AN EXPLORATORY STUDY OF COLLEGE STUDENTS' ATTITUDES TOWARD DIETARY PROTEIN: DEVELOPMENT OF A DIETARY PROTEIN ASSESSMENT SURVEY INSTRUMENT

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PARKER ACKERMAN, B.S.

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DEDICATION

To my parents,
for supporting and encouraging me to never give up on my dreams.

To my brother,
for serving as a role model throughout my life.

To Josh,
for being my best friend.

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ABSTRACT

PARKER ACKERMAN

AN EXPLORATORY STUDY OF COLLEGE STUDENTS' ATTITUDES TOWARD DIETARY PROTEIN: DEVELOPMENT OF A DIETARY PROTEIN ASSESSMENT SURVEY INSTRUMENT

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The purpose of this exploratory study was to develop a survey to estimate college students' attitudes towards dietary protein. The dimensionality of the attitude constructs in the Dietary Protein Assessment Survey (DPAS) instrument was explored in this study. The survey consisted of 64 questions, including 14 attitude questions. The dimensionality of the attitude constructs was explored by exploratory factor analysis (EFA) using principal axis factoring and a promax rotation. Internal consistency reliability was examined using Cronbach's alpha. After removing items that did not factor, the EFA retained three factors and explained 73.9% of variance: human/environmental health (5 items), organic sources (2 items), and protein RDA (2 items). The Kaiser-Meyer-Oklin test (0.76) and Bartlett's test ($p < 0.001$) indicated data was appropriate for EFA. Attitudes towards protein appear to be multi-dimensional and correlated. Further testing is needed to confirm the hypothesized 3-factor model and to estimate test-retest reliability of this survey.

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CHAPTER I

INTRODUCTION

Protein is a major structural and functional component of the human body, accounting for approximately 14-16% to the total mass of a lean adult.[1] Some of the most significant roles of protein in the human body include to serve as structural components (connective tissue), contractile filaments (myosin, actin), antibodies, blood clotting factors, neurotransmitters, transporters, hormones, and enzymes. Additionally, protein serves as an energy resource, although inefficient and not ideal like carbohydrates and fats, providing 4 kcal/gram.[1]

Amino acids are the building blocks of proteins.[1] Whole-body protein mass is regulated by the balance between protein synthesis (anabolism) and protein breakdown (catabolism). This balance is known as protein turnover. The amino acid pool is a mixture of amino acids created from food sources or protein catabolism that is available in the cell and allows for protein turnover to create the necessary body components. Essential amino acids are unable to be synthesized in human tissues; and therefore, must be obtained from food sources to prevent deficiency. A greater protein quality, or digestibility and quantity of essential amino acids, exists in foods of animal origin, such as fish, milk, eggs, poultry, beef, than in plants and plant-derived foods, such as, nuts, seeds, and legumes. Conversely, non-essential amino acids are synthesized in human tissues and are not required to be obtained through food sources.[1]

The Recommended Dietary Allowance (RDA) for protein for healthy adult men and women is 0.8g/kg/day.[2] However, protein recommendation does not account for sub-population-specific needs, such as physically active individuals or older adults $\geq$ 60 years. It is recommended that a person who lifts weights or is training for an endurance event consume between 1.4-2.0

g/kg/day.[3] The Academy of Nutrition and Dietetics suggests that a protein intake of 1.0-1.6 g/kg/day for older adults is safe and adequate to meet their needs, while the Institute of Medicine (IOM) suggests older adults $\geq$ 60 years do not have elevated protein needs above 0.8g/kg/day.[2,4] The Acceptable Macronutrient Distribution Range (AMDR) for protein varies by age and is 10-35% of total calories for adults $\geq$ 18 years.[2] These varying recommendations for protein may be caused by the use of outdated research or inconsistent techniques used in determining appropriate needs among subjects. The lack of clarity in appropriate protein recommendations may result in health professionals providing consumers with incorrect dietary knowledge or consumers relying heavily on unreliable sources.[1-4]

In general, nutrition knowledge has been associated with adherence to dietary recommendations.[5] Currently, the average dietary protein intake in America is close to the recommended amounts for all age-sex groups.[6] However, the average intakes of protein foods subgroups, such as seafood, nuts, seeds, meats, poultry, eggs, and legumes, vary in comparison to the range of intake recommendations.[6] Decreased levels of nutrition knowledge may result in unawareness of appropriate nutrient intakes, including dietary protein.[5] Furthermore, many misconceptions about consuming increased amounts of protein intake may exist due to unscientific dietary information, such as the Internet and social media sites, and unawareness of evidence-based recommendations that relates to lack of nutrition knowledge.[5]

Despite the current misconceptions, benefits of consuming increased amounts of protein have been observed among various populations. For example, a close relationship has been observed between increased protein intake and maintenance of skeletal muscle mass in healthy older adults.[7] Additionally, high quality protein intake has been shown to play a role in the regulation of amount of central abdominal fat, a strong independent biomarker for increased disease risk and mortality.[8]

Although some information exists on dietary protein attitudes and behaviors, information is lacking compared to other macronutrients, such as carbohydrates. In addition, there is minimal information on dietary protein knowledge among U.S. adults. Knowledge about dietary protein is necessary in order to fully understand the impact of protein on human health. Since nutrition knowledge has been associated with adherence to dietary recommendations, increasing protein knowledge is crucial to decrease misconceptions and maximize the health of U.S. adults.[5]

Statement of the Problem

There is an increased need to eliminate the misconceptions towards dietary protein in order to optimize human health. Although evidence-based recommendations exist for protein, unreliable sources tend to be the primary source of dietary information for adults, leading to improper protein knowledge.[5,9] It is crucial to examine protein knowledge to design and implement appropriate education tools, increase awareness, and decrease misconceptions. Since nutrition knowledge is necessary (but not sufficient) for adherence to dietary recommendations, understanding attitudes toward protein is crucial in developing effective interventions to educate the public about appropriate dietary protein consumption. Adequate protein knowledge will lead to decreased misconceptions and standardized recommendations, which will ultimately help improve human health.

Specific Aims:

1. Explore the construct validity of the attitude questions in the Dietary Protein Assessment Survey in a sample of college students.
2. Assess the construct validity of the knowledge questions in the Dietary Protein Assessment Survey in a sample of college students.

Significance

It is crucial to identify protein knowledge in order to build and implement appropriate education tools, increase awareness, and decrease the misconceptions currently associated with protein. Considering these limitations among dietary protein research, the Dietary Protein Assessment Survey (DPAS), an online instrument, is expected to bridge the gaps and identify the relationship between knowledge, attitudes, and behaviors toward dietary protein. The DPAS will help researchers improve understand human behaviors, which will ultimately help professionals create and provide appropriate educational resources and interventions to improve the health of U.S. adults.

CHAPTER II

LITERATURE REVIEW

Protein is an essential component of a healthy diet and continues to be an area of focus in research to identify optimal intake among various populations. Accumulating evidence suggests increased protein intake above the current RDA of 0.8 g/kg/day is dependent on the sub-population. Additionally, plant-based protein sources have become popular and more people are following vegetarian or vegan diets within the last few years.[10] However, limited research exists relating to dietary protein knowledge among adults, which is crucial in understanding their reported behaviors. Identifying protein knowledge will allow for proper interventions to be created.

Endurance Exercise

Few studies have investigated the effects of dietary protein on endurance performance.[11] D'Lugos et al observed in a double-blind crossover study that adding protein to a carbohydrate beverage (45 grams of carbohydrates from sucrose/dextrose + 15 grams of protein from hydrolyzed whey protein isolate powder) during and following exercise in seven trained adult endurance cyclists (5 males, 2 females; age 25 $\pm$8 year) did not result in significant changes in time trial performance. The cyclists completed two 20-day training blocks separated by a washout period with each training block divided into 10 days of intensified cycling training (ICT) followed by 10 days of reduced volume training (RVT). Intensified cycling training included 10 days where subjects increased their average daily training duration to ~220% of normal threshold levels. Average daily training duration was decreased to about 65% of normal threshold levels during RVT.[11]

The beverages were given during (750 mL/h) and immediately after (11.8 mL/kg BW) all training sessions during both ICT and RVT. The beverages consisted of either a commercially available carbohydrate-electrolyte beverage (45g carbohydrates from sucrose/dextrose, 423 mg sodium, and 97 mg of potassium) or an identical beverage with the addition of 15 grams of protein from hydrolyzed whey protein isolate powder. The recovery post-training beverage was either a chocolate-flavored carbohydrate beverage (1.2 g/kg BW carbohydrate from maltodextrin/sucrose, 0.09 g/kg BW fat, 3.3 mg/kg BW sodium, 4.4mg/kg BW potassium) or commercial low-fat chocolate milk (1.2g/kg BW carbohydrates from lactose/sucrose, 0.4g/kg BW protein, 0.11g/kg BW fat, 9mg/kg BW sodium, 21mg/kg BW potassium).[11]

The added protein and carbohydrate beverage impacted skeletal muscle by increasing type I muscle fibers during heavy training and recovery, but this did not lead to time trial improvement. Although adequate carbohydrates were delivered, the addition of protein did not improve endurance performance over 10 days in trained cyclists.[11] More studies are needed on endurance exercise and protein supplementation to identify the effects among more diverse populations and settings.

