International Journal of Research Studies in Medical and Health Sciences
Volume 2, Issue 6, 2017, PP 8-15
ISSN : 2456-6373

Vitamin D Deficiency in College-Age Male Basketball Players: Sports Medicine Physicians Can Play an Important Role

Micah Dunn MS, RD

Texas Tech University; Department of Kinesiology and Sport Management, Texas, USA

Dr. Jacalyn J. Robert-McComb, PhD, FACSM

Texas Tech University; Department of Kinesiology and Sport Management, Texas, USA

***Corresponding Author:** Dr. Jacalyn J. Robert-McComb; Texas Tech University; Department of Kinesiology and Sport Management; 3204 Main Street; Lubbock, Texas, USA*

ABSTRACT

Background: *Sport medicine physicians need to be aware of inherent risks in their plyers. Data has been reported on the inadequacy of serum 25(OH)D levels in high level professional athletes, especially those who compete indoors. However, there is no published data on serum 25(OH)D levels in college-age basketball players. Nor is there a plethora of published data on vitamin D supplementation and athletic performance. Therefore, the objectives of the present study were to investigate: (1) vitamin serum 25(OH)D levels in male college-age basketball players; (2) if vitamin D3 supplementation increased serum 25(OH)D levels to recommended levels; and (3) the effect of vitamin D3 supplementation on athletic performance.*

Methods: *This study was a double-blind, placebo controlled trial. Seventeen males were randomly divided into two groups: a placebo and a vitamin D3 supplementation group. Pre-post tests consisted of a series of athletic performance testing (vertical jump, 20 m sprint time trial, and 5-10-5 agility drill time trial). Blood samples were taken and analyzed for 25(OH)D using liquid chromatography, tandem mass spectrometry at baseline and 8-weeks post treatment.*

Results: *The results indicated that: (1) collegiate, recreational, and intramural basketball players were deficient in 25(OH)D levels at baseline; (2) vitamin D3 supplementation was effective at significantly increasing 25(OH)D levels post 8-weeks with a very large sample effect size (d =-2. 6); yet (3) there were no significant main effects or interactions in pre-post test athletic performance measurements. However, positive trends were seen in the data pre-post performance measurements for both groups and there was a moderate sample effect size for change in agility (d =-0.48.) from pre-post test between groups.*

Conclusion: *At baseline, college-age recreational and collegiate male basketball players have deficient serum 25(OH)D levels. However, 8-weeks of 4,000 IU of vitamin D3 (cholecalciferol) effectively increased serum 25(OH)D levels to normal levels which were >30 ng/mL. There were not, however, significant concomitant increases in athletic performance.*

Keywords: *Sports medicine, team physician, Vitamin D, Vitamin D3, college athletes, vitamin serum 25(OH)D levels, athletic performance, intramural, speed, agility, power*

INTRODUCTION

Sports medicine physicians need to be aware of the inherent risks in the sport that they serve. There are certain risk factors that can be easily controlled through diet and supplementation. There is interest in the vitamin D levels of athletes who compete indoors worldwide. In the United States (U. S.), data has been reported on the inadequacy of serum 25(OH)D levels in high level athletes, especially those who compete in doors. The National Basketball Association (NBA) released deidentified data on 279 players from 2009 through 2013. Vitamin D levels were categorized as follows: (a) deficient (<20ng/mL); (b) insufficient (20-32 ng/mL); and sufficient (>32ng/mL). Surprisingly, 79.3% were either vitamin D deficient or insufficient, as defined in this study. The average vitamin D levels for all players was 25.6 ± 10.2 ng/mL, which was categorized as insufficient. [1] In another study in the U. S., preliminary data in gymnasts report especially alarming levels of vitamin D, with 37% recording levels in the single digits. [2] These findings are extremely

disturbing to other athletes that spend the majority their time indoors.

