375*	.483**

Spearman rho correlation test, n=29 *significance at the 0.05 level (2-tailed).
**significance at the 0.01 level (2-tailed)

Table 3. Correlations between Dietary Vitamin D Intake and Vitamin D Awareness Scale for Females.

	Food	Multivitamin	Supplement	Multivitamin and Supplement	Total
Familiarity	.227	.199	.061	.212	.334*
Concern	.061	.336*	-.205	.315*	.224
Risk	.-027	.153	.221	.139	-.008
Health	.278*	.068	-.138	.055	.187
Performance	.088	-.139	.036	.-134	-.091
Likert Total	.163	.196	-.204	.186	.191

Spearman rho correlation test, n=52 *significance at the 0.05 level (2-tailed).
**significance at the 0.01 level (2-tailed)

Table 4. Proportions of Male Athletes (%) within each Category on Various 5-Point Likert Scales in Response to Vitamin D Awareness Questions.

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*A Lot*
How much have you heard about vitamin D?	0.0	24.1	48.3	20.7	6.9
	Very Unlikely	*Unlikely*	*Undecided*	*Likely*	*Very Likely*
Are you concerned about your vitamin D levels?	20.7	34.5	24.1	6.9	13.8
Do you believe you are at risk for vitamin D deficiency?	24.1	34.6	17.2	17.2	6.9
	Definitely Will not	*Probably Will Not*	*Don't Know*	*Probably Will*	*Definitely Will*
Do you believe that Vitamin D plays a role in your health?	0.0	0.0	13.7	41.3	45.0
Do you believe that vitamin D plays a role in your performance	0.0	6.9	24.1	44.9	24.1

Table 5. Proportions of Female Athletes (%) within each Category on Various 5-Point Likert Scales in Response to Vitamin D Awareness Questions.

Question	*Never*	*Rarely*	*Sometimes*	*Often*	*A Lot*
How much have you heard about vitamin D?	0.0	19.2	48.1	28.9	3.8
	Very Unlikely	*Unlikely*	*Undecided*	*Likely*	*Very Likely*
Are you concerned about your vitamin D levels?	13.4	48.1	13.5	19.2	5.8
Do you believe you are at risk for vitamin D deficiency?	11.6	50.0	7.7	28.8	1.9
	Definitely Will not	*Probably Will Not*	*Don't Know*	*Probably Will*	*Definitely Will*
Do you believe that Vitamin D plays a role in your health?	0.0	1.9	7.7	52.0	38.4
Do you believe that vitamin D plays a role in your performance	0.0	3.7	23.1	54.0	19.2

Table 6. Qualitative Reponses to Vitamin D Awareness Questions.

Questions	Responses (n)	Number and Proportion of Athletes Reporting Theme				
Do you know any factors that may affect your vitamin D levels? (list all)	119	Sun Related	Diet Related	Supplements	Other	No Response
		37 (45.7%)	24 (29.6%)	6 (7.4%)	15 (18.5%)	37 (45.7%)
If so, what benefits do you believe it (vitamin D) to have (on health)?	99	Mood	Bone	Energy	Other	No Response
		13 (16.1%)	12 (14.8%)	9 (11.1%)	33 (40.7%)	32 (39.5%)
If so, what benefits do you believe it (vitamin D to have (on performance)?	90	Energy	Mood	Bone	Other	No Response
		12 (14.8%)	6 (7.4%)	5 (6.2%)	21 (25.9%)	46 (56.8%)

*Proportions of athletes reporting each theme were out of n=81.