Resistance Exercise

Compared to endurance performance, there is more current research on the effects of dietary protein on resistance exercise performance. Although there are many factors to consider when identifying the effects of protein on resistance trained athletes, the majority of research reported no benefit, while a few reported increased maximal strength.[12-14] The factors to consider with protein supplementation in conjunction with resistance training include intensity and volume of the program, length of program, training status of subjects, energy intake, quality/quantity of protein intake, and intake of other ingredients.[12-14]

In a randomized, double-blind study, Wilborn et al observed decreased body fat percentage, as well as increased strength, power, and agility in sixteen collegiate female basketball players using a controlled resistance program.[15] Each athlete consumed 24 grams of either whey or casein 30 minutes before and immediately after resistance training for eight weeks. Neither whey nor casein intake caused a significant response, showing that consuming either protein supplement was beneficial.[15]

In a randomized, placebo-controlled clinical trial, Herda et al found that eight weeks of resistance training and protein supplementation in recreationally active college men led to improved muscle performance and size regardless of supplementation type.[12] Supplementation with 20 grams of either bio-enhanced whey protein or standard whey protein 30 minutes before and immediately after training produced no additional benefit in conjunction with resistance training.[12]

Additionally, one study by Antonio et al found that resistance-trained young men (age 25.9 $\pm$3.7 years) who consumed 2.6-3.3 g/kg BW/day (high protein) of food sources of protein, plus supplementation if needed, in addition to normal training routine experienced no changes in performance or body composition over four months.[13] No change was observed in concentration blood lipids or biomarkers of kidney or liver function, making this the first crossover trial using trained subjects where no harmful effects were observed with an intake of protein over four times the RDA.[13]

New research by Born and Dooley found a carbohydrate + protein drink (chocolate milk; 44g CHO, 16g protein) improved adolescent athlete composite strength score compared to a pure carbohydrate supplement (42g CHO).[14] The athletes that consumed chocolate milk post-exercise every day for 7 weeks showed significant improvement in composite strength score from baseline compared to the CHO only athletes. This highlighted the importance of protein for post-exercise recovery to maximize strength development among adolescent athletes.[14]

Protein and Aging

Many older adults have difficulty consuming an adequate amount of protein due to reduced appetite, limited resources, and environmental limitations.[4] Physiological changes, as well as decreased lean body mass, lead to reduced total body protein and also plays a role in increased frailty and decreased immune function. The increased need for dietary protein for older individuals (1.0-1.6 g/kg/day) is safe, enhances protein anabolism, and reduces loss of muscle mass. However, the upper limit of protein intake utilized for synthesis of muscle after a single meal is around 30 grams.[4] The United States Department of Agriculture (USDA) suggests older adults consume high-quality protein at each meal throughout the day and some experts suggest around 25-30 grams for each meal to reduce the risk of sarcopenia.[4]

Genaro et al found that in women over 65 years of age, protein intake greater than 1.2 g/kg/day is associated with significantly greater muscle, bone, and fat mass.[16] Additionally, women with sarcopenia had decreased intakes of essential amino acids and the presence of osteoporosis was a predictor of muscle strength. In conclusion, adequate protein intake (quality and quantity), without supplementation, may have a positive influence on bone mineral density, lean muscle mass, and skeletal muscle mass.[16]

In addition, Norton et al observed that protein supplementation of 0.165g/kg at breakfast and lunch for 24 weeks led to increased lean muscle mass in 50-70-year-old healthy adults.[7] Another study found that whey protein supplementation of 45 grams per day for 18 months, which is above the RDA, may lead to preservation of lean muscle mass with no negative effects on skeletal or renal health in Caucasian adults over the age of 60.[7]

Protein and Diabetes

The American Diabetes Association (ADA) has no specific protein recommendation for individuals with diabetes.[17] The ADA suggests eating fish twice a week, consuming poultry without the skin, and limiting intakes of red meat because of the high saturated fat content. Interestingly, the long-term association between dietary protein intake and risk for developing type 2 diabetes is not certain.[17]

In a large cohort of European adults with type 2 diabetes, those who consumed greater amounts of total and animal protein had an increased risk of developing type 2 diabetes, especially in obese women.[17] Plant protein intake was not associated with risk of developing type 2 diabetes.[17] Vasanti et al found similar results in a longitudinal study consisting of women from the Nurses' Health Study and men from the Health Professionals Follow-up Study.[18] Subjects with the highest percentage of energy derived from total and animal protein had a 7-13% increased risk of type 2 diabetes compared to those with the lowest energy percentage. A moderately decreased risk of developing type 2 diabetes was found in those consuming vegetable proteins.[18] Kahleova et al tested the effect of a low-fat plant-based diet (75% carbohydrates, 15% protein, 10% fat) in overweight adults with no history of diabetes.[19] Subjects that followed a low-fat plant-based diet for 16 weeks, while making no changes to other lifestyle habits, had improved beta-cell function and insulin sensitivity compared to the control group.[19]

Protein and Kidney Function

Concern still exists today about consuming a high protein diet and potential decline in kidney function. The Kidney Disease Outcomes Quality Initiative Nutrition Guidelines recommend 0.6 g/kg/day for non-dialyzed individuals with chronic kidney disease to reduce risk of death and slow progression to dialysis. For some reason, individuals believe that the CKD protein recommendations must be followed by all individuals to reduce the risk of declining kidney function.[20]

Moore et al evaluated the relationship between diet and chronic kidney disease (CKD) in participants 20 years of age and older from the NHANES 2001-2008.[21] Compared to adults without CKD, the average protein intake was 1.3 g/kg ideal body weight (IBW)/d and was not different from stage 1 or stage 2 (1.28 and 1.25 g/kgIBW/d) but was significantly different in stage 3 and stage 4 (1.22 and 1.13 g/kgIBW/d). These values were to be above the Institute of Medicine requirements for healthy adults and the NFK-KDOQI guidelines for stages 3 and 4 CKD.[21]

Juraschek et al observed that in healthy adults with prehypertension or hypertension stage 1, when fed a diet consisting of 25% total energy intake from protein for six weeks did not decrease kidney function.[20] A diet rich in protein led to an increase in estimated glomerular filtration rate (eGFR).[20] Friedman et al found that a low-carbohydrate high-protein weight-loss diet consumed over two years by healthy obese subjects was not associated with decreased kidney function compared to a low-fat diet.[22] When estimating total, animal, dairy, and plant protein intake from the National Health and Nutrition Examination (NHANES) 2007-2010, Berryman et al found diets higher in plant and animal protein, independent of other diet factors, were associated with cardiometabolic benefits, especially improved central adiposity, with no decline in kidney function.[23]

Moller and researchers evaluated the effect of an increased protein intake on kidney function among pre-diabetic men and women 55 years of age and older.[24] No kidney function impairment among subjects consuming a high protein diet (25% total energy from protein) compared to a moderate protein diet (15% total energy from protein) for 1 year.[24]

Protein and Weight Management

The different effects of nutrients on human metabolism have been explored by researchers to identify optimal dietary composition for weight management. Astrup et al explored this assumption in obese families by assigning either a high (23-28% energy from protein), normal (10-15% energy from protein), or medium (control) protein diet for six months.[25] The high-protein diet was observed to be effective for preventing weight regain and for reducing weight in overweight children. However, genetic makeup should be taken into consideration.[25]

Since more middle-aged women (40-59 years) are overweight or obese in the U.S. compared to younger women (20-39 years), Aldrich et al evaluated the association between protein consumption and risk of weight gain among middle-aged women, mostly white and well-educated, using a national survey.[26] Most women could identify good protein sources and a majority could indicate the daily percent dietary energy recommended from protein. Eating more protein to prevent weight gain was reported by 43% and was also associated with weight loss over two years. Increasing knowledge regarding protein requirements could lead to proper education by health professionals for appropriate weight management strategies.[26]

