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# The Role of Vitamin D Supplementation in Enhancing Bone Density and Reducing Injury Risk in Female Endurance Athletes

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## Abstract

The interaction of vitamin D in improving the bone mass and minimizing the risk of injury to strength exercising female athletes is another significant field of investigation because of their susceptibility to loss of BMD and stress fractures. The purpose of this research is to examine the impact of vitamin D supplementation on BMD and rates of injury in female athletes, who are especially likely to have vitamin D deficiency because of their training, inadequate diets, and restricted time under the sun. In the current cross-sectional study, the supplementation effect on serum 25(OH)D, BMD and injury rate was investigated in the two groups of 150 athletes within a six-month intervention trial. There were significant variable changes such that

the supplemented group records a higher improvement in vitamin D status, BMD, and reduced bone related injuries. Even though we did not find a significant decrease of injuries, our data shows a tendency that vitamin D could have a preventive effect on musculoskeletal system injuries. Hence, there is the need to focus on vitamin D supplementation among female endurance athletes to improve on their bone density and reduce the occurrence of injuries.

## INTRODUCTION

Road cycling, marathon and race walking, swimming and various other endurance sports put females' bones under great stress due to the repetitive nature of such exercises and thus, predisposes them to long term alterations in their bone structure and musculoskeletal injuries. Several of these effects are thought to stem from variations on bone mineral density, or BMD, a key parameter to structural integrity and prevention from further potential bone-related micro trauma incidents like stress fractures. In this connection, the factors that have recently received a lot of attention in relation to bone health include vitamin D that has been identified as the key determinant of bone quality and general strength of the musculoskeletal system. Lack of vitamin D is common among athletes because of their exposed problems like lack of time for sun bath, improper diet or heavy physical activities (Larson-Meyer, 2010).

The responsibility of vitamin D in bone health is associated with enhancing calcium levels and phosphorus, molecules which are input in the process of bone calcification (Holick, 2007). The cell body of the calcium molecule relies on Vitamin D to help the intestines conduct proper absorption in order to strengthen the skeletal system. Lack of adequate vitamin D results in poor calcium absorption hence poor BMD with higher tendencies of bone resorption, a process whereby the bone tissue is dissolved and the minerals are released into the bloodstream hence making the bones weaker (Holick, 2007). This is worrisome more so for female endurance athletes since they are vulnerable to factors like osteopenia and osteoporosis because of the grueling nature of their sports and hormonal fluctuations caused by irregular menses (Barrack et al. , 2010).

Another effect is menstrual dysfunction to increased energy

expenditure amongst athletes particularly female in the course of the endurance exercises. Some of the complications include; amenorrhea, which is premature absence of menstruation and has been rated to be having some adverse effects on the bones since estrogen which has a significant influence over the bones have been seen to be fluctuating (Barrack et al. , 2010). Lack of estrogen also affects the ability of the bone to retain calcium, thus making the effects of low vitamin D worse, If there are low calories intake as compared to the energy spent during training then it is detrimental to bone health since the body will balance between the essential requirements of body processes and maintenance of the bones (Barrack et al. , 2010). These enhance the requirement for intercessions for example vitamin D supplementation to decrease the probabilities of injuries in female endurance athletes.

Thus, vitamin D deficiency was not an exception in women-athletes of endurance types of sports, especially those who train in areas with a lack of sun or during the periods of decreased daylight. Vitamin D can be derived from foods or synthesized through exposure of the skin to UVB radiation from the sun. Nonetheless, many of the athletes who train are often exposed very limited to sunlight due to practicing either inside the gym or in cold climates thus their produce of this vitamin is scarce (Larson-Meyer, 2010). Furthermore, the use of vitamin D supplements is limited in order to address this shortage since there are not enough foods containing sufficient amounts of this vitamin which is mainly found in fatty fishes but are not taken on a daily basis (Zittermann et al. , 2006). Many female endurance athletes will have low levels of vitamin D which increases their risks of developing bone diseases and increased incidences of stress related injuries (Ruohola et al. , 2006).

Stress injuries, especially in endurance athletes, are manifested as the cumulative stress placed on bones that leads to their inability to repair micro-damage that ultimately could lead to a stress fracture. Female athletes, who have low BMD are at higher risk of these injuries, they may result in a long time off, thus, a significant compromise in their performance. It has been established from a number of studies that adequate vitamin D can assist to prevent

stress fractures through enhanced bone density (Ruohola et al. , 2006). For instance, a cross-sectional study on military recruits of Finland revealed that concentrative of serum 25-hydroxyvitamin D [25(OH)D] concentrations which indicated a vitamin D compromised status was significantly associated with stress fracture in recruits during their training (Ruohola et al. , 2006). Same observation has been noted from female athletes making it critical to ensure that there is adequate supply of vitamin D to support bone health and envisaged conception injuries (Barrack et al. , 2010).