While not professional players, a meta-analysis of seven different trials of vitamin D supplementation and performance parameters in healthy adults, showed that supplementation significantly increased muscle strength in the experimental group for upper (P=0.005) and lower limbs (P=0.04). Length of intervention time varied from 4 weeks to 6 months in this study and dosages differed from 4000 IU per day to 60,000 IU per week.[3] Given this large variation, it is difficult to make definitive conclusions from this analysis regarding optimal intervention time and required dosage for effective supplementation. In a study of 46 elite professional European athletes it was found that high doses of vitamin D3 supplementation (70,000 IU week) may be detrimental for its intended purposes due to increased 24,25[OH]2D production. Their data implied that lower doses of vitamin D3 ingested frequently may be most appropriate. [4]

Given the absence of any published data on the adequacy of serum 25(OH)D levels in college-age basketball players in the United States and the recommendation for lower doses of vitamin D3 ingested frequently, a study was conducted to: (1) to investigate serum 25(OH)D *levels in* National Collegiate Athletic Association *(*NCAA*) Division I* male college-age basketball players and college-age recreational intramural basketball players prior to supplementation on the Texas Tech University (TTU) campus; (2) to evaluate the effects of 4,000 IU Vitamin D3 supplementation on serum 25(OH)D levels; and (3) to examine the effects of 4,000 IU vitamin D3 supplementation on athletic performance.

Materials and Methods

Institutional Review Board Approval

The study was approved by the TTU Institutional Review Board. The design for this study was double-blind, placebo controlled trial, where neither the study participants nor researchers were aware of treatment, either vitamin D3 supplementation or placebo. Participants signed an informed consent form prior to study participation and all data collection. Participants from each group, collegiate, recreational, and intramural players were randomly assigned to a supplement or placebo group.

Definitions of Serum 25(OH)D Levels for the Study

Although discrepancy exists regarding the classification of 25(OH)D Vitamin D levels, baseline serum 25(OH)D levels were compared to sufficient 25(OH)D levels defined as >30 ng/mL.[5, 6, 7] The following categories were used in this study: (1) 25(OH)D levels below 20ng/mL were categorized as deficient; (2) between 20 and 30 ng/mL was defined as insufficient; and (3) sufficient levels were defined as 25(OH)D levels above 30 ng/mL.

Participants

Participants were recruited from the collegiate basketball team, intramural basketball games on the college campus, and dedicated recreational basketball players. Criteria for inclusion included the following, participants must: (1) be NCAA or recreational, intramural college-age (18-28 years) male basketball players; (2) have a stable physical training program for at least 1 year without plans to alter or change the regimen for the next 3 months; (3) play basketball 3 or more days a week, with plans to continue for at least 8-weeks following baseline testing; (4) have been playing basketball for 2 years or more; (5) not be ingesting a vitamin D3 supplement, with exclusion of a multi-vitamin 2 months prior to participation in the study; and (6) answer “no” to all Physical Activity Readiness Questionnaire (PAR-Q) questions and not have had an injury that would prevent them from completing the athletic performance testing.

Procedure for Descriptive Statistics

Information regarding height, weight, and body composition was analyzed on each participant. Participants were instructed to wear spandex without shoes during all body measurements. Weight was assessed using a standardized standing scale. The Bod Pod (COSMED USA Inc., Concord, CA) was used to gather data on body composition, fat and fat-free mass. Participants sat on the bench in the Bod Pod chamber with a swim cap and were instructed to breathe normally. Body composition was measured through the displacement of air inside the Bod Pod chamber. Lung volume was estimated based on gender, height, and body weight.

Pre-Post Test Procedures

The Texas Tech University Health Science Center (TTUHSC) medical and trained phlebotomy staff completed all blood draws 25(OH)D for the assessment of 25(OH)D levels Standard precautions were used to avoid any localized pain, bruising, or infection. After the 5ml blood collection, samples were inverted 5 times and centrifuged at 4,000 rpm for 5 min. Samples were then sent to Quest Diagnostics and analyzed for 25(OH)D using liquid chromatography, tandem mass spectrometry (LC-MS). Quest Diagnostics implemented standard laboratory quality control procedures.