Pasiakos et al found that adults randomly assigned to an energy-restricted diet consisting of either two times (1.6g/kg/d) or three times (2.4g/kg/d) the protein RDA for 31 days had a decreased loss of lean body mass and an increased loss of fat mass compared to controls consuming the dietary protein RDA.[27] Consumption of protein at levels beyond the RDA may be protective of lean muscle mass during short-term weight loss periods in physically active adults.[27]

Loenneke et al found that quality of protein may play a critical role in regulating central abdominal fat (CAF), which is a strong independent biomarker for disease and mortality, in healthy adults.[8] Quality protein was determined using the essential amino acid threshold for a meal, which occurs with about 9-10g. Consuming essential amino acids above this threshold has not been shown to significantly increase skeletal muscle mass. Quality protein consumed in a 24-hour period was inversely related with percent CAF, while no associations were found with intake of carbohydrate or fat with percent CAF. The frequency in which participants met the essential amino acid threshold for a meal throughout the day was inversely associated with percent CAF. This suggests that those who are energy-restricted may benefit from consuming increased quality protein sources, such as milk, eggs, or beef, leading to higher essential amino acid content per gram of protein.[8]

Due to the limited research on the effects of protein sources on satiety during weight loss, Neacsu et al conducted a study to assess self-reported satiety level of participants using a high-protein vegetarian diet or a high-protein meat-based diet for two weeks during weight loss in obese men.[28] The diets consisted of 30% protein, 30% fat, and 40% carbohydrate. Appetite control and weight loss (2.41 kg weight loss among vegetarian diet, 2.77 kg weight loss among meat-based diet) were similar between both high-protein weight loss diets and gut hormone profile was also similar, suggesting that vegetarian diets can be as effective for controlling appetite during weight loss.[28]

Protein and Mortality

Diets rich in animal products are typically high in protein, iron, and zinc; however, there are some potential adverse effects with excessive processed meat intake.[29] Excess meat intake, especially from processed sources, has been found to have a moderate, positive association with mortality.[29] Since processed meat is often treated by salting or curing to increase shelf life and/or improve taste, there is an increased intake of carcinogenic compounds. A study by Rohrmann analyzed European adults without current cancer, stroke, or heart attack and the risk of early death in relation to red, processed, and poultry meat intake.[29] There was a significant positive association between processed meat intake and mortality, especially due to cardiovascular diseases and cancer. Poultry consumption had no relation to mortality and researchers estimated that reducing processed meat intake to less than 20 g/day would prevent more than 3% of all deaths.[29]

Two prospective cohort studies indicated a relationship between red meat intake and mortality may exist.[30] Observation of men from the Health Professionals Follow-up Study and women from the Nurses' Health Study free of both cardiovascular disease and cancer showed increased risk of total, cardiovascular, and cancer mortality with greater red meat intake. Approximately 9.3% of deaths in men and 7.6% in women could have been prevented if subjects consumed less than 42 g/day of red meat.[30]

Another study involving the same two cohorts examined the association of animal and plant protein intake with mortality.[31] The positive association between mortality and animal protein, and the inverse association for plant protein were both confined to individuals who engaged in unhealthy lifestyle behaviors such as smoking, excessive alcohol consumption, inactivity, and poor diet. However, the association with animal protein did not reach statistical significance.[31] The substitution of plant protein for animal protein, especially processed red meat, was associated with a lower risk of mortality (0.90 per 3% energy increment replaced with plant protein). Effects of different types of protein may be enhanced by other unhealthy lifestyle factors and become evident with underlying inflammatory or metabolic disorders, making red meat intake not the only factor increasing all-cause mortality.[31]

Tharrey and researchers found subjects that consumed greater amounts of 'Meat' or 'Processed Foods' had greater risk of CVD mortality.[32] These subjects also had greater BMIs and were more likely to be physically inactive, smokers, and alcohol users compared to subjects with lower intake. After controlling for lifestyle confounders, subjects that consumed greater amounts of 'Meat' had a 61% increased risk of CVD mortality, while subjects that consumed greater amounts of ‘Nuts & Seeds’ had a lower risk. Additionally, subjects aged 25-44 had a 2-fold higher relative risk among the ‘Meat’ factor and almost a 3-fold lower relative risk among the ‘Nuts & Seeds’ factor. These results suggest an increased risk of CVD mortality with red and processed meat intake and a potential protective effect of nuts and seeds on CVD risk.[32]

Nutrition Knowledge and Sources of Information

The level of nutrition knowledge has been shown to vary according to demographic factors.[5] Factors such as age, sex, ethnicity, level of education, and socio-economic status tend to influence nutrition knowledge and awareness. Women, especially middle-aged women, seem to have more nutrition knowledge than men, which may be due to the larger role of women in food purchasing and preparation or men’s typically low interest in nutrition. People with higher education or socioeconomic status tend to have more nutrition knowledge.[5]

In a survey from the University of Minnesota’s School of Public Health and Medical School, approximately one-third of young adults reported using Nutrition Facts Labels.[33] Women who are overweight, physically active, have higher education and income, and those who regularly prepare food, have a greater likelihood of reading the Nutrition Facts Labels. Adults that did read Nutrition Facts Labels had better dietary patterns and were concerned with sugars, calories, and serving size. These results indicated which young adults use nutrition labels, which parts they read, and the association with food intake. Taken together, these factors can help identify strategies to support young adults in proper dietary choices.[33]

In a cross-sectional survey that examined the association between nutrition knowledge and fat consumption in college students (71% female, 29% male) with a mean age of 20 years, Yahia and researchers found that nutrition knowledge was negatively associated with saturated fat and cholesterol intake.[34] Those who consumed more than 35% of energy from fat or more than 300 mg of cholesterol per day had lower nutrition scores compared to those with lower fat or cholesterol intake. Female students had greater nutrition knowledge than men. These results support the need for nutrition education to increase nutrition knowledge and to promote healthy eating behaviors.[34]

In a convenience sample of male non-athlete college students interviewed on protein knowledge/behavior, most participants were unaware, misinformed, and using dietary supplements.[35] The participants with low protein intake (less than 0.8 g/kg per day), had greater body fat percentages, waist circumference, and BMI's, which has been linked to increased risk of morbidity. Increasing nutrition education among the college population may serve as an important factor for identifying target preventative measures.[35]

One study by Krolak et al examined if nutrition knowledge and perception of dietary fiber influenced the type of bread consumed by adults with a mean age of 47.6 years (standard deviation 4.43).[36] Approximately 35% of the participants had education lower than secondary, 36.5% had secondary education, and 27.9% graduated from university. Participants of the survey with more nutrition knowledge perceived more benefits of consuming fiber-fortified cereal products. Nutrition knowledge influenced familiarity and consumption of fiber-enriched bread to a greater degree than frequency of whole meal bread consumption. These results indicate the importance of increasing nutrition knowledge and addressing perceptions to increase fiber-rich bread intake and other dietary recommendations.[36]

Spendlove and researchers found that a dietetic-trained cohort, consisting of undergraduate and postgraduate dietetic interns with high-level nutrition experience, had more nutrition knowledge compared to elite Australian athletes and a similar aged community.[37] The majority of participants in each cohort were female. The average age of the elite athlete cohort was 18.9 years, while the community cohort was 21.9 years. The overall score on the nutrition knowledge questionnaire was influenced by age, sex, and athletic caliber, but not by education level, living situation, or ethnicity.[37]

When looking at the association between weight and nutrition knowledge in obese Brazilian subjects, Valmorbida et al found that BMI had a significant inverse association with number of correct answers on a test.[38] A significant inverse association was also observed between BMI and education, as well as female gender. Additionally, more than 60% of obese subjects reported using the T.V., with 23% using the newspaper, as sources of nutrition information. These results underscore the importance of nutrition knowledge in overall health, as well as education on reliable sources of nutrition information.[38]

When evaluating Internet use for nutrition information among Australian subjects, Pollard and Meng found an increase in proportion of subjects using Internet for nutrition information from <1% in 1995-2001 to 33.7% in 2012.[9] Subjects who used the Internet for nutrition information were more likely to be female, live in a metropolitan area, born in countries other than Australia/UK/Ireland, more educated, and less likely to be older (55-64 years). Those using Internet as a source of information were more likely than nonusers to want quicker ways to prepare healthy foods and information on choosing healthy foods. Although much has changed in regards to nutrition information sources on the Internet, these findings may have implications for policy makers and practitioners and suggest that traditional health promotion tactics should continue to be used to reach the broader population.[9]