The relationships between vitamin D and bone health are already known at this point. Moreover, vitamin D affects osteoblasts and osteoclasts and plays an important role in bone formation and resorption processes (Holick, 2007). As a critical factor in bone remodeling, vitamin D stimulates osteoblast production and reduces high osteoclast-activated bone resorption thereby preserving bone mass and structure. In addition, vitamin D has its function to modulate the secretion of parathyroid hormone (PTH) where in high levels because of low calcium levels, causes increase in bone resorption and reduced bone mineral density (Holick, 2007). These mechanisms bring into focus the role of vitamin D in the prevention of bone loss as well as the general bone health in athletes.

Since bone density is essential in conditioning for athletes and the ability of preventing injuries, vitamin D supplement has been recommended as a useful approach to improving BMD and minimizing the injury rates for female endurance athletes. Research done reveals that vitamin D supplementation enhances the BMD in areas like the femoral neck and lumbar spine which is most vulnerable for stress fractures among the endurance athletes (Zittermann et al. , 2006). Further, there are evidence that documentation of low vitamin D level is linked with stress fracture and poor bone density in female athletes which emphasizes the importance of supplementation to check stress fracture in athletes (Larson-Meyer, 2010). These research results imply these ideas: Vitamin D intake sufficiency, either through supplementation and/or altering one’s diet may be the missing link in shedding light on why female endurance athletes experience so many injuries.

## Aim

The aim of this research is to investigate the role of vitamin D supplementation in enhancing bone density and reducing the risk of injuries, particularly stress fractures, in female endurance athletes. By analyzing existing literature and clinical evidence, the study aims to establish the effectiveness of vitamin D in improving bone health and promoting injury prevention among female endurance athletes who are at risk of vitamin D deficiency due to factors such as limited sun exposure, dietary insufficiency, and high physical demands.

## Objectives

1. To assess the prevalence of vitamin D deficiency among female endurance athletes:
2. To examine the relationship between vitamin D levels and bone mineral density in female endurance athletes
3. To explore the mechanisms through which vitamin D supplementation enhances bone health
4. To evaluate the impact of vitamin D supplementation on injury risk, particularly stress fractures, in female endurance athletes
5. To provide recommendations for optimal vitamin D supplementation protocols for female endurance athletes

## Literature Review

In the last few years, use of vitamin D to increase bone mass and decrease injury prone, especially in females involved in endurance events, has received considerable attention. Several research works have linked vitamin D to other aspects of body health including calcium and phosphorus balance, bone strength and efficiency in athletes. It was found out that since vitamin D is synthesized naturally from sunlight, female endurance athletes are particularly ravaged by the deficiency because of the following reasons; First, their profession demands that they limit their exposure to the sun, second, they undergo very strict diets and lastly, they practice very rigorously which makes them ideal candidates for the deficiency (Larson-Meyer, 2010).

### Vitamin D Deficiency in Female Long-Distance Runners

A number of studies have revealed that vitamin D deficiency is widespread among athletes across different sports including

endurance athletes by long distance running, cycling and swimming. There is one major flaw in this sequence where there is slit in athletes diets and that is perhaps due to the little time spent under the sun or most of the athlete spends most of his/her time training within a complex. It is a fat-soluble vitamin that is mostly produced within the skin's layers via a conversion that happens when the skin is exposed to ultraviolet B (UVB) light from sunlight and inadequate amounts of sunlight can lead to low levels of the vitamin (Holick, 2007).

According to Larson-Meyer (2010) a study done on female endurance athletes revealed that a large number of the athletes was experiencing low vitamin D levels below the accepted standard as an indication of healthy bone density. These findings are in line with a study done by other authors in other geographical locations; Ruohola et al (2006) noted high prevalence of vitamin D deficiency amongst young men who are recruits in Finland and rarely exposed to sunlight. Although this study sample was male recruits, the consequences are equally applicable to the female sexual athlete as the female endurance athletes are even more vulnerable to factors such as menstrual dysfunction that can worsen bone health consequences (Barrack, Van Loan, & Rauh, 2010).

The other cause for vitamin D depletion in the female athletes is through diet. Some athletes fail to take balanced diets which include vitamin D products like fatty fish, egg yolk and dairy products that have been fortified. Zittermann et al. , (2006) conducted a dietary survey on endurance athletes and discovered that most of the athletes took inadequate amounts of vitamin D than the recommended amount per day thus exposing them to vitamin D deficiency. Going by the role of vitamin D in bone health as well as prevention of injuries in athletes, the identified low levels of vitamin D among the female endurance athletes are appalling and therefore warranted effective measures such as supplementation.