Participants completed 3 basketball sport-specific performance tests. The vertical jump was assessed using Vertec (JUMPUSA.com Sunnyvale, CA) vertical jump measurement system. A one-step approach method was implemented: Participants feet were together and their arms were used in an upward swinging motion to maximize jump height. There were 3 attempts with a 2 min rest between attempts. The highest jump was recorded and used for analysis.

The 20m sprint was assessed for quick acceleration. Two cones were placed 20m apart from each other on a NCAA regulated basketball court. Participants placed one foot at the starting cone and accelerated through to the second cone. Timers (2) were aligned at the 20m cone markers. Timing started with the initial movement by the participants and stopped when the subject passed the 2nd cone. Each participant performed 2 sprint attempts with 2 min of rest between each attempt. The 4 recorded times were averaged and used for analysis.

The 5-10-5-meter agility test was used to estimate agility. Cones (3) were placed 5m apart on the court. Participants began at the center cone, sprinted to the cone to the right, then to the cone on the left, and back again to the beginning cone. Multiple attempts (2) were given per participant with 2 min of rest between attempts. Two timers located at the center cone were used to record the time of each attempt. Timers began at the initial movement of the participant and stopped when the participant ran past the center cone at the completion of the drill. Time on each attempt were averaged and analyzed. Post-test procedures were identical to the pre-test procedures.

Treatment

Each participant began oral ingestion of either supplementation of 4,000 IU, 2 capsules of 2000 IU, of vitamin D3 [cholecalciferol (Stop Aging Now, Bethesda, MD)], or 2 capsules of a placebo each day for 8-weeks after pre-testing. The amount of vitamin D3 was chosen based on the recommendation of the National Institutes of Health Office of Dietary Supplements which states that the safe upper limit for vitamin D3 is 4,000 IU/day for children 9 years and older and for adults. The tolerable upper limit refers to the maximum level of daily nutrient intake that is likely to pose no risk of adverse effects. [8]

The supplements and placebos were divided into 7-day pill organizers. Eight of these containers containing either placebo or supplementation were then put in large envelopes and given to the participants. Verbal and written instructions were given about the timing of the intake for the 2 capsules each day in the 7-day organizers. Participants were instructed to take each pill during their meals to ensure better absorption of the vitamin D3 supplement. Participants were informed to check or initial the days when the supplement was ingested and leave the box blank on the days they failed to ingest the supplement. Compliance was monitored using a self-report check sheet. Researchers checked in with the participants throughout the 8-week supplementation period, through text messaging, phone calls, and in person visits to monitor compliance and safety. After 8-weeks of supplementation, 25(OH)D levels were assessed again using the same procedures previously described.

Statistical Analysis

SPSS Software (IBM Corporation, Somers, NY) was used for all statistical analysis. Descriptive statistics were computed for height, weight, ethnicity, age, and body composition.

An independent t-test was used to compare the means of the baseline measurements between the placebo group and vitamin D3 supplementation group for the following variables: (1) 25(OH)D levels; (2) vertical jump; (3) 20m sprint; (4) agility drill; and (5) body fat percentage to make sure that there were no pre-test differences. A Mixed Plot Repeated Measures ANOVA was conducted to analyze

the variables of interest [2 (group: placebo; supplementation) by 2 (test: pre-post test following the 8-week 4,000 IU of vitamin D3 supplementation period)]. Variables of interest were: (1) levels of serum 25(OH)D levels; (2) vertical jump height; (3) 20m sprint time, and (4) 5-10-5 agility drill time.

RESULTS

Thirty eligible participants signed the consent form. Thirteen participants did not complete the study due to personal reasons and time constraints. Seventeen participants completed all pre-post testing and participated in the 8-week study as either the experimental group taking the supplementation or the placebo group. Of the 17 participants, 53% were Caucasian and 47% were African American. The attrition rate was 43%. Pill counts were used to determine compliance. The compliance rate was 77% in the placebo group and 79% in the experimental group.

