Depression and Vitamin D Levels in Student-Athletes

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Abstract

Depression affects nearly seven percent of adults across the world, with a higher incidence rate in young adults ages 18 to 25. Student-athletes are a subpopulation of college students that are often overlooked in terms of depression. In addition to the prevalence and factors contributing to depression, this project examined the relationship between serum 25-hydroxyvitamin D (Vitamin D) levels and depression in 51 student-athletes. Student-athletes completed demographic information, the Center for Epidemiology Studies Depression Scale (CES-D), and blood draws. It was determined that: the incidence of depression increased from preseason to postseason, there was not a significant correlation between vitamin D and depression scores, and there was a significant correlation between depression scores and serum ferritin levels in females only.

Introduction

Currently, depression affects nearly 6.7% of adults during a 12-month span [32]. In the United States, that is 14.8 million people each year [23]. Across studies, the prevalence of depression in young adults is from 10% to 85% [26, 31]. According to the United States Department of Health and Human Services, depression affects a greater number of young adults ages 18 to 25. Depression usually first appears between an individual's teens and mid-twenties [2]. Therefore, college is often considered an at-risk period for the development of depression symptoms or other mental disorders [10].

According to the Diagnostic and Statistical Manual of Mental Disorders – 5 (DSM-5), depression or major depressive disorder is a mood disorder that negatively affects how an individual feels, thinks and acts [2]. The multifaceted disorder has a number of symptoms. The symptoms listed in the DSM-5 for depression include: feelings of sadness or depression, changes in appetite, changes in sleeping patterns, loss of interest in usually enjoyable activities, fatigue, increases in nervous gestures (such as pacing or hand-wringing), feelings of worthlessness or guilt, difficulties thinking and concentrating, indecisiveness, and thoughts of death [2]. For a diagnosis of depression, symptoms must last at least two weeks [2].

Depression is an illness that is often comorbid with anxiety, alcohol abuse, substance abuse and eating disorders [20]. As with any mood disorder, suicide is a major concern and it is estimated that 15% of people who suffer from severe depression will die by suicide [19, 27]. Depression, however, is considered a treatable disorder when diagnosed properly by trained professionals. Treatment is successful in 60% to 80% of patients. Depression is also a recurrent disorder; 70 to 80% of people with depression experience relapse [23]. The number of people with depression that receive treatment, however, is merely 25% [23]. With these statistics, it is not surprising that the World Health Organization (WHO) has named depression as the leading cause of disability, and a major contributor to the global burden of disease [23].

Depression is a mood disorder with a variety of risk factors. As mentioned by the article Bahrami et al. (2017), the causes of mood disorders are multifactorial and the causes involve complex interactions among genetic, biological and environmental factors. The DSM-V names four factors in depression: biochemistry, genetics, personality and environmental factors [2]. The biochemistry of depression is still largely misunderstood. Individuals with depression usually have a dysregulation of neurotransmitters, or brain chemicals that communicate information throughout the brain and body [20]. The three neurotransmitters that are related to mood, and therefore depression, are dopamine, serotonin and norepinephrine [20]. Berk et al. (2007), reported that the pilot data suggests that a substantially higher proportion of depressed individuals are vitamin D deficient [5]. The biochemistry of depression and vitamin D will be further discussed later. It is now understood that depression is a hereditary disorder, with genetics playing a large role. [20]. If one identical twin is diagnosed with depression, the other twin has a 70% chance of contracting the illness at some point during their life [2].

Personality has been increasingly attributed as a factor in the development of depression. Personality factors like perfectionism and low self-efficacy have been associated with a greater risk of depression [10, 20]. Additionally, personality factors such as appearance orientation have been associated with disordered eating status; depression and body image dissatisfaction is often concurred [6, 9].

Environmental factors associated with depression encompass a number of situations and events including relocation, death, relationships, drug use or abuse, alcohol use or abuse, exposure to violence or abuse, poverty or financial hardships, developmental factors, amount of stress experienced and health problems [2,20]. Adolescence is a time of great change in an individual's life from a biological and environmental standpoint, which could synergistically contribute to a rise in the prevalence of depression during this time [4].

Since college is an at-risk time for the development of depression and other mental disorders, many resources are devoted to ensuring proper education and support for students. An overlooked subpopulation on college campuses, however, is student-athletes. According to Armstrong et al. (2015), 20% of college students seek help for depression, but student-athletes seek help for depression even less. Between 2004 and 2008, suicide was the leading cause of death for student-athletes [3]. In 2017, it is still the fourth leading cause of death in this population [26]. Inconsistent measurements and reports suggest that there is likely an underreporting of mental health issues which is potentially a major concern within Athletics [26, 32].

Although there have been a number of studies examining the prevalence of depression in student-athletes, a wide range of results have been found. The prevalence rates of symptoms of depression range from 6.6% to 33.5% among studies because of differences in characteristics and reporting rates [24]. Wolanin et al. (2016), suggests that student-athletes are just as likely to experience depression as other college students. The researchers discuss two main theories behind the debate regarding whether student-athletes are at increased or decreased risk of depression in student-athletes. First, athletes are just as likely to experience depression due to increased stress, greater alcohol intake, and less social support. Athletes are, however, less likely to experience depression because of an expanded social network and team support. In recent years, the more accepted hypothesis is that depression is equally common among student-athletes and students [11, 27, 28, 32]. There are opposing views, however, as many studies in high school athletes suggest there are lower rates of depression in athletes than non-athletes, hypothesizing that social bonds and self-esteem make high school athletes less susceptible [3].

A study conducted by Wolanin et al. (2015) examined depressive symptoms in National College Athletic Association (NCAA) Division I student-athletes at a single university for three years. It was reported that the prevalence of clinically relevant depressive symptoms, defined by a CES-D score of greater than or equal to 16, was 23.7%. The prevalence of moderate to severe depression, defined by CES-D greater than or equal to 27, was 6.3%. Female student-athletes experienced a 28.5% prevalence in depressive symptoms whereas male student-athletes experienced a 17.6% prevalence in depressive symptoms; females exhibited 1.844 times the risk for having clinically relevant symptoms of depression. This is consistent with prevalence of depression between genders. An interesting finding from this study was that prevalence of depression varied between sports. Wolanin et al. (2015) ranked the relative risk ratio by sport and gender for clinically relevant depressive symptoms. The three teams that experienced the greatest relative risk were: female track and field (37.7% had clinical level of depression), female softball (30.4%) and female soccer (31.0%). Male track and field (25% had clinical level of depression), male baseball (17.8%) and male soccer (13.0%) were ranked fourth, fifth and seventh, respectively.

Cox et al. (2015) reported that 33.2% of collegiate student-athletes had clinically significant depressive symptoms. Additionally, 8.7% had CES-D scores of 30 or higher. After statistical analysis, it was determined that student athletes who were female, underclassmen, in-season or injured were more likely to be depressed. Scholarship level did not show any effect on depressive symptoms [11]. As suggested by Armstrong et al. (2015), Cox et al. (2015) observed that of the 33.2% of student-athletes with depression, only 8.3% ever received a diagnosis of depression, and a mere 3.7% were diagnosed by a healthcare professional within the last year. The study concluded that student-athletes were just as likely to experience depression but were 30% less likely to report it [11].

