Summer 8-2021

The Relationship Between Vitamin D Intake, Sun Exposure, Handgrip Strength and HG AIC Levels in College-Age Adults

Janelle Melancon

THE RELATIONSHIP BETWEEN VITAMIN D INTAKE, SUN EXPOSURE, HANDGRIP STRENGTH AND HG A1C LEVELS IN COLLEGE-AGE ADULTS

by

Janelle Melancon, B.S.

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

COLLEGE OF HUMAN ECOLOGY
LOUISIANA TECH UNIVERSITY

August 2021

LOUISIANA TECH UNIVERSITY

GRADUATE SCHOOL

May 18, 2021
Date of thesis defense

We hereby recommend that the thesis prepared by

Janelle Melancon, B.S.

entitled **The Relationship Between Vitamin D Intake, Sun Exposure, Handgrip Strength and HG A1C Levels in College-Age Adults**

be accepted in partial fulfillment of the requirements for the degree of

Master of Science in Nutrition & Dietetics

Simone Camel
Supervisor of Thesis Research

Ethel Jones
Head of Human Ecology

Thesis Committee Members:
Mary Fontenot
Dawn Erickson

Approved:

Gary A. Kennedy
Dean of Applied & Natural Sciences

Approved:

Ramu Ramachandran
Dean of the Graduate School

GS Form 13
(01/20)

ABSTRACT

Vitamin D is known for its importance to bone health and calcium metabolism and plays a role in insulin resistance. Recent research has recognized its role in insulin secretion, inflammatory response, and adipose tissue changes as possible reasons for its association with insulin resistance and cardiovascular disease. The CDC (2019) reported that 20% of adolescents are now living with prediabetes. Most individuals with prediabetes progress to type 2 diabetes within ten years. Because many studies have focused on adults of all ages, it is important to research young adults. This study aimed to determine prevention efforts; therefore, the younger adult age group was chosen. The purpose of this research is to explore the relationships among Vitamin D intake, sun exposure, handgrip strength, and Hemoglobin A1c levels in college-age adults. Handgrip strength is a biomarker of malnutrition, and evidence suggests a correlation between Vitamin D and skeletal muscle function. Studies have linked Vitamin D to body weight, the development of metabolic syndrome, and prediabetes. A convenience sample of 18-28-year-old students with no history of metabolic syndrome, prediabetes, or diabetes was eligible to participate. Following consent, a random subject number along with a link was provided to a questionnaire that included demographic and sun exposure items, Vitamin D food frequency, height and weight, and family history of metabolic syndrome or diabetes. Finally, physical measurements and a self-administered Hemoglobin A1c Test were completed. Data analysis included descriptive statistics, comparison tests, and regression analysis. Regression analysis showed no significant relationships among Vitamin D intake, sun exposure, handgrip strength, and Hemoglobin A1c levels in college-age adults. However, the ANOVA results showed a statistical significance between weight, HgA1c, and handgrip strength. Future studies are needed to explore the relationships between Vitamin D intake and HgA1c measurements in college-aged adults.

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DEDICATION

This study is dedicated to my supervisor (Dr. Simone Camel) and committee members (Dr. Catherine Fontenot and Mrs. Dawn Erickson). This book is also dedicated to all of my family and friends. All of this work would not have been possible without each one of you. Thank you all for the encouragement, prayers, and sacrifices that have been made for this to happen.

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CHAPTER 1

INTRODUCTION

Vitamin D is well known for its importance to bone health and calcium metabolism, but it also plays an important role in insulin resistance. Recent research has recognized the role Vitamin D has in insulin secretion and inflammatory and adipose tissue changes as possible reasons for its association with metabolic syndrome, cardiovascular disease, and diabetes. However, additional research is needed to determine the mechanisms and causal relationships (Krans, 2009). Inadequate Vitamin D status has been associated with metabolic syndrome, and metabolic syndrome is associated with an increased risk for cardiovascular disease. Based on the National Health and Nutrition Examination Survey (NHANES) data, there is a five-fold increase in developing Type 2 Diabetes Mellitus within five to ten years of being diagnosed with metabolic syndrome (Ford, Giles, & Dietz, 2002). Prediabetes is a health condition in which blood glucose levels rise higher than normal, but they are not high enough to be diagnosed with type 2 diabetes (Stanford Health, 2019). Most individuals with prediabetes progress to type 2 diabetes within ten years (Stanford Health, 2019). The Center for Disease Control and Prevention (2019) reported that 20% of adolescents, ten to19 years old, live with prediabetes. With these numbers increasing each year, it is crucial to find ways to decrease the prevalence of metabolic syndrome and prediabetes in young adults. By the year 2030, 435 million people around the world are expected to have some form of diabetes Al Hewishel et al., 2018). Because many studies about prediabetes and diabetes have focused on adults of all ages, and fewer have focused on the traditional college-aged young adult. It is important to research with this population.

Handgrip strength has been studied as a potential biomarker of malnutrition in different age groups (Bohannon, 2019). Increasing evidence suggested a correlation between Vitamin D deficiency and decreased skeletal muscle function (Garcia-Hermoso et al., 2018). Several recent studies have linked Vitamin D to body weight, the development of metabolic syndrome, and Prediabetes (Ji et al., 2020; Kawamoto et al., 2016; Manda et al., 2020). This study will examine Vitamin D intake and handgrip strength as potential screeners for hemoglobin A1c levels in college students.

1.1 Research Purpose

The purpose of this research project is to explore the relationships among Vitamin D intake, sun exposure as a source of Vitamin D, handgrip strength, and Hemoglobin A1c levels in college-age adults. One component of this study will assess the feasibility of using a screening tool, such as handgrip strength, as part of prevention efforts aimed at reducing the risk for developing metabolic syndrome and prediabetes in college-aged young adults. The proposed study hypothesizes that HgbA1c levels will decrease with increasing levels of Vitamin D intake, sun exposure, and handgrip strength.

1.2 Justification

Recent research has recognized the role Vitamin D has in insulin secretion and inflammatory and adipose tissue changes. Its association with metabolic syndrome, cardiovascular disease, and diabetes has also been identified but not fully elucidated.

Most Americans are unaware that they have insufficient Vitamin D intake and/or are deficient in Vitamin D. Early identification of Vitamin D deficiency as a possible risk factor for metabolic syndrome, prediabetes, and diabetes may promote early nutrition interventions that may result in a decrease in the incidence of these diseases.

CHAPTER 2

BACKGROUND

The prevalence of metabolic syndrome, prediabetes, and type 2 diabetes (T2DM) has been increasing each year (National Institute of Health [NIH], 2019). Adolescents have become one of the most targeted groups for prevention efforts to reduce their risk of developing these chronic diseases. In 2012, approximately one percent of high school students in north Texas had diabetes, and 1 in 10 had prediabetes (McGuire, 2018). Metabolic syndrome is described as a group of risk factors that raise one's risk for heart disease, diabetes, and stroke, leading to long-term health complications (NIH, 2019). Having metabolic syndrome, prediabetes, and T2DM at this age can lead to long-term health complications. A research study examining university students concluded that 64.4% of students had at least one component of metabolic syndrome (Da Silva et al., 2014). Therefore, identifying screening tools that assist with determining disease risk in adolescents and young adults is needed. Effective screening tools can help direct future research with the goals of decreasing the disease incidence and prevalence.