Descriptive Statistics

Descriptive statistics for the 17 participants are presented in Table 1. No significant differences existed between groups at baseline for any of the variables of interest in pre-post testing: (1) 25(OH)D levels, $t(15) = -0.6$, $p = 0.55$; (2) vertical jump, $t(15) = -2.4$, $p = 0.41$; (3) 20m sprint, $t(15) = 0.06$, $p = 0.44$; (4) agility drill, $t(15) = -0.11$, $p = 0.46$. Therefore, differences at baseline did not need to be controlled for in the study design.

Table1. *Descriptive Statistics and Baseline Measurements*

Variables	Mean (SD) Placebo	Mean (SD) Vit D
Age	18.25 (10.30)	21.1 (9.27)
Weight (kg)	27.67 (3.46)	27.67 (2.61)
Height (cm)	71.22 (2.20)	74.44 (4.39)
Body Fat Percentage	15.01 (8.42)	12.68 (5.71)
Ethnicity	4=AA; 4=C	4=AA; 5=C

Ethnicity: C=Caucasian, AA= African American

Baseline Serum 25(OH)D Levels

Baseline serum 25(OH)D levels were compared to sufficient 25(OH)D levels defined as >30 ng/mL.[5, 6, 7] Average baseline serum 25(OH)D levels for total participants (N = 17) was 19.33 ± 9.46 ng/mL, which is less than the value indicative of deficiency, 20 ng/mL. A single sample t-test revealed this value was significantly different from sufficient 25(OH)D levels defined as > 30 ng/mL $t(16) = -4.783$, $p < 0.001$.

Pre-Post Serum 25(OH)D Levels

The Mixed Plot Repeated Measures ANOVA revealed a significant main effect for test

$F(1,15) = 114.50$, $p < 0.001$ and a significant group x test interaction $F(1,15) = 15.01$, $p = < 0.002$. No significant difference was found for group. There was a large sample effect size for change in the serum 25(OH)D levels from pre-post test between groups ($d = 2.6$). Observed power was .057 for test, .178 for test x group, and .380 for group. Pre-post *M and SEM* are presented in Figure 1.

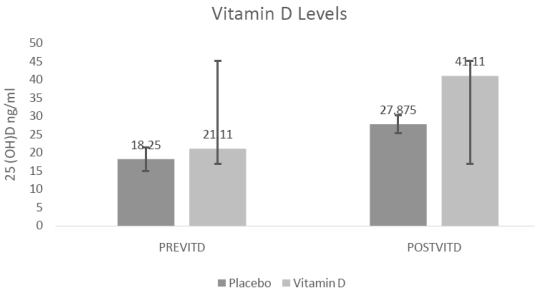

Figure1. *Pre-post test 25 (OH)D levels.*

Pre-Post Performance Measurements

The Mixed Plot Repeated Measures ANOVA revealed no significant main effects for test, group or significant interactions between test and group for the vertical jump used as an assessment of power, for the 20m sprint time used as an assessment of speed, nor the 5-10-5 agility drill used as an assessment of agility. There was a moderate effect size for agility ($d = -0.48$) but effect sizes were small for the vertical jump and sprint times, respectively ($d = .2$; $d = -.02$). The observed statistical power for test, group, and the interaction between group and test for the vertical jump was .05, .05, .07 respectively; the observed power for the 20m sprint was .36, .05, .05 respectively; and the observed power for the 5-10-5 agility drill was

.06, .18, .05 respectively. Pre-post *M and SEM* are presented in Figures 2-4.