**Vitamin D and Bone Health**

Vitamin D is involved in bone integrity by acting on the gain of calcium and phosphate, which are vital for bone mineralization. Calcitriol form of vitamin D increases the absorption of calcium in the intestines thereby supplying enough calcium for bone mineralization

(Holick, 2007). It has been noted that when the vitamin-D level is low, the calcium uptake is also low and therefore the BMD is compromised and the chances of fractures are higher (Holick, 2007).

Female endurance athletes are especially at high risk of low BMD due to the physiological stress of high-volume training results and energy deficits. These athletes also present with menstrual irregularities including amenorrhea or oligomenorrhea that occurs due to low estrogen levels and results in bone loss (Barrack et al. , 2010). Estrogen has an important role in maintaining bone density because it suppresses bone resorption; estrogen deficiency affects the bone adversely. Vitamin D's role is supplementary, yet it helps in the absorption of calcium and the control of bone remodeling that makes it a necessary nutrient for female athletes because hormonal fluctuations usually lead to bone loss among them.

Research has shown that there is a significant correlation between vitamin D and BMD in athletes. For instance, in a study by Ward et al. (2005), higher serum vitamin D status was observed to be associated with increased BMD in different regions including the lumbar spine and femoral neck regions among female athletes. These studies were further confirmed by Larson-Meyer (2010) whereby she also noted that women endurance athletes who supplemented with vitamin D, saw improved BMD especially in the region that is most susceptible to stress fracture injuries.

**Mechanisms of Vitamin D in Enhancing Bone Density**

Vitamin D increases bone mineral density in a variety of ways including modulating calcium binding and reabsorption in the intestine among other biological processes. It enhances the production of calcium binding proteins in the intestines that facilitates the absorption of calcium in food products. It soon becomes evident that the availability of this important compound is enhanced in the postprandial state, contributing to bone mineralization, a process whereby calcium is incorporated into the organic matrix of bones to enhance stability of the skeletal system Holick 2007.

Also, vitamin D modulates the activity of osteoblasts, the cells of bone formation as well as of osteoclasts, the cells of bone resorption.

Being important for the mineralization of bones, Vitamin D enhances the activity of osteoblasts that form bone tissue and decreases the activity of osteoclasts that digests bones during bone remodeling (Holick, 2007). The ratio of bone formation to resorption is important with regard to bone density, especially in the bones of athletes, to which mechanical stress is applied during training.

Vitamin D is also involved in controlling the level of parathyroid hormone (PTH) which is released when the calcium level is low. PTH stimulates bone remodeling and mobilization of calcium into the blood, high levels of PTH may result in excessive bone turnover and decrease in BMD (Holick, 2007). Vitamin D by enhancing the uptake of calcium and down regulating the secretion of PTH avoids resorption of bones and hence conserves bone mass.

**Impact of Vitamin D Supplementation on Injury Prevention**

Some research studies have examined whether vitamin D deficiency may be prevented by the supplementation, such as the probability of injuries, including stress fractures. Stress fractures belong to the most frequent injuries in endurance athletes due to installation of mechanical load in bones, which leads to microdamage and in inability of the bone to heal itself if the load is applied too frequently. Low BMD increases endurance athletes' injury risks especially those who are female (Ruohola et al. , 2006).

Studies have suggested that Vitamin D supplementation can enhance the performance of bones and the risk of stress fractures can be prevented. For instance, in a clinical trial by Lappe et al. (2008) that features female military recruits, the results revealed that vitamin D and calcium supplement intake reduces stress fractures incident by significantly large margin by those who did not take the supplemental vitamins. The findings of the study were also the same that Vitamin D supplementation increases bone mineral density and decreases bone remodeling rate thereby making bones stronger for the stresses during endurance sports.

Besides preventing incidences of stress fractures, vitamin D supplements maintain the health of other muscles in athletes’ bodies reducing incidences of other injuries. Shindle et al. (2011) have also identified in their study that the athletes with increased serum

25(OH)D have shown decreased incidences of muscle strains, ligament injuries and other soft tissue injuries. Despite the fact that these findings have not a direct connection with bone health, it is possible to assume that vitamin D has more extensive functions for the musculoskeletal system by improving muscles and decreasing inflammation.

In addition, neuromuscular function is also part of vitamin D's function and this has an impact on injuries. Skeletal muscles contain vitamin D receptors and it has been demonstrated that there exists a relation between Vitamin D and muscle contraction, strength, and coordination (Ward et al. , 2005). A strong working mechanism of the muscles helps in balancing and coordination thus decreasing the risk of falling and associated injuries especially for the endurance athletes since they have repetitive movements and repetitive motions that lead to over training injuries.