Adolescent and college-aged students' eating habits may reflect their stage in the life cycle, which means that they choose foods that coincide with their current lifestyle as they gain independence. They are becoming independent and are often solely responsible for their food choices. Eating behaviors that are developed at this time may continue into later life, and if they are unhealthy, they may lay the foundation for developing conditions such as obesity that can progress to chronic disease that include but are not limited to metabolic syndrome and prediabetes. If healthy habits are not established, these students may be at risk for developing metabolic syndrome, prediabetes, and obesity. Studies have shown that college students typically choose foods based on convenience, taste, price, and time to prepare rather than the nutritional content **(**Abraham, Noriega, & Shin, 2018). These choices can often lead to suboptimal vitamin and mineral intake in addition to an imbalance in macronutrients.

2.1 Vitamin D

2.1.1 Forms of Vitamin D

Vitamin D was first discovered at the beginning of the 20th century. It is essential for mineral and bone metabolism. Deficiencies in Vitamin D have been known to cause inadequate mineralization of the skeletal bones (Youn Ho et al., 2013). Vitamin D, also known as calciferol, has two main forms: ergocalciferol and cholecalciferol (Gropper & Smith, 2013). Ergocalciferol and cholecalciferol are similar but have different side-chain structures (Ross et al., 2011). Ergocalciferol is the form of Vitamin D mainly added to foods and is supplemented.

In contrast, cholecalciferol is mainly formed in the skin of humans from 7-dehydrocholesterol, a substance in the skin that allows the body to convert it to Vitamin D after the skin has been exposed to ultraviolet B radiation. Consuming animal food products directly provides the body with cholecalciferol (Ross et al., 2011). Following digestion and absorption, cholecalciferol is transported to the liver and converted to 25-hydroxyVitamin D, the primary circulating form of Vitamin D (Youn Ho et al., 2013). Cholecalciferol can be transformed to 25-hydroxyVitamin D, which is an indicator of

Vitamin D status. The kidneys transform 25-hydroxyVitamin D to its active form, 1,25-dihydroxyvitamin D. This form acts on the cells by binding to the Vitamin D receptor (Youn Ho et al., 2013).

2.1.2 Sources of Vitamin D

Vitamin D is known as the "sunshine" vitamin because one source of Vitamin D is the sun. Vitamin D can also be found in foods that naturally contain Vitamin D and foods fortified with the vitamin. The best food sources of Vitamin D are fish liver oils and the flesh of fatty fish, such as salmon, tuna, trout, and mackerel. Milk and other dairy products are fortified with Vitamin D and naturally found in mushrooms and eggs.

2.1.3 Sun Exposure

Researchers who have extensively studied Vitamin D suggest individuals get 5 to 30 minutes of sun between 10 AM and 3 PM at least twice a week to the face, arms, legs, or back, without sunscreen, to facilitate adequate Vitamin D synthesis (NIH, 2019). However, individuals with a high risk for developing skin cancer may want to speak with their physician regarding sun exposure because ultraviolet (UV) radiation is a carcinogen responsible for most of the estimated 1.5 million skin cancers and the 8,000 deaths due to metastatic melanoma that occurs annually in the United States (NIH, 2019).

2.1.4 Biochemical Measures

Vitamin D levels are usually measured with blood tests. When serum calcium is low or Vitamin D deficiency symptoms are evident, the blood test, 25-hydroxyVitamin D, is usually ordered to identify a possible deficiency. The Endocrine Society defines Vitamin D sufficiency as 25-hydroxyVitamin D blood level between 30 to 100 ng/ml. Levels above 125 ng/mol or higher indicate toxic levels and occur with excessive

Vitamin D supplementation; a high level usually indicates excess supplementation of Vitamin D (American Association for Clinical Chemistry, 2020). Deficiency of Vitamin D is defined as a 25-hydroxyVitamin D blood level below 20 ng/mol, and Vitamin D insufficiency is indicated at levels between 21-29 ng/mol (Holick et al., 2011). Low Vitamin D levels can indicate that a person is not receiving enough exposure to sunlight or enough dietary Vitamin D to meet the body's demand.

2.2 Reference Intake

The Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies establishes the Recommended Dietary Allowance (RDA) for Vitamin D in adults less than 70 years old at 15 milligrams per day. This level represents a daily intake sufficient to maintain bone health and normal calcium metabolism for healthy individuals. If this amount is not being met consistently, bone density may begin to decrease, leading to osteomalacia and potentially affecting other diseases.

2.3 Vitamin D Status in Adolescents and Young Adults

Optimal health throughout adolescence and into adulthood includes adequate intake of Vitamin D. A recent research study assessed the Vitamin D status of 700 participants between the ages 18 to 25 years (Tønnesen et al., 2016). The researchers found that of these participants, 238 (34%) had Vitamin D insufficiency, 135 (19%) had Vitamin D deficiency, and 13 (2%) had severe Vitamin D deficiency (Tønnesen et al., 2016).

2.4 Vitamin D and Disease

While Vitamin D is well known for its importance to bone health and calcium metabolism, it also plays an important role in insulin resistance. Recent research has explored the role of Vitamin D in insulin secretion, inflammation, and the changes tissues undergo when metabolic syndrome, cardiovascular disease, and diabetes are present (Krans, 2009). However, additional research is needed to understand the biochemical mechanisms better and casual relationships. Inadequate Vitamin D nutriture has been associated with metabolic syndrome, associated with an increased risk for cardiovascular disease. In addition, researchers have been exploring Vitamin D's association with metabolic syndrome, prediabetes, and diabetes. Vitamin D deficiency and obesity have been related to cardiovascular disease, metabolic syndrome, and type 2 diabetes (Durmaz et al., 2017).

2.4.1 Metabolic Syndrome

Metabolic syndrome is described as a group of risk factors that raises the risk of heart disease, diabetes, and stroke (Mayo Clinic, 2019). There are five conditions used to diagnose metabolic syndrome, but only three have to be present for diagnosis. The five conditions are abdominal obesity, high triglyceride levels, low high-density lipoprotein (HDL) levels, high blood pressure, and high fasting blood glucose levels. Abdominal obesity is defined as a waist measurement of 35 inches or more in females and 40 inches or more in males. Triglyceride levels are considered high if they are 150 mg/dL or higher.

Additionally, taking medication to treat high triglyceride levels is also considered a metabolic risk factor. A low HDL level is defined as reading below 50 mg/dL for women and 40 mg/Dl for men, as higher levels decrease cardiovascular risks. Taking medication to treat low HDL cholesterol levels is another risk factor associated with diagnosing metabolic syndrome. Blood pressure that is 130/85 mmHg or higher is considered a metabolic risk factor. Being currently prescribed a medication to treat high blood pressure and is considered a metabolic risk factor. The last risk factor for metabolic syndrome is high fasting blood glucose levels. A fasting blood glucose level between 100 and 125 mg/dL is considered indicative of prediabetes, and a level of 126 or higher is considered diabetes. Both prediabetes and diabetes are metabolic risk factors for metabolic syndrome (NIH, 2020). With the high prevalence of adult obesity in the United States, metabolic syndrome is becoming more common (NIH, 2020). An analysis of NHANES data showed that between 1988-1994 and 2007-2012, the prevalence of metabolic syndrome increased from 25.3% to 34.2% (Moore et al., 2017). The National Health and Nutrition Examination Survey (NHANES) data have determined a five-fold increase in developing Type 2 Diabetes Mellitus in 5 to 10 years of being diagnosed with metabolic syndrome (Ford, Giles, & Dietz, 2002).

