

COMPARISON OF HEMOGLOBIN LEVELS  
AMONG COLLEGE FRESHMEN AND  
UPPERCLASS WOMEN

by

Allison Goodenow

And Allison Redding

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Project Approved:

Supervising Professor: Gina Hill, PhD, RD, LD

Department of Nutritional Sciences

Molli Crenshaw

Department of Biology

## ABSTRACT

**Background:** Women of childbearing age are especially vulnerable to iron deficiency, the most common nutrient deficiency worldwide. The CDC reports about 16% of women of child bearing age are iron deficient in the United States.

**Objectives:** The purpose was to compare hemoglobin (Hgb) levels of freshmen women with upper-class females and compare the effect of diet and lifestyle on Hgb levels.

**Design:** This study utilized a cross-sectional research design. The Institutional Review Board of Texas Christian University (TCU) and the Department of Nutritional Sciences approved this study. Participants' hemoglobin levels were measured using the Masimo Pronto and each completed a questionnaire regarding diet and lifestyle factors.

**Participants:** A convenience sample of 130 women attending TCU were recruited. Inclusion criteria: apparently healthy women enrolled at TCU between the ages of 18-24. Participant recruitment and study intervention took place during Fall 2014.

**Main Outcome Measures:** Hemoglobin levels of freshmen would be significantly lower ( $p > 0.05$ ) than those of the upperclass women because freshmen are required to have a meal plan which provides access to a wide variety of pre-paid, healthy foods. Freshmen have more recently lived in a home environment where they more likely received daily healthful meals.

**Statistical Analyses Performed:** SPSS statistics for Windows, Version 23.0 was utilized to analyze data. An independent sample t-test was utilized to analyze significant difference in hemoglobin levels between the two tests. Bivariate correlates compared ordinal data from the food frequency questionnaire and lifestyle survey.

**Results:** Participants ( $n=130$ ) were  $19.4 \pm 1.3$  years old. Analysis determined there was no significant difference between the Hgb levels of freshmen ( $13.2 \pm 1.8$  g/dL) and upperclass women ( $13.4 \pm 1.7$  g/dL), ns. Approximately 15% ( $n=20$ ) of participants' hemoglobin level was  $< 12$  g/dL, considered "at risk" for iron deficiency. Dietary and lifestyle factors were similar between groups.

**Conclusions:** At this private university, iron deficiency anemia is not as prevalent as in the general population of young women and in other research studies. Future research, such as comparing hemoglobin levels of collegiate women at private university with those at a public university, may identify a more "at risk" population.

**Funding Source:** The Texas Christian University Department of Nutritional Sciences funded the study through the purchase of the Masimo Pronto Hgb measurement device.

**Key Words:** Hemoglobin, Iron, Iron deficiency anemia, Women of child-bearing age, Masimo Pronto

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## **CHAPTER I**

### **INTRODUCTION**

Iron deficiency anemia is among the most common diseases for adolescent women around the world. Over 2 billion people are anemic worldwide, and a majority of those are contribute to iron deficiency.<sup>1</sup> Alarmingly, 9% of women who are of childbearing age in the United States have been diagnosed with iron deficiency anemia according to the Center for Disease Control.<sup>2</sup> Maternal iron deficiency status plays a significant part on a growing fetus including decreasing fetal iron stores and causing infant iron-deficiency anemia. Furthermore, maternal iron deficiency during pregnancy can increase the likelihood of developing post-partum depression.<sup>3</sup> The prevalence of this disease in college aged women is important because iron deficiency can cause symptoms such as fatigue and irritability, having a significant impact on quality of life and academic performance.<sup>4</sup>

In college, students undergo major transformations in lifestyle. At Texas Christian University (TCU), students are required to live on campus for two years and purchase a full meal plan for their freshman and sophomore year. Typical eating habits are altered because they are now responsible for choosing from selections in the cafeteria for complete daily nutrition. Prior to college many students have been fed by their parents and were not as responsible for their own nutrition choices. Upperclass women, juniors and seniors, are no longer confined to eating in the school cafeteria and therefore have broader food and nutrition options. They are also responsible for selecting, planning, and preparing all of their own meals. How far removed students are from making their own

food choice can have an impact on the nutrient density, the amount of overall nutrition, in their meals. Students who are not on a meal plan or who don't know how to make healthy choices may not be consuming as many nutrients as they need for a healthy lifestyle.

While in college, many diet and lifestyle habits changes and adequate nutrition is not always a first priority. A study comparing iron intake of vegetarian women and non-vegetarian women at the university of California Polytechnic State University found that about 65% of all participants did not consume enough iron daily to meet the Recommended Daily Allowance (RDA) for 18mg iron<sup>5</sup> per day for women 19-50 years.<sup>6</sup> Women of child-bearing age, 12-49 years, who are not consuming enough iron may be putting themselves at risk for iron deficiency in the future. With iron deficiency being the largest mineral deficiency in the nation with side effects that can have drastic impacts on growth, cognitive function, and quality of life, it is important to know which populations are most at risk. The research conducted in this study is vital to understanding whether students constantly adapting to diet, lifestyle, and environment factors may be at risk for iron deficiency anemia.

### ***Research Objectives***

The purpose of the research study was to compare hemoglobin levels of freshmen and upperclass women. Furthermore, the reserachers wanted to determine the influence of lifestyle habits and intake of caffeine, calcium, vitamin C, and meat on hemoglobin levels. The researchers hypothesized that freshman would have a higher hemoglobin level than the upperclass women ( $p < 0.05$ ) for two reasons. First, freshmen have access to a larger variety of foods for each meal, specifically meats, fruits and vegetables, and whole grains, on the school meal plan than the upperclass women do. Secondly, freshmen have



more recently been living with parents or other caregivers in a home environment where they may have consumed a more well rounded diet.