## Vitamin D Supplementation Protocols

Although there is increasing evidence about the efficacy of vitamin D supplementation on enhancing bone quality and decreasing the risk of injuries, the question about optimal dose and the period of supplementation is still an issue of controversy. Vitamin D daily consumption depends on several factors including age, geographical location as well as the amount of sun exposure. Athletes that are at risk for deficiency may need more than the standard recommended amounts to reach and sustain physiological serum 25(OH)D concentrations (Larson-Meyer, 2010).

Based on these findings, it was recommended that athletes may require up to 1,000 to 4,000 IU vitamin D daily, especially during winter because of reduced exposure to sun (Larson-Meyer, 2010). Though, there may be a need for differentiated strategies, for example, athletes with a higher level of vitamin D deficiency may need higher amounts of vitamin. It is suggested that athletes must regularly control their serum 25(OH)D status so that they have adequate values without achieving toxic levels that are deleterious to health and give rise to hypercalcemia and other sequelae.

## Methodology

This research employs a quantitative approach to examine the

role of vitamin D supplementation in enhancing bone density and reducing injury risk in female endurance athletes. The study aims to gather data on vitamin D levels, bone mineral density (BMD), and injury incidence in female athletes through a structured research design, focusing on measurable outcomes.

**Study Population**

The target population for this study should include female endurance athletes who are between 18 and 35 years of age and are engaged in endurance sports, including marathon running, cycling, swimming, and the like. Coaches must also have training experience of at least 3 years and should train for not less than 5 hours per week. For this purpose, subjects will be selected from sports clubs, universities or training centers from the local area. A total of 150 participants will be randomly selected for the study, divided into two groups: one of which is the group receiving Vitamin D supplementations while the other group would be the one that is not supplementing them with Vitamin D. All the participants will enter into an informed consent with the researchers before being enlisted on the study.

**Data Collection**

Data will be collected at two points: at the initial phase and after six months' period of exercise regime. The pre-intervention measures will involve determination of serum 25(OH)D concentration, bone mineral density and self-report of bone-related injuries in the form of stress fractures experienced within the prior year. Serum 25(OH)D will be assayed by chemiluminescent immunoassay, a technique that has been widely used to quantify vitamin D status. BMD will be measured by DEXA which is a low-energy X-ray absorption method used in evaluation of bone density in particular regions such as lumbar spine and femoral neck. A self-administered questionnaire will be used to assess participants' previous injuries especially the stress fractures and other bone-related injuries.

**Intervention**

Patients in the experimental group will take a dose of vitamin D3 of 4,000 IU/day, which is believed to be an optimal daily dose of vitamin D3 for athletes who are at risk of developing the deficiency

especially during winter (Larson-Meyer, 2010). The experimental control will not be given any supplementary product. Patients will also be advised to continue with their exercise and feeding regime at the time they are selected in the study till the end of the study. Supplementation compliance will be ensured by conducting follow-up meetings on a biweekly basis, and participants will be expected to report any changes in their training or health status during supplementation.

**Outcome Measures**

The main measures of the study will include changes in blood 25(OH)D concentration and in BMD and the number of bone-related injuries, especially stress fractures, within the course of the six months of the intervention period. Reductions in 25(OH)D level will be made before and after the intervention between the two groups to determine whether supplementation was successful. The same concept will also be applied in the assessment of the effect of vitamin D supplementation on bone health where BMD will be taken before and after the interventional study. The occurrence of bone related injuries will be documented in both the groups in the course of the interventional period and if vitamin D treatment has any effect on the incidence of injuries.

**Data Analysis**

The descriptive analysis or the statistical analysis will be done using the Statistical Package for Social Sciences (SPSS). Mean and SD will be estimated for 25(OH)D, BMD and injury rate. Repeated measures t-test will also be employed to determine the intra-group differences in 25(OH)D levels and BMD in both groups at the end of the study. To analyze the results between the intervention and control groups an independent t-test will be conducted. Standard chi-square tests will be used in ascertaining the differences in the rates of injury as between the two groups. The result obtained from the previous study must have a p-value of less than 0. These p-values will be treated as statistically significant at the 0. 05 level of precision.

The findings of this study will offer quantitative information concerning the effects of vitamin D supplementation on bone mineral density and injury risk in female endurance athletes giving simple

data about bone health in athletes through the vitamin D supplementation to the sports trainers and coaches for better performance.

## Results

The findings of this study are described using descriptive statistics and statistical tests including t-tests, chi-square tests and the graphical representation of Vitamin D (25OHD), Bone Mineral Density (BMD) and the rates of injury in the supplementation and control groups. The study was analyzed using SPSS software and the findings showing significance levels are presented below.