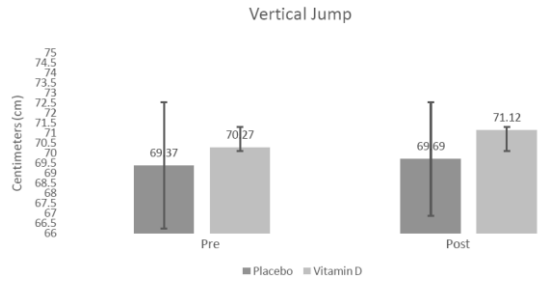

Figure2. *Pre-post test vertical jump*

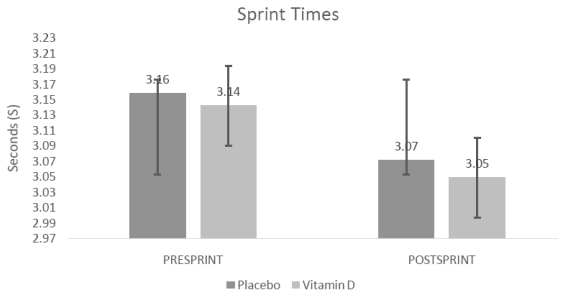

Figure3. *Pre-post test 20m sprint times*

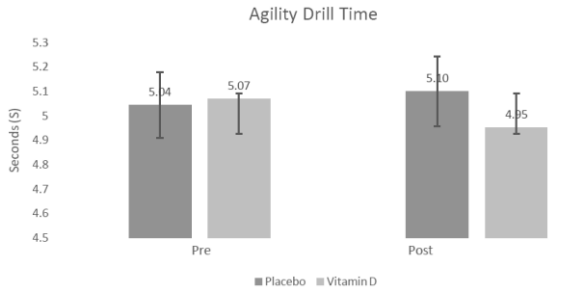

Figure4. *Pre-post test 5-10-5 drill times*

DISCUSSION

Study Aim 1: Baseline Serum 25(OH)D Levels

The most noteworthy finding in our study is that recreational and collegiate basketball players in our sample had an average *25(OH)D (vitamin D3)* level that was classified as deficient. The average level seen in our college-age population (19.33 ± 9.46 ng/mL) is far less than the average level found in professional soccer players in France [9] (31 ng/mL winter; 41 ng/mL summer) and Greece [5] (34.41 ng/mL competition season; 47.24 ng/mL off-season transition period). The percentage of players that were deficient in our study is also much higher than the percentage found in professional basketball players in the U.S. (32.3%). [1]Of the 17 participants, 52% of them recorded serum 25(OH)D levels below 20 ng/mL at baseline testing which is considered to be deficient. [1, 5, 9]

Deficient levels of vitamin D3 increase the risk of injury and inflammation. [2, 10, 11, 12, 13]Given the biomechanical risks and repetitive high forces when landing during practice and especially competition, basketball players are vulnerable to injury . This level of risk is compounded with deficient levels of vitamin D. Injury and inflammation can result in the cessation of competition without appropriate treatment for this deficiency.

Deficient levels of 25(OH)D has an impact on the life cycle in many stages of development and alsohas debilitating long term health outcomes if not abated. Llewellyn et al.[14] stated that vitamin D3 plays a potential role in brain development, cell differentiation, survival, and neuroprotection. Vitamin D3 is involved in reducing health risks for cancer, [15,16]diabetes, [11, 17] influenza and respiratory tract infections, [18] neuromuscular function, nonspecific musculoskeletal pain and stress fractures[19, 10, 12]Furthermore, many basketball players are African American and as a race they are at increased risk of cardiovascular disease. [20]Vitamin D3 has an effect on myocardial contractile function, the regulation of natriuretic hormone secretion, extracellular matrix remodeling, ventricular hypertrophy, and inflammatory cytokine regulation. [21, 22] Indirectly, vitamin D3 can also affect cardiac function by altering parathyroid hormone and serum calcium levels.

Study Aim 2: To Evaluate the Effects of 4,000 IU Vitamin D3 Supplementation on Serum 25(OH)D Levels