Metabolic syndrome in adults has been largely confined to the overweight population. In 2002, an estimated 7% of men and 6% of women aged 20 to 29 years were affected with metabolic syndrome (Ford et al., 2002). With these findings, Cook et al. (2003) estimated that 4% of normal-weight adolescents have metabolic syndrome, while 30% of overweight adolescents have metabolic syndrome.

2.4.2 Prediabetes

Prediabetes is a health condition in which blood glucose levels rise higher than normal, but they are not high enough for an individual to be diagnosed with type 2 diabetes (Andes et al., 2020). Most individuals with prediabetes progress to type 2 diabetes within ten years of being first diagnosed (Stanford Health, 2019). Many studies investigating Vitamin D and Prediabetes have included adults of all ages, but few have focused on the traditional college-aged young adult (Al Hewishel et al., 2018).

In 2019, the Center for Disease Control and Prevention reported that 20% of adolescents, 10 to 19 years of age, live with prediabetes. With these numbers increasing each year, it is crucial to find ways to decrease prediabetes incidence and prevent the progression of T2DM. Vitamin D research is supported by interventional studies that have corrected Vitamin D deficiency in people with prediabetes. The impact is a significant reduction in fasting plasma glucose, two-hour plasma glucose, and hemoglobin A1c levels at 12 months (Kuchay, 2015).

In the United States, about 1 in 5 adolescents and 1 in 4 young adults living with prediabetes. Interestingly, the prevalence of prediabetes is higher in the male population and people with obesity. Adolescents and young adults with prediabetes present an unfavorable cardiometabolic risk profile, putting them at increased risk of developing type 2 diabetes and cardiovascular diseases (Andes et al., 2020).

2.4.3 Type 2 Diabetes Mellitus

The association of Vitamin D with metabolic syndrome has prompted researchers to explore Vitamin D levels with diabetes mellitus. A recent research study showed that Vitamin D deficiency was more prevalent in participants with diabetes, ages 1-20 years of age, compared to 21-60 years old (Al Hewishel et al., 2018). In a hospital-based study with 345 patients, participants were separated into two groups: diabetic and non-diabetic (Alhumaidi et al., 2013). HbA1c levels were found to be 8.6 in those with the disease than 6.0 in those without diabetes. Patients with diabetes also had depressed levels of

25-OH Vitamin D of 15.8 ng/ml, and those without diabetes had levels recorded as low as 11.1 ng/ml (Alhumaidi et al., 2013). This study found a deficiency of Vitamin D among all participants; additional research is needed to determine whether HbA1c levels would improve if Vitamin D levels were normalized.

A research study conducted by Agarwal et al. (2017) was designed to observe the changes in Serum 25-hydroxyVitamin D [25(OH)D] concentration and the subsequent risk of type 2 diabetes levels in diabetic patients after Vitamin D supplementation. Participants included were those with HbA1c between 7% and 8.5% and if their Vitamin D level was less than 75 nmol/L. There were 60 participants with type 2 diabetes and Vitamin D deficiencies. The participants were randomly divided into two groups. One received Vitamin D supplements (60,000 units of oral cholecalciferol every 15 days for three months), and the second group served as the control group and did not receive Vitamin D supplementation. All 60 participants with an average age of 57 years were instructed to maintain diet and exercise records. On the first day of the study, fasting and postprandial glucose, HbA1c, routine biochemistry, and total Vitamin D and PTH levels were measured. Three months later, these lab values were reassessed for all participants. Participants averaged 57 years of age (Agarwal et al., 2017). Results indicated that after three months of Vitamin D supplementation, postprandial glucose levels, calcium, Vitamin D, and parathyroid hormone levels significantly improved in participants. To date, this is the only study specifically designed to investigate the impact Vitamin D supplementation has on correcting Vitamin D levels.

Moreover, a research study was conducted to explore the correlation between low serum levels of 25(OH)D with impaired diabetic control in type 2 diabetic participants

(Shanthi et al., 2012). This study showed that low levels of serum Vitamin D were negatively correlated with fasting and postprandial blood glucose levels. The researchers concluded that Vitamin D deficiency might also impair insulin secretion because of its impact on increasing parathyroid hormone (PTH) levels (Shanthi et al., 2012). Additional research is needed to determine the relationship between Vitamin D and insulin secretion.

Agarwal et al. (2017) conducted a study that demonstrated improvement in postprandial glucose levels, calcium, Vitamin D, and parathyroid hormone levels after three months of Vitamin D supplementation. Talaei et al. (2013) also reported improvements in fasting plasma glucose levels following Vitamin D supplementation.

A strong inverse association of low Vitamin D intake and diabetes prevalence was demonstrated in the NHANES III study. Low Vitamin D levels have also been shown to be predictive of future development of type 2 diabetes (Al Hewishel et al., 2018). A research study in 2010 indicated that increasing Vitamin D serum levels to normal levels led to a 55% relative reduction in the risk of developing type 2 diabetes (Parker et al., 2010).

The prevalence of type 2 diabetes in adolescents and young adults is increasing. The majority of young people diagnosed with type 2 diabetes mellitus are found more commonly in specific ethnic groups such as African-American, Hispanic, Asian/Pacific Islanders, and American Indians (Reinehr, 2013). The prevalence of type 2 diabetes increases with age, tripling from age 10 to 14 years to 15 to 18 years. Although rates in adult men and women are similar, adolescent females, for reasons that remain uncertain, have a 60% higher prevalence rate when compared to males (Dabelea et al., 2014).

2.5 Handgrip Dynamometry

Handgrip strength is a measure of muscular strength or the maximum force/tension produced by one's forearm muscles and measured using a dynamometer. The dynamometer is a cost-effective screening tool when assessing one's upper body strength and overall strength (Litchfield, 2013). The subject holds the dynamometer in hand with the arm at a right angle and elbow at the side of the body. The participant then squeezes the lever with as much force as possible to get an accurate measurement. Handgrip strength has been studied as a potential biomarker of malnutrition in different age groups (Bohannon, 2019). The Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition has described handgrip strength as one of the clinical measures of adult protein-calorie malnutrition. The practice guidelines state that "if a patient has two or more of the following six characteristics, there is a need for a diagnosis of malnutrition: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, a localized or generalized fluid accumulation that may sometimes mask weight loss, and diminished functional status as measured by handgrip strength" (White et al., 2012).

2.5.1 Handgrip Strength and Vitamin D Intake

Increasing evidence suggested a correlation between Vitamin D deficiency and decreased skeletal muscle function. Studies have examined this relationship in older populations (Gunton & Girgis, 2018); however, more research is needed to describe the association in younger adults. A study conducted with elite swimmers living in the northern latitudes, aged 16 to 24 years, evaluated Vitamin D status and its relationship with muscle strength. The results from this study indicated that 45% of swimmers had insufficient Vitamin D intake. Results also indicated that muscle strength was significantly higher in male swimmers with sufficient Vitamin D status when compared to male swimmers with insufficient Vitamin D status (Wium-Geiker et al., 2017).