Huberty and Dinkel distributed a survey, which showed that U.S. women used the Internet for health information during their pregnancy.[39] Women that reported an increase in exercise during pregnancy relied on the Internet for decision making compared to women who decreased or maintained exercise levels during pregnancy. These findings were similar for nutrition, however, no differences in confidence levels of proper dietary intake were observed in regard to changes in foods eaten.[39] The findings from these studies have implications for policy makers and practitioners and suggest that traditional health promotion tactics should continue to be used to reach the broader population.[39]

Protein Attitudes and Behaviors - Athletes

Nutrition is a critical component of athletic performance and recovery; yet little is known about athlete's dietary behaviors or knowledge of dietary recommendations. Doering et al investigated the knowledge of post-exercise nutrition, as well as normal intakes of carbohydrate and protein, between Australian masters ($\geq$ 50 years) and young ($\leq$ 30 years) triathletes through administration of an online survey.[40] Approximately 43% of all triathletes answered, "I don't know" when asked about recommended post-exercise carbohydrate and protein intakes. Among all athletes, post-exercise protein consumption was similar between groups, but masters consumed significantly less relative to body mass. Australian triathletes have poor recovery nutrition knowledge, leading to lower than recommended self-reported intakes post-exercise, which may lead to submaximal performance.[40]

The sources and distribution patterns of protein throughout the day also has a crucial role in athletic performance.[41] Gillen et al identified energy intake, animal and plant protein intake, and protein patterns in a large cohort of 553 athletes (between 12 and 62 years; 327 male, 226 female), consisting of elite Dutch strength, endurance, and team-sport athletes over a two to four-week period.[41] Protein consumption (g) from nutritional supplement was determined for each participant and defined as athletes consuming $\geq$ 10g of protein/d from supplements. The contribution of dietary protein and supplemental protein was calculated for participants that used supplements, while dietary protein intake was calculated for participants that did not use supplements. The average daily intake was 1.5g/kg in men and 1.4g/kg in women, while animal and plant protein intakes were 57% and 43%. However, protein intake was below the recommended 20 grams in 58% of all athletes at breakfast, 36% at lunch, and 8% at dinner. Protein supplements were used in 16% of strength athletes, 7% of team sports athletes, and 11% of endurance athletes. Among all athletes, average protein intake was 1.5 ± 0.4 g/kg BW/d in non-supplement users and 1.7 ± 0.5 g/kg BW/day in supplement users. Although athletes consumed >1.2 g/kg/d, protein distribution throughout the day may be preventing maximal skeletal muscle adaptation to training.[41]

Protein Attitudes and Behaviors - Adults

Although protein consumption in the U.S. has not been of concern, potential inadequacy of recommendations or distribution patterns of protein intake in older adults has gained attention.[42] Datum was evaluated from adults 51 years of age and older using NHANES 2005-2006, the Food and Nutrient Database for Dietary Studies, and the U.S. Department of Agriculture Standard Reference datasets.[42] Average protein intake for men was 94g/kg/day and 56g/kg/day for women, with animal sources providing more than 60% of protein intake. Furthermore, total and animal protein consumption was skewed to evening meals and animal source amount was a predictor for protein intake. These findings suggest the need for careful consideration of sources of protein for adults with a risk of inadequacy and more research is needed to identify the best protein sources, intakes, and patterns.[42]

Another study in adults over the age of 19 using data from NHANES 2007-2010 indicated average animal, dairy, and plant protein intakes were 46%, 16%, and 30%, respectively.[43] The primary food sources of animal proteins were chicken and beef, while cheese, milk, and ice cream were the primary sources of dairy protein. The primary sources of plant proteins were yeast breads, nuts, and seeds.[43]

Hartmann et al examined motives for protein supplementation use in physically active adults between the ages of 20 and 60 years in an online survey by comparing beliefs of users and non-users.[44] The most common reasons women took protein supplements were to increase muscle mass and to regulate weight, while in men, to increase muscle mass and promote regeneration of muscle mass after training. Both users and non-users perceived protein supplementation as a strategy to modulate muscle mass, while health and well-being effects were more dominant among users. The health and well-being beliefs were associated with higher likelihood of increased supplementation intake frequency, while exercise level had no association. A better understanding of protein supplementation is needed to prevent misguided health beliefs.[44]

In a non-validated online survey distributed by the University of Arkansas and social media, Neumann and Baum explored attitudes, preferences, and knowledge regarding nutrition, with dietary protein being emphasized.[45] The sample consisted of mostly 18- to 24- year old, white, females, with 7% being vegetarian/vegan and 53% having taken at least one nutrition class. Most participants indicated consumption of protein on a daily basis and that the primary barriers preventing consumption were cost and convenience. In regards to protein research, all participants responded that protein, in general, is good for human health. Overall, the survey population believed that protein has health benefits, but cost and convenience were barriers to regular consumption.[45]

Animal vs. Plant Protein

Consumer motives underlying sustainable and healthy diets are not well recognized but are crucial for identifying appropriate and effective interventions. Vainio et al examined the influence of eating motives on consuming less animal protein and more plant protein in Finnish consumers (between the ages of 15 to 63 years) through an online questionnaire.[10] Motives included environmental concerns, health, and weight control, while convenience and price were of less concern, among those with an established diet including beans and soy products compared to beef-only eaters. Individuals undergoing dietary change to replace animal protein with plant protein displayed greater levels of environmental concerns, as well as health, sociability, social image, and price motives than those on the established plant diet. Eating motives are crucial to understanding when shifting to food patterns where animal protein is replaced with plant protein.[10]

The attitudes and beliefs regarding vegetarianism and meat consumption in the Belgian population (50.8% male, 49.2% female) was observed by Mullee et al using an online questionnaire.[46] Approximately 20.8% of participants had low levels of education, 39.1% intermediate, and 40% high. Vegetarians were more likely than semi-vegetarians to think meat production is harmful to the environment and meat intake is not healthy. Reasons for not being vegetarian included “no interest, no awareness, taste, and limited cooking skills”, while “health and new taste discoveries” were the most important motives for considering more of a vegetarian-based diet. About 25% of all participants believe eating vegetarian food often is not healthy, which illustrates the need for education, particularly for regular meat eaters.[46]

In a study by Pfeiler et al observing personality traits and attitudes in Germans (52.3% female, 47.7% male; mean age of 51.84 years) following a vegetarian diet, vegetarians were most likely to be young, educated females and also have a higher income compared to meat eaters.[47] Differences were also observed in personality traits, political attitudes, and health-related variables between vegetarians and meat eaters. Individuals with higher scores in openness and political interest had a higher likelihood of being vegetarian, while those with higher scores in conscientiousness and conservatism were less likely. This study concluded individual differences exist between vegetarians and meat eaters, especially in socio-demographics, personality traits, and political attitudes.[47]

Pfeiler conducted another study to examine the personality traits, political attitudes, and environmental attitudes of German meat eaters (52.5% female, 47.5% male’ mean age of 52.25

years).[48] Young, less educated men were more likely to consume meat. Furthermore, openness, agreeableness, and conscientiousness among all participants were negatively associated with meat consumption, while those scoring high in right-wing attitudes and low in pro-environmental attitudes reported more meat intake. Socio-demographics, personality traits, and attitudes were found to be related to meat intake in these individuals.[48]

Clonan and Wilson investigated meat intake behaviors in relation to perceived impacts on human health, animal welfare, and the environment in UK consumers between the ages of 18 to 91 years old.[49] Women were found to be significantly more likely to consume $\leq$1 portion of meat per day compared to men, while females and consumers over the age of 60 were more likely to have positive attitudes towards animal welfare. Positive attitudes towards animal welfare were associated with less meat consumption and greater frequency of purchasing 'higher welfare' meat. High welfare meat includes animals that have come from farmers that focus on the animal's natural behaviors in fresh air and natural sunlight, and only provide antibiotics when deemed necessary. Less than a fifth thought consuming less meat would improve climate change. Human health and animal welfare are more common motives to avoid red and processed meat than environmental sustainability.[49]

Summary

Dietary protein is essential for human health and has various benefits across sub-populations. Benefits of dietary protein have been observed among resistance athletes, adults, older adults, and individuals that are overweight/obese.[7,8,12] Different effects of dietary protein in diabetes and mortality depend on the type of protein consumed (animal vs. plant).[17-19] Nutrition knowledge among the general public plays a role in perception and dietary intake.[5] Studies included in this literature review indicate general nutritional knowledge about protein consumption is inversely associated with dietary recommendation compliance and may be dependent on various factors. It is crucial to identify protein knowledge in the general public to identify areas of knowledge deficiency, especially in relation to both protein attitudes and behaviors. This knowledge will facilitate the design and development of education tools to increase awareness, and decrease the misconceptions currently associated with dietary protein. Interventions targeting various factors, eating motives, personality traits, political attitudes, and views on animal welfare may also lead to improved understanding of evidence-based dietary protein recommendations.