In the vitamin D3 supplementation group, $n = 9$, post 25(OH)D levels (41.11 ±11.49 ng/ml) showed a 94.8% increase in 25(OH)D levels from baseline (21.11 ng/ml ±- 9.27) and effectively raised the levels to those defined as sufficient (> 30 ng/ml). Based on our study results, we believe that a daily intake of 4,000 IU of vitamin D3 for 8-weeks is an adequate level of supplementation to effectively increase levels to those defined as sufficient (>30 ng/mL) for health reasons alone. [5, 6, 7] It must be emphasized again that this Tolerable Upper Intake Level (UL) of 4000 IU/dayby the National Institutes of Health Office of Dietary Supplements.is intended to specify the level above which the risk for harm begins to increase

for the general population. [8] There are some players with dark skin color that may need increased vitamin D3 supplementation for vitamin D3 synthesis. Melanin in the skin hinders vitamin D3 production and those with large amounts of melanin in their skin may even need up to 5000 IU/day as opposed to 4,000 IU or 2 capsules of 2,000 IU of vitamin D3, as in our study. [18] However, Owens et al. [4] suggested that weekly doses more than 5000 IU/day may be detrimental to health. Their study documented that high doses of vitamin D3 supplementation (70,000 IU/weekly) stimulated elevated concentrations of the vitamin D metabolite, $24,25[OH]_2D_3$. This metabolite has a negative regulatory effect on the transcriptional activity of $1,25[OH]_2D_3$ which persists even after the cessation of vitamin D3 supplementation.

Surprisingly, the placebo group, *n* = 8, post 25(OH)D levels (27.88 ±7.77 ng/ml) also increased by 52.8% from baseline (18.25 ±10.30 ng/ml) although post-levels were still not considered to be sufficient (> 30 ng/ml). We can only hypothesize that increased sun exposure may have played a role in the increase in our placebo's vitamin D3 levels since a 1-week spring break period occurred during our 8-week intervention or control period. We did not stipulate that participants could not spend additional time in the sun during this 1-week period and we have no documentation on the amount of time spent in the sun by the participants in our study.

An increase in serum 25(OH)D levels without supplementation was also found following the six-week off-season period compared to baseline in the soccer players from Greece.[5]They noted that the most plausible reason for the elevation of the vitamin D3 levels in their players following an off-season transition period was an increase in the exposure to UVB during the break and secondly a decrease in exercise induced stress during the break may also play a positive regulatory role. The conclusions from this study was that vitamin D3 levels plays a supportive role in exercise performance with training stimulus and quality of training being the major determinant of exercise performance.

Study Aim 3: Vitamin D3 Levels and Performance

Previous studies have shown that power, agility, and development of type 2 fibers may be affected by low levels of vitamin D [2, 10, 12]and improvements in physical performance have been found for adolescents as well as the elderly with higher vitamin D levels. [23,24] Unlike previous studies, we did not find significant improvements in performance following supplementation in our study. However, there were trends in enhanced performance with elevated serum 25(OH)D levels, but the trends did not reach a satisfactory level of significance. There was a moderate effect size for agility (*d* =-0.48). Vertical jump height increased and sprint and agility drill times decreased for both groups from pre-post test (see Figures 2- 4), but not significantly. This trend in our study is in parallel to the assumptions in the research thus far about serum 25(OH)D levels positively correlating with athletic performance, particularly vertical jump height and jump velocity.[24] Another study with professional soccer players in Greece [5] found correlations (>.5) between serum vitamin D3 levels and performance parameters in both pre and post experimental sessions.

There were many limitations within the study that may have affected our results regarding performance. The major limitation was a low study number. Another limitation was the high degree of variability in performance parameters within the groups. A third limitation is the low power of the test statistic. It is because of these limitations that we cannot reach any definitive conclusions about the effect of vitamin D3 supplementation on performance.

Closing Remarks

Research has shown that the risk of vitamin D3 deficiency increases in sports where players spend their time practicing and competing indoors as well as in sports that have a high percentage of dark-skinned athletes, since Melanin in the skin hinders vitamin D3 production. [18]The Team Physician at the collegiate level should work with the nutritionist and sports medicine team to enact a practical and effective screening and supplementation program for vitamin D3 deficiency for players in at-risk sports. There are multiple options for screening and supplementation.

A questionnaire for vitamin D3 deficiency at the Preparticipation Screening could be given under the guidance of the nutritionist. The nutritionist could then follow-up with any players that seemed to be at risk for vitamin D3 deficiency with a plan for supplementation. A UL of 4,000

IU/day of vitamin D3 does not even require a physician's prescription and is available over the counter, at a reasonable cost, in pharmacy and grocery stores.