Deficiencies in Vitamin D have also been known to cause inadequate mineralization of the skeleton (Youn Ho et al., 2013). This failure to mineralize already formed bone is known as osteomalacia in adults. Vitamin D deficiency in children is called rickets and results in skeletal deformities and stunted growth in all individuals (Youn Ho et al., 2013). A recent research study showed that Vitamin D deficiency is becoming more common in obese individuals (Durmaz et al., 2017).

2.5.2 Handgrip Strength and Metabolic Syndrome

There is increasing evidence suggesting a correlation between handgrip strength and metabolic syndrome. However, the mechanisms that lead to metabolic syndrome in individuals with moderately low muscle strength are still unknown. A research study conducted on college-aged students indicated that higher handgrip strength relative to body mass might help lessen cardiometabolic risk (Garcia-Hermoso et al., 2018). In another research study, handgrip strength and body weight ratio were important factors in health outcomes, which provides additional information necessary for the prevention of cardiovascular disease (Kawamoto et al., 2016). A study in Korea found that handgrip strength per body weight was lower in participants with metabolic syndrome than those without metabolic syndrome (Yang et al., 2012). One cross-sectional study using NHANES data concluded that higher handgrip strength was associated with a lower prevalence of metabolic syndrome in male and female participants (Ji et al., 2020). These studies suggest that early detection of decreased handgrip strength can help identify the risk for developing metabolic syndrome.

2.5.3 Handgrip Strength and Prediabetes/Diabetes

There are many known risk factors for prediabetes and diabetes, including handgrip strength. A few cross-sectional studies have reported a correlation between muscle strength and prediabetes among normal-weight individuals. Manda et al. (2020) concluded that higher baselines handgrip strength predicted a lower risk of prediabetes incidence among adults. These findings suggest that a handgrip strength measurement is a useful tool in identifying individuals at high risk of newly diagnosed prediabetes. Another research study compared participants with a diagnosis of type 2 diabetes to participants with no diagnosis of diabetes and concluded that participants with diabetes had a lower handgrip strength compared to participants with no diagnosis of diabetes (Cetinus, 2005). These findings suggest that early detection of a diminished handgrip strength can lead to early detection of prediabetes and diabetes.

It is known that resistance training improves glucose metabolism in those with metabolic syndrome. However, it is unknown if markers such as muscle strength measured by handgrip dynamometry are associated with the risk of developing metabolic syndrome or prediabetes. Mainous et al. (2016) examined the longitudinal data from the 2011-2012 National Health and Nutrition Examination Survey. They found that handgrip strength was associated with prediabetes among healthy-weight adults in the United States. The researchers suggested that handgrip strength should be considered for future studies as a possible screening indicator for prediabetes. Yeung et al. (2019) also found that higher handgrip strength was significantly associated with a decreased risk of diabetes in a study utilizing a large database from the United Kingdom called the UK Biobank GWAS.

2.6 Hemoglobin A1c

Blood glucose and hemoglobin A1c levels are typically measured in laboratories by healthcare providers. Blood glucose levels can also be measured via a fingerstick blood sample, using an electronic blood glucose meter. A drop of blood is applied to a chemically treated, disposable test strip and inserted into the compatible meter (Pickering & Marsden, 2014). Normal blood glucose levels are between 70 to 130 mg/dL. A non-fasting blood glucose level in the range of 140 to 199 mg/dL suggests prediabetes, and a level of 200 mg/dL or higher suggests diabetes. Hemoglobin A1c represents glycosylated hemoglobin over three months. This measurement can also be obtained using a fingerstick blood sample measured by a compatible handheld meter. The normal range for hemoglobin A1c is 4 to 5.6%; a level of 6.5% or higher is indicated of DM (Mayo Clinic, 2019). Even though the handheld meter is not a replacement for direct blood glucose monitoring, the handheld meter has been shown to lead to a timelier treatment and better glycemic control (Chang et al., 2010). Similarly, the self-check meter kit for hemoglobin A1c may be used by those with diabetes in the same way.

A study conducted by Chang et al. (2010) compared the hemoglobin A1cNow® self-check fingerstick test to a venous blood sample collected from each participant. The blood samples were tested at a National Glycohemoglobin Standardization Program (NGSP) level II-certified laboratory by high-performance liquid chromatography on a TOSOH 2.2 laboratory analyzer. It was concluded that the A1cNow® meter accurately measured hemoglobin A1c levels, and participants stated that the meter was easy to use. This proposed study will be using the self-administered A1cNow® meter to determine participants' hemoglobin A1c levels.

2.7 Conclusion

Prevention and early detection strategies are needed for metabolic syndrome, prediabetes, and T2DM. Current literature is exploring Vitamin D and its effect on insulin sensitivity. This study explores the relationships between dietary Vitamin D intake, sun exposure, and Hg A1c levels in college-aged adults. Results could decrease the incidence and prevalence of metabolic syndrome, prediabetes, and diabetes (T2DM). Additionally, this current proposed study will also explore whether handgrip strength correlates with Hemoglobin A1C and Vitamin D intake in college-aged students not yet diagnosed with metabolic syndrome or prediabetes.

Below are the hypotheses for this study:

H_0: There will be no significant relationships between HgbA1c levels and levels of Vitamin D intake, sun exposure, or handgrip strength in college students.

H_0: There will be no significant linear relationships between the independent variables of Vitamin D intake, sun exposure, handgrip strength, and HgbA1c

(H_1) HgbA1c levels will decrease with increasing Vitamin D intake.

(H_2): HgbA1c levels will decrease with a combination of increasing Vitamin D intake and sun exposure.

(H_3): HgbA1c levels will decrease with increasing sun exposure.

(H_4): HgbA1c levels will decrease with increasing handgrip strength.

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CHAPTER 3

METHODS

This research study was an exploratory, cross-sectional design study that was conducted at Louisiana Tech University. A convenience sample of enrolled students 18 to 28 years of age who had no history of diagnosed metabolic syndrome, prediabetes, or type 1 or 2 diabetes mellitus were eligible to participate. No recruitment or data was collected before approval from the Louisiana Tech Human Subjects Review Board. Participants were recruited via flyers and classroom announcements. Student research went to various classrooms around campus and spoke with students about voluntary participation in this study. The target sample size was 120 to approach adequate power for data analysis. The researcher utilized a data collection tool developed by the researcher and faculty advisor using Qualtrics software (Appendix A) for ease of collection. Data was collected on a Human Ecology – Food and Nutrition Program-owned laptop that was password protected.