## CHAPTER II

### REVIEW OF LITERATURE

#### *Iron: A trace mineral and a micronutrient*

Similar to macronutrients, which include carbohydrates, proteins, and lipids; micronutrients are necessary for the body to function properly. However, micronutrients are needed in much smaller quantities. Iron is an essential nutrient, meaning it must be consumed in the diet because the human body cannot create it on its own. Iron is a trace mineral, a type of micronutrient, and is present in the largest quantity of all the trace minerals in the human body.<sup>7,8</sup> Iron is important for many bodily processes including respiration, energy metabolism, immune function, and is one of the components of many enzymes. Approximately 70% of iron in the body is located in hemoglobin, an oxygen carrying protein in the blood, and myoglobin, a type of muscle cell.<sup>9</sup> Foods that contain iron include animal proteins such as beef, poultry and eggs, whole grains and enriched cereals, beans and lentils, and leafy green vegetables.<sup>7, 10</sup>

#### *Iron metabolism*

Iron is metabolized differently in the body depending on the type of dietary iron that is consumed. There are two different forms of iron present in foods, heme iron and non-heme iron. Animal foods contain both heme and non-heme iron, but plant and fortified foods only contain non-heme iron.<sup>7,8</sup> Heme iron is structured so that it is more bioavailable, or readily absorbed, in the body.<sup>7,8</sup> For this reason, animal foods are a richer, more easily absorbed source of iron for humans (40% absorption) than iron from plants or supplements (5-10% absorption).<sup>9</sup> When an individual consumes iron rich

foods, the iron will be extracted during digestion and then absorbed. Heme iron is soluble in alkaline environments, therefore absorption begins in the small intestines.<sup>9</sup> Cells called enterocytes contain transporters for heme iron which carry the molecules and distribute iron to cells depending on which cells need it the most at the time of absorption.<sup>9,11</sup> Non-heme iron has varying states of solubility and must undergo many modifications before it can be stored or used by the body.<sup>12</sup> This decreases how much of the iron consumed is delivered to the tissues.

An individual whose diet is low in iron may not maintain an adequate concentration of iron stores solely because of insufficient intake. Others may have a decreased ability to digest and/or absorb iron from dietary sources due to illness or a hereditary dysfunction that causes malabsorption to occur.<sup>11,13</sup> Still others may be consuming enough iron through their diet, but the iron is not being absorbed due to inhibiting factors in their diet. Certain foods consumed and digested in the same meal as the iron-containing foods may affect iron absorption. For example, foods containing vitamin C, such as citrus fruits and broccoli, improve iron absorption.<sup>7,9,13</sup> Studies suggest that 100 milligrams of ascorbic acid, a form of vitamin C, consumed with an iron rich meal increased iron absorption by four times.<sup>13</sup> In addition, cooking in iron pots and skillets can increase the amount of iron consumed by 80%.<sup>10</sup> On the other hand, phytates, polyphenols fiber, and calcium found in legumes, whole grains, coffee, tea and dairy can decrease iron absorption.<sup>7,9,13</sup> When foods containing phytates, polyphenols, fiber and calcium are consumed at the same time as an iron rich food, the iron will become bound and will eventually be excreted rather than absorbed and utilized by the body.<sup>9</sup> If there is

a lack of iron absorbed in the body for any of the above reasons iron deficiency which leads to anemia can occur.<sup>11</sup>

### ***Iron deficiency anemia***

Anemia, which is associated with low blood hemoglobin concentrations, is a common diagnosis that affects people of all ethnicities, ages, and socioeconomic groupings.<sup>4,12</sup> Anemia can have many different etiologies including deficiencies of folate, riboflavin, and vitamin B<sub>12</sub>. In addition, acute and chronic diseases such as cancer or malaria, or inherited blood disorders also contribute to anemia.<sup>4</sup> However, the most common cause of anemia is iron deficiency.<sup>1,11,12</sup> Iron deficiency anemia accounts for almost half of all anemia diagnoses and is the most common type of anemia in the United States.<sup>1</sup> Iron deficiency anemia results from inadequate iron supply for erythropoiesis, the production of red blood cells.<sup>12</sup> Several tests can be performed by a physician to diagnose iron deficiency anemia. Normal hemoglobin levels for non-pregnant women age 19-50 years lie between 12-16g/dL and between 13-17g/dL for men.<sup>6</sup>

Increased risk for iron deficiency anemia, on the other hand, can be observed in hemoglobin concentration in the blood because over half of all iron in the body is contained in hemoglobin.<sup>12</sup> As iron stores in the body are depleted, the concentration of hemoglobin levels in the blood decreases, resulting in less red blood cells circulating in the body.<sup>9</sup> Iron deficiency and iron deficiency anemia are common diagnoses for women due to routine genitourinary blood loss as a result of menstruation.<sup>7,9</sup> Additionally, women have a greater risk for developing iron deficiency compared to men because they can only store iron in the body for up to six months, while men have iron stores that can last for three or more years.<sup>9</sup>

## ***Previous research on those at higher risk for iron deficiency anemia***

### ***Risk for iron deficiency during pregnancy***

There are different variations of risk for iron deficiency, especially for women who are pregnant. The amount of daily iron intake increases for women during pregnancy due to the expansion of plasma and red blood cell mass in order to meet the demands of a growing fetus.<sup>7</sup> Iron deficiency during pregnancy can lead to increased risk for preterm labor, decreased birth weight, and increased risk of mortality for both the mother and newborn infant.<sup>14</sup> Lack of proper education and prenatal care potentially leads to inadequate iron intake, which can lead to deficiencies.<sup>7,8</sup> A recent report from the CDC found that 50% of pregnancies are not planned.<sup>1</sup> A woman of child bearing age who is iron deficient is likely to also be iron deficient during pregnancy, especially if the pregnancy is unplanned. This further underlines the need for proper education and intervention to decrease iron deficiency in women of childbearing age.

### ***Risk for low income households***

A cross-sectional study found that that babies born with anemia were more likely to be from families with low income and less maternal education.<sup>9</sup> The prevalence of anemia was almost double (36.6%) among children of migrant families as it was for local children (18.7%).<sup>15</sup> Several studies conducted in the U.S. have also attributed low income as a factor that effects access to healthy foods, and is therefore a contributing factor to iron deficiency.<sup>16,17,18</sup>

### ***Risk for iron deficiency in college age women***

Looker et al. found that 7.8 million American women of childbearing age were iron deficient.<sup>18</sup> Of those, 3.3 million had iron deficiency anemia. Both iron deficiencies resulting in anemia and iron deficiency without anemia can result in physiological problems including fatigue and irritability.<sup>7,9</sup> The California Polytechnic study of vegetarian and non-vegetarian college females revealed a majority of participants were not consuming the RDA for iron.<sup>5</sup> The RDA is the average amount of a nutrient that must be consumed daily in order to meet the nutrient requirements of nearly all individuals.<sup>6</sup> Both these studies and others<sup>19</sup> reveal that iron deficiency is a consistent issue in women of childbearing age, and specifically for women in college. Universities are places where intervention via education is relatively easy. Therefore, if risk does exist among college women, the correct health information can spread quickly and can make a large impact.

### ***Treating iron deficiency***

Fortunately, iron supplementation has been repeatedly shown to improve iron status, and to reduce symptoms and adverse outcomes in those with low iron status, especially during pregnancy. A meta-analysis of 48 randomized trials and 44 cohort studies on associations between maternal anemia prenatal iron use and adverse pregnancy outcomes revealed risk of low birth weight decreased by 3% for every 10mg increase iron supplement dose/day.<sup>12</sup> For those who are diagnosed with iron deficiency anemia, the typical treatment is an oral dose of 125-250mg per day of ferrous sulfate.<sup>6</sup> Research has repeatedly shown that iron supplementation is a safe, effective and relatively easy intervention.<sup>3,6,11</sup> Targeting those who are at risk for iron deficiency and providing more education is an important next step.