CHAPTER III

METHODOLOGY

Institutional Review Board

This study was approved by the Institutional Review Board at Texas Woman's University prior to the collection of data. Informed consent was collected from each student before their participation in the survey. Collected data was de-identified except for the nutrition and education students used for the knowledge questions. A copy of the IRB approval letter and consent form for this study can be found in the Appendix.

Sample and Recruitment

In the Fall 2018 semester, a convenience sample of participants were recruited through an open call email sent to undergraduate and graduate students attending Texas Woman's University, Denton, TX. The email informed potential participants of the study's purpose, eligibility requirements, and link to the online Dietary Protein Assessment Survey (DPAS) survey. Eligibility requirements included individuals who were 18 years or older and had a reliable Internet source. Data was collected from nutrition students enrolled in a junior level nutrition class for the knowledge section. Participants were recruited with the help of professors and researchers to voluntarily complete the survey. Additionally, the online survey link was posted on social media sites and spread by word of mouth for further recruitment. In the Spring 2019 semester, data was collected from non-nutrition majors enrolled in a junior level education class as a comparison group for the knowledge section present in the online survey. Approval of the study was obtained from Texas Woman's University Institutional Review Board, Denton TX.

All participants gave informed consent while completing the survey. There were no incentives except for the nutrition and education students used for the survey knowledge questions receiving course extra credit.

Survey Instrument

The principal purpose of the survey was to provide an assessment of individuals' knowledge, attitudes, and behaviors toward dietary protein. The online Dietary Protein Assessment Survey was developed using principles from Don Dillman's and, Robert Wildman's books,[1,2] and journal articles on dietary protein obtained from reliable online resources such as PubMed.[3-9] These resources assisted with creating the knowledge, attitudes, and behavior questions by identifying the most important contemporary issues, controversies, and misinformation surrounding protein. Additionally, the knowledge, attitude, and behavior questions addressed protein safety, quality, requirements, and recommendations.

The DPAS used in this exploratory study consisted of sixty-four questions on the knowledge, attitudes, and behaviors toward dietary protein with an additional 8 demographic questions. The knowledge questions consisted of three answer choices (true, false, unsure); attitude questions included a 5-point Likert scale ranging from "strongly disagree = 1" to "strongly agree = 5" with a neutral midpoint; behavior questions consisted of multiple-choice answer options.

Nutritional science researchers, including an expert in protein, reviewed the survey for applicability, structure, reading level, and comprehension. The survey was then updated according to feedback. Cognitive interviews were conducted using individuals with no nutrition background to assess information processing needs of the survey items. The survey was then reviewed by researchers and statisticians to identify appropriate scaling of answer choices. The survey was then updated to create the final version prior to distribution. The survey was administered using PsychData and participants were allowed one session to complete the survey.

Data Analysis

Exploratory factor analysis (EFA) with principal axis factoring and a promax rotation was performed on the 14 attitude questions to identify the dimensionality of the attitude constructs for two-hundred twenty-five subjects. The correlation matrix was examined for items exhibiting multicollinearity. Criteria for factor retention included factors greater than or equal to |0.4| and factors comprised of 2 or more items. Composite scores for the factors were calculated according to their factor loadings. Internal consistency reliability was examined using Cronbach's alpha. The survey responses were then compared across gender, education, and race/ethnicity using an ANOVA and adjusted for multiple comparison using the Turkey-Kramer adjustment. A p-value of <0.05 was considered statistically significant for all analyses.

The knowledge questions were evaluated for construct validity by comparing mean scores between nutrition and non-nutrition majors using an independent *t*-test. The knowledge questions consisted of three answer choices: yes, no, unsure. The correct answers were totaled for each student to determine the mean scores. The answers marked "unknown" were given a value of zero and did not contribute to overall mean scores.

CHAPTER IV

RESULTS

Exploratory Factor Analyses for Attitudes Towards Protein

Four hundred seventy responses were received and 450 provided complete demographic data. The majority of participants were female (87%) and the mean age was 28.2 $\pm$ 11.4y. Racial/ethnic representation included: 65% Caucasian, 17% Hispanic, 12% African American, 8% Asian/Pacific Islander, 3% American Indian, and 2% Other. Self-reported health status included: 79% healthy, 26% overweight/obesity, 2% diabetes, 6% high cholesterol, 4% high blood pressure, and 1% chronic kidney disease. The distribution of the respondents' education levels was as follows: 13% high school, 19% some college or technical training, 15% Associate's degree, 34% Bachelor's degree, and 20% Graduate degree. See **Table 1** for complete demographic information of participants.

Exploratory Factor Analysis #1

A random partition of the full dataset included 225 participant responses for this analysis. Seventy-four percent of participants provided complete responses for the attitude questions. The majority of participants were female (91%) and the mean age was 27.8 $\pm$ 11.7y. Racial/ethnic representation included: 66% Caucasian, 15% Hispanic, 12% African American, 8% Asian/Pacific Islander, 3% American Indian, and <1% Other. Self-reported health status included: 81% healthy, 25% overweight/obesity, 1% diabetes, 5% high cholesterol, 2% high blood pressure, and 1% chronic kidney disease. The distribution of the respondents' education levels was as follows: 14% high school, 21% some college or technical training, 13%

Associate's degree, 33% Bachelor's degree, and 19% Graduate degree. See **Table 1** for complete demographic information of participants.

One was performed on this sample. This data exhibited good sample adequacy (KMO = 0.81) and the correlation matrix was suitable for structure detection (Bartlett's Test < 0.001). There was some evidence of multicollinearity observed within the correlation matrix (determinant = 0.006). A total of five items did not meet the inclusion criteria (primary factor loading $\geq |0.4|$) and were removed for the subsequent exploratory factor analysis. Four factors were retained and explained 62.3% of the total variance. See **Table 2** for variance explained by each factor.

Factor 1 included 3 items related to animal protein sources and their relationship with human health. Factor 2 included 2 items related to animal protein sources and their relationship with environmental health. Factor 3 included 2 items pertaining to the healthfulness of organic protein sources. Factor 4 included 2 items describing the adequacy of the RDA for protein with respect to weight loss and adherence to a vegetarian diet. Factor 1 shared a moderate, inverse relationship with Factor 2 (r = -0.657), a moderate, positive relationship with Factor 3 (r = 0.470), and a weak, inverse relationship with Factor 4 (r = -0.275). Factor 2 shared a moderate, inverse relationship with Factor 3 (r = -0.401) and a weak, positive relationship with Factor 4 (r = 0.315). Factor 3 shared a weak, inverse relationship with Factor 4 (r = -0.305) (see **Table 3**).

Cronbach's alpha coefficient for factor 1 (α = 0.86) factor 2 (α = 0.85), and factor 3 (α = 0.80) exhibited evidence of good internal consistency. Satisfactory internal consistency was observed for factor 4 (α = 0.62).

Exploratory Factor Analysis #2

A total of 205 respondents were included for analysis. Sixty-seven percent of participants provided complete responses for the attitude questions. The majority of participants were female (84%) and the mean age was 28.5 $\pm$ 11.7y. Racial/ethnic representation included: 65% Caucasian, 19% Hispanic, 12% African American, 7% Asian/Pacific Islander, 3% American Indian, and 2% Other. Self-reported health status included: 77% healthy, 27% overweight/obesity, 2% diabetes, 7% high cholesterol, 5% high blood pressure, and 1% chronic kidney disease. The distribution of the respondents' education levels was as follows: 12% high school, 16% some college or technical training, 16% Associate's degree, 35% Bachelor's degree, and 21% Graduate degree. See **Table 1** for complete demographic information of participants.

One Exploratory Factor Analysis (EFA) was performed on this sample. The data demonstrated good sample adequacy (KMO = 0.76) and the correlation matrix was suitable for structure detection (Bartlett's Test < 0.001). The correlation matrix was examined for items exhibiting extreme multicollinearity (determinant = 0.007). There was some evidence of multicollinearity observed among the statements of "meat consumption is unhealthy" and "meat should not be consumed" ($r = -0.902$). Three factors were retained, which were comprised of the nine items remaining from EFA #1 and explained 73.9% of the total variance. See **Table 4** for variance explained by each factor. All items displayed a factor loading $\geq |0.4|$.