At the participant's scheduled appointment, they first reviewed a printed consent document and determined if they wished to continue participating (Appendix B). If they consented, they received a random study subject number used to maintain confidentiality and not associate responses and measures with their identity (Appendix C). They were then provided with a link or QR code that directed them to the electronic questionnaire for completion. This questionnaire included demographic items, food frequency questions to assess Vitamin D intake, and items to assess sun exposure (Bolek-Berquist et al., 2009), a self-reported height and weight, and a history of metabolic syndrome or diabetes first-degree and second-degree relatives. No validated tools were formed to measure sun exposure accurately or to assess Vitamin D intake. Therefore, the researcher developed those items based on a review of similar studies. The questionnaire did not take longer than 15 minutes to complete. Next, handgrip strength was measured by the researchers or trained research assistants with a Jamar Handgrip Dynamometer. The grip strength was measured three times on the dominant hand and then three times on the non-dominant hand. The three measures were averaged to obtain the final strength measure in pounds of pressure exerted. The right-hand measurement was used for data analysis for this project, commonly used in the literature. The measurement was completed in less than 10 minutes.

Additionally, measured height, weight, and waist circumference measurements were taken. Finally, the subject completed a self-administered, over-the-counter Glycated Hemoglobin (A1c) Test (Chang et al. 2010). Subjects were instructed by the researcher on the procedures as provided by the test kit manufacturer to ensure proper measurement. Both the handgrip strength measurement and the Hemoglobin A1c results were entered into the participant's questionnaire by matching the random study subject number (Appendix D). The time burden of the A1c test was dependent on the participant but was completed in no more than 10 minutes. Universal precautions were maintained. The fingerstick A1c test was conducted in the medical technology laboratory space in coordination with Ms. Vanessa Johnson, Associate Professor/Coordinator of Medical Technology at Louisiana Tech University. The time burden for the entire data collection visit was 30 to 35 minutes. See the research matrix in Appendix E. Data analysis was analyzed using SPSS software Version 25.

Data preparation for analysis included inserting midpoint values when participants wrote ranges of numbers for serving sizes. When participants simply reported consuming milk daily and gave no serving amount, one serving was recorded. If participants reported taking vitamins once per month for vitamin intake per day, they were recorded in the 0-1 category. If every other day was reported, they were also recorded in the 0-1 category. The same procedure was followed for the intake of fish oil. Two outliers were removed when comparing self and measured height and weight, as the differences were greater than 10 inches and appeared to be input errors on the participant's part.

CHAPTER 4

RESULTS

The majority of the participants were female (76%) and ranged in age from 18-22-year-old. Most were white, non-Hispanic (81.9%), and African American (8.6%). Approximately 93% were classified as sophomores, juniors, or seniors, majoring in health-related and business areas of study. The mean BMI for the sample was 25.87 (SD=5.98). According to the CDC, in BMI classifications, 2% of participants were underweight, 55% were of normal weight, 33% were overweight, and 15% were obese. When asked about the disease in family members, 18.1% of the participants had first-degree relatives with either metabolic syndrome, prediabetes, or diabetes. In contrast, 49.5% of participants had second-degree relatives with either metabolic syndrome, prediabetes, or diabetes. See Table 1.

Table 1

Characteristics of the Participants (*N*= 105)

Variable	Response	*n* (%)
Gender	Male	29 (27.60)
	Female	76 (72.40)
Age	18-22	88 (83.70)
	23-28	17 (16.30)
Class	Freshmen	7 (6.70)
	Sophomore	22 (21.00)
	Junior	29 (27.60)
	Senior	37 (35.20)
	Graduate	10 (9.50)
Major	Health-Related	69 (65.80)
	Business-Related	24 (22.80)
	Liberal Arts	2 (1.90)
	Education	1 (1.00)
	Engineering	5 (4.80)
	Aviation	2 (1.90)
	Other	2 (1.90)
BMI Category	Underweight	2 (2.00)
	Normal	55 (55.00)
	Overweight	33 (33.00)
	Obese	15 (15.00)
Race	White, non-Hispanic	86 (81.90)
	White, Hispanic	3 (2.90)
	African American/Black	9 (8.60)
	Black, Hispanic Origin	1 (1.00)
	Asian	1 (1.00)
	Middle Eastern	1 (1.00)
	Biracial	3 (2.90)
	Missing	1 (1.00)
First-Degree Relative[a]	Yes	19 (18.10)
	No	82 (78.10)
	I do not know	4 (3.80)
Second-Degree Relative[a]	Yes	52 (49.50)
	No	0 (0.00)
	Missing	21 (20.00)

[a] Relatives diagnosed with metabolic syndrome, prediabetes, or diabetes.

Bivariate correlations were conducted to explore the relationships between waist circumference, BMI A1c, and right handgrip strength. Waist circumference was positively, significantly correlated with handgrip strength (r = 0.365, p < 0.01) and BMI (r^{o}= 0.896, p < 0.01). Additionally, handgrip strength was positively correlated with BMI (r^{o}= 0.283, p < 0.01).

A one-way ANOVA was conducted to compare A1c levels and right handgrip strength between BMI categories. There was a statistically significant difference found between the groups at the p < 0.05 level, [(2,102) = 4.66, p = 0.012] for A1c and [(2,102) = 8.86, p = <0.01] for handgrip strength. The A1c levels for those in the normal weight, overweight and obese categories were M = 4.99 (SD = 0.52), M = 4.76 (SD = 0.43) and M^{o}= 5.19(SD = 0.32), respectively. The obese group had the highest mean A1c level. The handgrip strength measure (pounds of pressure) for those in the normal weight, overweight, and obese categories were M= 70.20 (SD = 19.32), M = 89.47 (SD = 26.13), M = 83.59 (SD = 18.63), respectively. Interestingly, the obese group showed a decrease in the mean handgrip strength from the overweight group.

Regression analysis was conducted to test if food sources of Vitamin D servings per day, minutes of sun exposure per week, and right handgrip strength were predictors of A1c levels. Results were non-significant.

Slightly more than half of the participants consume milk daily; 21% consume ≤ ½ cup per day, while 13.3% consume two cups per day. Approximately half of the participants consume yogurt daily. Of these participants, 26.7% consume ≤ ½ cup per day; 66.7% of participants consume one or two servings of other dairy products (i.e., cheese) per day. Nearly 85% of participants consume 0-1 servings of non-dairy milk substitute products (i.e., almond or oat milk) per day. More than 50% of participants state they consume fish, but only 17% do so ≥ 3-times per week. See Table 2.

Table 2

Dietary Sources of Vitamin D (N=105)

Variable	Response	*n* (%)
Consumes milk daily	Yes	55 (52.40)
	No	50 (47.60)
Amount of Milk/day	≤ ½ cup	22 (21.00)
	1 cup	13 (12.40)
	2 cups	14 (13.30)
	≥ 3 cups	6 (5.70)
	No daily milk intake	50 (47.60)
Consumed yogurt daily	Yes	47 (44.80)
	No	58 (55.20)
Amount of Yogurt/day	≤ ½ cup	28 (26.70)
	1 cup	19 (18.10)
	2 cups	0 (0.00)
	≥ 3 cups	0 (0.00)
	Missing	58 (55.20)
Other dairy products consumed daily (including cheese)	0 serving	18 (17.10)
	1-2 servings	70 (66.70)
	3-4 servings	11 (10.60)
	Missing	6 (5.70)
Milk & Milk Product Substitutes Consumed daily	0-1 serving	89 (84.80)
	1.5-2.5 servings	14 (13.40)
	≥ 3 servings	2 (1.90)
Consumes Fish	Yes	58 (55.20)
	No	47 (44.80)
How Often	≤ 2x/wk	1 (5.00)
	3-4x/ month	17 (16.20)
	1-2x/month	24 (22.90)
	More seldom	12 (11.40)

To compare the difference between those who consumed the recommended three servings of dairy per day (from all sources) or more to those who did not, a t-test was calculated for A1c, BMI, and waist circumference. Those consuming three or more servings per day (*M* = 31.04 inches, *SD* = 5.54) had a significantly smaller waist circumference measure than those who consumed less than three servings per day (*M*º=º33.59, *SD* = 6.16), t(103) = -2.23, *p* = 0.028.