### ***Collegiate eating habits and risk for iron deficiency anemia***

College is an important time for adolescents experiencing a newfound independence of living on their own. One of the responsibilities college students take on after leaving their parents' household are meal choices. Dietary and overall lifestyle habits are developed during the first critical years from home, and research suggests this generation is moving closer to weight gain and chronic disease rather than away from it.<sup>19</sup> In fact, college students are gaining weight at six times the weight of other populations, but their nutrition status is not improving.<sup>20</sup> Students living off campus, without a meal plan are less likely to consume a large variety of fruits, vegetables, and protein compared to students living on campus. With decreased consumption of healthy foods, it is less likely students are attaining the micronutrient nutrition they need to maintain adequate levels of these nutrients. Hence, college age women are a population within the child bearing age range who are also a population at risk for deficiencies, especially iron.

### ***Differences in dietary habits among freshmen and upperclass women at TCU***

When women first enter college at TCU, their dietary habits will go through a transition period. Students' food choices have now become entirely their own responsibility. However, the method by which student get their meals differs between freshmen and upperclass women. Students are required to purchase a meal plan during their first two years on TCU's campus. This meal plan gives them access to all food offered at the all-you-can eat school cafeteria, Market Square. Since freshman women are required to have a meal plan, it is likely they will consume a majority of their meals in the cafeteria. A prepared, pre-paid meal plan increases the likelihood freshman are eating on a regular basis and consuming enough food to maintain sufficient iron levels. By

contrast, most women in their junior and senior years no longer eat meals on campus with university food service. Upperclass women, who mostly live off campus, have a greater responsibility for choosing and preparing their own meals. Paying for groceries and preparing food at home could influence the amount of produce and lean meats these students buy based upon cost and how much effort is required for preparation. With that in mind, it's possible iron status decreases when food choices become entirely students' own responsibility.

### ***Summary of the literature***

Despite effective and relatively inexpensive treatments to reverse the diagnosis, iron deficiency anemia remains the most common anemia worldwide.<sup>4</sup> Researchers have determined many risks associated with both general iron deficiency and iron deficiency anemia, one of the most detrimental being the effects on pregnant mothers and newborns. The prevalence of risk for iron deficiency in women of childbearing age and the detrimental effects of poor iron status can have on women and their offspring underlines the need to investigate iron status in this population. Women at TCU are in the prime age range for child bearing and would benefit greatly knowing how important adequate iron stores are for all women. Therefore, comparing the similarities and differences in hemoglobin levels of freshmen to upperclass women will provide insight into which students are at greater risk for iron deficiency so that effective communication and education will inform student populations about the risks of poor iron status.



## **CHAPTER III**

### **METHODS**

#### ***Study design***

This study utilized a cross-sectional research design that consisted of two parts: a survey which included a lifestyle and food frequency questionnaire and a hemoglobin test. Participants completed both sections of the study in the same time period.

This study was approved by the Institutional Review Board (IRB) of Texas Christian University and the Department of Nutritional Sciences. Before partaking in this study, each participant signed a consent form which provided information about what would be asked of each study participants. It also included information about their rights during the study. Participants also signed a HIPPA document informing them about what the researchers would be collecting from them at the time of the study and the limited personnel who would have access to any information received during the study. Participation was voluntary and subjects were free to withdraw at any time. All information collected was recorded in such a manner that it could not be traced back to the participant.

#### ***Participant selection***

The inclusion criteria for the participants were female students enrolled at TCU between the ages of 18 and 24. All BMIs were included. Exclusion criteria was anyone not of female gender, younger than 18 or older than 24. One-hundred forty three women were interested in this study, but 13 people were excluded due to failure of hemoglobin reading. Therefore, 130 participants were included for data analyses.

Participants were recruited for this study by word of mouth, TCU Announce, and personal announcements at university sponsored organizations. All testing occurred on Texas Christian University campus or at various locations in the Fort Worth area. Researchers set up tables in public areas around campus and requested that female students participate. Areas included classroom buildings, the Rec Center, and the Student Union as well as requesting participants from various Panhellenic organizations.

Each study participant was asked to sign both a consent form and a HIPPA document before beginning the study. Once these forms were signed, participants were given a survey. The survey covered questions concerning both food frequency and lifestyle factors considered to be possible contributing factors to iron deficiency. Hemoglobin levels were then tested using the Masimo Pronto CO-Oximeter technology. All data was gathered and entered into the SPSS software and analyzed for any statistical significance.

## ***Protocol***

### ***Survey***

Using research regarding how lifestyle factors impact hemoglobin synthesis, and considering previously verified surveys and food frequency questionnaires used in similar studies, the research team created a questionnaire to fit the specific needs of this study. The questionnaire included questions about both lifestyle and eating habits in order to determine an individual's risk for iron deficiency anemia.

### **Food frequency questionnaire**

The food frequency questionnaire included a few different parts (see Appendix A). The first section inquired about fruits and vegetables. Several fruits and vegetables

contain iron and many fruits and vegetables contain vitamin C, which increases absorption of iron. Other fruits and vegetables contain calcium, which inhibits the absorption of iron. The second section inquired about meat, which contains heme iron, the most bioavailable form of iron. The third section inquired about whole grain intake, which contain iron as well. The next section inquired about dairy intake, which contains calcium. Further food frequency questions examined several other foods such as caffeine, which is an iron antagonist, and fast food. For each section, participants were asked to rate their frequency of intake based on the scale presented to them. The frequency of foods eaten was evaluated for how high the intake was for specific nutrient being examined- Iron, Calcium, and Vitamin C.

### **Lifestyle survey**

Participants were asked to identify age, race, and ethnicity at the beginning of the questionnaire because risk for iron deficiency is different for each demographic. Since the participant population were all college students, the questionnaire also included questions about class identification, major and whether the participant lives on or off campus. The participants were also asked if they had ever taken a nutrition class, as that learning experience may alter their perception of food and nutrition.

The lifestyle questions covered many different factors about daily activities of living. Students were asked about their meal habits including how often they ate at on-campus food service as well as how often they cooked for themselves or ate fast food. Questions were also asked about vitamin supplements, and how much and how often those are consumed. Participants were also asked to self identify as to the severity of their

menstrual cycle and how often they menstruated. They also completed a questionnaire about their alcohol consumption, smoking habits, and sleeping habits.