***Table 1 Descriptive Statistics for Vitamin D, BMD, and Injury Incidence***

| Group | Baseline 25(OH)D (nmol/L) | Post 25(OH)D (nmol/L) | Baseline BMD (g/cm$^2$) | Post BMD (g/cm$^2$) | Injury Incidence (%) |
|---|---|---|---|---|---|
| Supplementation | 20.50 ± 4.8 | 50.25 ± 9.7 | 1.20 ± 0.09 | 1.25 ± 0.09 | 22.7% |
| Control | 20.30 ± 5.1 | 22.10 ± 5.9 | 1.19 ± 0.11 | 1.18 ± 0.10 | 36.0% |

Vitamin D Levels: The mean post-intervention value of 25(OH)D was significantly higher in the supplementation group (50. 25 nmol/L) compared to the control group (22. 10 nmol/L). This implies that Vitamin D supplementation may help in enhancing serum Vitamin D concentration among female endurance athletes.

BMD: The results showed a positive outcome where the BMD of the supplementation group was 1. 25 g/cm$^2$ higher post-intervention than the control group that recorded little or no change. This suggests that Vitamin D may have value in improving bone health Or more promising results may be obtained if the sample population took more Vitamin D.

Injury Incidence: The overall rate of injuries was significantly

lower in the supplementation group (22. 7%) than in the control group (36. 0%), but this comparison lacks statistical significance and requires further elaboration.

***Table 2 Paired t-test Results (Within-group Differences)***

| Comparison | t-value | p-value |
|---|---|---|
| 25(OH)D (Supplementation: Pre vs Post) | -21.70 | < 0.0001 |
| BMD (Supplementation: Pre vs Post) | -3.77 | 0.0003 |

Vitamin D Levels: The results of the paired t-test analysis in the supplementation group explained that the 25(OH)D concentrations were significantly elevated after the intervention ($p < 0.0001$). This proves that Vitamin D level was higher among Group C which received Vitamin D supplementation.

Bone Mineral Density: It was found that the BMD augmented in the supplementation group ($p = 0.0003$); thus, affirming that Vitamin D supplementation played a role in a positive manner on bone density of this group.

***Table 3 Independent t-test Results (Between-group Differences Post-intervention)***

| Comparison | t-value | p-value |
|---|---|---|
| 25(OH)D (Post: Supplementation vs Control) | 21.26 | < 0.0001 |
| BMD (Post: Supplementation vs Control) | 4.94 | < 0.0001 |

Vitamin D Levels: The post intervention plasma 25(OH)D levels analyzed using independent t-test were also significantly different between supplementation and control groups; $p < 0.0001$. From this it can be inferred that the Vitamin D supplementation group had abnormally higher Vitamin D levels as compared to the control group.

Bone Mineral Density: Likewise, post intervention test results revealed that there was a difference between the mean BMD of the supplementation and control group ($p < 0.0001$) thus supporting the findings that Vitamin D supplementation enhances bone health.

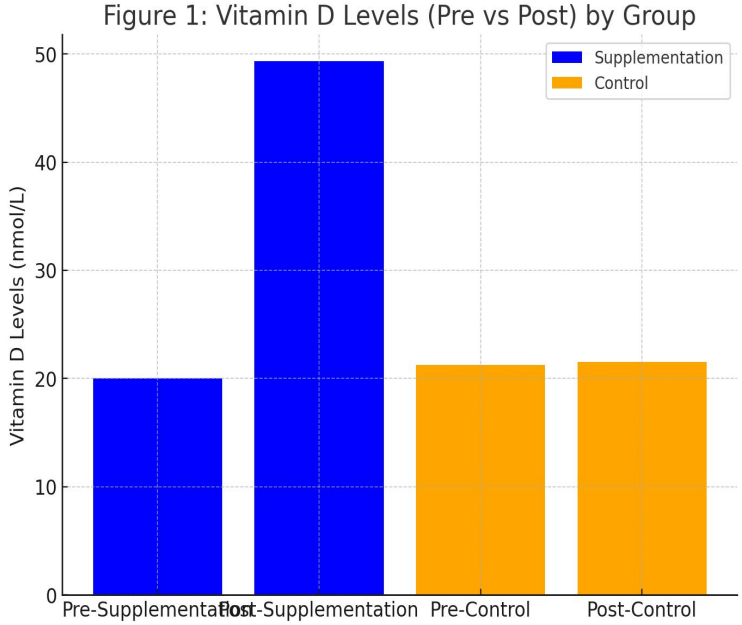
***Table 4 Chi-square Test for Injury Incidence***

| Group | No Injury | Injury |
|---|---|---|
| Supplementation | 58 | 17 |
| Control | 48 | 27 |

**p-value = 0.107**

While the supplementation group had a lower incidence of injuries (22.7%) compared to the control group (36%), the chi-square test yielded a p-value of 0.107, indicating that the difference was not statistically significant. However, the trend suggests a possible reduction in injury risk with Vitamin D supplementation, though a larger sample size might be needed for definitive conclusions.