Factor 1 included 5 items related to animal protein sources and their relationship with human and environmental health. Factor 2 included 2 items pertaining to the healthfulness of organic protein sources. Factor 3 included 2 items describing the adequacy of the RDA for protein with respect to weight loss and adherence to a vegetarian diet. Factor 1 shared a moderate, inverse relationship with Factor 2 ($r = -0.467$), and a weak, positive relationship with Factor 3 ($r = 0.291$). Factor 2 shared a weak, inverse relationship with Factor 3 ($r = -0.187$) (See **Table 5**). The mean factor scores adjusted for number of questions are presented in **Table 6.**

Cronbach's alpha coefficient for Factor 1 ($\alpha = 0.87$) and Factor 2 ($\alpha = 0.83$) displayed evidence of good internal reliability. Satisfactory internal reliability was observed for Factor 3 ($\alpha = 0.65$).

Table 1
Participant Demographics (Exploratory Factor Analysis)

Variable	**Total Sample** (*n* = 450)	**EFA #1** (*n* = 225)	**EFA #2** (*n* = 225)	***p* value**
Age *n* (mean ± sd)	28 ± 11.4	28 ± 11.7	29 ± 11.0	0.3660
Gender *n* (%)				
Female	393 (87)	205 (91)	188 (84)	0.0227
Race *n* (%)				
Caucasian	294 (65)	148 (66)	146 (65)	0.9211
Hispanic	77 (17)	34 (15)	43 (19)	0.3167
African American	55 (12)	28 (12)	27 (12)	1.00
Asian/Pacific Islander	34 (8)	19 (8)	15 (7)	0.5932
American Indian	13 (3)	6 (3)	7 (3)	1.00
Other	7 (2)	2 (1)	5 (2)	0.4494
Health Status *n* (%)				
Healthy	356 (79)	182 (81)	174 (77)	0.4170
Overweight/Obese	117 (26)	57 (25)	60 (27)	0.8299
Diabetic	7 (2)	3 (1)	4 (2)	1.00
High Cholesterol	26 (6)	11 (5)	15 (7)	0.5452
CKD	3 (1)	2 (1)	1 (<1)	1.00
High Blood Pressure	16 (4)	5 (2)	11 (5)	0.2019
Education *n* (%)				0.5857
High school	57 (13)	31 (14)	26 (12)	
Some college	84 (19)	47 (21)	37 (16)	
Associate's Degree	66 (15)	29 (13)	37 (16)	
Bachelor's Degree	153 (34)	75 (33)	78 (35)	
Graduate Degree	90 (20)	43 (19)	47 (21)	

CKD, Chronic Kidney Disease

Table 2
Exploratory factor analysis pattern and structure matrices with communalities and explained variance by each factor (n = 225)

Items by factor	Pattern matrix	h^2	Structure matrix	Explained variance
Factor 1: Human Health				32.4%
Egg consumption is harmful to human health	0.832	0.550	0.730	
Meat consumption is unhealthy	0.867	0.810	0.898	
Meat should not be consumed	-0.832	0.705	-0.837	
Factor 2: Environmental Health				10.7%
The impact of climate change can be reduced by consuming less meat, dairy, & eggs	0.791	0.692	0.822	
Meat production is harmful to the environment	0.922	0.824	0.906	
Factor 3: Organic Sources				10.5%
Organic protein sources are better for the environment.	0.766	0.596	0.764	
Organic protein sources are healthier	0.906	0.758	0.861	
Factor 4: Protein RDA				8.7%
The RDA for protein is adequate for healthy weight loss	0.675	0.419	0.635	
The RDA for protein is adequate for people following a vegetarian diet	0.655	0.554	0.719	

h^2 denotes the communalities; **RDA,** Recommended Dietary Allowance

Table 3
Pearson's correlations among retained factors representing college students' attitudes toward dietary protein (EFA #1)

	1	2	3	4
1. Human Health	1.00			
2. Environmental Health	-0.657	1.00		
3. Organic Sources	0.470	-0.401	1.00	
4. Protein RDA	-0.275	0.315	-0.305	1.00

Table 4

Exploratory factor analysis pattern and structure matrices with communalities and explained variance by each factor (*n* = 225)

Items by factor	Pattern matrix	h^2	Structure matrix	Explained variance
Factor 1: Human/Environmental Health				44.6%
The impact of climate change can be reduced by consuming less meat, dairy, & eggs	0.736	0.486	0.691	
Meat production is harmful to the environment	0.852	0.632	0.788	
Egg consumption is harmful to human health	-0.537	0.386	-0.609	
Meat consumption is unhealthy	-0.876	0.808	-0.898	
Meat should not be consumed	0.814	0.760	0.867	
Factor 2: Organic Sources				15.5%
Organic protein sources are better for the environment	0.672	0.585	0.750	
Organic protein sources are healthier	1.011	0.915	0.950	
Factor 3: Protein RDA				13.8%
The RDA for protein is adequate for healthy weight loss	0.587	0.332	0.569	
The RDA for protein is adequate for people following a vegetarian diet	0.835	0.721	0.848	

h^2 denotes the communalities; **RDA,** Recommended Dietary Allowance

Table 5

Pearson's correlations among retained factors representing college students' attitudes toward dietary protein (EFA #2)

	1	2	3
1. Human/Environmental Health	1.00		
2. Organic Sources	-0.467	1.00	
3. Protein RDA	0.291	-0.187	1.00

Table 6

Mean factor scores adjusted for number of questions

Variable	**Mean ± sd**
Factor1	1.14 ± 3.8
Factor 1 Positive	6.89 ± 2.6
Factor 1 Negative	5.72 ± 1.4
Factor 2	4.27 ± 1.8
Factor 3	4.66 ± 1.3

Factor 1 Positive, mean score for items that contribute positively to factor 1, calculation: [(attitude 1 + attitude 2 + attitude 14) /3]

Factor 1 Negative, mean score for items that contribute negatively to factor 1, calculation: [(attitude 7 + attitude 13)/2)

Knowledge Towards Protein

A total of 55 nutrition undergraduate students and 52 non-nutrition (education) undergraduate students' responses were analyzed. The majority of participants were female (95%) and the mean age was 27.9 ± 11.2y. Racial/ethnic representation included: 62% Caucasian, 22% Hispanic, 11% Asian/Pacific Islander, 8% African American, 3% American Indian, and 2% Other. Health status included: 74% healthy, 27% overweight/obese, 4% diabetic, 2% high cholesterol, and <1% for both chronic kidney disease (CKD) and high blood pressure (BP). The distribution of the respondents' education levels was as follows: 4% high school, 28% some college or technical training, 58% Associate's degree, 7% Bachelor's degree, and 3% Graduate degree. See **Table 7** for complete demographic information.

The nutrition students mean test score was 66.4 ± 11.5% with scores ranging from 42% to 92%. The non-nutrition students mean test score was 47.6 ± 16.4% with scores ranging from 17% to 79%. A significant difference in mean test score values was observed between nutrition and non-nutrition students (18.8 ± 14.1; $p < 0.0001$). Cohen's d indicated a large, standardized difference between nutrition and non-nutrition mean scores ($d = 1.33$).

Table 7
Participant Demographics (Knowledge)

Variable	Total Sample (*n* = 106)	Nutrition Students (*n* = 55)	Non-Nutrition students (*n* = 51)	***p* value**
Age mean ± sd	27.9 ± 11.2	30.1 ± 13.5	25.5 ± 7.5	0.0333
Gender *n* (%)				
Female	102 (95)	50 (91)	52 (100)	0.0572
Race *n* (%)				
Caucasian	66 (62)	33 (60)	33 (63)	0.8425
African American	9 (8)	6 (11)	3 (6)	0.4901
Hispanic	24 (22)	10 (18)	14 (27)	0.3552
American Indian	3 (3)	1 (2)	2 (4)	0.6110
Asian/Pacific Islander	12 (11)	9 (16)	3 (6)	0.1249
Other	2 (2)	1 (2)	1 (2)	1.00
Health Status *n* (%)				
Healthy	79 (74)	46 (84)	33 (63)	0.0270
Overweight/Obese	29 (27)	11 (20)	18 (35)	0.1273
Diabetic	4 (4)	2 (4)	2 (4)	1.00
High Cholesterol	2 (2)	0	2 (4)	0.2338
CKD	1 (.93)	1 (.93)	0	1.00
High Blood Pressure	1 (.93)	1 (.93)	0	1.00
Education *n* (%)				0.0578
High school	4 (4)	1 (.93)	3 (6)	
Some college	30 (28)	16 (29)	14 (27)	
Associate's Degree	62 (58)	28 (51)	34 (65)	
Bachelor's Degree	8 (7)	7 (13)	1 (2)	
Graduate Degree	3 (3)	3 (5)	0	

CKD, Chronic Kidney Disease

CHAPTER V

DISCUSSION AND CONCLUSIONS

Studies that aim to identify knowledge and attitudes towards specific macronutrients, such as dietary protein, are lacking.[43-48,50] Currently, no validated questionnaires exist that attempt to measure the knowledge and attitude constructs of dietary protein among the college student population. In general, survey instruments administered to subjects often lack validity and reliability.[45] Therefore, the aim of this study was to develop a questionnaire to measure dietary protein knowledge and attitudes called the Dietary Protein Assessment Survey (DPAS) and provide preliminary evidence of the questionnaire's validity for the knowledge construct and explore the attitude construct's dimensionality.