### *Hemoglobin test*

The Pronto by Masimo utilizes a noninvasive technology called Rainbow SET<sup>®</sup> CO-oximetry testing.<sup>21</sup> A sensor cuff covers the finger and shines a light through the nail to detect light refraction, measuring hemoglobin in that area of the body. The procedure is expedient, providing results after about two minutes, the machine displays the data. The Pronto also measures perfusion rate and O<sub>2</sub> saturation. According to the manufacturer, data cannot usually be collected from someone who is wearing fake nails, gel nail polish, or dark nail polish because the light technology will not get an accurate reading through the nail. Additionally, if a subject's hands were too cold, there was not enough blood running through the area in order to give an accurate assessment of hemoglobin. The monitor would sound, indicating the test did not work.

### *Survey and food frequency comparison*

Participants were grouped as either a high consumers or as not high consumers in the categories of iron-dense foods, vitamin C, meat, calcium and caffeine according to their answers on the food frequency questionnaire. If participants responded consuming  $\geq 7$  foods per week listed in the first four categories, they were considered a high consumer for that category. If participants responded to consuming  $>14$  caffeinated drinks per week, they were considered a high caffeine consumer (see **Table 1**). Those who were categorized as a high iron, vitamin C, or meat consumer were likely to absorb more iron from their diet than those who were not. In contrast, those who were high calcium or caffeine consumers were likely to absorb less iron from their diet.

### ***Statistical analyses***

SPSS was utilized to compare frequencies of certain answers with their corresponding hemoglobin levels, and with the risk for iron-deficiency anemia. The specific tests utilized included an independent t-test of the hemoglobin levels, and correlations comparing ordinal data from the questionnaire. Participants who were at risk for iron deficiency anemia were compared with other participants with normal hemoglobin levels in order to detect trends. All participants were compared in order to examine norms for this population and whether different groups differed from the group in its entirety.

### ***Hypothesis***

This study compared the difference between hemoglobin levels in freshmen, whose meals mostly come from the school cafeteria, to the upperclass women, who are essentially completely responsible for their own meals. The hypothesis for this study states freshmen will have a higher hemoglobin level than the upperclass women ( $p < 0.05$ ) for two reasons. First, Freshmen have access to a larger variety of foods for each meal, specifically meats, fruits and vegetables, and whole grains, on the school meal plan than the upperclass women do. Secondly, Freshmen have more recently been living with parents in a home environment where they may have consumed a more well rounded diet. Comparing hemoglobin levels of the two groups will help to better understand the potential risk for iron deficiency in this sample.

## CHAPTER IV

### RESULTS AND DISCUSSION

#### *Participants*

Participants were freshmen (n=68), juniors (n=40) and seniors (n=22) with a mean age of 19.3 +/- 1.3 years of age. Analysis of the data revealed that 15% of all participants, 16% of freshmen and 15% of upperclass women, had a hemoglobin level less than 12g/dL (see **Figure 1**). This group was determined to be “at risk” for iron deficiency because these participants had a hemoglobin level below the normal range of 12-16 g/dL for non pregnant females. A majority of participants identified themselves as White (91%) with the second highest race being Asian (4%). Additionally, 25% of those who identified their ethnicity as Hispanic or Latino had a hemoglobin level less than 12g/dL while only 16% of those who identified their ethnicity as something other than Hispanic or Latino had a hemoglobin level less than 12g/dL.

#### *Correlations between diet and lifestyle factors*

When analyzing the data, there were only a few differences in the number of high versus low consumers for each nutrient between freshmen and upperclass women. The diet and lifestyle analysis factors determined to be relevant for the purposes of this study are represented in **Table 2**. There was a slightly positive significant correlation between participants who were high iron consumers and high vitamin C consumers. This means that participants who consumed more iron rich foods tended to also consume more vitamin C rich foods.

### ***Hemoglobin comparison***

In **Figure 2** the “at risk” group was compared with the freshmen and upperclass women whose hemoglobin levels were within normal limits. All three groups had a similar number of high caffeine and high vitamin C consumers and there was not a significant correlation between these two dietary factors. When comparing all freshmen and all upperclass women in **Figure 3**, both groups had a similar percentage of high iron and high vitamin C consumers. As stated previously, **Table 2** illustrates that there is a significant, slightly positive correlation between participants who consumed high iron foods and participants who consumed high vitamin C foods. Further analysis using an independent sample t-test revealed there was no significant difference between the mean hemoglobin levels of freshmen compared to upperclass women, ns (see **Figure 4**).

### ***Discussion***

The aim of this study was to compare the hemoglobin levels of freshmen and upperclass women for the purpose of assessing risk for iron deficiency among this sample. Analysis of results found there was no significant difference between the two hemoglobin levels, nor were there many significant correlations between diet and lifestyle factors and hemoglobin levels.

When comparing the TCU sample from this study to the national average, reserachers did find a similar percent of students who were at risk for iron deficiency compared to the national average (15% vs 16% respectively). However, the results of this study did not match previous studies of women on other college campuses.<sup>5,19</sup> A previous unpublished study conducted on women at TCU found similar results to this research.

Only 0.7% of 2291 women at TCU were found to have a diagnosis of iron deficiency anemia. This is a much lower incidence when compared to the national average of 9%. These data support the researchers' conclusions that the sample of women at TCU is very unique to the national population.

### *Limitations*

Some limitations of this project include the sample size and the population that was studied. Several factors about the study group may have influenced a lower percentage of participants who were at risk for a decreased hemoglobin level. For example, the TCU student population is predominantly Caucasian (77.3%), which is not considered a high-risk ethnicity for iron deficiency.<sup>3</sup> TCU students living on campus must have a dining plan, meaning most of the participants had access to a large variety of food daily. Also, there were few participants in this study who were vegetarian or vegan (3.0%). Although family socioeconomic status was not measured directly, students who attend a private university, such as TCU, may come from higher income families and have access to health services and health education. All TCU students are required to have health insurance, which may increase the likelihood of participants currently accessing regular health care and increases the number of health care facilities from which they can receive health care. Additionally, TCU is located in an area of the city of Fort Worth, Texas where access to a wide variety of food increases the likelihood that students do not experience food insecurity and are eating nutrient-rich foods daily. The participants in this study were a very homogenous sample. All of the factors listed above may have influenced the percent of participants at risk for iron deficiency anemia.

### *Practical Implications*



Iron deficiency has been the leading mineral deficiency for some time both in the United States and globally. Knowing this, there are several ways to combat mineral deficiencies such as fortification of grains and cereals and the use of iron supplements. Both of these tactics have been successful in limiting iron deficiency nationally, but iron continues to remain an issue, especially for women of child bearing age.

With this research study, the sample of participants did reflect the national levels for risk of iron deficiency, but the risk and incidence of iron deficiency anemia was lower than other studies conducted with a sample of collegiate women. Using the data from this study and future studies among college females, more knowledge concerning who is more at risk and why can be used to protect women at an earlier age, and to prevent iron deficiency during critical periods of pregnancy and growth. Knowing that iron deficiency affects women of child bearing age specifically allows health care professionals such as doctors and dietitians to look for the signs and symptoms of iron deficiency. Catching more incidences at early stages before the deficiencies advances to a state of anemia may be the key to lowering the prevalence of iron deficiency anemia in our nation and around the world.