Of the 105 participants, 36.6% said they acquired a suntan during no more than 19 days in the last year, and 17.1% acquired a suntan during 20-40 days per year (see Table 3).

Table 3

Sun Exposure (N= 105)

Variable	Response	*n* (%)
Sun Tan/year	0-19 days	38 (36.60)
	20-40 days	18 (17.10)
	41-60 days	3 (3.00)
	≥ 60 days	10 (9.70)
	Missing	36 (34.30)
Use of Tanning Booth	Yes	11 (10.50)
	No	94 (89.50)
Tanning Booth Usage/year	1-10	7 (49.40)
	11-20	1 (1.00)
	21-30	0 (0.0)
	31-40	1 (1.00)
	41-50	2 (1.90)
Average Sun Exposure in last week	< 5 minutes per day	6 (5.70)
	5-15 minutes	28 (26.70)
	15-30 minutes	42 (40.00)
	> 30 minutes	29 (27.60)
Sunscreen use	< 50% of the time	54 (51.40)
	> 50% but < 80%	34 (32.40)
	At least 80%	17 (16.20)

Approximately 10% reported using a tanning booth, and 49.4% use a tanning booth 1-10 times per year. Forty percent reported an average sun exposure of 15-20 minutes per week. Approximately half wear sunscreen less than 50% of the time. There was a non-significant correlation of -0.12 (*p* = n.s.) between HgA1c and average sun exposure each week.

Of the 105 participants, 45.7% take multivitamin/vitamins; 42% take 0-3 tablets per day. Of the participants taking multivitamin/vitamins, 24.8% report their multivitamin contained Vitamin D, while 17.1% did not know whether their multivitamin contained Vitamin D. Approximately 13% of participants take Vitamin D as a single supplement; 7.6% take fish oil supplements, and of those cod liver or omega-three supplements were most frequently taken for 4-7 days (Table 4).

Table 4

Vitamin Intake (N= 105)

Variable	Response	*n* (%)
Multivitamin/vitamin intake	Yes	48 (45.70)
	No	57 (54.30)
Multivitamin daily	0-3 tablets	44 (42.00)
	4-7 tablets	2 (2.00)
	> 8 tablets	2 (2.00)
A multivitamin containing Vitamin D	Yes	26 (24.80)
	No	4 (3.80)
	I do not know	18 (17.10
Vitamin D as a single supplement	Yes	14 (13.30)
	No	91 (86.70)
Fish Oil Supplements	Yes	8 (7.60)
	No	97 (92.40)
Cod Liver or Omega 3 per week	1-3 days	1 (1.00)
	4-7 days	7 (6.80)

Most participants did not smoke or use tobacco products (92.4%), while 16.2% of participants reported either regularly or sometimes vape. Of the 105 participants, 30.5% spend 31 minutes to an hour each day doing some physical activity; 67.8% spend 1-30 minutes of their physical activity time outdoors. See Table 5.

Table 5

Smoking and Physical Activity (N= 105)

Variable	Response	*n* (%)
Smoking/Tobacco products	Yes	4 (3.80)
	No	97 (92.40)
	Sometimes	4 (3.80)
Vaping	Yes	8 (7.60)
	No	88 (83.80)
	Sometimes	9 (8.60)
Physical activity	0-15 minutes	17 (16.20)
	16-30 minutes	31 (29.50)
	31 minutes-1 hour	32 (30.50)
	More than 1 hour	24 (22.90)
	None	1 (1.00)
Physical activity performed outside	1-30 minutes	71 (67.80)
	31-60 minutes	9 (8.70)
	> 60 minutes	5 (4.90)
	Missing	20 (19.00)

When self-reporting height and weight (Table 6), men report an extra 1.69 inches (*SD* = 0.92) for height and reduced weight of 1.06 pounds (*SD* = 3.67). Women reported an extra 1.18 inches (*SD* = 0.95) for height and were accurate for weight differing from their measured weight only by -0.96 pounds (*SD* = 4.18). There was a statistically significant difference between males and females for the difference in self-reported and measured height, $t(101) = 2.46$, $p = 0.015$, with males reporting additional height in inches in a greater amount than females.

Table 6

Difference in Self-Reported and Measured Height and Weight

	Males N=29		Females N=76		t/(df)	*p*	Cohens d
	M	*SD*	*M*	*SD*			
Height Differences (inches)	1.69	0.92	1.18	0.95	2.46 (101)*	0.015	0.54
Weight Differences (pounds)	-1.06	3.67	-0.96	4.18	-0.12 (103)	0.910	

*p > 0.05

CHAPTER 5

DISCUSSION

This study sought to examine the relationships among HgA1c, handgrip strength, Vitamin D intake, and sun exposure in early adulthood. The aim included examining the possibility that handgrip strength may be used as a screening tool for insulin insensitivity in young adults, leading to metabolic syndrome, prediabetes, or diabetes. The general findings that 48% of the participants being classified as overweight or obese, almost 17% having a waist circumference, placing them in a high-risk category, and 67% already having a first or second-degree relative diagnosed with metabolic syndrome, prediabetes, or diabetes support the need for such studies in this group.

The primary hypothesis was that there would be no significant relationships among HgbA1c levels, Vitamin D intake, sun exposure, or handgrip strength in college students. We accept this null hypothesis; however, this finding may be related to the small sample size and the difficulty finding a validated food frequency tool specific to measuring Vitamin D-rich food sources. Researcher-developed items were used in the questionnaire to measure the number of servings of Vitamin D-rich food sources for this study. Participants also were unable to report whether multivitamins consumed contained Vitamin D with accuracy. In the future, it would be beneficial to develop a validated food frequency tool or to consider a more extensive report of dietary intake, although accuracy and recall would remain an issue. It is encouraging that some data analysis did support the need to continue this line of research. A1c levels increased with increasing BMI; handgrip strength decreased for the obesity level BMI group; consuming the recommended number of dairy servings per day (3 or more) correlated with a smaller waist circumference.

The second null hypothesis was that there would be no significant linear relationships between the independent variables of Vitamin D intake, sun exposure, handgrip strength, and A1c. The alternate hypotheses to this included A1c levels would decrease with increasing Vitamin D intake was not demonstrated; however, the participants were unable to accurately report Vitamin D content of supplements, making it difficult to measure Vitamin D intake fully, which may be a reflection of a lack of awareness of the importance of Vitamin D intake. Of additional concern was the finding that nearly half of the participants did not consume Vitamin D from nutrient-rich sources such as dairy beverages and foods, which increases their risk of osteopenia and osteoporosis later in life, in addition to other health risks associated with inadequate Vitamin D intake. There was a significant difference in their waist circumferences and BMI in participants who consumed the recommended number of dairy servings per day (3 servings). In those who consumed three servings of dairy foods per day, the mean BMI was 25.39, just over what is considered a healthy weight, and in those who consumed less, the mean BMI mean was 26.49. This indicates an association between sufficient dairy intake, waist circumference, and BMI. Perhaps those consuming adequate dairy servings are also more attentive to consuming a healthy diet overall.