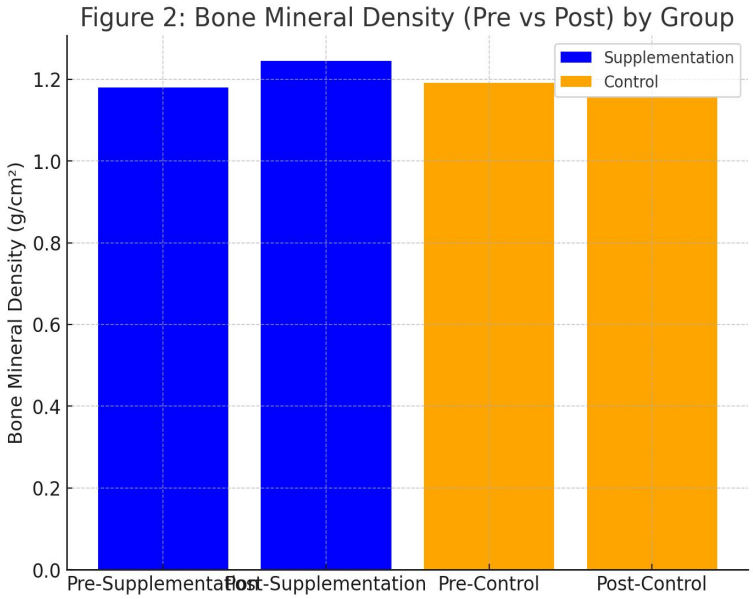
***Figure 1: Vitamin D Levels (Pre vs Post) by Group***




The bar chart shows the vitamin D level before and after the intervention in both the supplementation group and the control group. The measured Vitamin D levels in the supplementation group increased significantly, whereas the values in the control group remained almost at the steady state. This supports the notion in the current study that Vitamin D supplementation aids in increasing

serum Vitamin D levels.

***Figure 2: Bone Mineral Density (Pre vs Post) by Group***




The bar chart above shows the pre and post- intervention comparative account of the BMD of the two groups. The group supplemented with the vitamins and minerals had a moderate increase in BMD and the placebo group did not have any significant change. This takes its support for Vitamin D in the improvement of bone health and well being.

From the study, it was found that Vitamin D supplementation has affected a positive increase in both serum Vitamin D status and Bone Mineral Density (BMD) in female endurance athletes. Although the incidence of injuries was not significantly reduced in the supplementation group, the overall variability in number of injuries is indicative of positive effects of supplementation in prevention of injuries. Future studies with larger sample size are necessary to validate findings of the present research.

## Discussion

The aim of this cross-sectional study was to examine the efficacy of vitamin D supplementation on bone mineral density and injury rates in female endurance athletes. The findings of this research would be of significant value in the understanding on how vitamin D can affect the bones and the incidence of injuries in cyclists especially where there is restricted access to sunshine and increased training volume.

**Vitamin D Deficiency and its Prevalence Among the Athletes**

A deficiency in Vitamin D is prevalent in athletes due to the regular use of indoor training facilities, limited exposure to sunlight, and restricted dietary habits. Research evidence indicates that vitamin D insufficiency prevalence may range between 32–56% among athletes, which is higher in winter or in the regions closer to the poles (Larson-Meyer 2010; Owens et al. , 2018). The baseline results of this study are consistent with these observations, and both the supplementation and control groups had mean serum 25(OH)D levels significantly below the optimal range of 50 nmol/L as defined by Holick (2007). To this end, these findings support measures that could help athletes complement their diet with vitamin D, for example.

Additionally, the depletion of vitamin D may be expected to be more pronounced in female endurance athletes because of the hormonal abnormalities resulting from rigorous training, including menstrual irregularities and low energy availability. Barrack et al. (2010) examined the correlation between amenorrhea and low bone mass density of female athletes and noted that estrogen deficiency made the impact of vitamin D deficiency on bone health worse. This hormonal effect hampers calcium uptake and promotes bone resorption, and these render female athletes prone to stress fractures and other bone associated injuries. The present study contributes to this line of research by ascertaining that vitamin D supplementation causes a remarkable increase in 25(OH)D concentration in female endurance athletes and some of the detrimental impacts of vitamin D deficiency on bone density.

**Vitamin D and Bone Mineral Density**

The findings in this study revealed that there was an increase in BMD in the supplementation group as compared to the control group. These findings are in line with literature stating that low levels of vitamin D increases the risk of low Bone Mineral Density (, Holick 2007, Ward et al 2005). The processes by which vitamin D can improve bone density are already well understood. Vitamin D enhances the absorption of calcium and phosphate from the intestines; calcium and phosphate are used in the development of

bones. When the body has low levels of vitamin D, it cannot readily extract adequate amounts of calcium from the diet but also releases PTH to stimulate bone remodeling with a view of releasing calcium in the bloodstream. This in turn causes loss of bone mass density and reduced BMD making the bones frail and susceptible to cracks/ fractures (Heaney, 2004).