## CHAPTER V

### CONCLUSIONS

#### *Research Objectives*

Through the use of the Masimo Pronto and noninvasive hemoglobin testing technology, the researchers were able to compare the difference in hemoglobin levels between freshmen and upperclass women. While SPSS analysis independent sample t-test revealed there was no significant difference between the two groups, the current study was able to assess the differences in diet of freshmen and upperclass women through the food frequency questionnaire and lifestyle survey.

#### *Study Findings*

This research study did not find a significant difference in hemoglobin levels between college freshmen and upperclass women. The results of this study revealed that among this sample of 130 women, only 15% of participants were at risk for iron deficiency anemia due to having a hemoglobin level or <12 g/dL. This is a lower incidence than reported in previous studies comparing hemoglobin levels among college women nationwide.<sup>11</sup> However the percent of female students at TCU who had lower than normal hemoglobin levels were similar to the national average of 16%.<sup>2,13,23</sup> Additionally, the results of this study are similar to those of an unpublished study in 2012 conducted on hemoglobin levels of female students at TCU. The results of the previous study suggest that only 0.7% of female students were diagnosed with iron deficiency anemia compared to the national average which is 9%. This data further verifies that the sample surveyed in this study is unique to the general population.

### ***Suggestions for Further Research***

Further research should be done on this topic. The limitations could easily be avoided by conducting research with a larger scope. This study compared hemoglobin levels from one university, but different results may be found if hemoglobin levels were compared in women at both private and public universities. Additionally, there may have been more significant results in a study measuring the hemoglobin and eating habits of the same person over the course of several years. Further investigation with a broader population is required to adequately investigate the link between eating habits in college women and the potential risk for iron deficiency anemia. As iron deficiency anemia is estimated to affect 1.6 billion people throughout the world, it is clear that this is a nutritional deficiency that requires further study into its causes.<sup>15</sup>

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## APPENDIX A

### Iron Intake and Lifestyle Questionnaire

Please answer the questions as directed. These answers will only be used as a part of this study. They will not be communicated to anyone outside of the study.

1. What is your ethnicity?
  1. Hispanic or Latino
  2. Not Hispanic or Latino
  
2. What is your race?
  1. American Indian or Alaskan Native
  2. Asian
  3. Black or African American
  4. Native Hawaiian or other Pacific Islander
  5. White
  
3. What is your age? \_\_\_\_\_
  
4. What is your classification?
  1. Freshman (first year student)
  - 2.. Junior
  3. Senior
  4. Other \_\_\_\_\_
  
5. What is your major?  
\_\_\_\_\_
  
6. Have you previously taken or are you currently taking a nutrition class?
  1. YES
  2. NO
  
7. Where do you live 1. ON campus or 2. OFF campus?
  
8. On average, how many times a week do you consume these foods? Please mark one option only in each row.

Fruits and Vegetables

*\*One serving is one piece of fruit or ½ cup of fruits or vegetables. If you eat multiple servings per day, please mark that option.*

	1-2 /week	3-4/week	5-6/week	Daily	Multiple servings/day	1-2 times/month
Oranges						
Lemons/Limes						
Grapefruits						
Sweet Peppers						
Kale						
Kiwi						
Berries						
Tomatoes						
Broccoli						
Carrots						
Sweet Potatoes						
Spinach						

Meat

*\*One serving of meat is about the size of the palm of your hand. If you eat more than one serving of meat/day, please mark that option.*

	1-2/week	3- 4/week	5- 6/week	Daily	Multiple servings/day	1-2 times/month
Beef						
Pork						
Chicken/P oultry						
Fish						
Shellfish						
Other Meat						

Whole Grains

*\* A serving of grains is 1 piece of bread or ½ cup rice or oatmeal. If you eat more than a serving per day, please mark that option.*

	1- 2/week	3- 4/week	5- 6/week	Daily	Multiple servings/day	1-2 times/month
Fortified Cereals						
Whole Grain Bread						
Brown Rice						
Oatmeal						
Other Whole Grain Foods						



Dairy

*\*One serving of dairy is about 1 cup, although this is variable based upon the type of dairy. One serving of cheese is about a 1 inch cube. If you eat multiple servings per day, please mark that option.*

	1- 2/week	3- 4/week	5- 6/week	Daily	Multiple servings/day	1-2 times/month
Milk						
Cheese						
Sour Cream						
Cream Cheese						
Cottage Cheese						
Ice Cream						

Other

	1- 2/week	3- 4/week	5- 6/week	Daily	Multiple servings/day	1-2 times/month
Soy milk (1 cup)						
Tofu (1/2 cup)						
Other Soy Products (such as soy-based meat alternatives)						
Eggs (2)						
Coffee/Tea (8 oz cup)						
Dark Caffeinated Colas (12 oz can)						
Fast Food						

9. How often do you consume foods that are advertised as “high fiber”?

Rarely (1)	..... (2)	..... (3)	Sometimes (4)	..... (5)	..... (6)	Often (7)

10. Do you take an individual iron supplement? 1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

If yes, at what time of day do you take it?

1. Morning 2. Midday 3. Evening 4. Bedtime

11. What is the dosage of the supplement?

1. \_\_\_\_\_ milligrams (mg)/day  
2. I don't know

12. Do you take a multivitamin/mineral supplement? 1. YES 2. NO  
If yes, at what time of day do you take it?  
1. Morning 2. Midday 3. Evening 4. Bedtime
13. Are you a vegetarian? 1. YES 2. NO
14. How often do you eat in the dining hall (Market Square) on campus?  
1. Never 2. 2-3 times per week 3. 4-6 times per week  
4. Every day 5. More than once a day
15. How often do you eat fast food?  
1. Never 2. 2-3 times per week 3. 4-6 times per week  
4. Every day 5. More than once a day
16. How often do you prepare your own meals?  
1. Never 2. 2-3 times per week 3. 4-6 times per week  
4. Every day 5. More than once a day
17. Do you have a limited budget for purchasing groceries/food items?  
1. Yes 2. No
18. How often do you alter your eating habits in order to lose weight?  
1. Never 2. Seldom 3. Frequently 4. Almost always
19. Do you eat eggs? 1. YES 2. NO
20. Do you consume dairy products? 1. YES 2. NO
21. Do you eat fish? 1. YES 2. NO
22. Are you a vegan (no animal products)? 1. YES 2. NO

23. You make an effort to choose foods that contain iron so that you can consume enough iron in your diet.

Rarely (1)	..... (2)	..... (3)	Sometimes (4)	..... (5)	..... (6)	Often (7)

24. Do you take any medications that you know interfere with the absorption of iron? Some examples include some cholesterol-lowering medications, anti-ulcer medications, and calcium supplements.