This conclusion is supported by other studies. In a case study performed by Mentink (2001), all three-depressed student-athletes studied were unwilling to approach their coaches with mental health issues. Another study reported that 73% of student-athletes believe their coaches care about their mental well-being [21]. Schwenk et al. (2000) reported that student-athletes, while just as susceptible to depression, may be at a greater risk for underdiagnoses and inadequate treatment, as athletic performance issues are usually tackled by a physiological standpoint rather than a biopsychosocial standpoint. Similarly, athletic behaviors can mimic symptoms of mental disorders [27]. For example, meticulous attention to diet in a student would be viewed as concerning, while in a student-athlete would be viewed as dedicated.

Like the general population, females are more likely to report symptoms of depression but less likely to attempt suicide [26]. According to a study performed by Rao et al. (2016), NCAA football had the highest rates of suicide, and that African American student-athletes and male student-athletes were more likely to attempt suicide. A recent study by Baum (2005) reported that there are 71 documented athletes that have attempted, contemplated or completed suicide; 66 of those student athletes died by suicide [27, 32].

As early as 2005, the NCAA recognized increased levels of stress and high risk behaviors in student-athletes and implemented a campaign about managing mental health [3]. According to the NCAA GOALS (Growth, Opportunity, Aspirations and Learning of Students in College) study of current student-athletes, there is an increase in number of student-athletes experiencing anxiety and depression. Student-athletes reported that one-third struggled to find energy for other tasks because of the physical demands of their sport, and one-fourth reported they were exhausted because of the physical demands of their sport. These reports led to the implementation of numerous sources regarding student-athletes' mental health and well-being. In an NCAA publication, Thompson and Trattner Sherman (2007) published a list of symptoms that student-athletes, coaches, and athletic department staff should look for. The list includes a number of behavioral, cognitive, emotional, psychological, physical and medical symptoms [30].

In addition to factors that contribute to the development of depression in students, student-athletes experience unique factors that may also contribute to the development of depression. The life of a student-athlete incorporates more stress than that of the average student. Athletes reported higher levels of stress from extracurricular activities than non-athletic students in a study conducted by Cox (2010) [10]. Additional stress from participation in collegiate athletics has been studied by several experts [1, 20, 24, 26, 28, 30, 32]. The reported unique stressors to student-athletes are: daily athletic pressure, travel, injuries, media, social pressures, time demands, academic expectations, performance expectations, low support from athletic staff, coach, peer and parental pressure, termination of an athletic career, willingness to participate in high risk behavior, stigma, denial, overtraining, concussions, team dynamics and difficulties interacting with coaches and teammates [1, 20, 24, 26, 28, 30, 32]. An important issue addressed by several articles was athletic culture's perception on mental health [1, 19, 27]. Mental health can be perceived as "weakness" in athletic cultures and subcultures, and phrases such as "seeing a counsellor" or "being depressed" have historically had the connotation of "weakness" within athletics [3]. Reardon et al. (2010) reported that "athletes tend to minimize apparent signs of weakness," while NCAA (2014) similarly reported athletes find it more difficult to seek help. Athletes are often taught to "play through the pain," struggle through adversity and handle obstacles on their own [1]. The handbook also addressed the perception throughout athletic cultures that deems mental wellness not as necessary for athletic performance as physical wellness [1]. While changing the culture of athletic departments, viewing injuries from a biopsychosocial perspective rather than a physiological perspective could negate some of these lapses [27].

Within the student-athlete population, overtraining and burnout are synonymous. Overtraining, or overtraining syndrome, can threaten both the mental and physical health of a student athlete [32]. Overtraining was introduced by Freeudenberger in 1974 [8]. Overtraining is defined as a long-term decrement in performance, usually accompanied by various psychological, immunological, hormonal and metabolic changes [28, 32]. The signs and symptoms of overtraining, as mentioned by Armstrong et al. (2015) are: changes in sleeping patterns, changes in appetite, exhaustion, lowered self-esteem, irritability, anxiety, changes in weight, lack of concentration, physical illness, and decreased performance. The decrement to performance and its accompanying somatic changes make overtraining very similar to depression [28]. Brennenmier et al. (2001) determined that depression and burnout are not identical but are positively related. Depression and overtraining both produce immunological effects where natural killer cell and humoral immunological parameters become suppressed [28]. Depression and overtraining are both related to central fatigue, with similar changes in neurotransmitter levels and functions [28]. The difference between overtraining and depression is in the role of dysfunction; the dysfunction occurs in athletic performance with overtraining, and social, cognitive and work with depression [28].

A thoroughly investigated risk athletes face is injury. Injuries were mentioned in eight studies regarding student-athletes and depression [1,3, 11, 20, 24, 26, 30, 32]. Over half (51%) of the athletes that experienced an injury over the course of the study conducted by Leddy et al. (1994) reported mild to severe depression symptoms, measured by the Beck Depression Inventory. Similarly, Brewer & Petrie (1995) found athletes who experienced an injury during the previous year gave correlated with higher depression symptom scores than non-injured athletes. Armstrong et al. (2015) reported that type of injury, and personality, were both associated with depressive symptoms following an injury. Athletes with an anterior cruciate ligament (ACL) injury had more severe levels of depression and increased duration of depression compared to athletes with a concussion [32]. It has also been reported that in a survey of 1,044 retired NFL players, the 9-year risk of depression diagnosis increased as the number of self-reported concussions increased [32].

Cox (2015) suggested that injuries are problematic for athletes because of the relation to athletic identity. In 2010, the NCAA reported that 76% of male athletes had a high athletic identity, while 63% had a high academic identity [16]. Wolanin et al. (2016) suggests that athletes may prove to experience depressive symptoms with a decline in athletic performance. Since student-athletes invest time and effort into athletics, their athletic identity is significant to who they are as people. Career-ending injuries and career termination have all been associated with maladaptive coping strategies, depression, anxiety, higher levels of hostility or anger, and substance abuse [32]. It is hypothesized that involuntary career termination, such as a career-ending injury or being cut from a team, is more likely to result in negative behavior changes [32].

There are 400,000 NCAA student-athletes actively competing every year [32]. For many of these athletes, personality can play a factor in developing depression or other mental disorders. Cox (2015) deems that perfectionists are outcome driven, like many student-athletes.

Athletic failure, to a perfectionistic student-athlete, can be a stressor that contributes to negative coping strategies or the development of depression [11]. Moore (2010) similarly suggested that the reason that female student-athletes with negative performance and lack of proper coping skills are more likely to develop depression. Self-efficacy, or the belief in one's ability to succeed in specific situations, has been associated with depression [20]. Researchers also report that self-efficacy can influence athletic performance [20]. Student-athletes are not immune to mental disorders or low self-efficacy. Many student-athletes experience "state anxiety;" state anxiety is appropriate anxiety before competition that does not permeate one's entire life [27].