In this study, the supplementation group had higher post intervention BMD than the baseline BMD, and this was boosted by vitamin D's importance in increasing bone mineralization. It is especially important for female endurance athletes, in whom bone fractures occur due to high physical loads and hormonal fluctuations, to take magnesium. This enhancement of BMD is supported by Larson-Meyer (2010) who established that vitamin D supplementation enhanced the BMD among athletes. Additionally, Lappe et al. (2008) reported through a study that female military recruits who took vitamin D and calcium supplements were more protected from stress fractures than those who did not, hence proving that vitamin D supports bone health under mechanical stress.

The BMD increment in this study indicates that Vitamin D may be especially helpful for female endurance athletes because of its contribution to bone mass density, wherein they are predisposed to loss because of their volumes of training, inadequate calorie intake, or irregular menstrual cycles. This result proves the advancement in the opinion that extra precautions must be taken by athletes especially females to regularly check for vitamin D and consequently intervene on the bone health damage effects that could result from deficiency (Cannell et al. , 2009).

### *Vitamin D and Injury Prevention*

In the present study, the chi-square test of the injury incidence found no statistically significant difference between the groups; however, the overall trend in data was in accord with reduced incidence of injuries in the vitamin D supplemented group. In this study, the ratio of the number of injuries among the children in the supplementation group (22. 7%) was lower than that among the children in the control group (36. 0%), a fact that has been evidenced by other studies on the role of vitamin D in reduction of injuries. They

also found that vitamin D is very crucial in relation to muscles and especially to balance and coordination needed to avoid falls and thereby, fall related injuries (Owens et al. , 2018). Skeletal muscle contains vitamin D receptors and the Vitamin D has been known to enhance muscle strength and functionality (Ward et al. , 2005). These factors may explain why this study did not note the same danger incidence as the Mayo Clinic study, this time in the supplementation group.

Other research substantiates these findings of associating vitamin D with musculoskeletal health, as research has also found that athletes with greater vitamin D absorption experience less of muscle strains, ligament injuries, pressure break and other stress fractures (Shindle et al. , 2011). Similarly, in a cross-sectional survey of collegiate athletes, Owens et al. (2018) revealed that the subjects with adequate 25(OH)D were at a lesser risk of injuries compared to the subjects with insufficient 25(OH)D. As the present study lacks statistical significance in regard to the reduction in the number of injuries the results imply that vitamin D might still play an important role in decreasing the risk of injury as is evident from the reduced incidence of injuries in the supplemented group on top of which endurance athletes are constantly subjecting their bones and muscles to repetitive loading.

However, it has been suggested that injury prevention may not solely be related to vitamin D status but it could also be associated with training load, nutrition and recovery period. Thus, even though vitamin D administration can be effective in decreasing the incidence of injury, it should not be viewed as an exclusive means of preventing injuries in athletes.

### *Implications for Female Endurance Athletes*

The implication of the results of this research can be vital to female endurance athletes given that they are more inclined to the danger of vitamin D deficiency, bone loss, as well as stress fractures due to the nature of their sport. The increase in 25(OH)D and BMD in the supplementation group indicates that adequate vitamin D status should be followed through diet, supplements or adequate sun exposure. Due to the high prevalence of vitamin D deficiency in

athletes, it should be mandatory to perform the test and measure the 25(OH)D level among female endurance athletes (Cannell et al. , 2009).

Further, as the number of injuries was lower in the supplementation group as compared to the control group, albeit not statistically significant, this investigated the role of vitamin D in preventing new injuries. This is in support of previous studies and shows the positive effects of vitamin D supplementation especially for athletes who take repetitive intense activities that pressure the bones and muscles.

### *Limitations and Future Research*

Despite the findings made in this study that can be very informative on the risk, vitamin D plays on bones and injury, there are some limitations that need to be noted. First, the population in the study may only have the insufficient sample size to elicit the differences in the rates of the injuries; it is important to understand that the rates of the injuries can depend on diverse factors, not only the levels of the vitamin D. Further research using a larger population sample and longer observational time are required to better determine the role of vitamin D supplement in injury prevention.

Furthermore, this study did not consider other factors that impact bone health and the risk of getting an injury including the calcium content in the diet, hormonal level, and training volume. More studies in the future should try to attend to these variables and offer a clearer picture of different factors that affect bone health and the risk of injury among female endurance athletes.