1. YES    2. NO

25. How often do you have a menstrual period?

1. I currently do not have a menstrual period.
2. Once every 2-3 months
3. Monthly
4. 2-3 times a month
5. Other \_\_\_\_\_

26. If you have a menstrual period, usually how many days do your menstrual periods last?

1. 1-2 days    2. 3-4 days    3. 5-7 days    4. More than 7 days

27. If you have a menstrual period, usually how heavy are your menstrual periods?

1. Light    2. Medium-Light    3. Medium    4. Medium-Heavy    5. Heavy

28. Are you on birth control? 1. YES    2. NO

29. Do you smoke? 1. YES    2. NO

If yes, how often? \_\_\_\_\_ cigarettes/per day    OR    \_\_\_\_\_ cigarettes/week

30. Do you drink alcohol? 1. YES    2. NO

If yes, how often? \_\_\_\_\_ times/per week

31. Over the last month, on average, how many hours of sleep do you get each day/night?

1. Less than 4 hours/night
2. 4-6 hours/night
3. 7-9 hours/ night
4. 10-12 hours/ night

**Thank you for taking part in this survey.**

## TABLES

**Table 1: Categories for high consumers of certain nutrients**

<b>Food frequency category</b>	<b>High consumer</b>
Iron	>7 servings per week
Meat	>7 servings per week
Vitamin C	>7 servings per week
Calcium	>7 servings per week
Alcohol	>7 servings per week
Fast Food	>6 times per week
Caffeine	>14 servings per week

Table 1 shows how food frequency and lifestyle factors were categorized into high consumers for certain nutrients. High consumers for both freshmen and upperclass women groups were used to describe the participant sample diet similarities and differences as well as factors in analyzing bivariate correlated in Table 2.

**Table 2: Bivariate correlates between several different diet and lifestyle factors of participants (n=130)**

	Hgb	RISK (Hgb <12g/dL)	High vitamin C consumer	High iron consumer	High caffeine consumer	Takes a Multivitamin	Heavy menstrual cycle	High alcohol consumer	High meat consumer	Prepare food at home most of the time	Fast food consumer most of the time	Nutrition sciences major
<b>Hgb</b>		r=.649 p<.001**	r=-.140 p=.113	r=-.052 p=.558	r=.08 p=.368	r=-.044 p=.621	r=.035 p=.690	r=-.022 p=.801	r=-.023 p=.793	r=.014 p=.873	r=-.059 p=.873	r=.073 p=.411
<b>RISK (Hgb &lt;12g/dL)</b>			r=.161 p=.067	r=.011 p=.905	r=.014 p=.873	r=-.073 p=.408	r=-.048 p=.586	r=-.100 p=.258	r=.037 p=.676	r=.120 p=.174	r=-.081 p=.362	r=.003 p=.970
<b>High Vitamin C consumer</b>				r=.322 p<.001**	r=-.036 p=.686	r=.060 p=.496	r=-.024 p=.784	r=.034 p=.703	r=-.041 p=.061	r=.047 p=.592	r=.255 p=.003**	r=.193 p=.028*
<b>High Iron Consumer</b>					r=.031 p=.724	r=.060 p=.500	r=-.048 p=.587	r=-.009 p=.916	r=-.215 p=.014*	r=-.092 p=.296	r=.163 p=.064	r=.182 p=.039*
<b>High caffeine Consumer</b>						r=.066 p=.455	r=.091 p=.306	r=.135 p=.125	r=.120 p=.173	r=.004 p=.963	r=-.154 p=.081	r=.046 p=.601
<b>Takes a Multivitamin</b>							r=.012 p=.891	r=.014 p=.878	r=-.013 p=.881	r=-.061 p=.493	r=.042 p=.638	r=.109 p=.215
<b>Heavy Menstrual Cycle</b>								r=.002 p=.982	r=.028 p=.754	r=-.079 p=.372	r=-.106 p=.230	r=.123 p=.166
<b>High alcohol consumer</b>									r=.172 p=.051	r=-.228 p=.009**	r=.035 p=.693	r=-.015 p=.862
<b>High meat consumer</b>										r=.015 p=.868	r=.062 p=.485	r=-.142 p=.108
<b>Prepare food at home most of the time</b>											r=-.418 p<.001**	r=-.313 p<.001**
<b>Fast food consumer most of the time</b>												r=.157 p=.074
<b>Nutrition Sciences Major</b>												

\*Indicates significance at the p<0.05.

\*\*Indicates significance at the p<0.01.

Hgb= abbreviation for hemoglobin.

High vitamin C consumer=>7 servings per week; High iron consumer=>7servings per week; High caffeine consumer =>14 servings per week; High alcohol consumer =>7servings per week; High meat consumer=>7servings per week.