Although not many studies have been conducted on student-athletes with anxiety disorders, it is likely that student-athletes experience anxiety at the same rate as the student population. A reason for the mistaken belief that student-athletes are immune to mental disorders could be the "Halo Effect." Mentink et al. (2001), defines the halo effect as the process of allowing one characteristic of an individual or group to overshadow all other characteristics of that individual or group. The research team suggested that the halo effect might contribute to the camouflaging of depression in athletes [19]. Pressures brought on by media, coaches, teammates, fans and heightened scrutiny have been mentioned as stressors to student-athletes in a number of studies [1, 19, 20, 30]. Female student-athletes, in particular, have to deal with conflicting pressures. On one hand, there is the desire to be strong, and the other is the desire to remain feminine in terms of social standards of beauty [5]. Development of depression and other mental disorders, however, can be triggered or exacerbated by pressure, which a student-athlete is no stranger to.

Student-athletes are considered a "high risk" population in college aged students because of alcohol use and abuse, eating disorders, overtraining and the stressors of injuries [3]. Alcohol use and abuse is more common in student-athletes when compared to the student population [3]. Student-athletes also experience higher rates of eating disorders; this is especially true in female student-athletes whose sports are most impacted by weight [3]. These statistics are concerning because both substance abuse and eating disorders are considered risk factors for depression and are found to occur comorbid with depression [20, 27].

There are studies that report associations between depression and several nutritional deficiencies such as folate, selenium, iron, zinc, fatty acids, and vitamin D [23]. Nutrition is also associated with obsessive compulsive disorder (OCD), major depressive disorder (MDD), bipolar disorder and schizophrenia [23]. New studies are examining the relationship between nutrients and other dietary components to mental disorders such as depression. For example, increases in incidence of depressive disorders are paralleled changes of fat sources in Western diets, which provides further evidence for a relationship between nutrition and depression [4, 12].

Similarly, Bahrami et al. (2017) states, data has shown an inverse association between serum vitamin D level and risk for depression and other mental disorders. The inverse relationship between vitamin D and depression is a common theme within depression literature [4, 5, 14, 15, 23, 29], though there is data that suggests there is no significant relationship [4,15].

Although the literature suggests that vitamin D plays a role in mental disorders, the mechanism is not yet understood [23]. There are reports indicating that vitamin D plays a neuroprotective role in hippocampal cell survival [5]. It is reported that there are myriad vitamin D receptors in the hypothalamus, which is important to endocrine function [14, 23]. Vitamin D receptors are also expressed throughout the central nervous system and the limbic system [4]. The limbic system is important for memory, behavior and mood [4]. There are also high concentrations of vitamin D receptors in the amygdala, thalamus, the dorsal raphe nucleus, the dorsal nucleus of the vagus and the motor neurons located both cranially and spinally [14]. Shipowick et al. (2009) mentioned three physiologic pathways between vitamin D and depressive symptoms developed by two independent research teams. The three pathways were: the active form of vitamin D has been shown to stimulate serotonin [13], a neurotransmitter that is associated with mood elevation; the glucocorticoid receptor gene activation is found to be up-regulated in depression, and vitamin D has been associated with its down-regulation; and Vitamin D has been found to be neuroprotective [22]. Bahrami et al. (2017) stated that vitamin D had the following metabolite functions in the brain: neuroprotection, immunomodulation, biosynthesis of neurotransmitters and brain development. Hogberg et al. (2012) suggested that because changes in the vitamin D deficiency scale in areas such as fatigue, pain, weakness and insomnia give complaints similar to that of malaise during inflammatory states, that the immune system may be a link between vitamin D deficiency and symptoms of depression. To further investigate the role of vitamin D in the brain, research is being conducted on rats [5]. Vitamin D was reported to play an important role in the development of the brain in rats [23].

Vitamin D is a steroid hormone that made through dermal synthesis from sunlight or dietary intake [4]. Vitamin D2, ergocalciferol, is ingested through plant sources; vitamin D3, cholecalciferol, is obtained through ingestion of animal sources or through sunlight [15]. Both forms of vitamin D are hydroxylated in the liver to become 25-hydroxyvitamin D (25[OH]D), the major circulating form found in the body [15, 29]. 25-hydroxyvitamin D is then activated to 1,25-dihydroxyvitamin D in the kidneys by 1- â-hydroxylase in a tightly regulated process [15, 29]. Although the process primarily takes place in the kidneys, both vitamin D receptors and 1-â-hydroxylase enzymes can be found in other organs, including the brain [15, 29]. 1,25-

dihydroxyvitamin D is the biologically active vitamin D metabolite [15]. This is the molecule that binds to vitamin D receptors throughout the body. It is interesting to note that both the active, 1,25-dihydroxyvitamin D, and inactive, 25-hydroxyvitamin D, forms of vitamin D can cross the blood brain barrier [29].

The literature concludes that the best method for analyzing vitamin D in the body is through serum hydroxyvitamin D (25[OH]D) levels [14, 23]. This method is used to assess the status of an individual's vitamin D. Through this method, an individual can be diagnosed as vitamin D insufficient or vitamin D deficient. To be considered vitamin D insufficient, an individual must have less than 30 ng/mL; to be considered deficient, an individual must have less than 20 ng/mL [23].

Hogberg et al. (2012) conducted a study that investigated depression symptoms and vitamin D. The participants of the study were 54 depressed adolescent females from Sweden; 19 of the participants were moderately depressed and 35 were severely depressed. There was no difference in initial 25[OH]D level between moderately depressed or severely depressed participants. Hogberg's research team supplemented the participants with 4000 IU daily for one month, or 2000 IU daily for two months. The results of the study showed that 11% of the participants were vitamin D deficient, basal 25[OH]D levels were positively correlated with well-being and negatively correlated for tiredness and bodily weakness, and well-being significantly increased following vitamin D supplementation [14]. Another conclusion reported by Hogberg et al. (2012) was that there was a significant decrease in Mood and Feeling Questionnaires (MFQ-S) after supplementation; scores were reduced from 14.1, indicating depression, to 7.1, which is below the depression cutoff.

Similar findings were reported in a number of vitamin D supplementation studies. Penckofer et al. (2010) found groups of overweight or obese individuals that received vitamin D supplementation had significant improvements in depression scores. Shipowick et al. (29) found significant reductions in depressive symptoms following supplementation of vitamin D. Baharmi et al. (2017) treated 940 girls with vitamin D3 at 50,000 IU per week for nine weeks and measured its effects on depression and aggression, in their study. Following the nine-week supplementation period, there was a significant reduction on mild, moderate and severe depression scores and no effect on aggression [4]. In a study conducted by May et al. (2010), individuals with the lowest baseline level of 25[OH]D were most likely to develop clinical diagnoses of depression during the follow up interview. Similarly, Bahrami et al. (2017) reported that higher concentrations of 25-hydroxyvitamin D3 in adolescents and children were associated with lower depression levels.

The primary aims of this study were to investigate: 1) the prevalence of depression in collegiate soccer players and cross country runners across a single season and 2) assess the relationship between depression and vitamin D. We hypothesized that: 1) the prevalence of depression would approach that of the general collegiate population (~20%) and 2) depression would negatively be related to vitamin D status (i.e. the lower the vitamin D, the increased likelihood of depression measured by the CES-D).

Methods

Members of a Midwestern University's NCAA Division 1 (DI) male and female soccer players and male and female cross country runners were recruited to participate in this observational study conducted over the Fall 2017 competitive season. After signing written informed consent, all consenting student-athletes participated in the following tests both preseason (August 2017) and postseason (December 2017). To remove any potential bias from a winning or losing season, post-testing was conducted 4-6 weeks following the completion of each team's respective season.