The sports medicine team in conjunction with the nutritionist and team physician could also enact more sophisticated measures of screening and implementation for at-risk athletes for vitamin D3 deficiency by utilizing mandated laboratory testing. In 2010, the National Collegiate Athletic Association (NCAA) implemented universal sickle cell trait (SCT) screening of all Division I student-athletes. This opportunity for blood sampling could be used for adding the Vitamin D 25-hydroxy test. If insufficient or deficient levels were found, the team physician could issue a prescription with follow-up screenings utilizing the Vitamin D 25-hydroxy test for vitamin D3 adequacy. The advantage of a sports medicine physician issuing a prescription is that he or she can more closely follow compliance by examining refill requests. However, caution is advised if prescribing more than 5000 IU/day since Owens et al. [4] suggested that weekly doses more than 5000 IU/day has detrimental side effects. The sports medicine physician could schedule routine office visits following supplementation at 4 months, 6 months or between semesters and prior to the start of competition to check the players continued health status and well-being.

CONCLUSION

College-age recreational and collegiate male basketball players have significantly deficient serum 25(OH)D levels (19.33 ng/mL) compared to normal (>30 ng/mL). Eight-weeks of 4,000 IU of vitamin D3 (cholecalciferol) effectively increased serum 25(OH)D levels to normal levels. There were not, however, concomitant increases in performance. Sport Medicine Physicians can play a role in alleviating deficiency by establishing a screening program for at-risk sports and prescribing supplementation for athletes who are deficient.

ACKNOWLEDGEMENT

This study was supported by a grant from Texas Tech University (TTU) Athletics. We would like to acknowledge Jennifer Mitchelll M.D., Sports Medicine Physician at TTU, for her help with the implementation of the study. We would also like to thank Dr. Melanie Hart for help with the statistics.

REFERENCES

[1] Fishman MP, Lombardo SJ and Kharrazi FD. Vitamin D Deficiency Among Professional Basketball Players. Orthopaedic Journal of Sports Medicine 2016; 4.
DOI: 10.1177/2325967116655742.

[2] Larson-Meyer DE and Willis KS. Vitamin D and Athletes. Current Sports Medicine Reports 2010; 9: 220-226. DOI: 10.1249/JSR.0b013e3181e7dd45.

[3] Tomlinson PB, Joseph C and Angioi M. Effects of vitamin D supplementation on upper and lower body muscle strength levels in healthy individuals. A systematic review with meta-analysis. Journal of Science and Medicine in Sport 2015; 18: 575-580. DOI: 10.1016/j.jsams.2014.07.022.

[4] Owens DJ, Tang JC, Bradley WJ, et al. Efficacy of High-Dose Vitamin D Supplements for Elite Athletes. Med Sci Sports Exerc 2017; 49: 349-356. DOI: 10.1249/MSS.0000000000001105.

[5] Koundourakis NE, Androulakis NE, Malliaraki N, et al. Vitamin D and Exercise Performance in Professional Soccer Players. Plos One 2014; 9. DOI: 10.1371/journal.pone.0101659.

[6] Kramer H, Berns JS, Choi MJ, et al. 25-Hydroxyvitamin D Testing and Supplementation in CKD: An NKF-KDOQI Controversies Report. American Journal of Kidney Diseases 2014; 64: 499-509. DOI: 10.1053/j.ajkd.2014.05.018.

[7] Cannell JJ, Hollis BW, Sorenson MB, et al. Athletic Performance and Vitamin D. Medicine and Science in Sports and Exercise 2009; 41: 1102-1110. DOI: 10.1249/MSS.0b013e3181930c2b.

[8] National Institutes of Health Office of Dietary Supplements. Vitamin D Fact Sheet for Consumers. 2016.

[9] Edouard P, Serra JM, Lafleur M, et al. Prevalence of vitamin D deficiency in high-level athletics athletes. Ann Phys Rehabil Med 2016; 59S: e22. DOI: 10.1016/j.rehab.2016.07.053.