## FIGURES

**Figure 1: Participants (n=130) with normal hemoglobin (Hgb) compared to those with Hgb below normal**

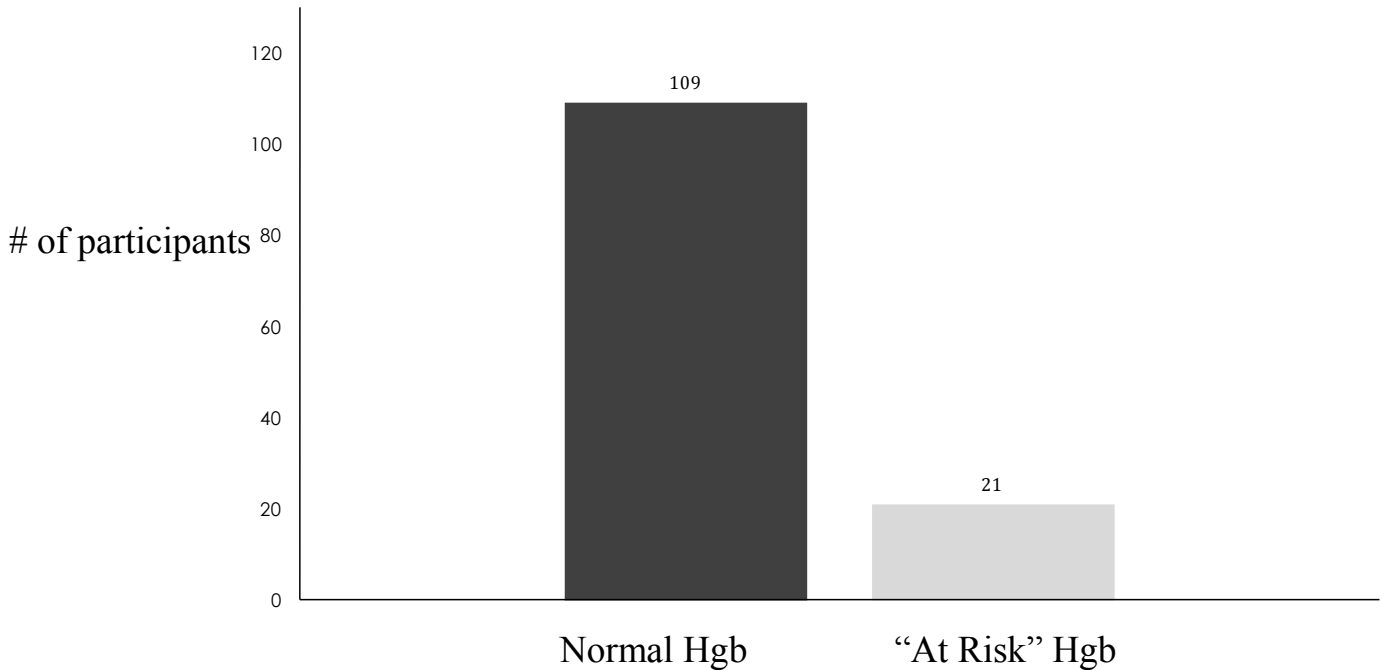


Figure 1: Participants (n=130) with Normal hemoglobin (Hgb) compared to those with Hgb below normal.

Hgb= hemoglobin.

Normal Hgb (for non pregnant women)= 12-16 grams/deciliter (g/dL).

"At Risk" Hgb (for non pregnant women)= <12 g/dL.

**Figure 2: Comparison of freshmen, upperclass women, and “at risk” groups of high caffeine and high iron consumers**

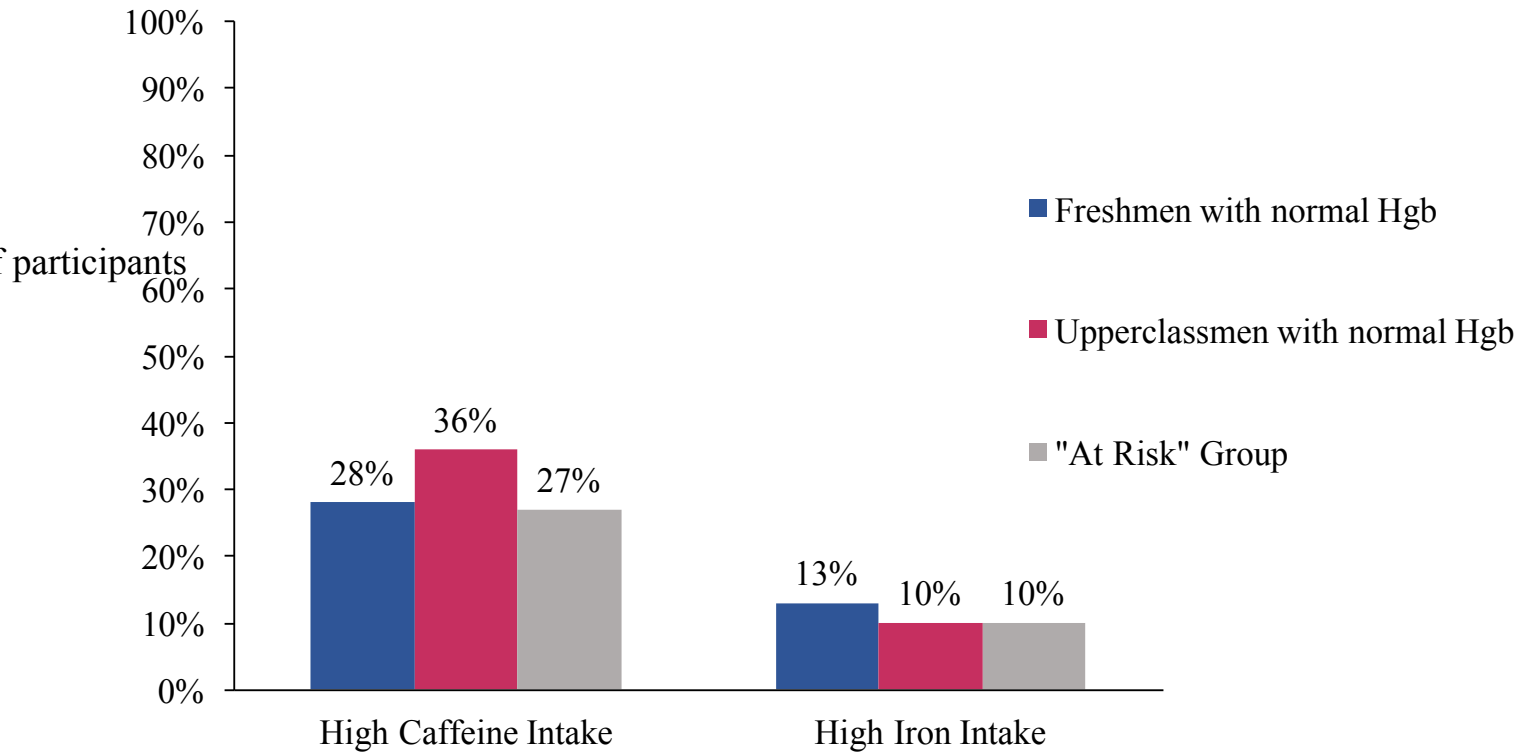


Figure 2: Comparing high caffeine intake and high iron intake with freshmen and upperclass women with normal Hgb and the “at risk” group

Hgb = hemoglobin

“At risk” group = any participant with Hgb less than 12g/dL

n=130

High iron consumer = >7servings per week; High caffeine consumer = >14 servings per