Depression was assessed using the previously validated 20-question Center for Epidemiology Studies Depression Scale (CES-D). Five milliliters of blood was collected via venipuncture, in the Human Performance Lab at Oakland University, obtained in a supine position. The serum was analyzed at local hospital laboratory (Crittenton Hospital) for assessment of 25-OH-Vitamin D (vitamin D) and ferritin (Cobas e immunoassay). Serum ferritin was a secondary biomarker, typically measured in our endurance athletes, but not originally considered a primary marker of interest.

Statistical analyses were performed using Statistica 13.3 (TIBCO), using paired (preseason versus postseason data) and unpaired t-tests to assess differences between: sports teams, males and females, and those with and without depression. Simple regression analyses were used to assess relationships between depression with biomarkers (serum vitamin D and ferritin). Statistical significance was set *a priori* at $p<0.05$. All data presented as the mean value ± Standard Deviation (range of minimum-maximum values, unless otherwise indicated.

Results

Combined

	Combined	Male	Female
Number of Participants	51	22	29
Age	**20.0 ± 1.4** *(18 - 23)*	**20.2 ± 1.5** *(18 - 23)*	**19.8± 1.4** *(18 - 23)*
Height (m)	**1.7 ± 0.1** *(1.6 - 1.9)*	**1.8 ± 0.1**** ** *(1.6 - 1.9)*	**1.7 ± 0.1** *(1.6 - 1.8)*
Weight (kg)	**66.2 ± 10.2** *(46.7 - 94.1)*	**72.9 ± 9.4****** *(55.3 - 94.1)*	**61.1 ± 7.5** *(46.7- 79.4)*
Pre-season Vitamin D (ng/mL)	**48.6 ± 20.0** *(19.0 - 99.7)*	**45.5 ± 17.2** *(19.0 - 91.0)*	**50.9 ± 22.0** *(23.1 - 99.7)*
Pre-season Ferritin (ng/mL)	**71.4 ± 56.5** *(9.2 - 297.3)*	**99.2 ± 65.3**** *(25.1 - 297.3)*	**50.2 ± 37.8** *(9.2 - 165.1)*
Pre-season CES-D Score	**6.0 ± 4.1** *(0 - 23)*	**5.9 ± 4.7** *(0 - 23)*	**6.1 ± 3.6** *(0 - 16)*
Post-season Vitamin D (ng/mL)	**43.3 ± 18.1** *(11.5 - 96.1)*	**38.7 ± 14.1** *(11.5 - 68.3)*	**46.8 ± 20.2** *(20.9 - 96.1)*
Post-season Ferritin (ng/mL)	**70.0± 45.7** *(19.1 - 249.6)*	**83.0 ± 53.1** *(22.9 - 249.6)*	**60.2 ± 37.1** *(19.1 - 151.6)*
Post-season CES-D Score	**8.9 ± 6.5** *(0 - 27)*	**9.0 ± 6.4** *(1 - 26)*	**8.8 ± 6.7** *(0 - 27)*
△ Vitamin D (ng/mL)	**-5.3 ± 11.9** *(-34.0- 31.7)*	**-6.8 ± 11.2** *(-29.6- 16.5)*	**-4.1 ± 12.5** *(-34.0 - 31.7)*
△ Ferritin (ng/mL)	**-1.3 ± 45.3** *(-164.5 - 163.9)*	**-16.2 ± 60.8*** *(-164.5 - 163.9)*	**9.9 ± 24.4** *(-22.1 - 77.4)*
△ CES-D Score	**2.9 ± 6.1** *(-12.0 - 21.0)*	**3.1 ± 4.8** *(-6 - 17)*	**2.7 ± 6.9** *(-12 - 21)*
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001			

Table 1. Data in total from preseason testing and postseason testing. 51 participants completed the preseason and postseason testing, including both blood draws. There were 22 male participants and 29 female participants.

As noted in Table 1, there were a total of 51 participants (22 male, 29 female) with complete preseason and postseason data included in these analyses. The participants ranged from 1.6 m to 1.9 m, averaging 1.7 ± 0.1 m. Participants weighed an average of 66.2 ± 10.2 kg, ranging from 46.7 kg to 94.1 kg. All 51 participants completed the preseason and postseason testing.

Vitamin D varied between males and females; females had a higher mean value of vitamin D than males, but not significantly so. Four female participants had preseason values below the normal level of vitamin D, 30 ng/mL; five male participants had preseason vitamin D levels below this threshold. In postseason, five females had vitamin D values below 30 ng/mL, including the four below 30 ng/mL in preseason. Five male participants had postseason vitamin D levels below 30 ng/mL; four of the five were also under during preseason.

The results of ferritin between genders was consistent with other reports. Females had significantly lower levels of ferritin than males during preseason testing ($p < 0.005$). Females had lower levels of ferritin in postseason, but not significantly so. This result is consistent with general knowledge of ferritin levels when comparing postpubescent females to males. Five females in preseason were under the normal range for ferritin in athletes, which is 35 ng/mL. Four females were under 20 ng/mL in preseason, which is the upper limit for iron-deficient anemia. In postseason, only one female was under 35 ng/mL. As supported by positive Δ ferritin, there was an increase in the mean ferritin values from preseason to postseason. In both preseason and postseason, one male participant had ferritin values under 35 ng/mL. Neither of these participants had ferritin values under 20 ng/mL.

The CES-D scores indicate the prevalence of depressive symptoms. The mean depression score in preseason for the entire sample was 6.0 ± 4.1. In postseason, both males and females showed an increase in CES-D scores. The males Δ CES-D was 3.1 ± 4.8, while the females Δ CES-D was 2.7 ± 6.9. Postseason CES-D scores for the entire sample were 8.9 ± 6.5. The preseason CES-D score was significantly lower than the postseason CES-D score for the entire sample ($p < 0.01$). The increase in CES-D scores shows an increase in depressive symptoms in the sample.

	CES-D < 16	CES-D ≥ 16
Number of Participants	49	2
Age	19.9 ± 1.4	21.0 ± 0
Height (m)	1.7 ± 0.1	1.7 ± 0.1
Weight (kg)	66.2 ± 10.2	65.1 ± 14.4
Pre-season Vitamin D (ng/mL)	49.4 ± 20.0	28.0 ± 0.2
Pre-season Ferritin (ng/mL)	71.0 ± 57.0	81.8 ± 60.0
Pre-season CES-D Score	5.4 ± 3.0	19.5 ± 4.9
Post-season Vitamin D (ng/mL)	43.9 ± 18.2	27.7 ± 0.9
Post-season Ferritin (ng/mL)	69.8 ± 45.7	75.7 ± 63.9
Post-season CES-D Score	8.4 ± 6.0	21.0 ± 7.1
△ Vitamin D (ng/mL)	-5.5 ± 12.1	-0.3 ± 0.7
△ Ferritin (ng/mL)	-1.1 ± 46.2	-6.0 ± 3.9
△ CES-D Score	2.9 ± 6.2	1.5 ± 2.1
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001		

Table 2. Data separated by preseason CES-D score. CES-D scores < 16 are below the standard cut off for clinically relevant symptoms of depression. 49 participants were below the cutoff in preseason. Two participants (3.9%) scored ≥ 16, which is considered clinically relevant for symptoms of depression.