[10] Plotnikoff GA and Quigley JM. Prevalence of severe hypovitaininosis D in patients with persistent, nonspecific musculoskeletal pain. Mayo Clinic Proceedings 2003; 78: 1463-1470.

[11] Pittas AG, Lau J, Hu FB, et al. Review: The role of vitamin D and calcium in type 2 diabetes. A systematic review and meta-analysis. Journal of Clinical Endocrinology & Metabolism 2007; 92: 2017-2029. DOI: 10.1210/jc.2007-0298.

[12] Lappe J, Cullen D, Haynatzki G, et al. Calcium and vitamin D supplementation decreases incidence of stress fractures in female Navy recruits. Journal of Bone and Mineral Research 2008; 23: 741-749. DOI: 10.1359/jbmr. 0080102.

[13] Willis KS, Peterson NJ and Larson-Meyer DE. Should we be concerned about the vitamin D status of athletes? International Journal of Sport Nutrition and Exercise Metabolism 2008; 18: 204-224.

[14] Llewellyn DJ, Langa KM and Lang IA. Serum 25-Hydroxyvitamin D Concentration and Cognitive Impairment. Journal of Geriatric Psychiatry and Neurology 2009; 22: 188-195. DOI: 10.1177/0891988708327888.

[15] Holick MF. Vitamin D and sunlight: Strategies for cancer prevention and other health benefits. Clinical Journal of the American Society of Nephrology 2008; 3: 1548-1554. DOI: 10.2215/cjn.01350308.

[16] Garland CF, Garland FC, Gorham ED, et al. The role of vitamin D in cancer prevention. American Journal of Public Health 2006; 96: 252-261.

[17] Gordon PL, Sakkas GK, Doyle JW, et al. Relationship between vitamin D and muscle size and strength in patients on hemodialysis. Journal of Renal Nutrition 2007; 17: 397-407. DOI: 10.1053/j.jrn.2007.06.001.

[18] Cannell JJ, Vieth R, Umhau JC, et al. Epidemic influenza and vitamin D. Epidemiology and Infection 2006; 134: 1129-1140. DOI: 10.1017/s0950268806007175.

[19] Dhesi JK, Jackson SHD, Bearne LM, et al. Vitamin D supplementation improves neuromuscular function in older people who fall. Age and Ageing 2004; 33: 589-595. DOI: 10.1093/ageing/afh209.

[20] Vanga SR, Good M, Howard PA, et al. Role of Vitamin D in Cardiovascular Health. American Journal of Cardiology 2010; 106: 798-805. DOI: 10.1016/j.amjcard.2010.04.042.

[21] Weishaar RE, Kim SN, Saunders DE, et al. INVOLVEMENT OF VITAMIN-D3 WITH CARDIOVASCULAR FUNCTION .3. EFFECTS ON PHYSICAL AND MORPHOLOGICAL PROPERTIES. American Journal of Physiology 1990; 258: E134-E142.

[22] Tishkoff DX, Nibbelink KA, Holmberg KH, et al. Functional vitamin D receptor (VDR) in the t-tubules of cardiac myocytes: VDR knockout cardiomyocyte contractility. Endocrinology 2008; 149: 558-564. DOI: 10.1210/en.2007-0805.

[23] Houston DK, Cesari M, Ferrucci L, et al. Association between vitamin D status and physical performance: The InCHIANTI study. Journal of the American Geriatrics Society 2006; 54: S28-S28.

[24] Ward KA, Das G, Berry JL, et al. Vitamin D Status and Muscle Function in Post-Menarchal Adolescent Girls. Journal of Clinical Endocrinology & Metabolism 2009; 94: 559-563. DOI: 10.1210/jc.2008-1284.

Citation: *Jacalyn J, Micah D,. Vitamin D Deficiency in College-Age Male Basketball Players: Sports Medicine Physicians Can Play an Important Role. International Journal of Research Studies in Medical and Health Sciences. 2017;2(6):8-15.*