### Figure 3: High vitamin C and high iron intake of freshmen and upperclass women

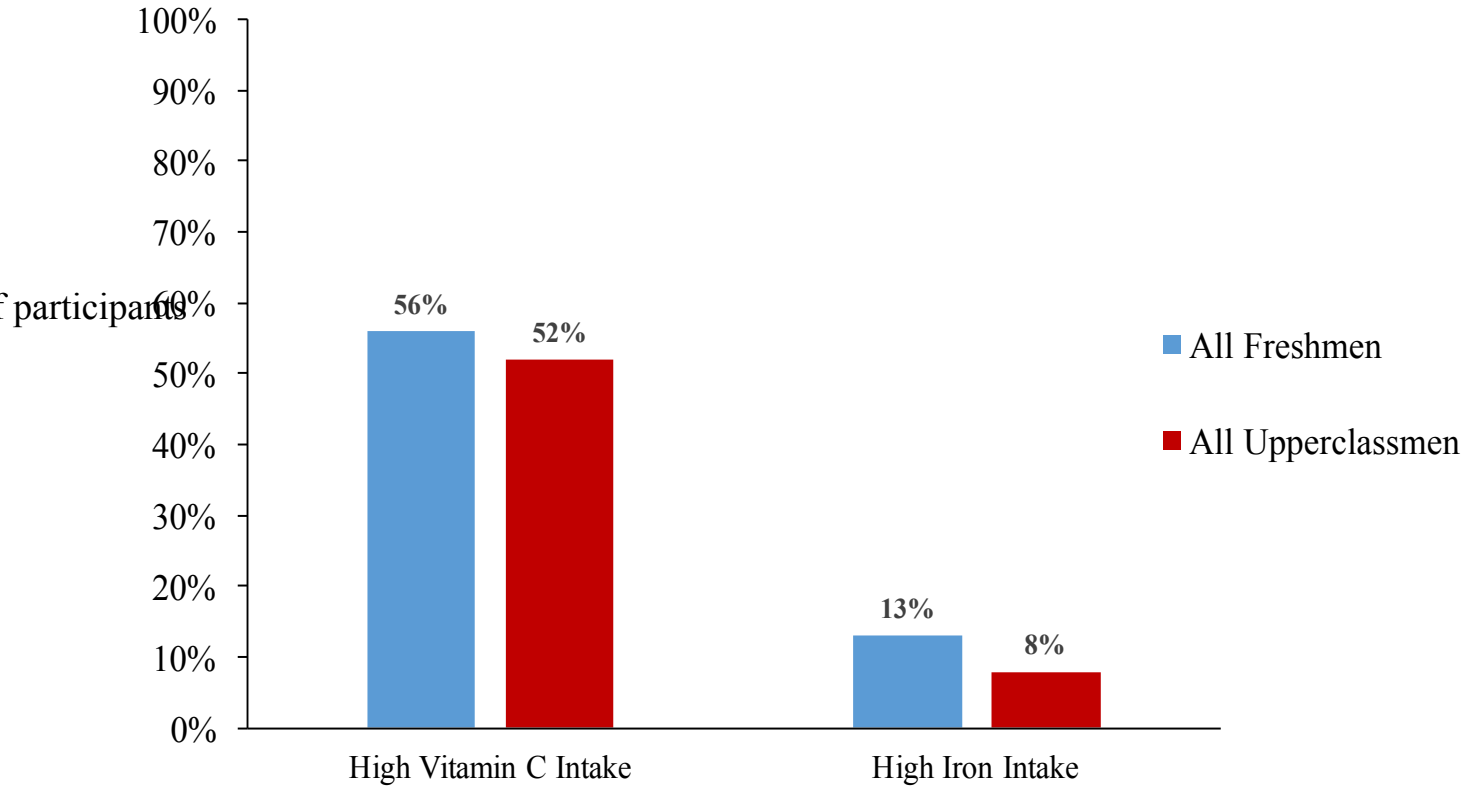


Figure 3: High vitamin C and high iron of all freshmen and upperclass women participants. (n=130)  
High vitamin C consumer = >7 servings per week; High iron consumer = >7servings per week



**Figure 4: Average hemoglobin levels of freshmen and upperclass women**

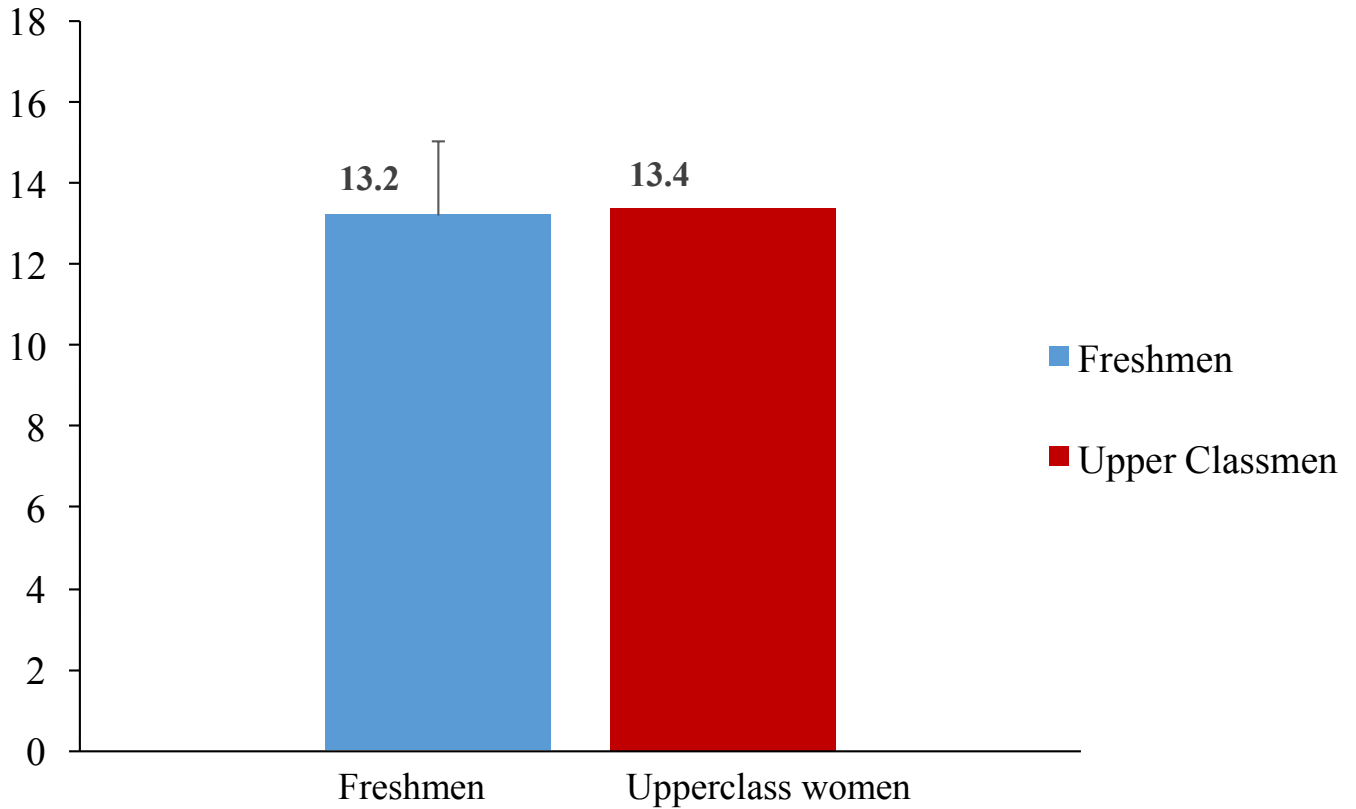


Figure 4: Average hemoglobin levels of freshmen and upperclass women  
g/dL = grams per deciliter as a unit of hemoglobin in the blood  
All data is presented as mean +/- SEM  
n=130