	CES-D < 16	**CES-D ≥ 16**
Number of Participants	44	7
Age	19.9 ± 1.5	20.3 ± 1.0
Height (m)	1.7 ± 0.1	1.7 ± 0.1
Weight (kg)	66.7 ± 10.3	62.8 ± 9.89
Pre-season Vitamin D (ng/mL)	50.2 ± 20.6	38.4 ± 13.1
Pre-season Ferritin (ng/mL)	74.8 ± 58.7	49.9 ± 35.8
Pre-season CES-D Score	5.5 ± 3.1	9.4 ± 7.2*
Post-season Vitamin D (ng/mL)	44.3 ± 19.1	37.1 ± 8.6
Post-season Ferritin (ng/mL)	72.2 ± 47.1	56.5 ± 35.2
Post-season CES-D Score	6.9 ± 4.2	21.3 ± 4.4****
△ Vitamin D (ng/mL)	-5.9 ± 12.2	-1.3 ± 10.1
△ Ferritin (ng/mL)	-2.6 ± 48.5	6.6 ± 14.1
△ CES-D Score	1.4 ± 4.4	11.9 ± 7.6****
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001		

Table 3. Data separated by postseason CES-D score. CES-D scores < 16 are below the standard cut off for clinically relevant symptoms of depression. 44 participants were below the cutoff in preseason. Seven participants (13.7%) scored ≥ 16, which is considered clinically relevant for symptoms of depression.

Table 2 and Table 3 compare the individuals with CES-D scores below the clinically relevant cut off (<16), and individuals above the cut-off (≥ 16). In preseason, only two (3.9%) participants had CES-D scores greater than or equal to 16. In postseason, seven participants had CES-D scores greater than or equal to 16 (13.7%). These seven participants had a lower average value of preseason vitamin D, preseason ferritin and postseason vitamin D. The average value of post ferritin in the seven participants with CES-D scores greater than or equal to 16 was higher than participants with CES-D scores less than 16. Although these trends were not significant, there were trends to support that higher CES-D scores were associated with vitamin D and ferritin levels. The nonsignificant trends between vitamin D and CES-D can be observed in Figure 1 and Figure 2, for preseason and postseason, respectively.

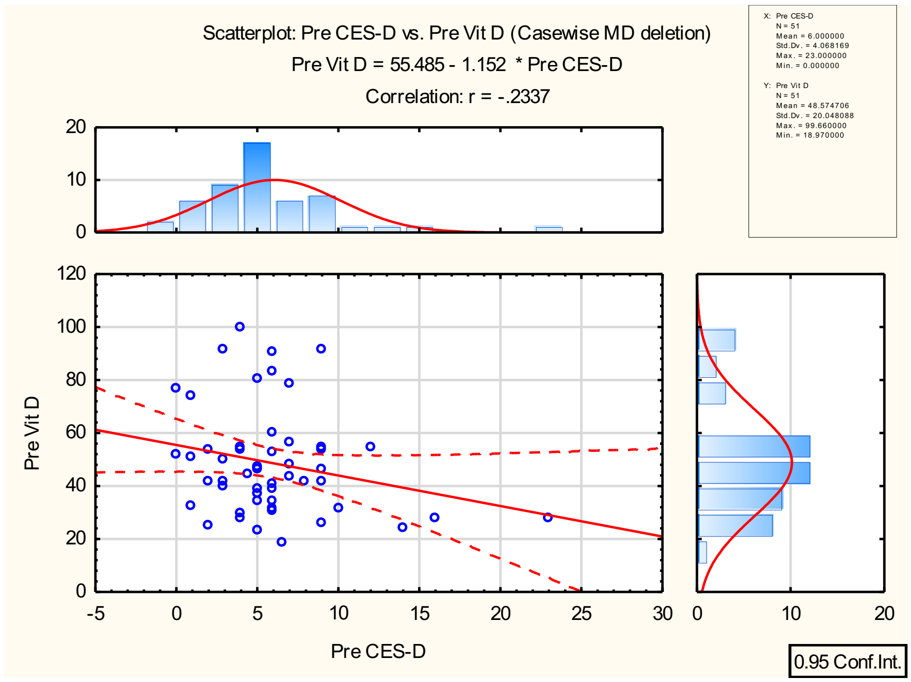

Figure 1. *Preseason vitamin D against preseason CES-D scores. R = -0.2337.*

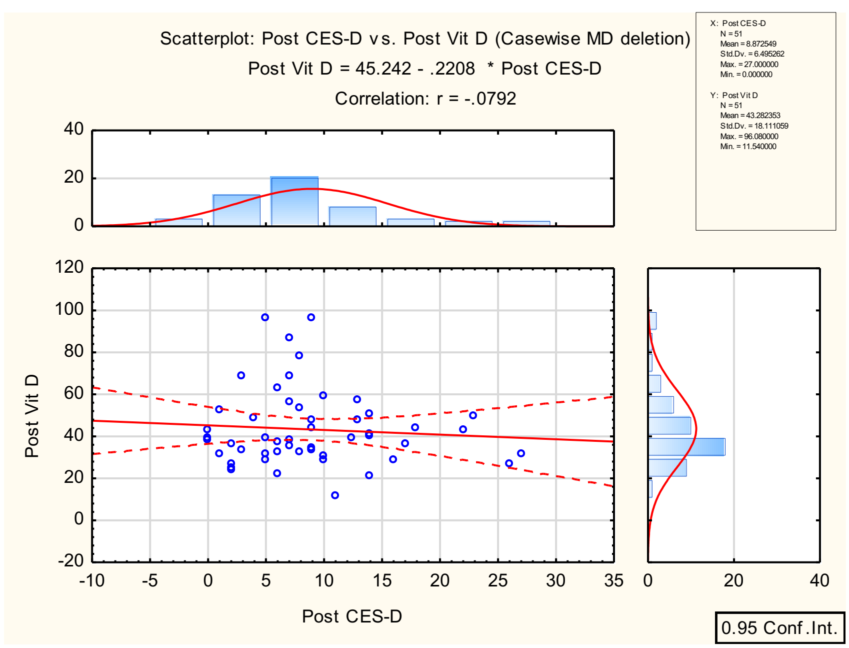

Figure 2. *Postseason vitamin D against postseason CES-D scores. R = -0.079.*

Teams

	Cross Country	Soccer
Number of Participants	20	31
Age	20.0 ± 1.8	20.0 ± 1.1
Height (m)	1.7 ± 0.1	1.7 ± 0.1
Weight (kg)	60.7 ± 8.2	69.7 ± 9.9
Pre-season Vitamin D (ng/mL)	61.6 ± 18.8	40.2 ± 16.1
Pre-season Ferritin (ng/mL)	63.9 ± 37.0	76.1 ± 66.3
Pre-season CES-D Score	4.9 ± 2.9	6.7 ± 4.6
Post-season Vitamin D (ng/mL)	45.8 ± 15.7	41.7 ± 19.6
Post-season Ferritin (ng/mL)	64.9 ± 31.5	73.3 ± 53.1
Post-season CES-D Score	7.8 ± 6.2	9.6 ± 6.7
△ Vitamin D (ng/mL)	-15.8 ± 8.3	1.5 ± 8.5
△ Ferritin (ng/mL)	1.0 ± 29.4	-2.8 ± 53.6
△ CES-D Score	2.9 ± 5.5	2.9 ± 6.4
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001		