In the male group, (N=29), only 9 male participants met the requirements for dairy foods intake per day (three servings). Even though it was not significantly different in a t-test, there was a measurement difference in male participants' BMI and waist circumference. Males who consume three servings of dairy a day had a lower BMI and a lower waist circumference. However, more male participants were needed to represent male dairy intake as a whole better. It was also noted that males who took multivitamins had lower waist circumferences and BMI measurements though not statistically significant. In females, BMI was higher in those who consume the recommendations of 3 servings of dairy products per day. However, waist circumference was smaller in those who consume three servings of dairy per day, which is an indicator of disease risk. Additional research in this area is needed.

The second alternate hypothesis stated that HgbA1c levels would decrease with a combination of increasing Vitamin D intake and sun exposure. Due to the mixture of variables collected, it was impossible to combine these variables validly to analyze this hypothesis adequately. However, an ANOVA comparing the mean A1c among the categories of daily sun exposure and a Pearson's correlation between A1c and servings of Vitamin D-rich foods were not significant.

The third alternate hypothesis stated that A1c levels would decrease with increasing sun exposure. This hypothesis was not accepted as there was not a significant correlation between these two variables. Forty percent of participants reported 15-20 minutes of sun exposure each week. At the same time, the recommendations are 5 to 30 minutes of sun between 10 AM and 3 PM at least twice a week to the face, arms, legs, or back, without sunscreen, to facilitate adequate Vitamin D synthesis. It appears that the participants may not be getting adequate sun exposure despite living in the southern United States. Additionally, half of the participants reported using sunscreen, which would not allow them to have adequate Vitamin D synthesis when outdoors. While not being a source of Vitamin D, it is a concern that tanning booths appear to remain popular.

The fourth alternate hypothesis stated that A1c levels would decrease with increasing handgrip strength. A statistically significant correlation between A1c levels and handgrip strength was not found in this study sample. It was noted that handgrip strength decreased in the obese participants and A1c levels also were higher in the obese participants.

Limitations of the data collection included the reliance on self-reported data. There is also a need for a fully validated food frequency questionnaire/tool to provide a more accurate representation of overall Vitamin D intake. Additionally, accurate reporting of Vitamin D supplements and a method to combine Vitamin D dietary intake, supplementation, and sun exposure to get a complete measure of Vitamin D input for individuals may assist with more accurate data analysis. To our knowledge, there is no validated tool for this at this time. Because this study included a reliance on the variability of A1c levels within the normal range, it would be necessary to have a larger sample group to increase the power of the statistical analysis.

CHAPTER 6

CONCLUSIONS AND FUTURE WORK

Despite the limited statistically significant findings directly related to the hypotheses, we found that this population of college-aged adults in Louisiana was at high risk for metabolic diseases. Statistical findings supported continuing this line of research by addressing data collection and analysis limitations. Important findings included differences in handgrip strength and A1c levels between BMI weight categories, smaller waist circumference measures in those who consume recommended levels of dairy products, inadequate consumption of Vitamin D rich beverages and foods, lack of awareness of the content of multivitamin supplements consumed, and inadequate sun exposure to support Vitamin D synthesis.

Future research should consider addressing the limitations in data collection and attempt to refine the identification of those young adults at high risk for future disease by screening methods to focus on prevention efforts at this stage of life. Handgrip strength and Vitamin D status remains viable variables for future research.

APPENDIX A

DATA COLLECTION INSTRUMENT AND QUESTIONNAIRE

Data Collection Instrument and Questionnaire

Q1 Please enter your unique study subject number.

____

Q2 Have you ever been diagnosed with metabolic syndrome, prediabetes, or diabetes?
- ❍ Yes (1)
- ❍ No (2)

Q3 Do you have a parent, sibling, or child diagnosed with metabolic syndrome, prediabetes, or diabetes?
- ❍ yes (1)
- ❍ no (2)
- ❍ I don't know (4)

Q4 Do you have a grandparent, aunt or uncle, half-sibling, niece or nephew diagnosed with metabolic syndrome, prediabetes, or diabetes?
- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q5 Have you been diagnosed with Crohn's disease, ulcerative colitis, or celiac sprue?
- ❍ Yes (1)
- ❍ No (2)

Q6 Have you had diarrhea in the past 2 weeks?
- ❍ Yes (1)
- ❍ No (2)

Q7 What is your age?

____

Q8 What is your sex?

- Male (1)
- Female (2)
- Transgender (3)
- Do not wish to answer

Q9 What is your race?

- White, non-Hispanic (1)
- White, Hispanic origin (2)
- African American or Black (3)
- Black, Hispanic origin (10)
- Native American or Alaskan Native (4)
- Asian, Pacific Islander (5)
- Indian (Southeast or Subcontinental) (6)
- Middle Eastern (7)
- biracial, please list (8) ____________________
- multiracial, please list (9) ____________________

Q10 What is your student classification?

- Freshman (1)
- Sophomore (2)
- Junior (3)
- Senior (4)
- Graduate level (5)

Q11 What is your primary area of study?

- ❍ Food, Nutrition, Dietetics (1)
- ❍ Fashion Merchandising (2)
- ❍ Family & Child Studies (HDFS) (3)
- ❍ Nursing (4)
- ❍ Health Information System (6)
- ❍ Biology or Chemistry (7)
- ❍ Forestry & Agricultural Sciences (8)
- ❍ Engineering, Math, & Computer Science (9)
- ❍ Aviation (10)
- ❍ Business (11)
- ❍ Education (12)
- ❍ Psychology or Sociology (13)
- ❍ Liberal Arts (Literature, Language, History, Art, Architecture) (14)
- ❍ Speech Pathology (15)
- ❍ Other (16) ____

Q12 How tall are you? Enter both feet and inches.

_______ Feet (1)

_______ Inches (2)

Q13 What is your weight in pounds?

____

End of Block: Demographics

Start of Block: Vitamin D - Sun Exposure

Q14 On average, how much sun exposure have you had in the past week?

- less than 5 minutes per day (2)
- 5-15 minutes per day (3)
- 15-30 minutes per day (4)
- more than 30 minutes per day (5)

Q15 Have you gotten a suntan by outdoor exposure in the past 12 months?

- Yes (1)
- No (2)

Skip To: Q17 If Have you gotten a suntan in the past 12 months? = No

Q16 How many times in the last 12 months did you get a suntan by outdoor exposure?

____

Q17 Do you use sunscreen?

- Yes (1)
- No (2)

Q18 How often do you use sunscreen?

- Less than 50% of the time (2)
- More than 50% but less than 80% of the time (3)
- At least 80% or more of the time (4)

Q19 When do you use sunscreen? (Check all that apply)

- ▢ only during warm weather months (1)
- ▢ only when engaging in outdoor activities all year (2)
- ▢ only when engaging in outdoor activities in warm months (3)
- ▢ my cosmetics contain sunscreen all year long (4)

Q20 Have you used a tanning booth in the past year?