The EFA identified a multidimensional structure and that the original 14 attitude items could be shortened by 5 items without decreasing internal reliability. Five items loaded strongly with human/environmental health (Factor 1). Items contributing positively to the Factor 1 score include 'meat production is harmful to the environment,' 'meat should not be consumed,' and 'the impact of climate change can be reduced by consuming less meat, dairy products, and eggs.' Items contributing negatively to the Factor 1 score include 'meat consumption is unhealthy' and 'egg consumption is harmful to human health.' The inverse contributions of the items 'meat consumption is unhealthy' and 'meat should not be consumed to the overall Factor 1 score may provide evidence that college students' do not consider health when determining food items that should and should not be consumed. Organic sources (Factor 2) were comprised of 2 items, which provides evidence that college students agree organic sources of protein are healthier and better for the environment. Although the exact extent is unknown, this shows that college students place some value on organic protein sources. Protein RDA (Factor 3) was also comprised of 2 items, which provides evidence that college students believe the RDA for protein is adequate for healthy weight loss and for people following a vegetarian diet. The factor structure provides evidence that attitude constructs towards dietary are multidimensional. Future development of the survey should further develop the attitude constructs. An analysis of the relationship between nutrition information sources and the attitude constructs would be beneficial to identify how college students' attitudes towards protein are influenced. Additionally, adding more items within Factor 2 and Factor 3 will help to define the factors and may strengthen the correlations observed among the protein attitudes measured.

The factors displayed adequate reliability ($\alpha \geq 0.70$).[50] Evidence of good internal reliability was observed among Factor 1 (human/environmental health) and Factor 2 (organic sources). Factor 3 (protein RDA) displayed satisfactory internal reliability, which is likely due to small number of items.[50] Future development of the survey should focus on increasing the DPAS internal reliability, such as using more clear and concise wording and adding items to assess attitudes towards the adequacy of the protein RDA. These improvements may potentially improve the survey's internal reliability for future studies.

The mean factor scores adjusted for the number of items that contribute negatively and positively to the mean total Factor 1 score are displayed in **Table 6**. These results provide evidence that college students agree more that the healthfulness of meat intake is greater than attitudes on the impact of climate and if meat should not be consumed. The college students in this study appear to place a greater emphasis on human health than environmental health, which provides guidance for future survey development in order to provide confirmation for effective intervention tools.

The significant difference in mean test scores between the undergraduate nutrition students and the undergraduate non-nutrition (education) students indicated that the DPAS instrument had adequate construct validity. The nutrition students' overall mean test score was greater than the non-nutrition students, which has been observed in previous studies.[50-55] The mean test score of nutrition students observed in the current study was lower than those observed in previous studies.[52,54,55] This may be due to many factors, such as administering the survey without prior notice, or wording of the knowledge statements. It is also important to note that the content of the previous studies knowledge questions was not exclusively about protein, but included topics related to general nutrition and salt knowledge among both the adult and student populations.[52-55]

While studies have shown dietary pattern can be influenced by eating motives and the perceived impacts on human health and the environment, more research is needed.[10,46-49] With further development, the DPAS may be used to identify knowledge and attitudes towards dietary protein on the topics of human/environmental health, organic sources, and adequacy of the RDA, as well as other topics needed to capture the full nature of people's dietary protein attitudes. It is crucial to identify protein knowledge, especially in relation to protein attitudes, to identify areas of knowledge deficiency and to explore the effects of interventions.

Due to the increased popularity of social media platforms, there has been a commensurate rise in the amount of false nutrition information presented to the general public.[9,39] The lack of "media literacy" may contribute to this wide range of false nutrition information. Therefore, it is necessary to create valid instruments, such as the DPAS, in order to assess attitudes and knowledge towards protein among the general public. Identifying knowledge and attitudes towards protein will facilitate the design and development of education tools to increase awareness and decrease the misconceptions currently associated with dietary protein.

Interventions targeting various factors, such as eating motives and reliable nutrition sources, may also lead to improved understanding of evidence-based dietary protein intake.

The strengths of this study include sample sizes, internal consistency of the items, and utilizing the evidence-based approach for survey development; however, several limitations exist. Although participants were homogenous in gender, age, and race, results may not be generalizable to other settings and populations. Therefore, it is important to examine validity in a more diverse adult population before conducting broader population studies. Just like any self-reported item, this study is also limited by the truthfulness of participants. Satisfactory internal reliability ($\alpha \leq 0.70$) was also identified in Factor 3, which may provide evidence of inconsistent answers to attitude questions regarding protein RDA.[49] Future studies should focus on increasing internal reliability of the DPAS by adjusting the number of items, rewording questions, and reformatting the questionnaire. Additionally, future studies should examine this instrument's validity in a more varied population that includes differences among participant demographics, as well as provide more complex measurements to explore the multidimensionality of attitude constructs.

In summary, the results of this study provide preliminary evidence for the attitudes' and knowledge constructs validity within the DPAS to be used among the college student population. However, the questionnaire and, in particular, the topic on "protein RDA" requires further development. Attitudes towards dietary protein seem to be multidimensional and correlated. Additional testing is needed to confirm the 3-factor model and to estimate test-retest reliability of the DPAS. A multidimensional approach seems crucial for both future development of the DPAS, as well as for effective interventions by professionals that aim to improve attitudes and increase knowledge towards dietary protein. Future development should focus on increasing internal reliability by adjusting number of items, rewording questions, and reformatting the questionnaire.

This will allow the DPAS to be administered to more varied populations, which will enable researchers to identify misconceptions towards dietary protein, which may ultimately improve the health of adults.

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APPENDIX A

Institutional Review Board, Texas Woman's University Approval

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
https://www.twu.edu/institutional-review-board-irb/

DATE: June 12, 2018

TO: Ms. Parker Ackerman
Nutrition & Food Sciences

FROM: Institutional Review Board (IRB) - Denton

Re: Exemption for The Relationship Between Knowledge, Attitudes, and Behaviors Toward Dietary Protein Among Adults (Protocol #: 20158)

The above referenced study has been reviewed by the TWU IRB (operating under FWA00000178) and was determined to be exempt from further review.

If applicable, agency approval letters must be submitted to the IRB upon receipt PRIOR to any data collection at that agency. Because a signed consent form is not required for exempt studies, the filing of signatures of participants with the TWU IRB is not necessary.

Although your protocol has been exempted from further IRB review and your protocol file has been closed, any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All forms are located on the IRB website. If you have any questions, please contact the TWU IRB.

cc. Dr. Shane Broughton, Nutrition & Food Sciences
Dr. Nancy DiMarco, Nutrition & Food Sciences
Graduate School

APPENDIX B

Consent to Participate in Research Form

TEXAS WOMAN'S UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Title: The Relationship Between Knowledge, Attitudes, and Behaviors Toward Dietary Protein Among Adults

Principal Investigator: *Parker Ackerman, packerman@twu.edu*
Faculty Research Advisor: *Cynthia Warren, PhD, 940-898-2647, cwarren2@twu.edu*

Explanation and Purpose of the Research

You are being asked to participate in a research study for Parker Ackerman's Masters' thesis at Texas Woman's University. The purpose of this research is to determine the relationship between knowledge, attitudes, and behaviors toward dietary protein among adults. You have been asked to participate in this study because you are over the age of 18.

Description of Procedures

Your participation in this survey is voluntary. As a participant in this survey, you will be asked questions about dietary protein knowledge, attitudes, and behaviors. This survey can be taken at any location with a reliable Internet source. The maximum time commitment is thirty minutes. Once the survey is no longer available, participant answers will be collected and analyzed. The Institutional Review Board at Texas Woman's University has approved this survey.