Table 4. Results from participants divided by sport. There were 20 cross country runners and 31 soccer players

Vitamin D, ferritin and CES-D scores were compared based on the sport of participants. There were 20 cross country runners and 31 soccer players in the sample. When comparing cross country to soccer, there was a significant difference in preseason vitamin D values and Δ vitamin D. Cross country (61.6 ± 18.8 ng/mL) was significantly higher than soccer (40.2 ± 16.1 ng/mL) in preseason vitamin D. Cross country was significantly lower in Δ vitamin D (-15.8 ± 8.3 ng/mL) than soccer (1.5 ± 8.5 ng/mL). Cross country maintained a higher mean value of vitamin D in postseason, but the difference was not significant. Soccer had higher values than cross country in preseason ferritin, preseason CES-D, postseason ferritin and postseason CES-D, though not significantly so.

Females

	Females Combined	Cross Country	Soccer
Number of Participants	29	10	19
Age	19.8 ± 1.4	19.7 ± 1.8	19.8 ± 1.1
Height (m)	1.7 ± 0.1	1.7 ± 0.1	1.7 ± 0
Weight (kg)	61.1 ± 7.5	55.0 ± 5.4***	64.3 ± 6.5
Pre-season Vitamin D (ng/mL)	50.9 ± 22.0	66.3 ± 20.6**	42.9 ± 18.4
Pre-season Ferritin (ng/mL)	50.2 ± 37.8	51.6 ± 41.9	49.5 ± 36.7
Pre-season CES-D Score	6.1 ± 3.6	4.4 ± 3.1	7.0 ± 3.7
Post-season Vitamin D (ng/mL)	46.8 ± 20.2	50.3 ± 18.3	44.9 ± 21.3
Post-season Ferritin (ng/mL)	60.2 ± 37.1	63.8 ± 38.9	58.2 ± 37.0
Post-season CES-D Score	8.8 ± 6.7	6.3 ± 5.7	10.1 ± 7.0
△ Vitamin D (ng/mL)	-4.1 ± 12.5	-15.9 ± 10.2****	2.1 ± 8.6
△ Ferritin (ng/mL)	9.9 ± 24.4	12.2 ± 27.5	8.7 ± 23.3
△ CES-D Score	2.7 ± 6.9	1.9 ± 4.8	3.2 ± 7.9
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001			

Table 5. Data from 29 female participants. There were 10 cross country runners and 19 soccer players.

The 29 female participants included 10 cross country runners and 19 soccer players. The sample had higher levels, although not significant, of preseason vitamin D, preseason CES-D scores, and postseason vitamin D when compared to males. The females had significantly lower levels of preseason ferritin, and lower levels of postseason ferritin than the male participants.

Correlational analysis of the female participants concluded with interesting data. It was shown that preseason ferritin was significantly correlated to the postseason CES-D score, Figure 3, (r = -0.3777), and the Δ CES-D score, Figure 4, (r=0.3947). Similarly, postseason ferritin was significantly correlated to postseason CES-D scores, Figure 5 (r=-0.4519) and the Δ CES-D score, Figure 6 (r=0.39599). Similarly, postseason vitamin D was significantly correlated to to Δ ferritin (r = 0.3947).

When comparing female participants by sport, cross country runners had significantly higher preseason vitamin D levels than soccer players (p < 0.005). Cross country runners had higher levels of postseason vitamin D, but the difference was not significant. The Δ vitamin D score was significantly different between the two groups; cross country (-15.9 ± 10.2 ng/mL) was significantly lower than soccer (2.1 ± 1.4 ng/mL). The data provided nonsignificant differences: soccer had higher preseason CES-D, postseason CES-D and Δ CES-D scores, cross country had higher preseason ferritin, postseason ferritin and Δ ferritin values.

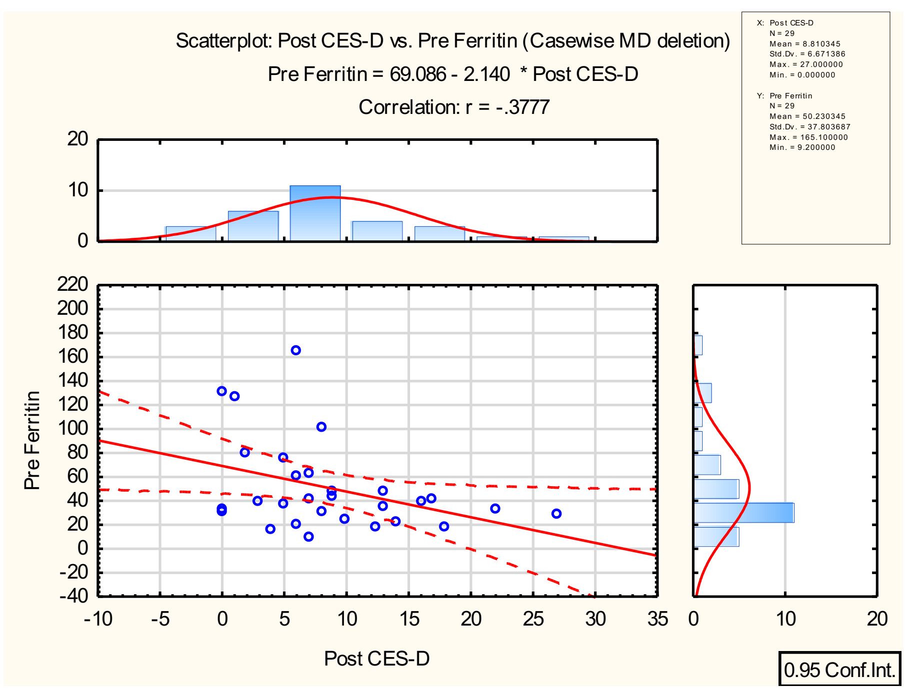

Figure 3. Female preseason ferritin scores correlated with postseason CES-D scores, N=29, r = 0.3777