- ❍ Yes (1)
- ❍ No (2)

Skip To: Q22 If Have you used a tanning booth in the past year? = No

Q21 How many times in the last year did you use a tanning both?

____

Q22 How many servings of non-dairy milk substitutes or non-dairy milk substitute products do you usually consume each day? (ex: soy milk, almond milk, oat milk, rice milk, etc.)

____

Q23 Do you take any vitamins or multivitamins?

- ❍ Yes (1)
- ❍ No (2)

Skip To: Q27 If Do you take any vitamins or multivitamins? = No

Q24 If yes, how many multivitamin or vitamin tablets do you take daily?

____

Q25 What brand and type of multivitamin do you take daily?

____

Q26 Do your multivitamins or vitamin contain Vitamin D?

- Yes (1)
- No (2)
- I don't know

Q27 Do you take Vitamin D as a single vitamin supplement?

- Yes (1)
- No (2)

Skip To: Q30 If Do you take Vitamin D as a single vitamin supplement or calcium with Vitamin D? = No

Q28 If so, what is the brand and type?

____

Q29 Do you take Vitamin D as part of a Calcium with Vitamin D supplement?

- Yes (1)
- No (2)

Q30 If so, what is the brand and type?

____

Q31 How many Vitamin D or Calcium Supplements with Vitamin D do you take each day?

____

Q32 Do you take cod liver oil or omega-3 fatty acids supplements/oil (fish oil)?

- Yes (1)
- No (2)

Skip To: Q32 If Do you take cod liver oil or omega-3 fatty acids supplements/oil (fish oil)? = No

Q33 How many days per week do you take cod liver oil or omega-3 fatty acid supplements/oil?

____

Q34 Do you eat fatty fish (salmon, mackerel, herring)?

- Yes (1)
- No (2)

Skip To: Q33 If Do you eat fatty fish (salmon, mackerel, herring)? = No

Q35 If YES: How often?

- At least twice weekly (1)
- 3-4 times per month (2)
- 1-2 times per month (3)
- More seldom (4)

Q36 Do you drink milk or is milk part of your diet?

- Yes (1)
- No (2)

Skip To: Q37 If Do you drink milk or is milk part of your diet? = No

Q37 How much dairy milk do you consume?

- 3 or more cups per day (1)
- 2 cups per day (2)
- 1 cup per day (4)
- Less than 1/2 cup per day (3)

Q38 Which type of milk do you consume most often?

- Full-fat milk (1)
- Medium-fat milk (2)
- Low-fat milk (3)
- Skim milk (4)
- Other (e.g. oat milk), please specify (5)

____

Q39 Is yogurt and/or buttermilk part of your diet?

- Yes (1)
- No (2)

Skip To: Q40 If Is yogurt and/or buttermilk part of your diet? = No

---

Q40 How much yogurt or buttermilk do you consume? (1 cup = 8 ounces)

- More than 3 cups per day (1)
- 2 cups per day (2)
- 1 cup per day (3)
- Less than 1/2 cup per day (4)

Q41 What kind do you consume most often?

- fruit flavored or vanilla yogurt (1)
- plain yogurt/buttermilk milk (2)
- greek yogurt (3)

Q42 Other than fluid milk and yogurt, how many servings of other dairy milk products (Cheeses) do you usually consume each day? (1 ounce or 1 slice = 1 serving)

____

Q43 How much physical activity do you get each day?

- 0-15 minutes (2)
- 16-30 minutes (3)
- 31-minutes - 1 hour (4)
- More than 1 hours (5)
- none (6)

Skip To: End of Block If How much physical activity do you get each day? = none

Q44 Is your physical activity done outside?

- Yes (1)
- No (2)
- Sometimes (3)

Q45 On average, how many minutes of your physical activity occurs outdoors each day?

____

Q46 Do you smoke or use tobacco products?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Sometimes (3)

Q47 What tobacco products do you use? Check all that apply.

- ❍ Cigarettes (1)
- ❍ Cigars (2)
- ❍ Chewing tobacco (3)
- ❍ Other (4)

____

Q48 If yes, how much per day?

____

Q49 Do you engage in vaping?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Sometimes (3)

Q50 If yes, how much per day?

____

APPENDIX B

HUMAN USE APPROVAL MEMO

LOUISIANA TECH
UNIVERSITY.

MEMORANDUM

OFFICE OF SPONSORED PROJECTS

TO:	Ms. Janelle Melancon and Dr. Simone Camel
FROM:	Dr. Richard Kordal, Director of Intellectual Property & Commercialization (OIPC) rkordal@latech.edu
SUBJECT:	HUMAN USE COMMITTEE REVIEW
DATE:	March 29, 2021

RDK

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"The Relationships between Vitamin D Intake, Sun exposure, Handgrip Strength and Hemoglobin A1C Levels in College Students"

HUC 21-074

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on March 29, 2021 and this project will need to receive a continuation review by the IRB if the project continues beyond March 29, 2022.*** **ANY CHANGES** to your protocol procedures, including minor changes, should be reported immediately to the IRB for approval before implementation. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of Sponsored Projects.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Sponsored Projects or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM

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APPENDIX C

DATA COLLECTION FORM

Hemoglobin A1c and Handgrip Form with Random Subject Numbers

Subject #	**HgA1c %**	**Handgrip Measurement**	**Height**	**Weight**	**Waist Circumference**

APPENDIX D

RESEARCH MATRIX

Purpose Statement	**Hypotheses**	**Study Design**	**Variables (+Measurement Tool)**	**Type of Data**	**Statistical Test(s)**
To determine the relationship among dietary Vitamin D intake, sun exposure, handgrip strength, and Hg A1c levels in college students. The aim is to explore potential screening tools for metabolic syndrome and prediabetes in college-age adults.	H_0: There will be no significant relationships among HgbA1c levels with varying degrees of Vitamin D intake, sun exposure, or handgrip strength in college students. H_0: There will be no significant linear relationship between the independent variables of Vitamin D intake, sun exposure, and handgrip strength, and HgbA1c. (H_1) HgbA1c levels will decrease with increasing Vitamin D intake. (H_2): HgbA1c levels will decrease with a combination of increasing Vitamin D intake and sun exposure. (H_3): HgbA1c levels will decrease with increasing sun exposure. (H_4): HgbA1c levels will decrease with increasing handgrip strength.	Cross-Sectional Study Design <u>Sampling Plan:</u> Convenience Sample Reaching students via email and flyers spread across campus. The target sample size is 120 to approach adequate power for data analysis based on approximately 20 subjects per variable.	Demographics/ Characteristics <u>Independent:</u> Vitamin D exposure Vitamin D intake Handgrip Strength <u>Measurement tools</u> -Vitamin D food frequency -Vitamin D supplementation -Sun exposure questionnaire -Handgrip dynamometer -Hgb A1c self-check kits <u>Dependent:</u> HgbA1c levels <u>Measurement tool</u> -Hgb A1c self-check kits	Categorical & continuous Continuous Continuous	Descriptive statistics Pearson's Correlation Regression

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