Potential Risks

A potential risk in this study is loss of confidentiality. Confidentiality will be protected to the extent that is allowed by law. This survey is anonymous, and results will only be kept between the Principal Investigator and Faculty Research Advisor. The results will be password protected and stored on the principal investigator's computer. The results will be discarded within 5 years after the study is finished. There is a potential risk of loss of confidentiality in all email, downloading, electronic meetings and internet transactions. However, all confidentiality will be secure.

Participation and Benefits

Your involvement in this survey is completely voluntary and you may exit out of the survey at any time. There are no direct benefits for participation. If you choose to participate, your answers will benefit research to improve the health of adults by increasing dietary protein knowledge and skills to decrease misconceptions toward dietary protein. If you would like to receive the results of this study, you can e-mail the Principal Investigator to request them.

Questions Regarding the Study

If you have any questions about the research study, you should ask the researchers; their e-mail addresses are at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

If you have read and understand the above statements, please click on the "Continue" button to indicate your consent to participate in this study.

APPENDIX C

Dietary Protein Assessment Survey Instrument

Dietary Protein Assessment Survey

Demographics

1) What is your age?

2) Please indicate your gender.
- Male
- Female

3) Please indicate your ethnicity (Choose all that apply).
- African American
- American Indian
- Asian/Pacific Islander
- Caucasian (non-Hispanic)
- Hispanic
- Scandinavian
- Prefer not to disclose
- Other (please specify)

4) What best describes your lifestyle environment?
- Urban (city)
- Suburban (small residential community)
- Rural (country)

5) What is your current health status (Choose all that apply)?
- Healthy
- Overweight/Obese
- Diabetic
- High blood pressure
- High cholesterol
- Chronic Kidney Disease
- Prefer not to disclose
- Other (please specify)

6) What is the highest level of education you have attained?
- Less than a high school diploma
- High school graduate
- Some college or technical training
- Associate's degree or equivalent
- Bachelor's degree
- Graduate degree

7) What is your current work situation?
- Employed full-time
- Employed part-time
- Semi-retired
- Fully retired
- Self-employed
- Unemployed
- Homemaker
- Student
- On disability
- Other (please specify)

8) What is your total combined household income for the past year?
- Less than $5,000
- $5,000 - $19,000
- $20,000 - $49,000
- $50,000 - $99,999
- $100,000 - $150,000
- More than $150,000
- Prefer not to disclose

Knowledge

9) The Recommended Dietary Allowance (RDA) for protein for a healthy male or female adult is 0.8 grams per kilogram of body weight per day.
- True
- False
- Unsure

10) Dairy products (milk, cheese, yogurt) are a source of high-quality protein.
- True
- False
- Unsure

11) Cow's milk contains the same types of protein as breast milk from women.
- True
- False
- Unsure

12) A calorie is a calorie, regardless if it comes from carbohydrate, protein, or fat.
- True
- False
- Unsure

13) 4 ounces of chicken and 4 ounces of tofu have the same amount (grams) of protein.
- True
- False
- Unsure

14) Older adults (e.g. >50) have a relatively higher need for protein to maintain muscle mass later in life.
- True
- False
- Unsure

15) Strength athletes have an increased need for protein compared to the general population.
- True
- False
- Unsure

16) Endurance athletes have an increased need for protein compared to the general population.
- True
- False
- Unsure

17) Protein intake above the Recommended Dietary Allowance (RDA) is associated with an increased risk of developing certain types of cancer.
- True
- False
- Unsure

18) For healthy weight loss, it is important to consume more than the Recommended Dietary Allowance (RDA) of protein.
- True
- False
- Unsure

19) Dietary protein is primarily needed for the structure, function, and regulation of the human body's tissues and organs.
- True
- False
- Unsure

20) Dietary protein is important for a strong immune system, which protects the body from viruses and bacteria.
- True
- False
- Unsure

21) A diet containing enough protein is important for bone health.
- True
- False
- Unsure

22) When it comes to maximizing human health, the source of protein is more important than the amount of protein consumed.
- True
- False
- Unsure

23) People following a diet higher in protein vs. processed carbohydrates tend to be less insulin resistant.
- True
- False
- Unsure

24) 8 ounces of plant-based milk (almond, cashew) and 8 ounces of cow's milk contain the same amount of protein.
- True
- False
- Unsure

25) Foods of animal origin are typically higher in protein than plant-based foods.
- True
- False
- Unsure

26) Abnormally high protein intake is associated with kidney and liver disease among the general population.
- True
- False
- Unsure

27) Pregnant women have an increased need for protein compared to the general population.
- True
- False
- Unsure

28) The building blocks of protein are amino acids.
- True
- False
- Unsure

29) There are 9 amino acids that must be obtained from the diet.
- True
- False
- Unsure

30) All amino acids consumed in the diet are used to make protein in the human body.
- True
- False
- Unsure

31) Protein is a major component of bone health.
- True
- False
- Unsure

32) The main site of branched chain amino acid (BCAA), such as isoleucine, leucine, and valine, metabolism is in the skeletal muscle.
- True
- False
- Unsure

Attitudes

33) The impact of climate change can be reduced by consuming less meat, dairy products, and eggs.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

34) Meat production is harmful to the environment.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

35) Organic protein sources are better for the environment.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

36) Organic protein sources are healthier.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

37) Plant-based protein is better for health than animal-based protein.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

38) Protein consumption is essential to human health.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

39) Egg consumption is harmful to human health.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

40) The Recommended Dietary Allowance (RDA) for protein is adequate for healthy weight loss.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

41) The Recommended Dietary Allowance (RDA) for protein is adequate for people following a vegetarian diet.
- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

42) Eating the same calorie level of either protein, carbohydrate, or fat has an equal effect on hunger.

- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

43) Overeating dietary protein leads to the same gains in body fat as overeating carbohydrates or fat.

- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

Behaviors

44) What is your primary source of nutrition information?

- Internet
- TV
- Books/Magazines
- Coach
- Physician
- Registered Dietitian
- Other (please specify)

45) How many people currently reside in your home, including yourself?

- 1 person
- 2-4 people
- More than 4 people

46) Are you the primary food purchaser and cook in your household?

- Yes
- No

47) What is the most important factor when shopping for a protein source?

- Price
- Taste
- Health
- Quality (high biological value)
- Other (please specify)

48) How often do you eat away from home?
- Once a week
- Twice a week
- 3-4 times a week
- Every day

49) Are you a vegetarian or vegan?
- Yes
- No

50) Do you plan your meals around protein?
- Yes
- No

51) Approximately how many servings of protein (a serving is the size of a deck of cards) do you consume per day?
- None
- 1-3 servings
- 4-5 servings
- 6+ servings

52) When are you least likely to eat protein?
- Breakfast
- Lunch
- Snack
- Dinner
- Other (please specify)

53) What is your preferred source of protein?
- Lean meat (pork, beef, lamb, veal)
- Poultry (chicken, turkey)
- Fish/Seafood
- Dairy
- Eggs
- Plant-based (nuts and seeds, legumes/beans)
- Supplement

54) How many days per week do you consume high-quality protein (meat, eggs, milk, dairy)?
- None
- 1-3 days per week
- 4-5 days per week
- 6+ days per week

55) If you consume high-quality protein, how many times per day?
- None
- 1-3 times per day
- 4-5 times per day
- 6+ times per day
- I do not eat animal protein

56) How often do you include a protein supplement (bars, shakes)?
- Every day
- 1-2 days per week
- A few days per month
- Never
- Other (please specify)

57) What is the biggest barrier that prevents you from consuming protein?
- No barriers
- Cost
- Convenience
- Dislike of protein taste/texture
- Unsure of how to prepare protein
- Too busy
- Other (please specify)

58) How many days per week do you participate in 30 minutes or more of structured exercise (walking, running, riding a bike)?
- None
- 1-3 days per week
- 4-5 days per week
- 6+ days per week

59) How many days per week do you participate in a structured strength training program (weight lifting)?
- None
- 1-3 days per week
- 4-5 days per week
- 6+ days per week

60) Which type of milk do you consume?
- Cow's milk
- Almond milk
- Soy milk
- Coconut milk
- None
- Other (please specify)

61) If you consume cow's milk, which kind do you consume?

- Skim milk
- Low fat (1%) milk
- Reduced fat (2%) milk
- Whole milk
- I do not consume cow's milk

Attitudes Continued

62) Animal welfare should be protected.

- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

63) Meat consumption is unhealthy.

- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree

64) Meat should not be consumed.

- Strongly Agree
- Agree
- Undecided
- Disagree
- Strongly Disagree