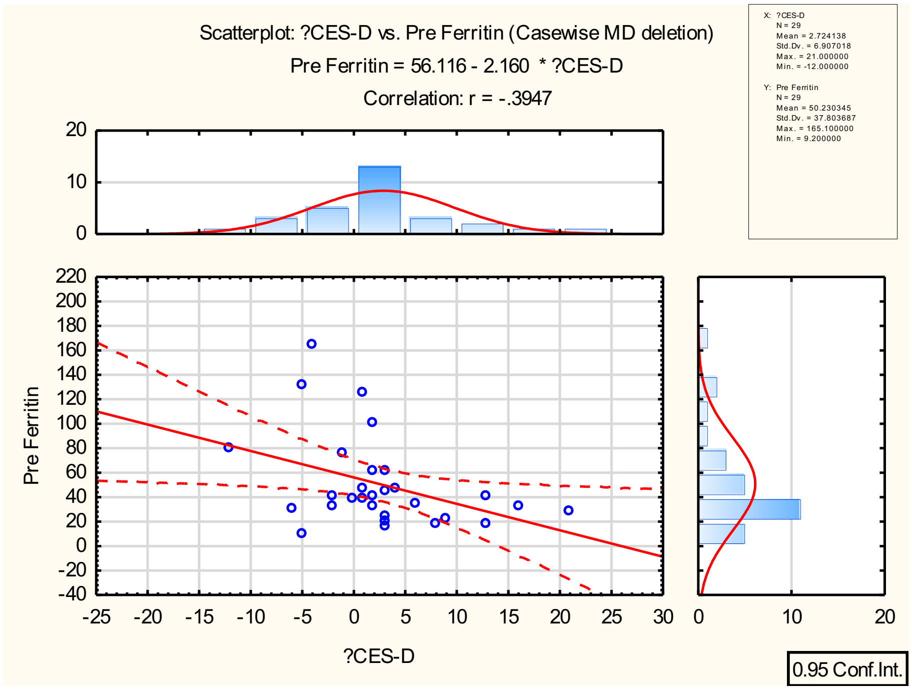

Figure 4. *Female preseason ferritin correlated to Δ CES-D score, N=29, r = -0.3947.*

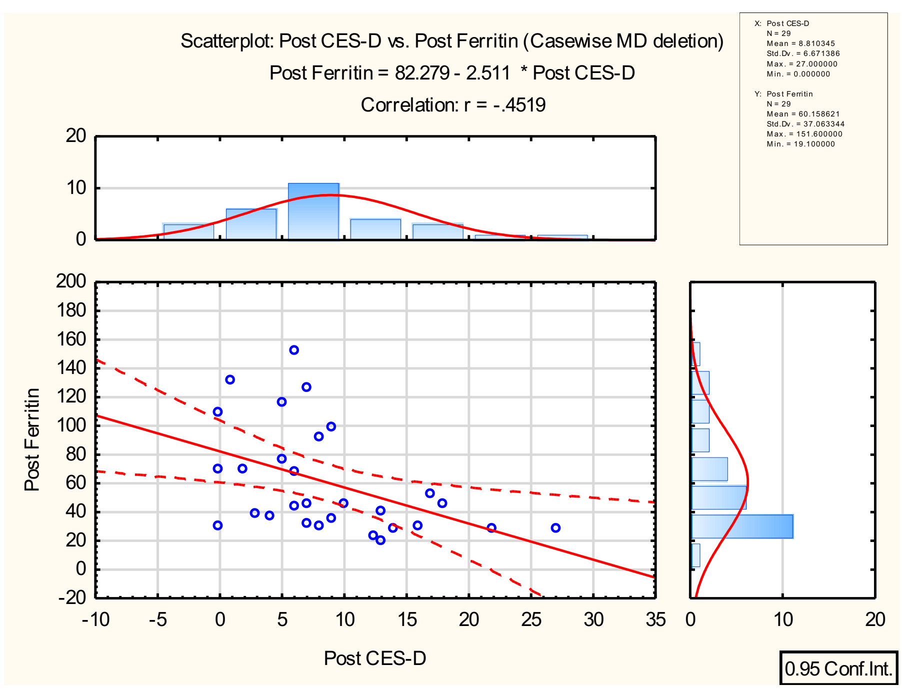

Figure 5. *Female postseason ferritin correlated to postseason CES-D scores, N=29, r = -0.4519.*

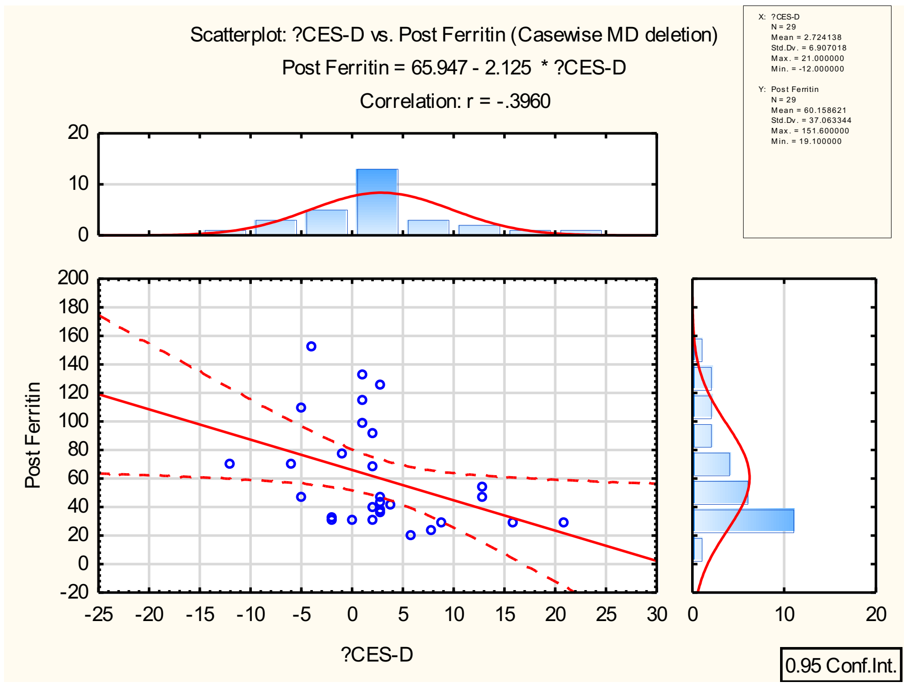

Figure 6. Female postseason ferritin correlated to to Δ CES-D score, N=29, r = -0.3960.

Although the results of the t-tests were not significant, analysis showed a lower postseason vitamin D score compared to preseason vitamin D score in females. Similarly, preseason CES-D scores were lower than postseason CES-D scores, indicating that the female participants reported a greater number of symptoms of depression in postseason. Ferritin, however, increased from preseason to postseason. This is likely the result of supplementation because of the number of female athletes below 20 ng/mL, the upper limit of anemia.

Five female participants had postseason CES-D scores greater than or equal to 16, indicating a clinically relevant level of depression symptoms. When comparing females with postseason CES-D scores less than 16 (N=24) to females with postseason CES-D scores greater than or equal to 16 (N=5), there were nonsignificant differences between the groups. The participants with CES-D scores greater than or equal to 16 had lower levels of preseason vitamin D, preseason ferritin, postseason vitamin D, and postseason ferritin. This is accompanied by a non-significantly higher value for both Δ vitamin D and Δ ferritin.

Males

	Male	Cross Country	Soccer
Number of	22	10	12
Age	20.2 ± 1.5	20.2 ± 2.0	20.3 ± 1.1
Height (m)	1.8 ± 0.1	1.7 ± 0.1	1.8 ± 0.1
Weight (kg)	72.9 ± 9.4	66.5 ± 6.4	78.3 ± 8.2
Pre-season Vitamin D (ng/mL)	45.5 ± 17.2	56.9 ± 16.5	36.0 ± 11.2
Pre-season Ferritin (ng/mL)	99.2 ± 65.3	76.3 ± 28.3	118.3 ± 81.3
Pre-season CES-D	5.9 ± 4.7	5.3 ± 2.8	6.4 ± 5.9
Post-season Vitamin D (ng/mL)	38.7 ± 14.1	41.2 ± 11.8	36.6 ± 15.9
Post-season Ferritin (ng/mL)	83.0 ± 53.1	66.0 ± 24.1	97.2 ± 66.5
Post-season CES-D	9.0 ± 6.4	9.2 ± 6.7	8.8 ± 6.5
△ Vitamin D (ng/mL)	-6.8 ± 11.2	-15.7 ± 6.4	0.6 ± 8.7
△ Ferritin (ng/mL)	-16.2 ± 60.8	-10.3 ± 28.2	-21.1 ± 79.6
△ CES-D Score	3.1 ± 4.8	3.9 ± 6.3	2.4 ± 3.4
*p < 0.05, **p<0.01, ***p<0.001, ****p<0.0001			

Table 6. Data from 29 female participants. There were 10 cross country runners and 19 soccer players.