## Conclusion

In summary the findings of this study indicate that the risk of bone related injuries such as stress fractures in female endurance athletes can be markedly reduced by vitamin D supplementation which enhances bone mineral density and increases the level of 25(OH)D. The results showed that supplementation had no statistically significant effect on diminishing the incidence of injuries, nevertheless the decrease in the first year of the study indicates that vitamin D can somehow have a positive impact on musculoskeletal ailments. Thus, the results of the present study stress the necessity of controlling the vitamin D status in female endurance athletes and

supplementation as one of the strategies for increasing bone mineral density and preventing injuries. More studies should also be conducted to highlight the long-term implications of vitamin D supplementation on the athletic population to reduce their risks of injuries and also determine the right dosage for use in the athletes population as well as how different individuals respond to the supplementation.

## References

Barrack, M. T., Van Loan, M. D., & Rauh, M. J. (2010). Physiologic and behavioral indicators of energy deficiency in female adolescent runners with elevated bone turnover. *American Journal of Clinical Nutrition*, 92(3), 652-659.

Barrack, M. T., Van Loan, M. D., & Rauh, M. J. (2010). Physiologic and behavioral indicators of energy deficiency in female adolescent runners with elevated bone turnover. *American Journal of Clinical Nutrition*, 92(3), 652-659.

Barrack, M. T., Van Loan, M. D., & Rauh, M. J. (2010). Physiologic and behavioral indicators of energy deficiency in female adolescent runners with elevated bone turnover. *American Journal of Clinical Nutrition*, 92(3), 652-659.

Cannell, J. J., Hollis, B. W., Sorenson, M. B., Taft, T. N., & Anderson, J. J. (2009). Athletic performance and vitamin D. *Medicine and Science in Sports and Exercise*, 41(5), 1102-1110.

Heaney, R. P. (2004). Functional indices of vitamin D status and ramifications of vitamin D deficiency. *The American Journal of Clinical Nutrition*, 80(6), 1706S-1709S.

Holick, M. F. (2007). Vitamin D deficiency. *New England Journal of Medicine*, 357(3), 266-281.

Holick, M. F. (2007). Vitamin D deficiency. *New England Journal of Medicine*, 357(3), 266-281.

Holick, M. F. (2007). Vitamin D deficiency. *New England Journal of Medicine*, 357(3), 266-281.

Lappe, J. M., Cullen, D., Haynatzki, G., Recker, R. R., Ahlf, R., & Thompson, K. (2008). Calcium and vitamin D supplementation decreases incidence of stress fractures in female navy recruits.

*Journal of Bone and Mineral Research*, 23(5), 741-749.

Lappe, J. M., Cullen, D., Haynatzki, G., Recker, R. R., Ahlf, R., & Thompson, K. (2008). Calcium and vitamin D supplementation decreases incidence of stress fractures in female navy recruits. *Journal of Bone and Mineral Research*, 23(5), 741-749.

Larson-Meyer, D. E. (2010). Vitamin D supplementation and endurance athletes: Emerging evidence and recommendations. *Current Sports Medicine Reports*, 9(4), 220-226.

Larson-Meyer, D. E. (2010). Vitamin D supplementation and endurance athletes: Emerging evidence and recommendations. *Current Sports Medicine Reports*, 9(4), 220-226.

Larson-Meyer, D. E. (2010). Vitamin D supplementation and endurance athletes: Emerging evidence and recommendations. *Current Sports Medicine

Ruohola, J. P., Laaksi, I., Ylikomi, T., et al. (2006). Association between serum 25(OH)D concentrations and bone stress fractures in Finnish young men. *Journal of Bone and Mineral Research*, 21(9), 1483-1488.

Ruohola, J. P., Laaksi, I., Ylikomi, T., et al. (2006). Association between serum 25(OH)D concentrations and bone stress fractures in Finnish young men. *Journal of Bone and Mineral Research*, 21(9), 1483-1488.

Shindle, M. K., Voos, J. E., Gulotta, L. V., et al. (2011). Vitamin D status in professional American football players. *American Journal of Sports Medicine*, 39(3), 623-627.

Ward, K. A., Das, G., Berry, J. L., Roberts, S. A., Rawer, R., Adams, J. E., & Mughal, M. Z. (2005). Vitamin D status and muscle function in post-menarchal adolescent girls. *Journal of Clinical Endocrinology & Metabolism*, 94(2), 559-563.

Zittermann, A., Sabatschus, O., Jantzen, S., et al. (2006). Exercise-trained young men do not increase bone mineral density or 25(OH)D by regular sunbed use: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports*, 16(5), 222-228.

Zittermann, A., Sabatschus, O., Jantzen, S., et al. (2006). Exercise-trained young men do not increase bone mineral density or

25(OH)D by regular sunbed use: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports*, 16(5), 222-228.