There were 22 male participants in the sample; 10 were cross country runners and 12 soccer players. The male cross country runners, like the female cross country runners, had significantly higher levels of preseason vitamin D than the male soccer players. The difference between the Δ vitamin D of male cross country runners and soccer players Δ vitamin D was also significant. Cross country runners had a lower Δ vitamin D (-15.7 ± 6.4 ng/mL) than the soccer players (0.6 ± 3.4 ng/mL). Male soccer players had a higher mean than cross country runners in preseason ferritin, preseason CES-D, and postseason ferritin. Cross country runners had a higher mean than soccer players in postseason CES-D, and Δ CES-D.

Although the results of the t-tests were not significant, analysis showed a lower postseason vitamin D score compared to preseason vitamin D score in males. Ferritin also decreased from preseason testing to postseason testing. The CES-D scores increased from preseason (5.9 ± 4.7) to postseason (9.0 ± 6.4). Although the results were not significant ($p > 0.07$), the trend shows that there is an increase in CES-D scores, and therefore depressive symptoms, over the course of a season (Δ CES-D = 3.1 ± 4.8).

One male participant had a preseason CES-D score higher than the cut off value 16; in postseason, two males had CES-D scores greater than 16. These results are consistent with the literature that females experience depression at greater rates than males. In the postseason testing, the postseason vitamin D was lower in the participants with CES-D scores greater than 16 when compared to participants with CES-D scores less than 16. Surprisingly, the mean postseason ferritin was higher in the participants above the cut off than below the cut off. This varies from the results in the female participants; it should be noted, however, that there were only two participants that scored above 16 in the postseason CES-D.

Discussion

In this study, vitamin D and ferritin varied between genders. Females had a higher mean value of vitamin D compared to males, although not significantly so. Preseason vitamin D was correlated to preseason CES-D score ($r = -0.2337$), suggesting that lower levels of vitamin D are associated with higher CES-D scores. Postseason vitamin D, however, was not correlated to postseason CES-D scores ($r = -0.0791$). Ferritin results were consistent with other studies. Females had significantly lower levels of ferritin in preseason, and nonsignificantly lower levels of ferritin in postseason. Females generally have lower levels of ferritin due to the loss of blood during menstruation. Females exhibited a positive Δ ferritin, indicating a higher mean level of postseason ferritin than preseason ferritin. The reason for this unique finding can be contributed to four female soccer players taking supplements of multivitamins and iron. Student-athletes were recommended by the Oakland University Registered Dietician to begin taking supplements for iron deficiency if their preseason ferritin was below 30 ng/mL. The fourth participant supplementing has a personal and familial history of anemia. Both males and females experienced a positive Δ CES-D, indicating an increase in prevalence of depressive symptoms. There are a number of reasons that can contribute to the increase in CES-D scores, including: biochemistry, genetics, personality, environmental factors, athletic stress, injuries, expectations, termination of career, willingness to participate in high risk behavior, stigma, denial, overtraining, concussions, team dynamics, and interactions with coaches and teammates [1, 3, 20, 24, 26, 28, 30, 32].

Soccer players and cross country runners had significantly different levels of preseason vitamin D and Δ vitamin D. Cross country runners had significantly higher levels of preseason vitamin D, which was an interesting finding because both soccer players and cross country runners train outside during the summer in Michigan. An explanation for this may be that soccer players train with more clothing on than cross country runners. Similarly, the Δ vitamin D between sports was significantly different. Cross country runners experienced a negative Δ vitamin D, indicating a mean loss of vitamin D from preseason to postseason. In contrast, soccer players experienced a positive Δ vitamin D. This result is because of the supplementation with multivitamins by three female soccer players after preseason testing.

An unsuspected finding from this study was the significant correlation of both preseason ferritin and postseason ferritin to postseason CES-D and Δ CES-D in the females. The correlation of preseason and postseason ferritin to postseason CES-D and Δ CES-D was only significant in analysis of female participants, not in the analysis of male participants or the combined sample. Since females are more likely to experience depression and more likely to have lower levels of iron and ferritin, the correlation found in female participants makes sense. In female participants, like the complete sample, cross country runners experienced significantly higher levels of preseason vitamin D and significantly lower levels of Δ CES-D than soccer players. As mentioned above, female cross country runners may train in less clothing than soccer players during the summer months. This would lead to increased sun exposure in the cross country runners, leading to higher levels of vitamin D.

The male participants experienced similar outcomes. Male cross country runners experienced significantly higher values of preseason vitamin D and lower Δ vitamin D. As mentioned above, the amount of clothing during outdoor practices could be reason for the discrepancy. Similarly, the cross country runners may exhibit significantly lower levels of Δ vitamin D because as the weather changes, there is less sun exposure, resulting in a lower fall for people with greater sun exposure. The decrease in vitamin D in male participants was expected, as the weather in Michigan changes drastically from August to December. CES-D scores increased in the male participants, although not significantly. The increased CES-D score means the prevalence of depression symptoms in the male participants increased as the season progressed.

The study included 51 participants, which is a fair amount for a trial in collegiate student athletes. Other strengths of this study include the use of blood serum to evaluate vitamin D and ferritin levels, as well as the time points used for preseason and postseason. Participants were tested in August 2017, when preseason was beginning for each team. Participants were then tested in December 2017, nearly one month after the completion of competitive season, to attempt to negate the effects of the outcome of season, which could be considered a cofounding variable. The weaknesses of this study are that more female participants completed both preseason and postseason testing, and that only two sports are represented. To further research, it would be best to include sports that compete indoors, such as volleyball or basketball, in addition to outdoors. Another weakness is that only one university's student-athletes were represented, which makes it more difficult to generalize. This is especially true given the latitude of Oakland University.

In summary:

1) The incidence of clinically relevant depression in our runners and soccer players (as determined by the CES-D questionnaire) was 3.9% preseason and 13.7% postseason; females were more likely to be depressed.
2) The prevalence of depression increased from preseason to postseason, with two athletes classified as depressed in preseason continuing into the postseason with self-reported symptoms of depression. Therefore, coaches should be mindful that depression increases as the season goes on and those athletes should have free access to counselors and/or psychologists to discuss strategies to combat deepening depression over the season.

3) There was a trend for those athletes reporting depression to have lower 25-OH vitamin D levels, which the difference between groups was not significant.
4) There were significant associations between depression scores versus serum ferritin in female athletes only. This suggests that depression, as detected in the CES-D, may be an early warning sign of iron-deficiency in female runners and soccer players.

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